Human Resource Development for a South African Nuclear Power Plant Project: Risk Management Perspective

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1. Introduction

The safe and reliable operation of nuclear power plants (NPPs) is of utmost importance to South Africa's energy security and environmental sustainability. As the country seeks to meet its increasing energy demands, it must also address the inherent risks associated with nuclear power generation. In this context, adoption of a Human Resource Development (HRD)-centered risk management approach emerges as one of the strong components to ensure the continued safety and success to South African NPP undertaking. The HRD-centered risk management approach places human performance and organizational culture at the forefront of risk assessment and mitigation [1]. It recognizes that well-trained, competent, and safety-conscious personnel are essential to the safe operation of NPPs. Given the complexity of nuclear technologies, the potential for human error necessitates a comprehensive approach that addresses the human factor in risk management. The skills development program of a country aspiring to expand its nuclear capabilities must encompass human resource development, educational and training initiatives, knowledge management, and the establishment of knowledge networks at both national and global levels [2]. This paper will assess the impact of a well-executed HRD strategy on risk management of a nuclear power plant throughout its life. The study's literature review emphasizes on four essential elements among many in the HRD strategic outline: workforce planning, education and training, recruitment, and stakeholder engagement [3], all of which are thoroughly examined, **Figure 1**. The study concludes that employing HRD planning as a means to alleviate risks, with a particular focus on areas that require attention may serve as a proactive measure to mitigate potential challenges and enhance the overall effectiveness of the project.

Figure 1: Typical elements of a human resources development strategy [4]

2. An Overview of Human Capacity and Development in South Africa

What gives an organization its competitive advantage? What enables it to become more productive, well-managed, and efficiently organized? While the argument can be made that the organization's product or service is its reason for existence, the delivery of that product or service is reliant on having the right human resource capacity. South Africa developed a White Paper on Human Resource Management in the public sector set out to achieve diverse, competent, and well-managed workforce capable of and committed to delivering high quality services to South African citizens. This document promotes the values of fairness, equity, accessibility, transparency, accountability, participation and professionalism. In the context of a South African NPP, HRD planning must adapt that outlined by the guidance of the nuclear industry body while aligning with government established policies. While the nation has seen significant growth in the construction industry, this has resulted in a shortage of skilled workers. This shortage primarily stems from various factors, including insufficient practical

exposure, the closure of training schools, the mass exodus of skilled workforce, and a decreased influx of newly skilled employees into the construction industry, especially among the younger generations. Additionally, factors such as economic conditions, a deficit of first-level staff skilled at supervision, and a lack of basic education and mandatory certifications are contributors [10]. The higher education sector in the country is thriving, boasting a dynamic array of esteemed institutions of higher learning and universities that consistently rank among the top globally. The national education system continues to face significant challenges, including inequality, inadequate infrastructure, and subpar academic performance. The concern surrounding the quality and relevance of training students receive from programs, such as Further Education and Training (FET) Colleges, and how it aligns with industry demands has had a detrimental impact on the supply of skilled workers in the pipeline [11]. After operating a twin-unit nuclear power plant for more than three decades, the country is somewhat in a comparatively advantageous position to tackle progressive recruitment challenges by leveraging the valuable lessons learned through the years. Recently, the increased interest in South African mega projects has led to heightened stakeholder visibility, particularly among trade unions. Employer organizations continuously engage in negotiations with trade unions to establish project labor agreements (PLAs) for major construction projects involving multiple sectors, such as energy power plants. These agreements aim to foster labor management consistency on-site, ensuring smooth collaboration among the various stakeholders. While nuclear engineers represent a minority of the workforce in a nuclear power project, the majority consists of non-nuclear engineers and skilled technicians [3] [4], and the nation holds a considerable proportion of these skills.

2.1 Workforce Planning

Workforce planning is crucial for assessing competency requirements in a nuclear power program. It necessitates meticulous consideration and design during the initial phases of the HRD program. The process involves assessing the requirements for personnel and their skill sets across different operational areas. IAEA recommends conducting workforce planning assessments at different program phases (feasibility; site investigation and bid preparations; design, construction, and commissioning) for organizations involved in the nuclear program, such as Nuclear Energy Programme Implementation Organization (NEPIO), regulator, and utility [4]. **Figure 2** illustrates a conventional flowchart for workforce planning that can be adopted by these organizations.

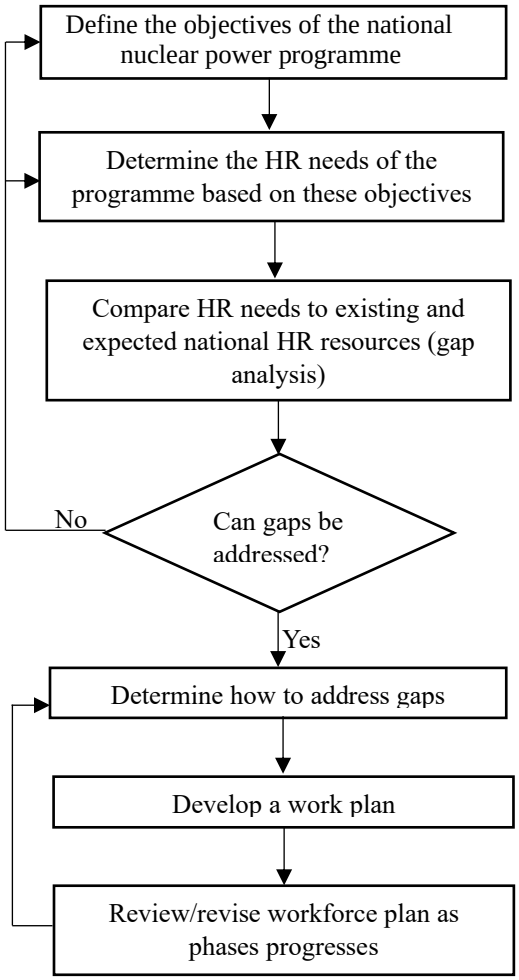

Figure 2: Simplified workforce planning flowchart [4]

2.2 Education and Training

Education and training refer to creating domestic academic and vocational structures to produce skilled workers or attract them from national or global labor markets. To ensure the long-term sustainability of the NPP programme, a highly skilled workforce and a consistent influx of new recruits are essential. Countries with minimal or no commercial nuclear power experience likely lack the necessary academic base. Considering that training nuclear specialists may span between 5 to 10 years; it will take even longer for countries to domestically establish the educational facilities needed for such training [3] [5]. The consensus among most nations is that the synergy between industry, educational institutions, and the

government is an essential element in enhancing nuclear education and in attracting the younger talent to the field. Communication between academia and industry reaps several benefits for both parties. Primarily, the knowledge and skills of university graduates are better matched to the needs of the industry, and therefore industrial training can be more tailored to specific industry needs. Secondly, potential areas of collaboration can be accurately identified. This collaboration can be exemplified through actions taken by the industry such as: student placements, joint research projects, visiting professors, and by providing advisory information to the nuclear university staff that design and teach the curriculum [6].

2.3 Recruitment

Recruitment processes and strategies vary from one country to another, and this presents a challenge to the nuclear energy programme of newcomer countries particularly because they lack high caliber staff. This may necessitate recruitment of international staff that comes at a hefty price. A comprehensive workforce plan yields a recruitment strategy that aligns with the project objectives. In addition to addressing gap analysis based on workforce planning results, a well-tailored recruitment strategy should encompass factors such as cultural diversity, professional values, and attitudes. Effective stakeholder engagement has a strong connection to recruitment. When the risks, benefits, and objectives of the civil nuclear program are not communicated properly, it can lead to adverse effects on overall recruitment [3].

2.4 Stakeholder Engagement

Establishment of a robust HRD strategy for nuclear energy programmes poses a challenge for organizations and committees worldwide, especially as the nuclear industry holistically grapples with gaining public acceptance. Engaging with stakeholders is indispensable in the context of HRD planning. Involving all stakeholders, including those without direct decision-making roles, can bolster public confidence in the application of nuclear science and technology [7]. This in turn strengthens communication among the key organizations in the nuclear programme. The program's viability heavily depends on how effectively governments and the nuclear sector communicate and consult with stakeholders in the development of the necessary human capacity. The nuclear sector can attract the right skills and talent when individuals view the sector as route to a rewarding career. Both monetary incentives and the sense of meaningful contribution towards societal and national growth are essential for appeasement [3]. Promoting a dialogue with civil society fulfills multiple functions in supporting nuclear programme activities, failure to engage can result in doubt over the government's commitment or capabilities to manage the program, leading to uncertainties that may deter potential recruits.

3. Review of Literature relevant to NPP Risk Management

Each phase of the NPP cycle has inherent risks that must be identified and managed. The risk management approach mirrors that of conventional projects. Initially, risk identification is carried out. This is followed by the selection of techniques or strategies to manage the identified risks. The chosen management strategies or techniques are then implemented. As the concluding stage of the process, the efficacy of the implemented solutions is subject to ongoing monitoring and evaluation [8]. A brief summary of risk categories includes strategic risks that can impose changes in energy policies and public opposition, while project risks encompass delays and cost overruns. Preparation risks might involve geological surprises and legal challenges, whereas construction risks relate to engineering failures and material shortages. Operational risks include equipment failures and cybersecurity threats, while human resource risks cover staffing and training issues. Commercial and financial risks are linked to market fluctuations and investment challenges, and decommissioning risks involve the dismantling of the plant, including environmental concerns and waste disposal [9].

4. Questionnaire Design

The questionnaire layout begins with a concise introduction explaining the study's purpose and significance. Three initial questions are aimed at gathering demographic information i.e., role, years of experience and location. The main segment comprises 16 questions, organized into sections, each section concentrating on one of the four emphasized elements. These questions encompass a mixture of formats, including multiple-choice, rating scales, and open-ended questions, thereby enabling comprehensive data collection and analysis. The concluding question invites respondents to contribute additional comments regarding the subject. To ensure participant confidentiality, responses are treated as anonymous. A pilot test with a small group was conducted prior to distribution to identify any concerns on question clarity, length, and comprehensibility.

5. Survey

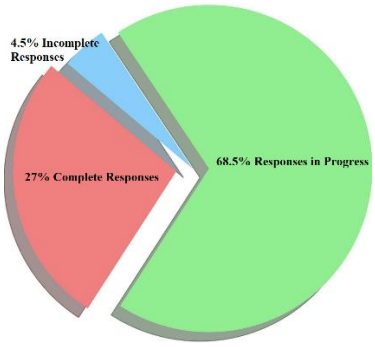

Figure 3: Survey distribution and responses

A total of 89 online surveys are distributed, 28 of them have been returned with 4 incomplete responses. Percentile representation is in **Figure 3**.

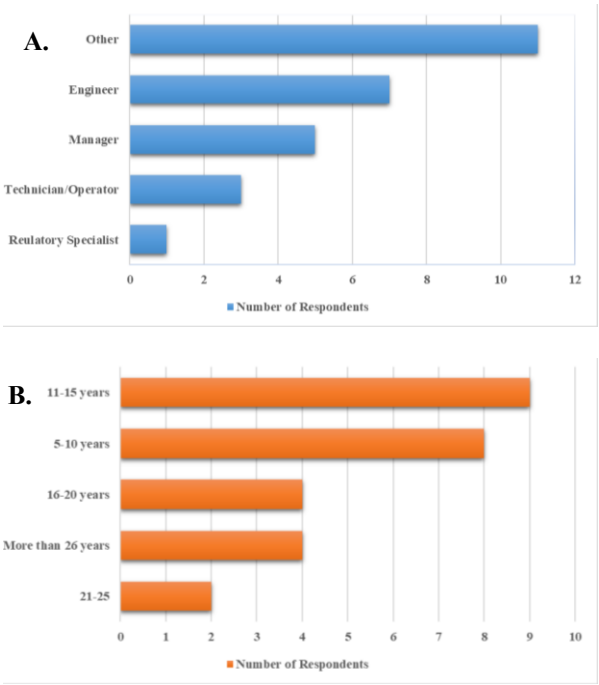

Figure 4: Responses distribution charts **A.** Roles of respondents **B.** Years of experience

The most frequent role among the respondents is 'Engineer', followed by 'Manager' and 'Technician/Operator' respectively as seen in **Figure 4A**. The most common experience range among respondents is '11-15 years', followed by '5-10 years' and 'more than 26 years'. Fewer respondents fall within the '16-20 years' and '21-25 years' categories. See **Figure 4B**.

6. Results and Discussion

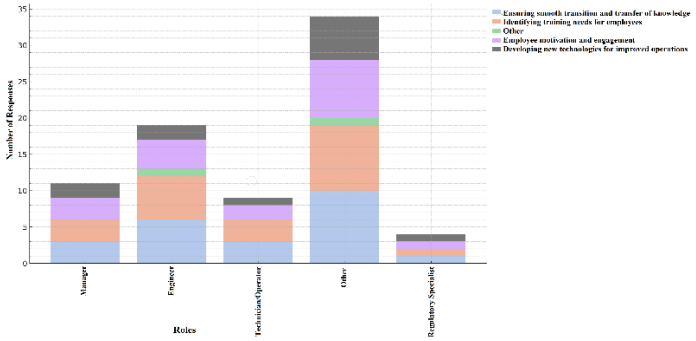

Figure 5: Workforce planning key objectives ranks

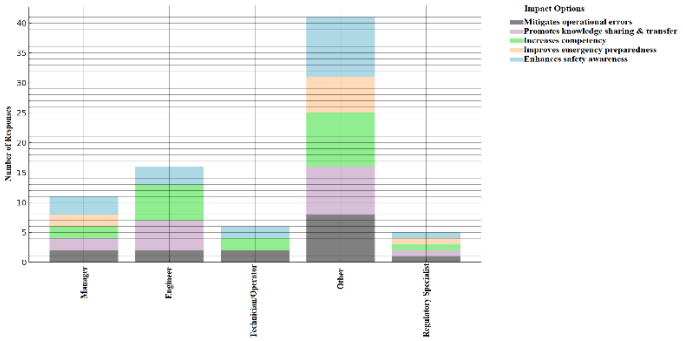

Figure 6: Education and training factor appraisals

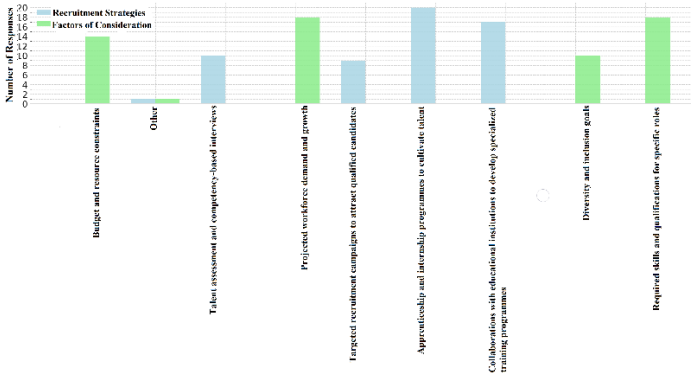

Figure 7: Recruitment approaches and hurdles chart

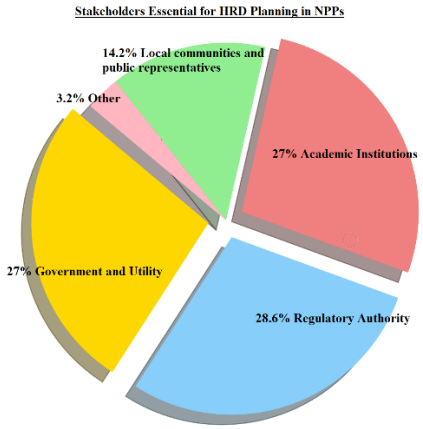

Figure 8: Stakeholder involvement representation

Extracted on an ongoing online survey conducted among international nuclear professionals, the aim of which is to assess the impact of HRD in enhancing risk management in nuclear power plant projects, 27% of the participants have responded. There is a prevalent conviction that:

1) Facilitating seamless knowledge transition and transfer; recognizing the training requirements of employees respectively are essential in the realm of workforce planning, **Figure 5**.
2) Education and training increases competency and enhances safety awareness. Moreover, sharing knowledge with international entities promotes the interchange of best methods and experiences learned from international projects, **Figure 6**.
3) Apprenticeship and internship programs aimed at nurturing talent are considered the optimal recruitment approach. In forming recruitment strategies, factors such as relevant skills and qualifications alongside forecasted workforce demand and growth must be carefully considered, **Figure 7**.
4) In essence, active involvement of stakeholders, including governments, regulatory entities, and academic institutions, is equally vital in HRD planning for NPP projects, **Figure 8**.

7. Conclusion

In conclusion, the overall inconsistencies observed within the South African construction industry are likely to have direct repercussions on the future NPP project's prospects and success. The success and productivity of a nuclear power plant project hinge on having the right human resource capacity. Employing HRD planning as a method to alleviate risks, with a particular focus on areas that require attention may serve as a proactive measure to mitigate potential challenges and enhance the overall effectiveness of the project. By strategically addressing and prioritizing alignment of education with the industry needs, fostering labor upskilling, implementing effective recruitment approaches, and embracing stakeholder participation can result in the country mastering the art of continuously minimizing NPP project risks from inception to retirement.

Acknowledgements

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