

Technician level needs and skills development guidelines for the South African
nuclear energy industry.

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Abstract

The increasing demand for electrical energy to bring about development and social change has brought about renewed interest in the use of nuclear power as one of the sources of electrical energy. The nuclear power industry has had a few decades of low activity due to previous accidents which turned the public perception against the use of nuclear as an electrical power source. The low activity has resulted in the shortage of nuclear skills as the skill previously available is now aged and about to reach retirement.

The South African Government has recently announced its commitment to having nuclear in the energy mix. This will require construction of new nuclear power plants. This research arises from the need to understand whether the required human capital will be available, looking specifically at technician level in the nuclear energy industry.

The main research goal of the study was to find what training and development initiatives are currently being used in industry and what needs to be in place to ensure that the industry is ready for the nuclear new-build. The researcher then proposes training and development initiatives that should be put in place to meet the demand that will be created by the nuclear new-build.

Keywords

Integrated Resource Plan 2010

Nuclear new-build

Nuclear skill certification

Nuclear human capital requirement

Nuclear energy policy

Technician training

Training and development

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List of acronyms

CEO – Chief executive officer

CO₂ – Carbon dioxide

DoE – Department of Energy

DST – Department of Science and Technology

GDP – Gross Domestic Product

GNP – Gross Nominal Product

GWe – Gigawatt electrical

IAEA – International Atomic Energy Agency

ILO – International Labour Organisation

IRP – Integrated Resource Plan

KILM – Key Indicators of the Labour Market

MW – Megawatt

NEA – Nuclear Energy Agency

Nersa – National Energy Regulator of South Africa

NIASA – Nuclear Industry Association of South Africa

PBMR – Pebble Bed Modular Reactor

R & D – Research and development

Chapter 1 : Introduction

1.1 Research motivation

A number of research papers have been produced with regard to the upper level skill set distribution, training and development within the South African nuclear energy industry, (Matube, 2009; Thugwaneta et al.,2008; Potgieter,2010). Low level skill set have also been addressed by previous research as shown by Van Rooyen, 2010; Sean 2007, amongst others. For the purposes of this dissertation, upper level skill set is defined as those who possess a minimum of a Bachelor's degree in engineering, while the low skill set is defined as artisan level and below.

A number of universities within the country have started providing nuclear exposure to undergraduate engineering students as well as a number of postgraduate qualifications that are currently being offered or are in the process of being formulated for offering at various universities.

Research publications on the number of technicians trained each year in the nuclear industry are not readily available, and as such this research aims to bridge this existing knowledge gap. Skills development in the nuclear sector is a responsibility accepted by each IAEA member state under the Convention on Nuclear Safety which aims to stem the loss of tacit knowledge due to workforce aging. Article 11.2 states that “[e]ach Contracting Party shall take appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life” (IAEA 2004).

For South Africa to properly and successfully plan for the required human capital of the size expected of constructing nuclear power plants, all necessary parameters need to be well understood and well communicated. One of these parameters is the availability of skills at different levels. One of those skills level is at technician level. Knowing and understanding the availability of skills will aid in formulating and putting in place the necessary required interventions needed to ensure that those skill gaps, if any, that exist are bridged.

1.2 Research problem

IRP2010 (Integrated Resource Plan 2010) was promulgated by the South African Government, hereafter referred to as the Government, by the Minister of Energy in the Government Gazette on the 6th May 2011. The IRP is a national electricity plan which directs the expansion of the electricity supply over a given period of time, in this case 2010 - 2030, revised every two years.

The plan includes Government's commitment to include Nuclear energy in the national energy mix. Government, according to the plan, is committed to construct new nuclear plants with a capacity of 9600MW by the year 2030. Construction of new nuclear plants will require a number of skill sets at different levels. IRP2010 also affirms Government's commitment to localisation of the nuclear industry especially during the construction phase.

Due to the relative long planning, negotiation and construction of nuclear power plants, the need to understand South Africa's localisation potential and capacity

is of great importance. Localisation cannot take place without the availability of the required local skills.

This is not only due to the provision of needed skill sets but also due to the fact that localisation can act as a catalyst for reducing unemployment in a country that is beset by high levels of unemployment, with those unemployed usually lacking the required skills and competence.

One of the critical skills required during construction, as well as operation, of nuclear power plants is, among others, at the technician level. Successful localisation of nuclear equipment and services will require a fleet approach to ensure economies of scale, meeting nuclear quality and regulatory standards, technology and skills transfers from vendors, funding and skills development. Success thus heavily relies on the skills available at all levels required for a nuclear power plant construction.

The main technical skills required during construction of a nuclear power plant can be divided in three main categories, namely: (i) Engineers – upper level skill set, (ii) Technicians – mid-level skill set, and (iii) Craftsmanship/Artisans – low level skill set. Category (i) and (iii) have been addressed in previous researches (Deane, 2006; Greyvenstein, 2008; Pouris, 2009; Van Rooyen, 2010) as shall be shown in the dissertation but for category (ii) there is a gap in knowledge that needs addressing.

The knowledge gap exists in terms of research publications undertaken on skills availability, training and development opportunities and initiatives as well what is currently being done within the industry to address any skill shortage that exist.

This dissertation accordingly seeks to address this situation by providing a skill gap analysis and guideline that can be used to develop a generic national training program for technicians in the nuclear energy industry.

1.3 Research objective

The specific objective of the research is to look at what training and development programmes:

- i. are currently employed by different stakeholders to train technicians in the nuclear energy industry in South Africa in order to address skills shortages and ensure nuclear industry standard competence, primarily during the construction phase.**
- ii. need to be in place to meet additional skills load implied by participating in the nuclear new build programme.**
- iii. are required to bridge the gap to support the nuclear new build programme for the maximum benefit of the country.**

In addition to the specific objectives, a brief comparison of the training programmes/initiatives in South Africa versus those employed by South Korea nuclear localisation, which is considered one of the most successful localisation programmes within the global nuclear industry. The comparison will help in validating the research findings and making useful recommendations.

1.4 Dissertation overview

The course of the research is as follow:

Chapter one is an introduction to the research and primarily has an orientation function.

Chapter two looks at the literature review in terms of existing knowledge available, what has been done in the area of research interest and what knowledge gap exist. A literature review can be defined as a sharp, precise, systematic study of existing literature concerning a specific problem (Smith, 1993).

The chapter starts off by looking at the skills requirements in the nuclear energy industry and the drivers for these skills requirements. It then looks at the main role players/stakeholders in the nuclear industry. The chapter concludes by giving a clear definition of the skills classification as will be used throughout this dissertation.

Chapter three looks at the research design, and research methodology followed in the dissertation both from the theoretical point and how this theory was applied in undertaking this research.

The chapter describes how the empirical research data was gathered, the population size, questionnaire used and how the interviews were conducted.

Chapter four presents and describes the results of the empirical study, with an analysis of the qualitative data collected in terms of research objectives. A discussion on what the human capital requirement is projected to be during the construction phase is presented.

A gap analysis of the current situation is undertaken in line with the research findings. Finally a training guideline is proposed to address the existing gap.

Chapter five presents research conclusions and recommendations, research limitations and the suggestions regarding future fields of study, which could be embarked on because of this research.

1.5 Chapter one conclusion

South Africa's success hinges on having sufficient skills to take the economy forward. The availability of electrical energy is an important component of economic growth and nuclear energy has the potential of playing the role of catalyst for economic growth.

There is an acknowledged shortage of skills worldwide, especially in the technical sector. The challenge facing South African organisations is the ability to fill technical vacancies and for the nuclear new-build to take, an aggressive programme of skills development need to be in place if the new-build programme is going to be any success. This chapter provided a high-level executive summary of the rationale for the study.

The next chapter provides a review of literature to ascertain the current level of knowledge on each of the research questions, and to understand the inter-dependencies between the research objectives.

Chapter 2 : Literature Review

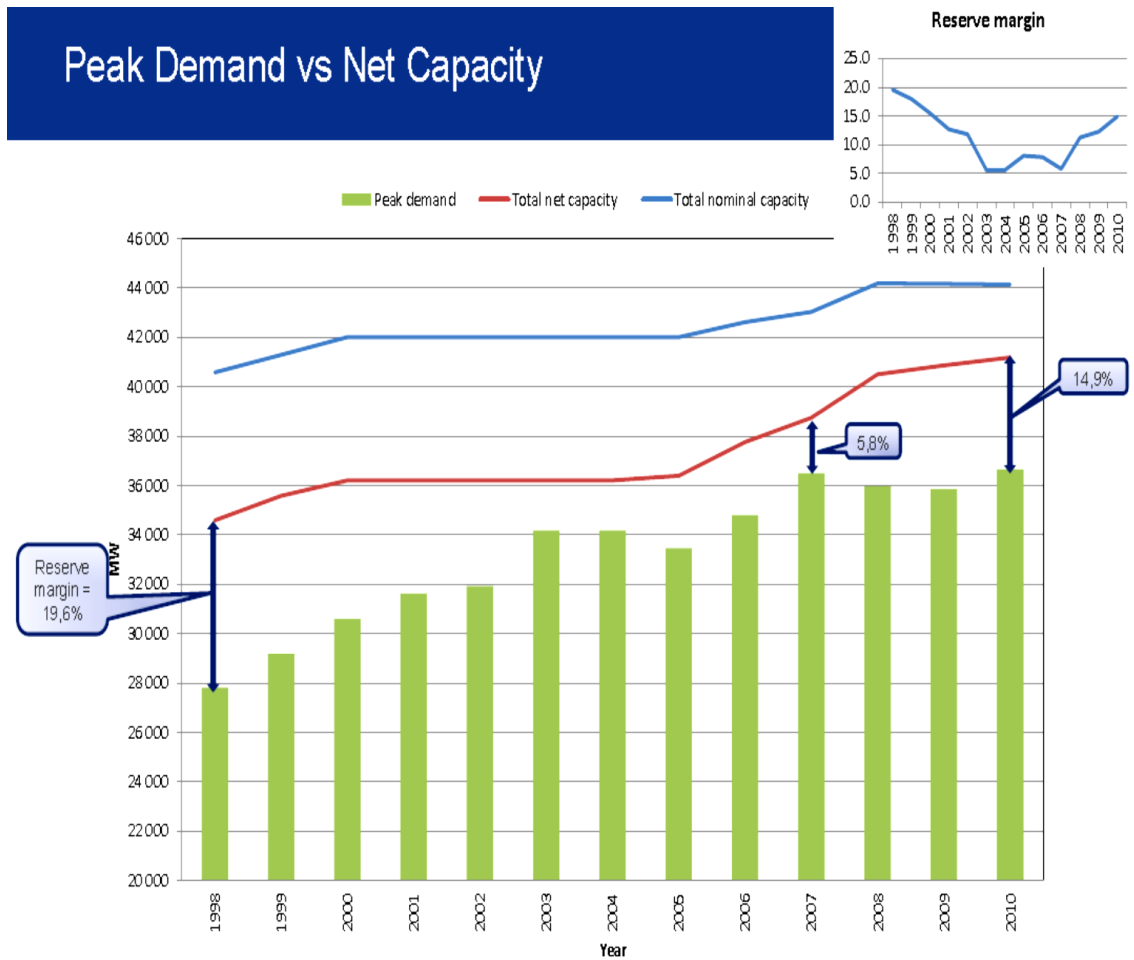
2.1 Nuclear skills requirement

There is a serious shortage of energy facing the world as well as climate change concerns that need urgent resolve. A large global population suffers from inadequacy of energy that is essential in reducing poverty, raise living standards, improve healthcare and increase industrial and agricultural productivity (IAEA_b, 2007).

The International Atomic Energy Agency, (IAEA), projected in 2008 that the total world primary energy demand will grow by 45% between 2008 and 2030 at an annual average rate of 1.6%. Demand for electricity grows faster than that of primary energy, usually at double the rate of primary energy. Demand for electricity is soaring dramatically in developing countries, leading to the pursuit of nuclear power as a suitable long term energy supply option in support of economic and industrial growth as well as carbon emission cuts (OECD_b, 2008).

Around the world, a number of countries are investing in or considering building new nuclear power plants. This nuclear new build activity is in stark contrast to muted nuclear build over the last 20 years (Goodfellow, 2003). With the potential to generate safe and affordable electricity for many years without significant greenhouse gas emissions, nuclear energy holds enormous promise especially in South Africa, where demand is fast outstripping supply.

The inadequacy of the reserve electricity margin is well illustrated by the power shortages that dogged the country in 2007 as indicated in the figure below.

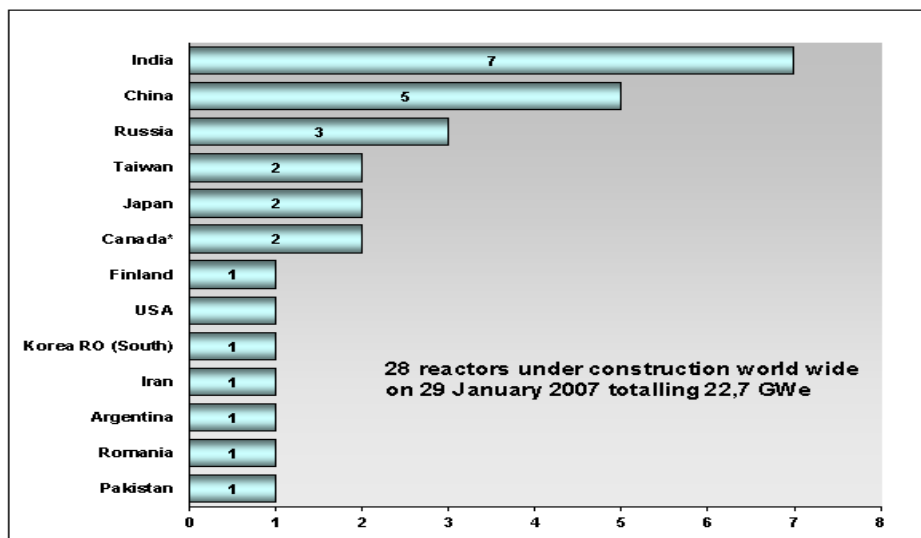


With the approval of the IRP2010 by Government, which envisage constructing nuclear power plants with a 9600 MW capacity as part of the energy mix, which will greatly increase Eskom’s capacity to supply electricity and increase the country’s electricity reserve margin, but this will also require intensive manpower capacity.

Nuclear energy had suffered pessimistic years in the 1980's and early 1990's which can be, at least partially, attributed to various national government policy shifts away from nuclear power following the Three Mile Island in 1979 in the USA and the Chernobyl nuclear plant explosion in Russia that happened in 1986. These two incidents had a huge impact on the way nuclear energy was viewed in terms of reliability and safety, especially in the western world.

The legacy of these two incidents can be seen continuing throughout the 1990's and early 2000's with only a small number of new power plants constructed.

Figure 1: Nuclear reactors under construction in 2007 (WNE, 2010)



Predictions by the nuclear industry foresee an increase in global capacity from the current level of 373 GWe to up to between 1100 and 3500 GWe in 2060, with the bulk of the new power plants projected to be in emerging economies (WNA, 2010). According to the World Nuclear Association (WNA), there were 28 nuclear plants being constructed as of 29 January 2007 but this number had

risen to 60 plants by June 2011 with china being the biggest contributor to this rise in numbers.

Figure 2: Reactors under construction in 2007 (WNA, 2007)

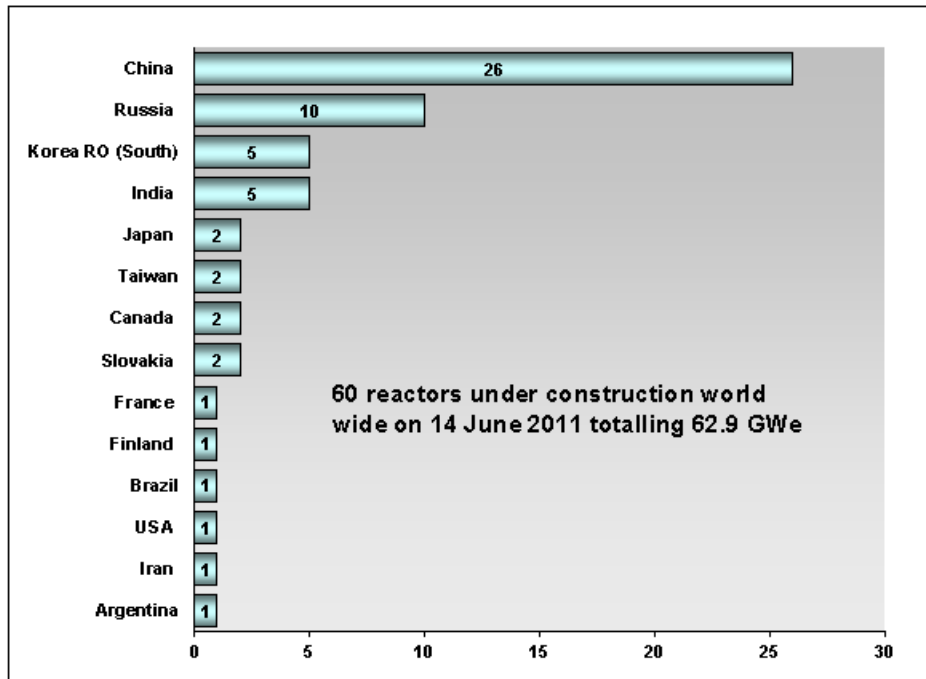


Figure 3: Nuclear reactors under construction in 2011 (WNE, 2011)

From the two figures above it is clear that nuclear energy have seen a revival of fortunes which bodes well for the industry and those who so wish to enter the nuclear career path. Given the commitment that is undertaken when committing to nuclear energy as part of the electrical energy supply mix, the recent revival is unlikely to decrease any time soon.

Given the indicated revival in a number of countries and those that are not currently involved in new-nuclear build but who has indicated in interest in having nuclear energy for civilian energy supply, effort need to be placed in developing human capital that will be required to construct, operate and manage these nuclear facilities.

Individual countries need to ensure that they develop their own human resources and reach agreements with other countries involved in the nuclear new build to ensure that those scarce skills are not poached by other countries who can offer better financial rewards, thus preventing those countries that have invested heavily in training their people from reaping the rewards.

Nuclear energy is considered to be clean energy due to the fact that there are no greenhouse gases released such as CO₂ and other gases that are released in coal and gas fired power plants during operation. Electricity generation is a major contributor to CO₂ emissions, and the need for low carbon technologies has intensified. There is also an ample supply of uranium which is likely to last at least another 400 years, (WNA, 2010). Concerns about the safety of nuclear power plants have also been addressed aggressively to allay fears of those who doubt the relative safety of these nuclear plants.

In the intervening years, much design work has gone into ensuring that nuclear reactors are as safe as reasonably possible. The safety and reliability of nuclear reactors have to a certain degree been demonstrated by countries that have been using nuclear power with no serious incident such as France.

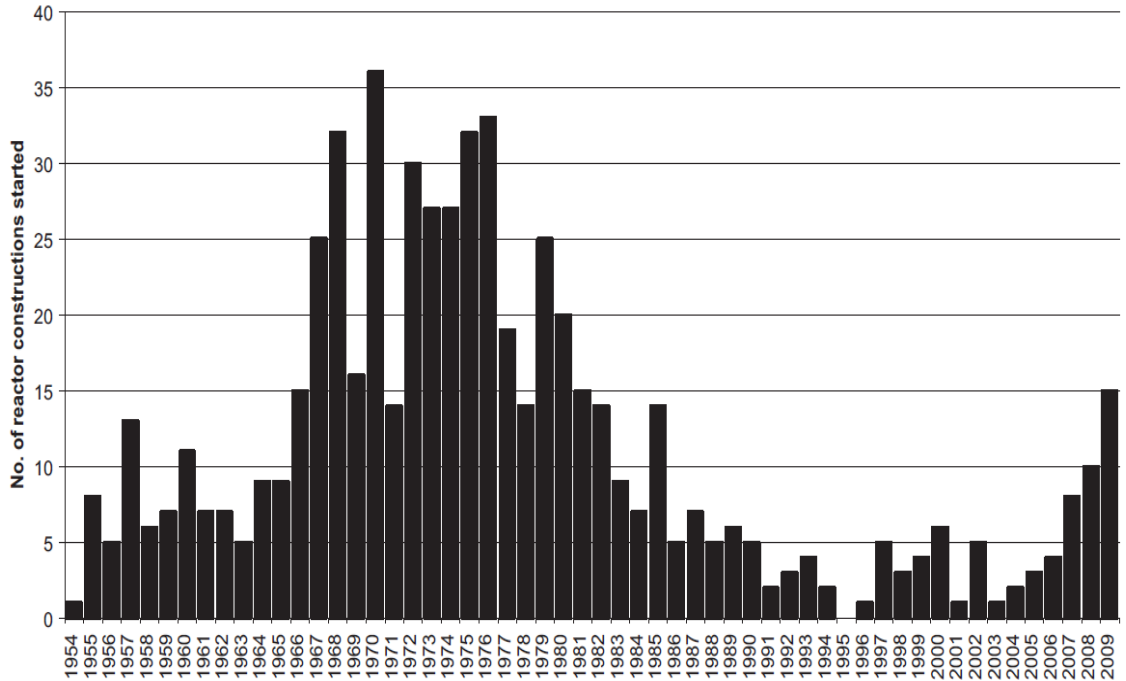


Figure 4: Global nuclear new build from 1954 to 2009 (Based on the data from IAEA (2009))

The historical rate of nuclear plant construction globally is shown in the figure above. The number of nuclear reactors under construction has even grown further as shown in the previous figures, indicating construction per country. It can be realistically expected that this revival is likely to keep on expanding due to the economic growth of China and other emerging economies which requires electrical energy to supply the industries.

In addition, there is a pressure on governments and power utilities to cut down on carbon emissions and provide cleaner energy without compromising energy supply security. Eskom is the biggest contributor of greenhouse emission in South Africa, as shown in the figure below. The figure shows that if Eskom was a country, it will be listed as the 25th biggest emitter of CO₂. Switching to a substantial supply of electrical supply from nuclear energy will help reduce the

country's total emissions.

Nuclear energy in South Africa will translate into a multitude of jobs being created, both front–end and back-end jobs, as there is a considerable uranium deposits, which is used in nuclear power plants. The aforementioned renewed interest has resulted in many countries reviving their nuclear energy programs to meet energy demands and developmental needs whilst cutting their CO₂ emissions.

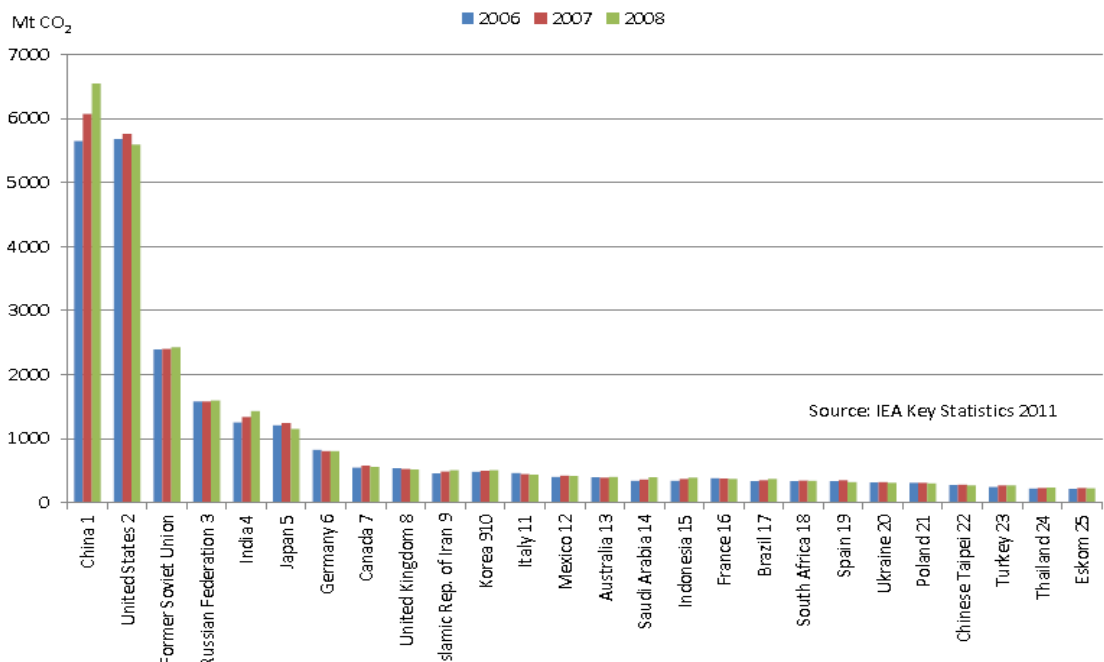


Figure 6: Global CO₂ Emissions (Mt) (IEA, 2011)

One of the most significant barriers to constructing new nuclear power plants is the availability of qualified and well trained manpower to successfully construct and operate nuclear power plants. For South Africa to take full advantage of the new build programme and obtain maximum benefit, it is essential that a robust programme be in place for skills development needed, at the right time and right

quantity. Nuclear energy not only provides a safe, secure and sustainable energy future, but provides much needed employment in manufacturing and construction of nuclear power plants (Cogent, 2008).

This is even more significant in South Africa where there is a high level of unemployment especially amongst the youth.

With regard to human capital development, a country's economic competitiveness is measured not only by the aggregate skills of a country's workforce, but also more importantly by the flexibility and capacity of the workforce to adjust speedily to the rapid changes in technology, production, trade and work organisation. Consequently, the ability to respond to these changes with speed and efficiency has now become the area where many countries seek a competitive advantage.

According to Ziderman (1997:352), *“There has been a move from primary reliance on policies that emphasised capital investment in plant, machinery and infrastructure, or export-led growth strategies, to a broader approach that assigns a central role to investments in human capital. Expenditures on improved education, training and health are now no longer regarded solely (or mainly) as benefits stemming from economic growth and rising incomes; increasingly, they are also seen as investments in human capital that make this sustained economic growth possible. This approach is shared not only by national governments, but is endorsed in the investment policies of international aid agencies.”*

Nuclear energy is a demanding technology for which specific knowledge and training is required (Csik, 2004). It can then be argued that this will even be more challenging in a developing country such as South Africa which has not undertaken a project of such magnitude before.

It is imperative that for South Africa to successfully embark upon nuclear new build programme, a manpower development programme need to be established and implemented. The IAEA, 2004, states that the availability of adequately trained and qualified manpower is one of the main essential conditions of success for any nuclear power programme.

The establishment and implementation of the training programme requires an organised effort, fully supported by the Government in every way possible including financial, (Csik, 2004). Indeed nuclear energy requires a strong government intervention in guiding the economic development as the technology requires a high degree of supply chain coordination which the government is capable of unifying as argued in Rochlin, 1994.

The presence of government strategy which links national development fosters the formation of national culture which tolerates risks associated with risk prone technologies, nuclear energy being one such technology. It is clear from the IRP2010 that the Government is willing to take the lead in the provision of nuclear energy in South Africa.

In terms of training facilities, South Africa already has a number of tertiary institutions that have the capability of training personnel required by the nuclear industry, if capacity is improved. Universities of Technologies that offers engineering qualifications are listed in the table below.

To incorporate the nuclear curriculum into the existing engineering curriculums, leadership and funding will be needed from industry, Government and academia. Government has taken a clear position on the inclusion of nuclear energy in the national energy mix as well as providing funding for the training of human resources needed for the successful implementation of nuclear new build programme (Matube, 2008).

Institution
Cape Peninsula University of Technology
Central University of Technology
Mangosuthu University of Technology
Tshwane University of Technology
University of Venda for Science and Technology
Vaal University of Technology
University of Johannesburg

Table 1: Institutions of high learning for technicians

The nuclear energy policy June 2008 supports the use of nuclear power (DME, 2008) to mitigate the effects of CO₂ emissions, create jobs and ensure electricity supply security. This policy provides for an ambitious programme that encompasses the entire nuclear fuel cycle. It commits the government to developing and maintaining a technically competent workforce to accomplish the policy objectives. The policy states that a “strategy and implementation plan for development and recruitment of suitable persons will be developed”.

There is a need to understand the skills requirement in the South African context to enable policy makers to plan appropriately. Nuclear energy is already part of the energy mix in South Africa albeit at a low percentage of six (6%), which is planned to be increased to 46% by 2030. The country can draw from the already existing know-how of what is needed to construct and operate a nuclear power plant (Haskins 2008).

South Africa’s nuclear energy ambition started in the 1980’s with the construction of Koeberg Nuclear Power Plant located north of Cape Town. The plant consist of two pressurised water reactors each with a capacity of delivering 900 MW, built by the French firm Framatome, now Areva. The plant is owned and operated by the national electricity utility Eskom. Despite this early entrance into nuclear energy, only 6% of the total energy supply is delivered from Koeberg power plant.

Much of the country's electrical energy, about 90% (Lorentzen, 2008) is derived from coal resources. Most of the coal reserves are located about 1500km from Cape Town and feasibility studies done in the 1970's had shown that it will be more economical to build a nuclear reactor near Cape Town than transmit power over that range.

The 1998 White Paper on Energy Policy (DoE, 1998) set out a number of policy objectives with some of the policy objectives relevant to nuclear energy. The policy document supported the diversification of energy sources and affirmed Government's commitment to using electrical energy for social progress and establishment of targets for the reduction of energy related emissions that are harmful to the environment and to human health.

The White Paper on Energy Policy was followed by the Draft Nuclear Energy Policy and Strategy of July 2007 (DoE 2008), which supports the usage of nuclear energy as set out in the objectives of the White Paper explicitly.

The 2007 policy paper provides for an ambitious programme encompassing the entire fuel cycle with a view of providing energy security and contributing to job creation and skills upgrading among others. The Policy further affirms Government's commitment to nuclear energy by pledging funding for the development of human resources capable of managing the nuclear infrastructure in partnership with universities/university of technologies and other industry stakeholders.

The Nuclear Energy Act of 2008 requires the Minister of Energy to develop and publish an Integrated Energy Resource Plan (IRP). This was done on the 6th May 2011 in the government gazette. In turn the Department of Energy, (DoE), mandated the System Operation and Planning division within Eskom to produce the IRP for electricity in consultation with the DoE and the National Energy Regulator of South Africa (NERSA).

This culminated in the drafting and release of the IRP2010 which have consequently been accepted by cabinet and published in the government gazette by the Minister of Energy on the 6th May 2011. Increasing the nuclear energy from the current installed capacity of 6% to the planned capacity of 46% will create a multitude of job opportunities in the country across the value chain, (Potgieter, 2010).

The IAEA places responsibility upon each member state for skills development under the Convention on Nuclear safety under Article 11.2 (IAEA, 2002). Government has recognised that there is a lack of qualified personnel required for the planned nuclear expansion and that this will be detrimental to the growth of the industry if not adequately addressed.

Government, together with industry has undertaken to address the skills shortage in the nuclear energy sector aggressively (Matube, 2009). Skills development initiatives in the industry will assist in preserving the skills that are already present whilst developing and nurturing new talent. If not well planned, sufficient manpower with the required skills and competence, capable of undertaking the

planned nuclear projects successfully will not be available if these shortages are not addressed (Thugwaneta, 2008). It is important that the skill shortages are well understood so that they can be properly addressed.

Globally, there is a shortage of engineers, nuclear project managers and technicians across all engineering disciplines, nuclear safety personnel and high integrity welders among others, (Cogent, 2008). South Africa is no different in this regard, and being a developing country, it can be reasonably assumed that the local skills shortage will be higher than the global average. This point is further illustrated in Lorentzen and Pietersen (2008), who state that engineering skills are in shortage globally and not only in South Africa.

An international survey done by Manpower Inc., in 2010 found that in South Africa, engineers, technicians and skilled manual trade workers, are the three categories of skills most in demand in the country. Dean (2006), reports that industry bodies have reported a shortage of skills across all qualifications from artisans to research and development staff as well as specialist engineers.

Dean further notes that fewer young people are entering the technical career path, while skills in demand in the knowledge economy take longer and longer to acquire. This can partially be attributed to lower passes in mathematics and science in matric.

An effective strategy for skills development requires an understanding of what the potential demand in the industry in the coming years will be. It is imperative that the current available workforce in the industry be kept abreast with new developments and these skills built on and transferred to the new entrants.

Areas where skills developments are most required must be thoroughly understood. Skills planning for nuclear new build programmes require long induction periods due to the levels of training and experience required to produce the highest level of workmanship, quality assurance and the many safety aspects critical to the sector. A skill set required in the construction of a nuclear power plant can be classified as shown in the figure below.

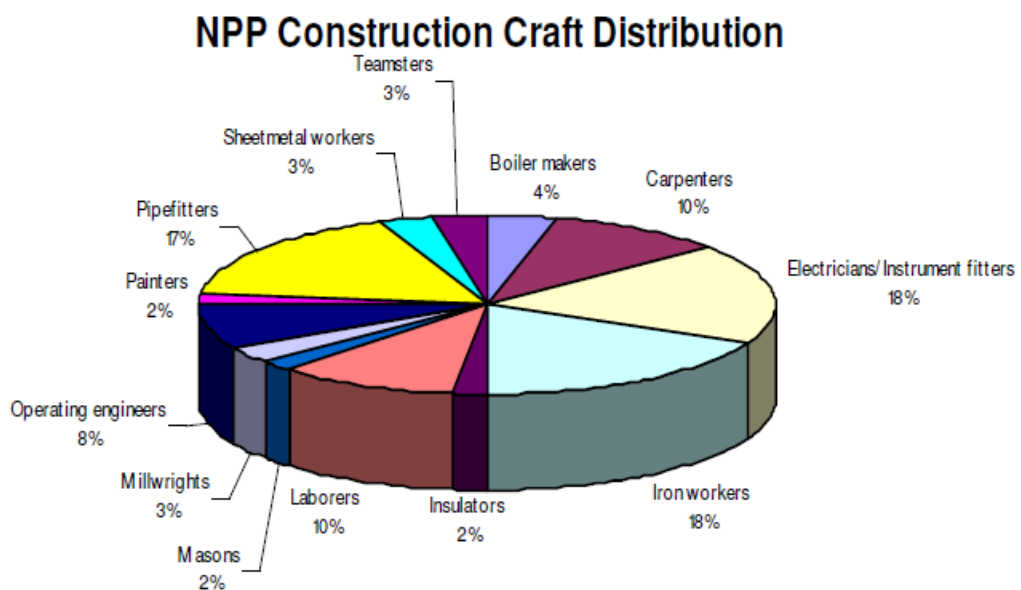


Figure 7: NPP skills distribution. Cavallini (2011)

The figure above not only show the potential of job creation presented by a nuclear new build but also illustrate the challenge that must be met to ensure that those skills will be available locally as and when required.

If it is taken that for the skills shown in the figure above, all with the exception of engineers, labourers, carpenters and painters holds a national diploma in a technical field, it can be stated that technicians make up about 75% of the labour force required. In addition to the skills required for the actual new build programme, what is not shown in the pie chart are the induced jobs that will be

created in the nearby community such as medical personnel, teachers, new business employees and local municipality employees, (Cavallini, 2011).

Cavallini, 2011, further argues that the nuclear new build will not only contribute to the provision of electrical energy that is urgently needed by a growing economy, but will also result in creating jobs outside the electrical energy sector. The creation of these jobs, which most will be sustainable beyond the construction phase, bodes well for a country that suffers from widespread unemployment.

The construction phase consists of the largest workforce grouping, making up about 60% of employment during new build projects. The importance of planning and budgeting for skills required for construction to ensure that the project is delivered on time and at cost cannot be over-emphasised (Cogent, 2010).

Recent studies have shown that nuclear education and training have suffered a decline in recent years to various degrees internationally (Pouris, 2009). If no action is taken, the nuclear industry risk facing a qualified manpower shortage required for regulation and operation of existing nuclear facilities as well as the construction of new ones in those countries that wish to do so (OECD, 2008).

This is even greater in a developing country like South Africa where there already is a skills shortage in almost all important sectors of the economy and even to a higher degree in the technical sector. The majority of those trained in nuclear engineering are now reaching retirement and there is a need to retain these skills

to ensure that there is a skill transfer to the new generation entering the nuclear industry.

The Nuclear Energy Agency (NEA) have identified a number of problems facing nuclear human development programmes and among these is the issue of how to retain existing skills and competencies for the long period that the plant takes to construct and also for the operational lifespan of the plant while attracting young talent to the sector (OECD_c, 2008). Given that South Africa already has a nuclear power plant, a workforce already exist but the needed workforce for the new build programme will be at least four times the current workforce according to the nuclear industry body NIASA (NIASA, 2008).

Energy must be expanded in training of new entrants as well as upgrading the existing skills in order to successfully support the new build programme as planned in the IRP2010. The IAEA have commissioned a number of studies in infrastructure and manpower development in order to be able to advise member countries on either new projects or how to upgrade the old skill sets already in the industry (IAEA_a, 2002). The above mentioned studies provides valuable information on what needs to be in place in order to successfully launch a nuclear power programme and it is advisable that the study be used as a guideline on manpower training and development.

In recent years, a number of studies has been undertaken to examine the concern that nuclear education and training are in decline. In July 2000, the OECD/NEA published a report entitled ***Nuclear Education and Training: Cause***

for Concern?, (OECD_a, 2000), with recommendations to address the skills shortages in the nuclear industry. The actions taken by governments have been varied, with improvements in some areas, and little change in others (NEA, 2007).

NEA further states that in some countries, specific plans to support universities have been successful in reversing the declining trends of the number of graduates in nuclear engineering and related disciplines. Many experts have argued that the availability of a highly skilled labour force contributes towards productivity and enhance the profitability of investment in training and development (Krugman, 1994).

South Africa has put plans in place for supporting Universities in nuclear education which is expected to contribute to the availability of nuclear skills. It is imperative to compare international trends with the South African scenario in order to draw parallels as well as lessons that can be learnt. A good comparison in terms of training will be France, which have operated a nuclear programme successfully for a long period of time with no incident of major concern.

The successful operation of nuclear plants in France must be due to a number of factors with competent and well-trained human resources being one of them. A good localisation model will be the South Korean model as they have managed to localise up to 95% of the nuclear content in their nuclear new-build, (Choi, 2008), (KAIF, 2006).

South Korea, when it embarked upon its nuclear programme, it put a number of programs in place to ensure that the country gain maximum benefits from the nuclear programme. At the initial stage, during the 1960's, a number of promising students where sent abroad to learn different aspects of nuclear engineering. At completion of studies, they were offered good salaries and career certainty (KAIF, 2006).

The country also entered into technology transfer with international vendors, in order for the local company to gain the working knowledge of nuclear technology. This ensured that as the number of reactors constructed increased, so did the local industry participation, resulting in a localisation contribution of about 95% when the last reactor was constructed (Chatuverdi, 1990) & (Choi, 2008).

As the availability of qualified human resources is a prerequisite, for the construction and the safe operation of nuclear power plants as well as to recourse to nuclear energy in general, the OECD Steering Committee for Nuclear Energy has agreed to convey to its members governments the following statements:

“Governments should regularly carry out assessments of both requirements for, and availability of, qualified human resources to match identified needs.

Governments, academia, industry and research organisations should collaborate both nationally and internationally to enhance nuclear education and availability of nuclear expertise, including financial support to universities and scholarships to students.

Governments, whether or not they choose to utilise nuclear power, should also encourage large, high-profile, international R&D programmes which attract students and young professionals to become the nuclear experts required for the future.”

Most countries have recognised the need to secure qualified human resources in the nuclear energy field, inter alia, due to the long lead time in existing programmes and consideration of new energy production options, (OECD, 2000). Most developing countries have primarily relied on turnkey nuclear reactors, while a few have concentrated their efforts to localise the nuclear power technology for the benefit of their people in terms of knowledge management and skills development, (Chaturverdi, 1990).

Korea was one of the countries that used the localisation strategy successfully and had reportedly localised up to 95% of the nuclear power technology by 2005 (KAIF, 2006). It is important that South Africa learns from this localisation strategy and adapt some of the key lessons learned from the Korean experience.

While no all-encompassing formula exists for countries wanting to participate in the nuclear new-build, there are lessons to be learned from the Korean experience. Parallels can be drawn between the current South African economy/economic growth and the Korean economic growth at the time it introduced nuclear power and how the Korean economy have grown thereafter.

Korea's gross domestic product (GDP) growth has been over eight percent (8%) per annum over the past years (1964- 1999) (World Bank Data), and much of this success has been attributed to the localisation programme of the nuclear programme and the spin-off's from the programme in terms of developing a knowledge based economy which encouraged innovation and entrepreneurship.

South African economic growth has been hovering around 4.6 % for the past 5 years (Stats SA, 2011) while the Government has targeted a sustained growth of 6% or more (NPC, 2011) to enable job creation and reduce unemployment which currently is at 25% overall and at about 45% for the South African youths (Stats SA, 2011). In the 1960's Korea was one of the world's poorest countries, with a per capita gross national product (GNP) of \$79.

Currently Korea's per capita GNP is \$17074, (2010 figures obtained from World Bank development indicators). For comparison purposes, South Africa's current GNP as of 2010 is \$7158 (Stats SA).

Korea's economic growth has accompanied better income distribution and improved quality of life for the majority of its people (Cordoza, 1997). Cordoza argues that beside the education and training of human resources, research and development (R&D) activities are essential for building knowledge based economies. R&D expenditure is thus an important factor in strengthening innovation and is equitable to economic development.

To encourage R&D and guarantee access to new knowledge, accelerate the rate of innovation, the Koreans adopted a mixed strategy which combined in-house R&D, strategic alliances, acquisition of high-tech firms, establishing international R&D networks and development of their own engineering design as well as organisational capabilities (Choi, 2009). These collaborative arrangements represented an important step in the process of diversifying in the resource knowledge and expertise.

To this end, RSA have set-up a number of programmes such as SANHARP, THRIP and DST Internships to address these concerns amongst others.

Government have committed itself to investing US \$ 5 billion over a 20 year period in developing the electrical power cluster in South Africa to drive innovation within the electrical power industry (TSPRO, 2009). Included in this amount is money that will be dedicated to developing human capacity at all levels in the industry with a strong emphasis placed on the nuclear industry.

The South African cabinet approved the National Nuclear Policy and Strategy in 2008 to establish institutional mechanisms to manage this investment (DOE, 2009). The policy clearly outlines the objectives, responsibilities and the institutional roles for the developing nuclear industry. One of the programmes that South Africa have set up which is nuclear specific is the collaboration programme between South Africa and Korea provided under ROKSA, whereby engineers are given a course on nuclear technology via the internet by Korean engineers/instructors (Thugwaneta, 2008). It needs to be explored if this

programme can be extended to the training and development of technicians in the industry.

South Africa needs to look at the steps taken by Korea in their localisation strategy and determine which will be applicable to the South African setting and how those lessons can be adapted to the local conditions in order to gain maximum benefit for the country. Reference cases such as Korea and France innovation cluster creation shows that it takes up to four decades to create a globally competitive nuclear power industry (Adam, 2008).

The South African Power Project, TSPRO, a ministerial level group that is steered by senior industry leaders in the electrical power industry with a heavy focus on nuclear engineering, is another initiative taken by Government and private industry in support of skill development and increase South Africa's localization capacity of the new-build programme. The project aims to define the role of Government, SOE's and the private sector in developing a globally competitive electrical power cluster to support the new-build programmes.

Its vision is: "To establish an integrated and sustainable power industry cluster to meet the long term needs of South Africa and wider markets" (TSAPRO, 2009).

TSAPRO further states that: "Government intervention will be required at different levels to support the journey for the South African power industry... The cluster will stimulate in the order of \$200 billion in GDP contribution, result in an improvement of \$25 billion in exports and, at its peak, create approximately 63 000 jobs" (TSAPRO, 2008). The project identifies a number of strategies that

need to be in place, with the skills strategy being identified as the most important of all strategies that need to be in place.

The drivers for nuclear skills requirements are shown in the figure below. As can be seen from the diagram in the figure, it is not only new build alone that contribute to the skills requirement in the industry but that there are other equally important sections of the industry competing for the same set of skills. This competing of skills between different sectors must be taken into account when planning for the required skills.

The training and development plan must thus take into account that skills not only need to be developed for new build alone but for other sectors as well within the industry. The Figure below also shows PBMR as a contributing to the skills requirement, it should be noted that this programme have been discontinued at the time of writing.

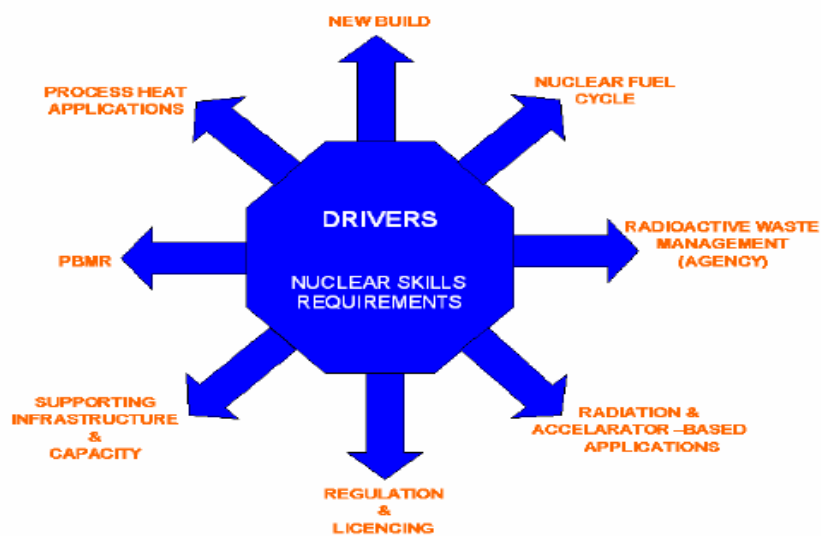


Figure 8: Nuclear skills driver in South Africa. (SANHARP, 2011)

2.2 Main stakeholders in the nuclear industry

For the purposes of this dissertation, when a reference is made to the stakeholders within industry, this will be in reference to the main role players in the nuclear energy sphere as listed below.

- i. ESKOM
- ii. National Nuclear Regulator – NNR
- iii. NECSA
- iv. Nuclear Consultants International
- v. Lesedi Nuclear Services (Areva)
- vi. Westinghouse Electric SA

In addition to the above-mentioned, other significant role players are the Department of Energy, the Department of Science and Technology (DST) and Department of Labour (DoL), which is referred to collectively as the Government.

2.2.1.1 *ESKOM*

Eskom is the South African electricity public utility and generates about 95% of South Africa's electricity which is about 60% of the total electricity consumption on the African continent. Globally, it is the world's eleventh-largest power utility in terms of generating capacity and ninth in terms of sale (Eskom, 2009). It also boasts the world's largest dry-cooling power station in Kendall Power station. Eskom's Koeberg Nuclear Power Plant is the only nuclear power plant on the African continent. Currently two additional coal fired power station are being built to meet rising electricity demand.

Eskom has an in-house training programme for technicians where a number of courses are offered for up-skilling of already qualified technicians. In addition to the in-house training, it has re-introduced the Eskom cadet programme which is aimed at bridging the gap for those learners with poor matric results who are keen on following a technical career path. This programme was run successfully in the past at Koeberg Power Plant and it will help in providing the much needed mathematics and science foundations that can form a basis for entering a technician qualification at a university of technology.

Eskom has prepared a paper on the current and future situation which was presented by the Eskom CEO to the parliamentary committee on energy on the 11 February 2008.

The paper identified a number of challenges that need to be addressed in the coming years if it is to be able to keep on supplying the required amount of electrical energy. These challenges were identified as:

- i. Ensuring the continuity of electrical supply
- ii. Successful execution of capacity expansion programme
- iii. Maintaining financial and sustainability of Eskom
- iv. Climate change response
- v. Successful implementation of electricity distribution industry restructuring
- vi. Building public confidence in Eskom and the system after the electricity crisis of 2007.

It is the author's view that these challenges will not be successfully resolved if the skills required in undertaking and meeting the above challenges are not readily available and well planned for. Eskom has further predicted that an additional 40 GW of electricity will be needed in the coming years to meet demand as shown in the figure below.

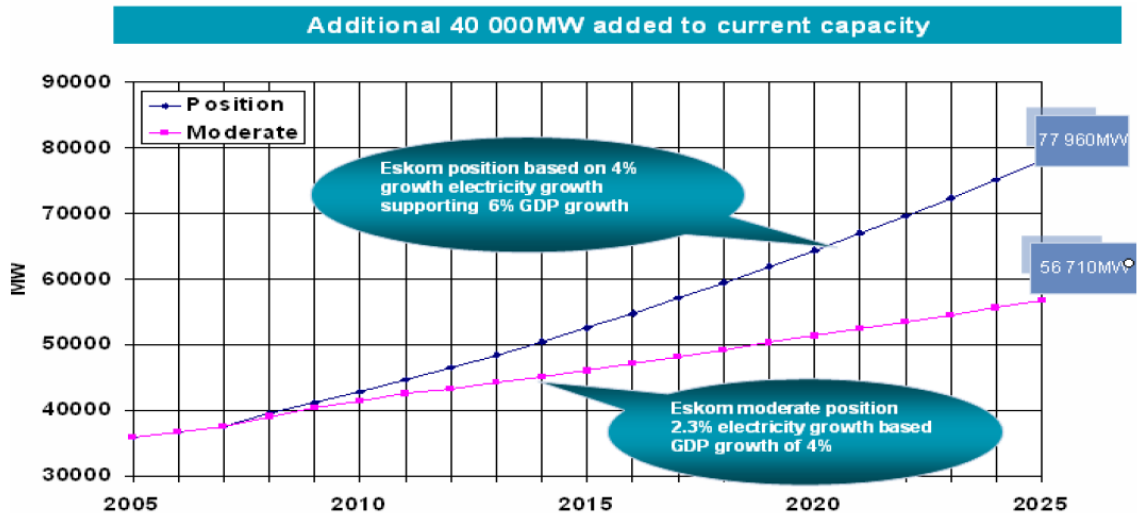


Figure 9: Eskom long term electricity demand forecast. (Source: Eskom annual report, 2010)

The forecast shown above depicts two scenarios, depending on the country's economic growth. It cannot be emphasised enough that a high economic growth is extremely desired in a country which has a high unemployment rate. Economic growth cannot take place without sufficient electrical energy, this places the heaviest burden on the utility to meet the demand.

Indeed it can be argued that the ability to supply electricity has a direct effect on the economic growth and thus development of the country.

2.2.1.2 NECSA

NECSA, South African Nuclear Energy Corporation, was established in 1999 as a public company wholly owned by the state, in terms of the Nuclear Energy Act No.46 of 1999.

Section 13 of the Act states that Necsa is mandated to:

- i. Undertake and promote research and development in the field of nuclear energy, radiation science and technology.
- ii. Process source material, special nuclear material and restricted material and to reprocess and enrich source material as well as nuclear material.

- iii. Co-operate with any person or entity in matters falling within these functions subject to approval by the Energy Minister.

In addition, Necsa is also responsible for managing certain institutional obligations of the country in terms of international agreements, or in the national or public interest, concerning matters arising from or involving the use of nuclear energy. The company has about 1600 employees where the majority, who fall in the technicians and crafts, are based at the main operating site at Pelindaba outside Pretoria. The research reactor, SAFARI-1, is located at the main site. Statutory courses in nuclear sector are provided at the Nuclear Development Centre, which provides training for artisans, engineers-in-training and technicians among others.

There has been a noted reduction in staff turnover at Necsa in the critical skills category and this has been attributed to increased investment in human capacity building and the retention scheme for engineers and technicians.

Job category	2010	2009	2008	2007
Management	6.6	6.9	4.8	10.2
Engineers and scientists	5.8	10.8	10.7	11.2
Technicians	9.4	9.2	14.8	15.3

Table 2: Staff turnover in critical skills at Necsa (%). Source (Necsa annual report, 2010)

While the table above shows a decline in staff turnover, it also shows that the turnover of technicians is higher than that at management and engineer level. The causal factors leading to this need to be carefully investigated as it can

undermine the training and development initiatives put in place. In fact it will be counter-intuitive to invest huge sums of money in training of technicians who may end up leaving after receiving their training.

Necsa has collaborated with IThemba Labs to provide training at technician level. In addition to this collaboration, it has teamed up with Areva, where the two companies formed a new company called Arecsa, which provides training for technicians at different levels. There is also a joint programme between Arecsa and NWU, offering a course in nuclear project management.

2.2.1.3 NNR

As with Necsa, the NNR is a national entity established by the National Nuclear Act, Act No. 47 of 1999. The NNR is responsible for the protection of the public, property and environment from nuclear damage. Act No. 47 of 1999 governs and control the regulator through a Board of Directors. The Board of Directors are appointed by the Energy Minister, who is the executive authority responsible for the NNR. The Minister also appoints the Chief Executive Officer (CEO) in consultation with the Board of Directors. The Directors of the board are non-executive and the CEO is also a member of the Board. The CEO appoints the rest of the staff as directed by the Board.

The NNR is divided into five divisions as set out in the NNR Act:

- i. Power Reactor Division
- ii. Nuclear Technology and Natural Sources Division
- iii. Assessment Group
- iv. Regulatory Strategy Development Division
- v. Corporate Support Services

NNR staffs are responsible for carrying out technical assessment, authorization, compliance assurance functions and providing the necessary infrastructural support for the effective regulation of safety.

2.2.1.4 Lesedi Nuclear Services

Lesedi Nuclear Services is a subsidiary of the French entity Areva NP, one of the world leading companies in design and construction of nuclear power plants and the supply of fuel, maintenance and modernisation services.

The company was founded to provide technical resources for the nuclear power industry, primarily the Eskom Koeberg Nuclear Power Plant. Lesedi provide services in project management, design engineering, maintenance and operation, plant engineering and technical personnel.

The company employs over 300 people including over 60 qualified engineers and technicians with extensive nuclear expertise.

2.2.1.5 Westinghouse Electric SA

Westinghouse Electric SA is a subsidiary of Westinghouse Electric Company based in the United States of America (USA) which was officially launched in 2007 as a result of the finalisation of acquisition of a South African company, IST Nuclear.

IST Nuclear was a leading service provider to the now downsized Pebble Bed Modular Reactor Company (PBMR) and was instrumental in the early development of the PBMR and provided a helium test facility for the PBMR.

Despite the closing down of the PBMR, Westinghouse Electric has kept their

operation open in South Africa in anticipation for the nuclear new build programme.

2.2.1.6 Nuclear Consultants International

Nuclear Consultants International is a subsidiary of AMEC Nuclear, the United Kingdom's (UK) largest nuclear consultancy company. The company is an approved supplier to ESKOM's Koeberg Nuclear Power Plant where it competes with Lesedi for providing turnkey project management services.

2.3 Skill levels in the nuclear industry

The skills levels in the nuclear industry are defined as per definition from the Department of Energy – *survey of nuclear industry human resources needs and skills development initiatives -2009*, which are stated as follows:

2.3.1 Managers:

Persons that are concerned with policy-making, planning, organizing, staffing, directing, and/or controlling the activities of an organization through a subordinate.

2.3.2 Engineers:

“All persons actually engaged in engineering work at a level which requires knowledge of a field of engineering, equivalent at least to that acquired through completion of a 4-year university course.”

2.3.3 Scientists:

“All persons actually engaged in scientific work at a level which requires knowledge of mathematical, physical or life sciences, equivalent at least to that acquired through completion of a 4-year university course.”

2.3.4 All other professional workers:

“All persons (other than managers, engineers and scientists) engaged in work such as accounting, purchasing, personnel, and finance which requires knowledge at least equivalent to that acquired through completion of a 4-year university course.”

2.3.5 Technicians – subject of this study:

“All persons actually engaged in technical work at a level which requires knowledge of engineering, mathematical, physical, or life sciences, comparable to two years of university study at technical colleges or other formal post-high school training or through equivalent on-the-job training or experience. Typical job titles are health physics/radiation protection technician, instrumentation and control technician, chemical technician and electronic technician.”

2.3.6 Artisan/craftsman

“Any employee who has completed or is deemed to have completed a contract of apprenticeship in a trade designated or deemed to have been designated in terms of the Manpower Training Act., of 1981, or any employee who holds a certificate conferring artisan status”.

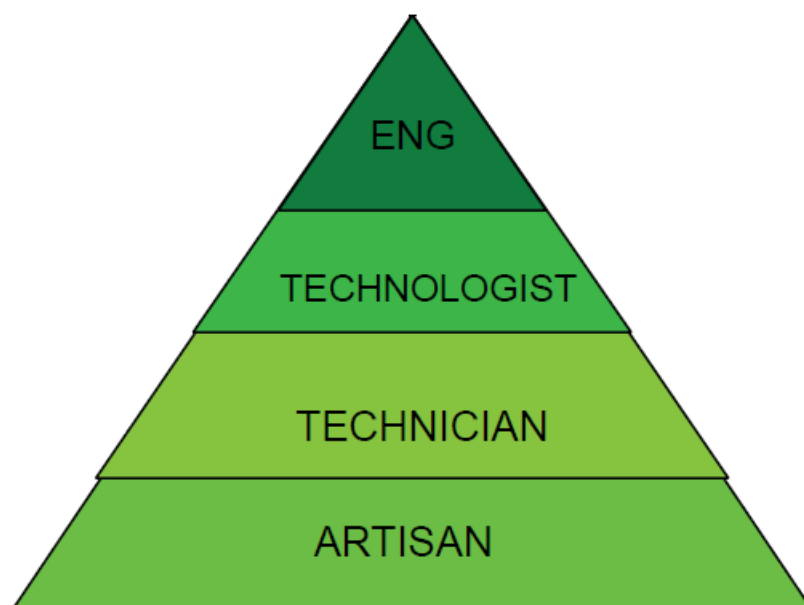


Figure 10: Engineering team pyramid. (Source: JIPSA, 2009)

The figure above shows the traditional pyramidal model of the engineering team. This figure illustrates the importance of understanding the skills shortage experienced by the engineering team and how the base foundation is important in stabilising the whole set-up. It illustrates the importance of the artisan and technician level as the required foundation for the engineering team which thus need addressing to ensure stability of the whole set-up.

2.3.7 Technician requirements during construction

This section seeks to provide an estimate of the technicians that will be required during construction of the nuclear plants with the capability of 9600 MW. The human resources numbers required, including that of technicians, can be determined from the power plant output capacity. The United States of America (USA), Department of Energy, has developed a method of determining the human resource needs for a given nuclear power plant construction.

The above-mentioned report titled “DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment” dated October 21, 2005 provides a comprehensive methodology on how to determine the required amount of workforce for a given nuclear power plant construction and operation. While using the American parameters, one needs to keep in mind that employment factors differ from country to country. The American parameters thus need to be adapted to the South African scenario, as no readily available parameters exist for the South African context and usage of the U.S Department of Energy parameters was used. In order to make the data applicable, the USA data was adapted to the South African context which is more labour intensive than the USA.

The NIASA subcommittee on education recommends the use of the Greenpeace regional multiplier, which uses the average labour productivity, excluding agriculture, measured as GDP per worker as described by the International Labour Organisation (ILO), Key Indicators of the Labour Market database (KILM). The ILO projects that the South African average labour productivity will remain at 22% of that of the OECD countries until 2030 (NIASA, 2011). This projection results in a Greenpeace regional job multiplier of 4.6.

In order to test the appropriateness of the multiplier, Greenpeace compares the OECD employment factor to the available South African factors. It then states that the factors were between 1.6 and 3.7 times greater than the OECD factors, which resulted in a weighted average ratio to determine a general regional multiplier which was calculated at 2.15. As there are no local employment factors for nuclear construction, this weighted average of 2.15 was used in the calculations.

	South Africa	OECD	Capacity in 2020	Ratio
	Jobs / MW	Jobs / MW	GW	
O&M coal (existing)	0.29	0.10	38.5	2.9
O&M coal (new)	0.16	0.10	9.6	1.6
O&M nuclear	0.66	0.3	1.3	2.1
O&M hydro	0.04	0.2	1.1	0.2
Construction coal (new)	10.4	6.5	38.5	1.6
CMI Solar Water Heating	22.4	6.1	-	3.7
TOTAL				2.15

Table 3: Local employment factors vs. OECD factors (Adapted from NIASA)

With these factors applied, the total construction human capital per year projections, excluding artisans is shown in the figure below.

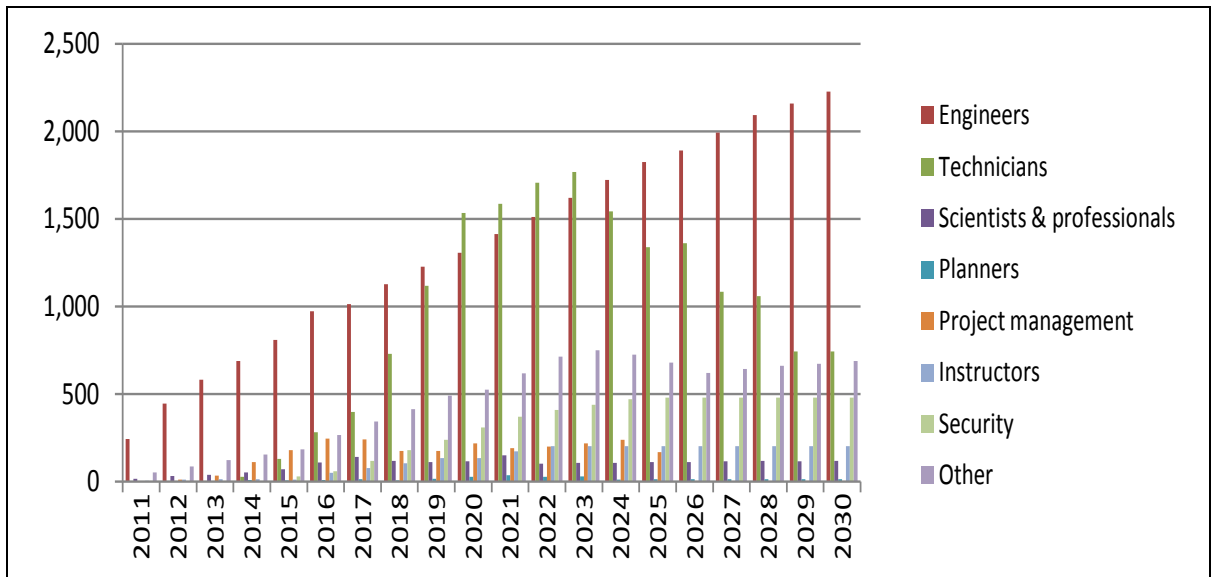


Figure 11: Human resource need per year.

2.4 Conclusion to chapter two

A comprehensive literature review was undertaken to establish existing viewpoints on the current technician training initiatives are employed in the nuclear energy industry. The focus was to understand:

- What is currently being done to address the skills shortages that already exist
- What is the likely numbers that will be required in order to meet the new build skills requirements during construction primarily at technician level
- What South Africa can learn from other countries that have embarked upon nuclear technology such as South Korea.

The next chapter outlines the research design proposed for this study. A qualitative study is done via the use of questionnaires as well as semi-structured interviews with major role-players in the industry. Chapter three below scientifically answer the research questions and objectives identified in Chapter one and supported by the literature review contained in chapter two.

Chapter 3 : Experimental Design

3.1 The role of methodology in research

Methodology provides a framework that gives guidance about all components of the investigation being carried out. It gives the researcher a framework for organising logistics and procedures to be followed in the research process. It enables the reader to understand the researcher's perspective and logic.

Methodology seeks to provide control as to the way the inquiry will be undertaken (Cresswell, 2003; Kumar, 2005). It is a guide to context, explaining relationships, evaluating the information as well as its validity, and helping develop theories, strategies or actions required to address the problem (De Vos et al., 1998; Ritchie & Lewis, 2003). The methodology thus helps show the link to the theoretical framework that informs the research carried out.

3.2 Conventional research methods

Two conventional methods exist, namely Qualitative and Quantitative Methods. These two methods differ significantly depending on the way one intends to generate knowledge through the type of inquiry undertaken. Qualitative approach is based on the inquirer making knowledge claims based on constructionist perspectives or participatory perspective. In quantitative approach, the researcher uses post-positivism claims for developing knowledge, using experiments and survey to produce data that is eventually used to test a hypothesis (Cresswell, 2003).

Quantitative	Qualitative
Objective	Subjective
Research questions: how many, strength of association	Research question: What, Why?
'Hard' science	'soft' science
Literature review must be done early in study	Literature review may be done as study progress or afterwards
Tests theory	Develops theory
One reality: focus is concise and narrow	Multiple realities: focus is complex and broad
Facts are value free and unbiased	Facts are value laden and biased
Reduction, control, precision	Discovery, description, understanding, shared interpretation
Measureable	Interpretative
Mechanistic: parts equal whole	Organismic: whole is greater than parts
Report statistical analysis	Reports rich narrative, individual interpretation
Basic elements of analysis on numbers	Basic element of analysis is words/ideas

Table 4: Difference between Qualitative and Quantitative research methods. (Source, Sanghera, 2009)

3.3 Research method used in this dissertation.

In this research a limited qualitative survey was undertaken where a narrative response was expected. The survey was undertaken through the sending of questionnaires to companies and/or persons of interest. After the questionnaires were returned by the respondents, 4 structured interviews were carried out.

The interviews conducted face-to-face were conducted at:

- i. Necsca
- ii. Eskom
- iii. Department of Energy.
- iv. A telephonic interview was done with the Training and development Officer at Lesedi Nuclear services.

The questionnaires are as shown in the appendix.

3.4 Survey methods

3.4.1 Data collection

A qualitative approach was used through the use of questionnaires and structured interview(s). The data collection method used was to initially approach the Human Resources (HR)/Training and Development Department(s) via e-mail or telephone to explain nature of the study and obtain permission from the relevant authorities to conduct research.

To ensure credibility and minimise bias, triangulation method was applied for the interview with selected respondents. This credibility shall be measured against the Lincoln & Guba Model criteria (Lincoln & Guba, 1985).

These researchers suggested that research shall be measured against the following criteria:

- i. Credibility/ internal validity
- ii. Applicability/external validity
- iii. Consistency/reliability

iv. Conformability

These criteria was ensured by the use of interview technique whereby the researcher rehearsed with a peer beforehand to test the relevance and ease of understanding of the questions posed, interviewing and observation of respondent during interview for internal validity. David & Sutton, 2004, found that this allows for greater credibility.

3.4.2 Questionnaire

The questionnaire was constructed in any easy to understand manner and respondents were supplied with instructions on how to complete the questionnaire.

Anonymity can be provided for if requested due to industry sensitive/confidential information, none of the respondents requested that the responses be anonymous. Only one single questionnaire for all respondents was developed, respondents answer relevant sections with non-relevant questions marked with an n/a, (not applicable), if not applicable, respondent were asked to motivate why it is not applicable.

The questionnaire explains the research expectation to the respondent and possible benefits in a clear and simple language. Participation was voluntary, reasons for non-participation welcome but not mandatory. Due date for questionnaire return was be 14 days after receipt. After due date, if no response received, the researcher followed up with respondent to in order to remind the respondent of completing the questionnaire.

3.4.3 Research population

Research population sample is a collection of items of interest in the research. It represents a group that can be generalised to the research, often defined in terms of demography, geography, time, occupation, or some other combination of the above (Wolcott, 2009). In this case the research population is defined in terms of demography and occupation – technicians in the nuclear energy industry, geography – nuclear energy industry organisations in South Africa. The sampling strategy used was homogeneous and convenient as the focus shall be on a specific subgroup, namely organisations that have an interest in the nuclear new-build programme in South Africa.

The research population in this research thus consist of:

- i. Arecsa
- ii. Government Departments
- iii. Eskom
- iv. Necsa
- v. NIASA
- vi. NNR
- vii. Nuclear Consultants International
- viii. Lesedi Nuclear Services
- ix. Westinghouse SA

Homogeneity refers to the similarity of the participants in that they are all likely to be involved/will be involved in the nuclear new build in a certain capacity.

This list by no means states that these are the only organisations that will be involved in the nuclear new-build in South Africa.

3.4.4 Research ethics

In undertaking the research, ethical considerations might arise and the researcher needs to be aware of this. This research study adhere to the research ethic regulations as set by North West University-Potchefstroom, Research Ethic Committee and permission was obtained from the necessary 'gate-keepers' where applicable before commencement of research.

The purpose of research was explained in plain and unambiguous terms to obtain informed consent from the participant(s). The necessity for and value/benefit of the research study was also explained to the respondents. Informed consent was obtained from appointing authority prior to conducting interviews. Cognisance of the fact that certain information could be market sensitive due to possible competition during the bidding process is well understood by the researcher and the respondents were made aware of this.

Assurance that confidentiality shall be provided that the source information provided will remain confidential if so requested unless this information is publicly available. If the information is deemed to be public knowledge, this shall be clearly stated and the public domain/forum where this information is available shall be stated with date accessed. Confidentiality in this case is defined as 'an active attempt to remove from the research records any elements that might indicate respondent identity' (Berg, 1995, p.213).

Only the researcher, research supervisor/study leader and any other persons so appointed by the University for academic evaluation purposes shall have access to the collected raw data.

3.4.5 Data analysis

Data analysis in qualitative research is done at the same time as it is collected, and the reliability of the data is enhanced by this approach. This is supported by Merriam (1998, p. 151), who argues that data collection and analysis is a simultaneous process in qualitative research.

This gives the researcher an opportunity to analyse data immediately, thereby allowing the researcher to make adjustments along the way, even to the point of changing the data collection method if deemed necessary.

The components of data analysis flow model are show in the figure below.

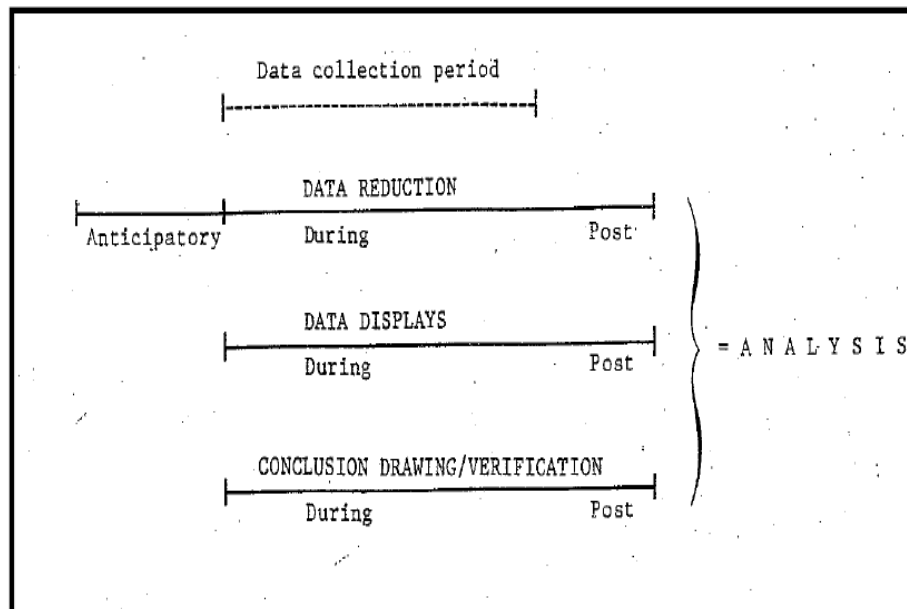


Figure 12: Data analysis flow model. (Source: Miles & Huberman, 1984, p.22)

In this research study, the qualitative data for the conducted interviews were analysed by Tesch's Method as cited in Tesch (Creswell, 1994) as follows:

- i. Obtain sense of whole interview.
- ii. Closely examine interview as a whole and determine underlying meanings.
- iii. List all emerging themes/topics and cluster them together
- iv. Assign codes to appropriate sections of the text and find new emerging categories.

- v. Identify the most descriptive wording for the topics found and form categories.
- vi. Develop abbreviations for each category in order to help in writing analysis.
- vii. Assemble data materials in one place for each category, perform preliminary analysis.

3.5 Conclusion to chapter 3

To understand the need for nuclear technician skills primarily for the projected nuclear new-build, an exploratory relational study was undertaken of the industry. The literature review supported the research questions and provided sufficient input into the design of a theoretical skills development model. The next chapter provided detailed results.

Chapter 4 : Research Findings

4.1 Research findings

4.1.1 Presentation of findings

In the previous chapter the research design was outlined and the research methodology and research approach were discussed. The research approach was described as of a qualitative nature and non-experimental, based on primary empirical data as a unit of analysis. The research methodology referred to the target population, research procedure, measuring instruments, and the statistical procedures used in the analysis of data.

The present chapter deals with the research results. ***The primary objective of this study is to understand what organisations are currently doing in terms of skills development at the technician level and secondly to look at what needs to be in place for a successful nuclear new-build.*** The researcher's intention is to suggest a skills development model that may have different interventions depending on what the organisations may need at different levels of skill sets.

The findings presented in this chapter hence seeks to present the result that are specific to the development/training/retention of nuclear skills at the specified level as found in the research responses, and how these relates and compares to the literature surveyed.

The responses from the nuclear industry through the qualitative survey conducted shows that there are about 2150 nuclear technicians in the industry with 75% of these employed by Eskom and Necsa. Eskom is currently the biggest employer of nuclear technicians. Civil and Mechanical technicians with nuclear certification and coded welders were identified as the critical skills that will be in shortage for new build at this level during the construction phase.

The interviews established that the industry role-players show a reluctance to start preparing for nuclear new build in terms of skills upgrade and training. A number of respondents attributed this reluctance to a lack of firm decisiveness on the part of Government as the nuclear new-build programme have been viewed by industry as a 'stop-start' issue for a number of years with no clear timeline of when the project itself shall start.

Respondents within the industry sphere indicated that they will be eager to be involved in localisation if there were clear guidelines and assistance with the costs involved in localising content. While all stakeholders indicated that they have relevant initiatives in place for skills development and acquisition, only Necsa and Eskom have substantial training and development programme.

The Necsa CEO at the time, Dr Rob Adam, stated during an interview that localisation strategy must be put in place such that at the end of a 20 year period, a cluster of high technology industries are in place to support the manufacturing of reactors, reactor fuel supply and to provide civil and maintenance services to the nuclear power plants. Adam further indicated that a decision needs to be

taken on whether to have a deep localization program or a shallow localization program, or to have both programs in tandem.

A deep localization program would entail the establishment of conversion, enrichment and fuel manufacturing capabilities and the manufacturing of reactor key components. A shallow localization program would in contrast entail the manufacture of pumps, valves and non-nuclear components as well as involvement in civil engineering aspects. For this to be successfully achieved, a progressive human capital development program need to be in place, as a large number of qualified persons at different levels will be required including technicians. Shallow localization is in easy reach hampered only by the availability of skills.

Necsa has a training program for artisans and technicians on site, located at the Nuclear Skills Development Centre, where they train internal candidates as well as those candidates for internship through the Departments of Labour, and the Department of Science and Technology.

Candidates on internship programme are put on 12 months contracts in order to gain the requisite knowledge and experience. This training takes place in a classroom setting as well as on the job training (80%).

In addition to this, Necsa also has a program in place to rehire employees that have retired from key skills area in order to have these employees as mentors to the new entrants, adult education programme to improve Maths and Science as well as individual skills development initiatives.

The Learning and People Development Office coordinates training and also prepares the work skills and facilitates all Seta's. Eskom has a training facility located in Midrand, Johannesburg, and another one in Cape Town. These facilities are mainly used to train Eskom employees according to Eskom's need. The nuclear new build department uses a number of initiatives to acquire and retain skills. The skills development is done through dedicated mentorship and coaching for the required nuclear skills training programmes.

All the new entrants are provided with a mentor who guides the trainees during the first 12 months of employment. This guidance includes personal development as well as technical skill development. A number of short courses are also presented to technicians when deemed necessary by the training department, where some of these courses are provided in-house and others by external organisations.

At Koeberg, Eskom has revived the nuclear technician course, which provides a generic nuclear training at technician level which enables technicians to work in a nuclear environment. In this course training is provided in all phases of a nuclear power plant in terms of safety, radiation shielding, plant operation and maintenance among others.

A training programme has also been recently launched which aims to improve Maths and Science results for those who are keen on entering the nuclear industry. While this programme is primarily aimed at those who want to become plant operators, those who perform well can be entered into the Nuclear Technician Course.

The Department of Public Enterprises indicated that it had already estimated in 2008 that Eskom will need about 4000 employees by 2012, with the bulk of these employees, (+/- 75%), in the technical area which translates into an average hiring of 450 to 660 per annum. The Department of Public Enterprises indicates that due to the current new-build programmes, with the two coal fired power stations already being constructed, the numbers are likely to be higher than the initial projection.

The table below presents the numbers as provided by the Department of Public Enterprises in the survey and during the interview conducted. These numbers do not take into account the massive implications of the nuclear new-build and the actual numbers are likely to be higher than presented below.

Eskom skills need by 2012 according to the Department of Public Enterprises	
Skill type	Quantity
Architectural, Building and Surveying Technicians	65
Civil Engineering Draftspersons and Technicians	90
Electrical Engineering Draftspersons and Technicians	512
Electronic Engineering Draftspersons and Technicians	261
Mechanical Engineering Draftspersons and Technicians	102
Other Building and Engineering Technicians	122
ICT Support Technicians	15
Power Plant Process Technicians	235
Metal Fitters and Machinists	192
Electricians	1632
Miscellaneous Technicians	81

Table 5: Eskom skills need by 2012

The Eskom New-Build Department could not provide the author with the actual numbers needed currently or future needs citing confidentiality issues. The Department of Public Enterprises, further projected that state owned enterprises, Eskom and Transnet, will need about 15800 in order to be able to carry out the infrastructure programmes that have been recently announced by government, with artisans amounting to 54%, followed by technologist and technicians at 27%.

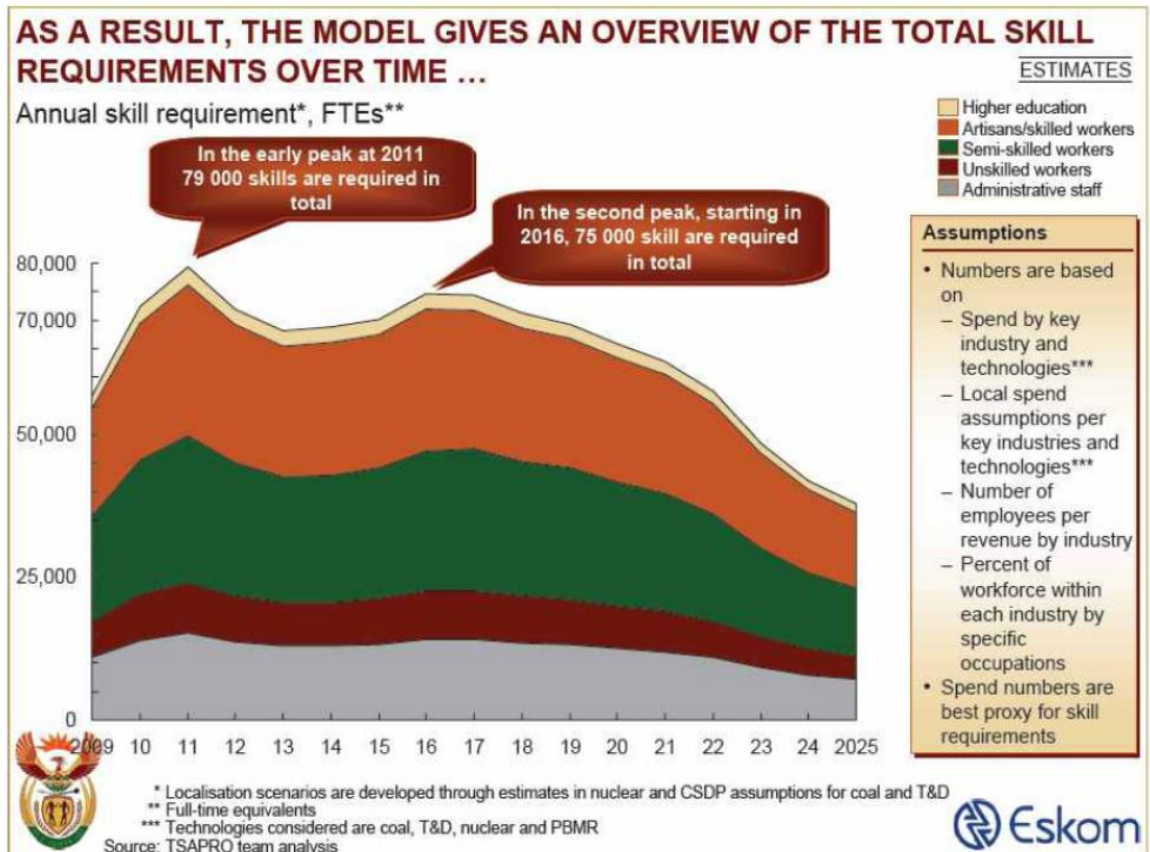


Figure 13: Annual skills requirement for Eskom's need. (Source: TSAPRO, 2009)

The figure above represents the Eskom skill requirement when it was planned that the nuclear new-build would take off in 2010, with the peak of skills required estimated at about a total workforce of 79 000 with the bulk of that at Artisan/technician level. This figure still gives a good basis of what the skill requirements are likely to be, though Eskom indicates that the numbers are likely to be higher than represented.

The Department of Science and Technology indicated that it has an initiative in place called the South African Nuclear Human Asset and Research Programme (SANHARP), which is fully dedicated to the development of nuclear skills. This programme supports from school students to PhD candidates, and aims to encourage school people to take up science subjects in high school which will

enable them to enter technical studies at tertiary level. Substantial funding in this programme goes to University students but it is also used to support technician training in the form of bursaries that cover tuition fees and also living expenses.

SANHARP aims to align skills availability in nuclear sector with planned technology platforms. The program addresses amongst others, the replacement of an aging relevant workforce, under-development of the local manufacturing supply chain, length of training required to reach acceptable competencies and industry-university linkages.

A consistent response in the research was the reference made by respondents that skills development in the nuclear sector and to a large scale the engineering and science sector is hampered by the poor performance and/or lack of matriculants in science and mathematics. Overwhelmingly, the quality of foundation education in South Africa was pointed out as the biggest hurdle to skill development in the technical sector as most of the matriculants are not well prepared in mathematics and science subjects.

NIASA, the industry body that represent the nuclear industry in South Africa, indicates the highest shortage of skills concern all qualifications, with technicians being the third scarcest skills in the labour market. Technicians such as welders, electrical and electronic technicians, control and instrumentation, civil and mechanical technicians are in shortage.

The length of training required for training was cited as a concern to the localisation project given the already shortage of skills available at this level. As an example, it takes on average a minimum of 3 to 4 years to train a coded welder and 5 years to obtain advanced welding skills which are even more in demand. Trainees with poor science background will take even longer to train.

The Department of Labour indicates that while the introduction of Seta's for artisans training are contributing to the availability of skills, the trainees are mostly not at the competency level required in a nuclear environment. Furthermore, the Department indicates that there is not only a skills shortage but also a lack of experience, expertise and specialization that needs addressing as a matter of urgency.

4.1.2 Discussion and recommendations on findings

The parameters described earlier developed by the USA Department of Energy, provides a good foundation on determining the total workforce required for different disciplines, at least theoretically. . These numbers need to be compared with numbers provided by vendors of GEN III+ technology, as each design requires different man-hours.

The actual number of technicians, amongst other required personnel will depend on the technology chosen by Government. For purposes of assessing the South African labour infrastructure, the average per unit construction labour was used, with an adaptation to South African conditions. In this instance only the craft

construction labour needs at technician level, were considered with other levels and on-site support labour being beyond the scope of this dissertation.

To adjust these American numbers to South African conditions, employment factors relating to South Africa were applied by applying a regional labour multiplier given that South Africa is more labour intensive than the United States. To do this, a regional multiplier was used, which is based on Greenpeace's report "South African Energy Sector Jobs to 2030", (Greenpeace, 2008).

Greenpeace used the average labour productivity (excluding agriculture), measured as GDP per worker, from the International Labour Organisation (ILO) Key Indicators of the Labour Market (KILM) database. These numbers are further supported by the OECD and the IEA (IEA, 2007). These multipliers were further compared with a report produced by the Oxford Economics group based at Oxford University, with a report titled: *Economic, Employment and Environmental Benefits of Renewed U.S. Investment in Nuclear Energy - National and State Analysis, 2008*.

These calculated numbers as shown in the figures below, were then compared with the numbers from NIASA (NIASA, 2011) in order to see if there is any correlation. The calculated numbers were further compared with the empirical numbers obtained from the survey conducted in the research. The comparison of these figures helps with confirming the **validity** of the research. As there is a small variance between the figures obtained in the research and the three reports

(NIASA & IEA, Oxford economics), it serves to confirm the accuracy of these numbers. The numbers are presented in the figures below.

From the human resource parameters described earlier to determine workforce requirement and applying the necessary adjustment factors to account for labour intensiveness, the need for technicians' peaks gradually to a maximum of 1770 in 2022, assuming construction starts in 2013.

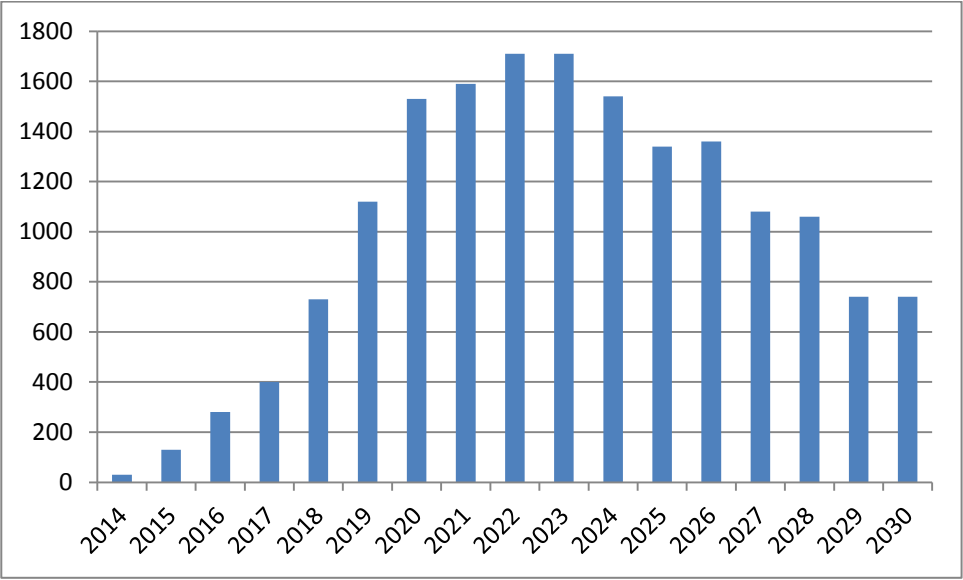


Figure 14: Theoretical technician requirement for new-build

Based on this calculation, the first need comes in 2014 for about 30 multi-disciplinary technicians. On this calculation, to meet peak demand in 2023, 150 technicians need to be produced each year for the nuclear industry alone. Taking into account the long lead time needed for those qualified to reach a level of acceptable nuclear competence, these numbers indicate that an aggressive and well planned training and development plan need to be in place.

The projected numbers could increase depending on the technology chosen as the projected numbers are technology neutral. It is important to compare the rate of annual production of technicians to those of other professions in order to get a full picture of the challenges faced at each qualification level.

Resources Required	Start Employment Year	Numbers per year
Engineers	2013	110
Project Managers	2013	30
Technicians	2014	150
Artisans (O & M)	2015	30
Scientists	2013	20

Table 6: Multi-disciplinary human capital needs per year.

From the table above, it is clear that the biggest challenge of meeting the nuclear skills need is presented at technician level where the highest rate of production per year is needed compared to the other disciplines.

These figures are quite similar to those from the NIASA report which had used different parameters to calculate the labour needs and thus indicate that the average number calculations are accurate though these will be adjusted once it is known what technology will be chosen and which vendors will be supply the reactors. With the average construction number known for the construction phase, there is a need to assess the current throughput from the tertiary institutions in order to address any bottleneck issues that may affect the throughput.

The challenges in increasing throughput need to be looked at in terms of the availability of adequately prepared high school learners, funding and teaching resources, including the availability of qualified and competent trainers at learning institutions. A holistic long term approach is needed to address the throughput problem while solving both the short-term needs and long term goals.

It is important to look at the enrolment and graduation figures over a 10 year period of some of the technician disciplines that will be required during the construction phase of the power plant as well as during the plant operation. The data presented below was obtained from the Department of Higher Education online system HEMIS, which records the total annual number of enrolments nationally, as well as covering all demographics such as institution, course of study, race and home language among other things.

The relevant data is shown in the figures below. The figures below shows enrolment and graduation data at technician level of chemical engineering, civil engineering, electrical engineering, industrial engineering, manufacturing engineering, mechanical engineering and nuclear engineering.

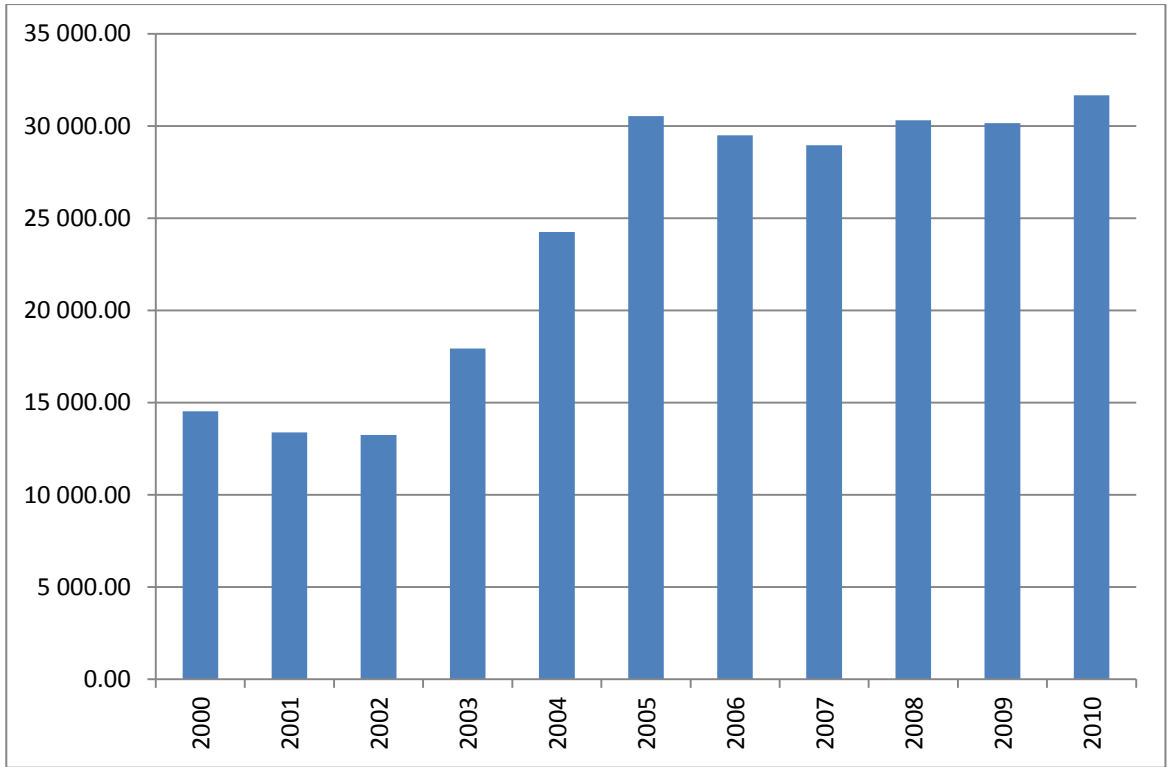


Figure 15: National enrolments for technicians relevant to nuclear new-build (HEMIS).

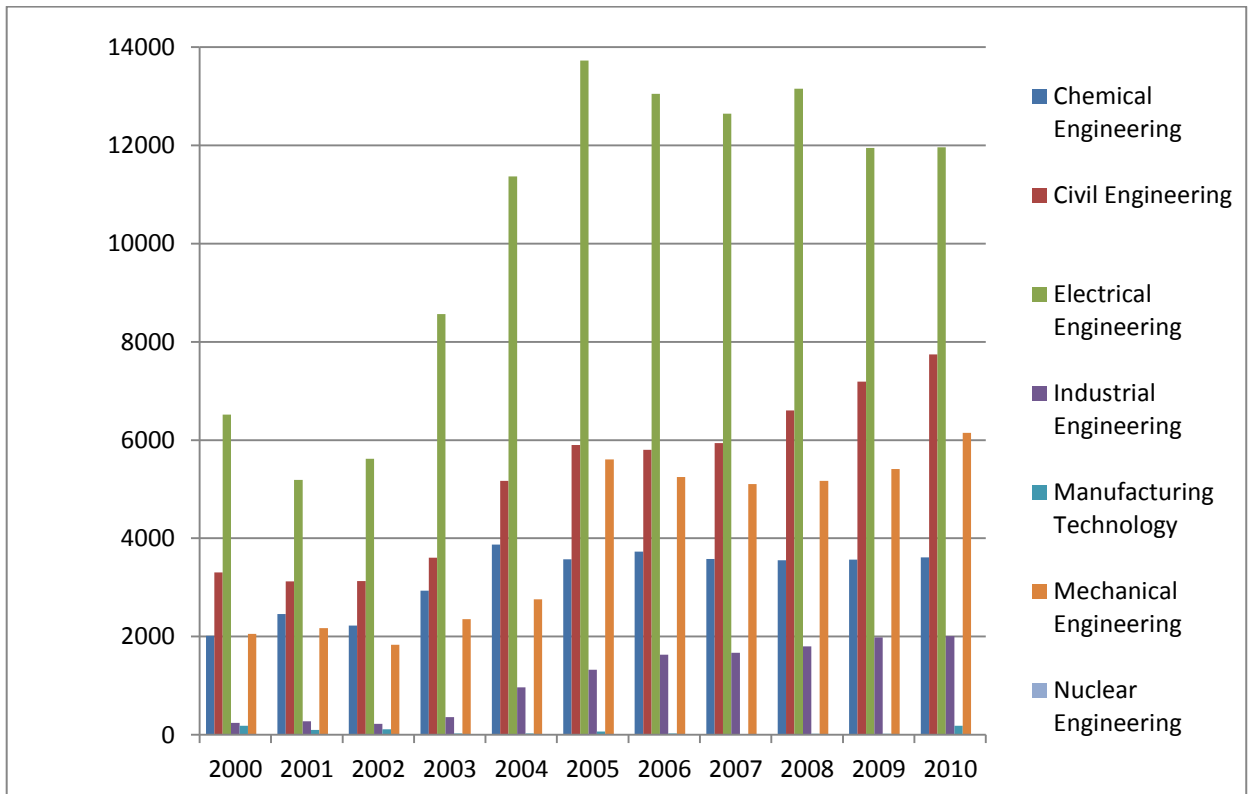


Figure 16: National enrolment per discipline (HEMIS)

The figures above shows that national enrolment has been steadily increasing between 2000 and 2010, which shows that there is an interest in the field of study which bodes well for the industry.

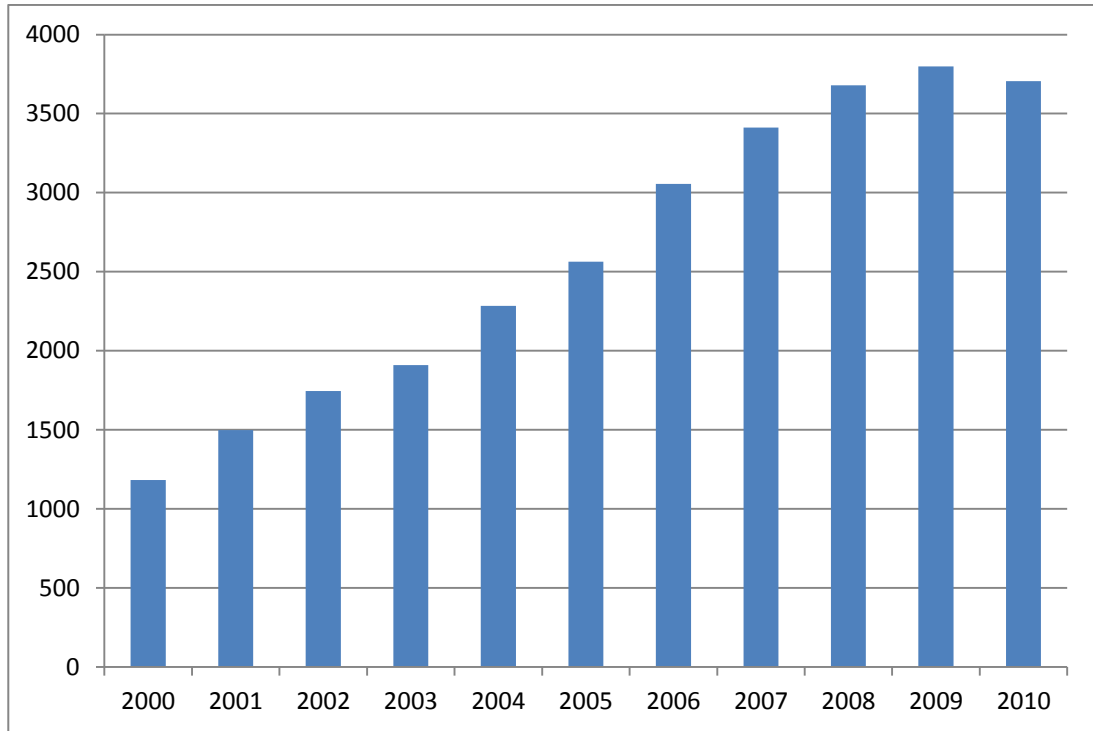


Figure 17: National graduations (HEMIS)

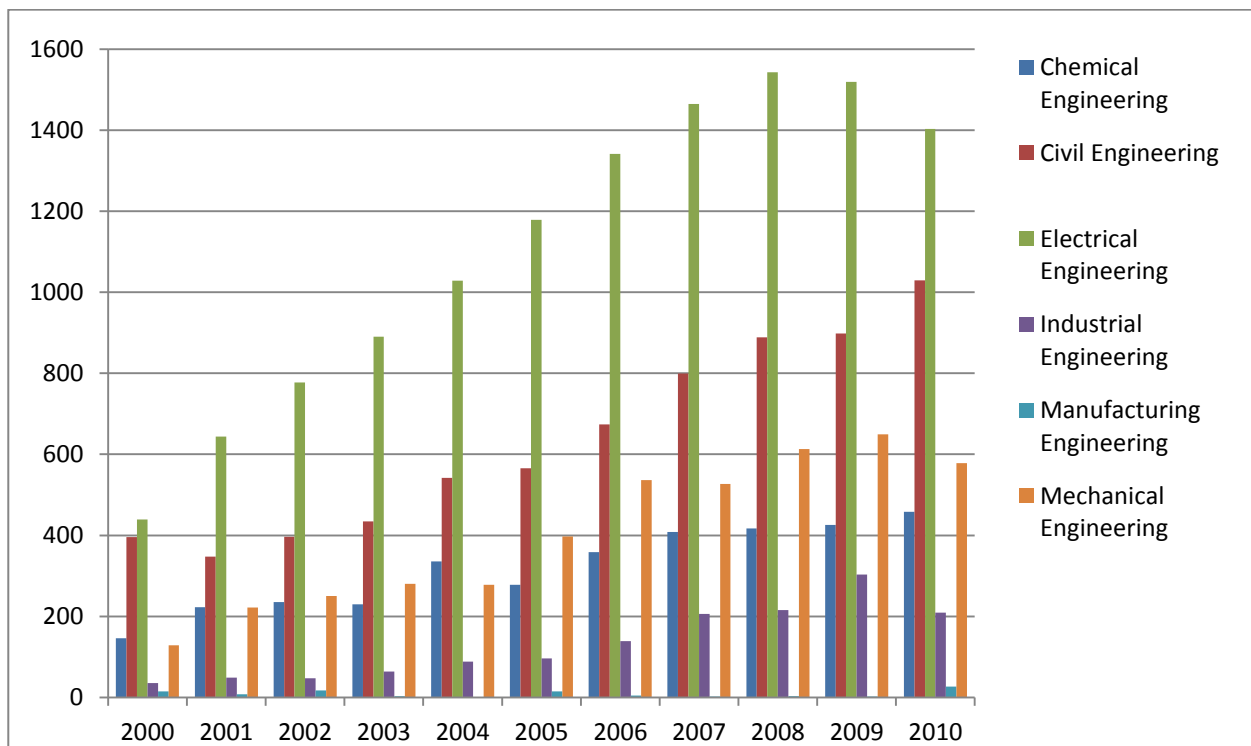


Figure 18: graduation per discipline (HEMIS)

From the figures above, it shows that there is a big discrepancy between the enrolment numbers and those that manage to graduate at all, let alone those that graduate in record time. This is a formidable challenge that requires urgent attention from all stakeholders. This points to the argument made earlier about the poor preparations in high school, especially in Mathematics and Science subjects. The lack of adequate preparation in technical subject contributes heavily to a low throughput of technicians though other factors may also play a role such as lack of funding amongst others. It is a cause for alarm that the throughput rates are so low despite the gradual increases over the years.

For example, the 2008 intake in Mechanical engineering would have graduated in 2010, and looking at the numbers, intake was about 6120 and out of this group, the graduation in 2010 was a mere 580. This represent a less that ten percent throughput per intake and the trend is similar across all disciplines considered in this study. There is a big room for improvement as it shows that the interest in the fields of studies but those that enters the tertiary institutions seems to be ill prepared for the studies resulting in a lower throughput of graduates.

The research findings indicate that if the nuclear new-build programme were to commence in 2013, the industry will find it challenging to meet the localisation requirement as set by the government. Unless the aforementioned challenges are addressed, the country will not be able to benefit from localisation opportunities offered by international partners involved in the nuclear new-build. While there are concerted efforts by a number of organisations, not least Government departments, to address the shortage of skills at different levels,

these initiatives, while a good starting point, are not adequate to address the anticipated shortage, neither the existing one.

Despite the fact that there is a big discrepancy in terms of enrolment and graduation, technicians struggle to find placement in industry to do their experiential training which is required in order to have the qualification conferred. Most respondents attributed this to market uncertainty and this is another matter that needs urgent attention. Industry must also play its role in skills development as it stands to benefit greatly from the availability of required skills.

The demand for skills across the different technical sectors requires careful planning at national level due to long induction periods required for certain critical skills sets to acquire the highest level of workmanship that is required in a nuclear project. There are issues around capacity as well as capability of available skills and of new entrants into the labour market.

4.2 Nuclear certification

It is informative to understand the certification level currently being employed in the nuclear energy industry in South Africa. As a way of comparison, the nuclear regulator in the United States classify levels of certification of all nuclear employees including technicians depending on the level of training and experience. While basic nuclear operation skills such nuclear safety is universal, it is imperative to understand the certification level covering the whole spectrum.

The research survey revealed that the majority of technicians are employed by Eskom and Necsa, with the other organisation employing negligible numbers. The technicians employed by the other organisations are also likely to be subjected to the same certification as most would be contracted to work either at Eskom or Necsa. A discussion was held in this regard with both Eskom and Necsa to find out what certification levels are in place and whether these are internationally bench marked.

In these discussions, with the respective training and development departments, it was indicated that no “set” certification levels are currently being employed though employees do go through the necessary training.

For there to be uniformity, it is a necessity that there be an industry wide certification level which will ensure that skills can be transferred from one organisation to another without a need for further training as the employees would have been trained to the same standards.

4.3 Technician training gap analysis

From the research finding, the results points to the fact that there is a lack of coordination in planning and execution in terms of training especially at the basic level of obtaining the qualification. There is a need to develop a generic nuclear technician course (NTC) at national level, which can be tailored to the one offered by Eskom at Koeberg.

In addition to the NTC, it will be beneficial if the nuclear industry, perhaps under the leadership and coordination of NIASA approaches the education institutions to explore expanding the current technician curriculum at the Universities of Technology to include a few courses in nuclear engineering to expose those prospective technicians that are not as sure yet whether they would like to join the nuclear industry.

The education institutions can then approach the Department of Higher Education for permission to offer the course. The nuclear industry can offer incentives in terms of funding and also providing assurances to prospective technicians about career opportunities that will be available to them once they have completed their studies. A funding model must to be developed for funding training and development to meet skills need. There need to be a properly coordinated and centralised training programme, whereby Universities of Technologies can collaborate on the provision of educational training.

Eskom and Necsa already have a wealth of knowledge in training technicians in the nuclear environment and this can be put to good use by the University of Technologies. In order for the current training to be expanded at national level, Government will have to take a leading role in coordinating the collaboration between academia and industry. According to the figures provided by Eskom, the estimated cost for a nuclear technician course is about R40 000 per annum. This figure can be expected to rise by 10% yearly. This figure does not include the training cost, which is estimated to be at the same value. These figures can be

reduced considerably if the nuclear modules are integrated into universities of technologies curricula.

If 150 technicians technician are needed per year, this constitutes an education cost of R4.5 million per annum, not a small figure by any account. It should also be kept in mind that there is a lack of qualified trainers to provide training to a larger audience which will result in costs escalating as well as these trainers will need to be trained first.

4.4 Training guideline

In order to have a good overview of what is a needed in terms of different skills, a national skills register must be develop and maintained, to record what skills at each level has been produced in the country, what skills are currently being produced vs. what is needed by the economy. The register can be used as a guideline in terms of prioritising training and development of training programmes across the nuclear technical spectrum.

It is concerning that annual enrolment data for technicians is not readily available, neither the annual throughput of the education institutions. Of further concern is that there is not a nuclear specific certification level that can serve as a guide to inform employers of what level/training has a person undergone in order to avoid unnecessary training costs and to also ensure that people are provided with the appropriate training before being given certain responsibilities especially given the fact that the nuclear industry is a high risk industry when it comes to safety procedures.

The engineering regulating body, the Engineering Council of South Africa, ECSA, can only provide the numbers of those that are registered with it, as it is not mandatory to be registered with the body, though it is beneficial to be registered with it. Mandatory registration with the body will address concerns of inadequate training and development as each technician will be trained according to the set guidelines and will serve as a necessary quality control mechanism.

It is recommended that the guideline developed by Cogent for skills prioritisation in the report titled “*Next Generation – Skills for New Build Nuclear*” (March 2010) be adapted to the South Africa, to register skills needed versus those being currently produced. This recommendation is based on the fact that it bears resemblance to South African concerns and will be a good starting point in training guideline development.

The above-mentioned report has also been recommended by the IEA (IEA, 2011), OECD (OECD, 2010) and was referred to a report by Deloitte titled: *Nuclear renaissance and the global supply chain* (Deloitte, 2011). This gives an indication that the report is considered credible given that these eminent organisations have referred to it as a possible benchmark in skills planning.

The Cogent guideline identifies risk skills and summarise them in one table with rankings provided according to the judged skill risk shortage. The table is reproduced below. The skills register can be adapted to any skills required as and when needed. The one area that can be criticised in the Cogent table of skills risk register is that it does not comprehensively address the area of certification and what constitute a certain qualification level.

As such, the table must be properly adapted so that it is clear when as an example, if one lists Control and Instrumentation Engineer, than one must be able to deduce straight away whether this refer to an engineer with a BEng qualification or one with a BTech as these names tend to be used interchangeably in industry. Again, this indicates the importance of having a nuclear specific certification level. Nonetheless, it is a good starting point to have a skills register nationally.

Risk Register for a Single Reactor Unit	Skill Area or Competence	Probability Of current skill deficit	Demand timescale	Risk of skill gap	Priority rating
		High = 3 Medium = 2 Low = 1	Short = 3 Medium = 2 Long = 1		High = 7-9 Medium = 4-6 Low = 1-3
1.	Project and Programme	3	3	9	High

Design &	Managers				
Planning	Safety Case Authors	3	3	9	High
	Design Engineers (various)	3	3	9	High
	Geotechnical Engineers	3	3	9	High
	Environmental Engineers	3	2	6	Medium
	Regulators	3	3	9	High
2.	Design Engineers (various)	3	3	9	High
Equipment	Manufacturing Engineers	3	3	9	High
t	Control & Instrumentation	3	3	9	High
Manufacture	Welders (high integrity, materials)	3	3	9	High
	Cost Control	1	3	3	Low
	Non-Destructive Engineer	3	2	9	Medium
3.	Planners/Estimators	3	3	9	High
Engineering	Non-Destructive Engineers	3	3	9	High
ng	Welders (40% high integrity)	3	2	6	Medium
Construction	First-line Supervision	3	2	6	Medium
	Mechanicals	2	2	4	Medium
	Electricals	2	3	6	Medium

					m
	Controls and Instrumentation	3	2	6	Medium
	Manufacturing Engineers	1	2	2	Low
	Scientists	2	1	2	Low
4. Commissioning	Energy Production Operators	1	2	2	Low
Operation	Maintenance Operations	1	2	2	Low
Maintenance	Safety & Security	1	2	2	Low
	Radiation Protection	2	2	4	Medium
	Project Management	3	2	6	Medium
	Engineering Design	3	2	6	Medium
	Scientific & Technical Support	2	2	4	Medium
	Commercial	1	1	1	Low

5. General	The basic requirements of working on nuclear sites	2	3	6	Medium
Nuclear Culture and	The understanding and awareness of the nuclear industry	2	3	6	Medium
Experience of the workforce	The Project Management skills required to deliver effective projects	3	3	9	High

Table 7: skills register (Source: Cogent, 2008)

The nuclear technician course as provided by Eskom at Koeberg power plant is a very good foundation for developing the training guideline for technicians in South Africa. This will need to be adapted to cover areas such as welding certification, nuclear regulatory matters and issues pertaining to the construction on nuclear power plants and project management. A nuclear technology primer can be used where those with already a national diploma can spend an extra year on nuclear studies in order to obtain a nuclear certification in addition to the diploma already obtained.

4.5 Conclusion to chapter four

In this chapter, the results of the qualitative survey and the semi-structured interviews results were reported. The Chapter further discussed these findings whilst providing set recommendations on the general findings. The next chapter will discuss results and conclusions drawn from the literature review and the empirical research. Interpretation is provided for the key findings.

Chapter 5 : Research study conclusions

The purpose of this chapter is to integrate the research questions, research objectives and literature review with the empirical findings in order to draw conclusions.

5.1 Conclusions on the main research questions

5.1.1 What training and development programmes are currently employed by different stakeholders to train technicians in the nuclear energy industry in South Africa?

Eskom have a number of training and development programmes currently in place. The established Eskom Academy in Midrand, Johannesburg, is used to train new technicians on the job specifics as well as nuclear exposure. The academy is also used for up-skilling of old employees as the need arises.

At Necsa, technicians are trained at the Nuclear Skills Development Centre, located at the main site in Pelindaba. New entrants are initially provided with theoretical training covering safety and technical components. The theoretical component is followed by on-the-job training, where new technicians are taught practical skills.

Necsa also collaborates with IThemba Labs, DoL and DST with regard to training initiatives, whereby DST provide the funding for training, while DoL co-ordinate the placement of trainees with Necsa. Necsa thus provide the training facilities for those technicians that are not in their employment but employed by DST and/or

DoL. Much of this training is provided under the SANHARP programme. Arecsa provides training in conjunction with NWU, mostly to senior technicians and engineers.

The other role-players such as Lesedi Nuclear Services, Westinghouse and Nuclear Consultant Internationals have training programmes but these are at a small scale compared to Eskom and Necsa. These organisations have a small number of intakes per year but these trainees are also taken through training programmes that are tailored to the organisation needs. Since these entities mostly provide services to Eskom and Necsa, their training is similar to those provided by the two organisations.

NNR does not have a specific training programme for technicians but trains the employees as and when needed. Most of the training programmes at the NNR are on the regulatory and compliance matters.

5.1.2 What training and development training programmes need to be in place to meet nuclear new-build skills demand?

In order to meet the skills requirements that will be needed during the construction phase and also during the plant operation, it is essential to implement a coherent and generic training programme at national level. The Nuclear Technician Course that is currently offered by Eskom at Koeberg power station must be adapted to technician courses at Universities of Technology.

Government, through DST and Department of Higher Education need to take the lead in co-ordinating the national training programme. There must be collaboration between industry role-players and academia, to ensure that the Universities of Technology are producing what the industry needs. While the Universities of Technology not only train candidates for the nuclear industry, the industry is barely visible at these institutions in terms of awareness.

5.1.3 What initiatives are needed to bridge the skills gap?

The most significant initiative for bridging the skills gap in the technical field is to ensure that quality education is provided at high school level. Currently, the quality of maths and science passes is low and this place a heavy burden on the tertiary institutions to bring these learners up to the standard required. The nature of the problem precludes quick-fixes.

A shortage of adequately prepared school leavers that have the capability of entering the technical streams at institutions of high learning is prevalent. A number of initiatives have been taken to improve this situation, with a good example being the Dinaledi school projects. NIASA as the industry body can team up with the national government to set up initiatives of this kind.

The current throughput from tertiary institutions for technicians must be addressed as it was found that only about 30% of total enrolments manage to graduate. This low throughput is most likely because of students entering tertiary

education with a poor background in maths and science, thus struggling to keep up with the rigorous academic demand in the technical field.

To meet the peak demand, 150 technicians per annum must be produced between 2013 and 2023 for the nuclear industry alone, which competes with other industries for the same technical skills. The nuclear industry therefore need to address this as a matter of urgency, how it will meet that demand given that the supply currently falls way short of the requisite amount.

There is no collaboration between different industry stakeholders due to the fear that the company may lose the employees to their competitors. Much more significant, there is no noteworthy collaboration between learning institutions and industry. Among the industry sphere, there is a sentiment that there is no clear guidance from Government with regard to the commencement of the nuclear new build program.

As stated above, it is essential for more collaboration between industry role-players, especially between Eskom, Necsa and Government departments to be in place. In order for the industry to gain maximum benefit from the new build programme, a well-planned programme need to be in place in terms of skills development, who will be producing what skills, when those skills must be produced , cost involved and how funding will be provided for.

A skills register need to be developed that will classify skills according to scarcity and industry need. Employers fear that if employees are trained in anticipation for the new-build programme and Government takes longer to launch the project, the trained employees will become frustrated and are likely to leave the country in order to put the acquired skills into practise. This will incur losses for the company as it will not be able to recoup/benefit from the investment made on training employees if there are no clear timeline/guidelines on when the programme will start.

The same is applicable for training new trainees in specific skill sets in anticipation of new build, while there is no guarantee that the employers will be able to benefit from the training programmes put in place for skills development. It is therefore important from the Government side to send a clear message on what the project plan is with regard to the nuclear new-build launch date.

5.1.4 What lessons can South Africa Learn from other countries that have embarked upon nuclear technology such as South Korea?

There are lessons to be learnt from the South Korean experience, it terms of how they developed their workforce, what worked for them and what did not work. South Africa needs to look at how the South Korean experience can be adapted to the South African situation. The South Korean experience in nuclear technology has been discussed in the literature review, and to avoid repetition, it is not repeated here. The reader is referred to chapter two for this coverage.

5.2 Conclusion to chapter five

The research findings indicated that there is a need for an aggressive skills development to be put in place in the nuclear energy industry in South Africa. The research indicates that there is no adequate coordination between various role-players in the industry which can serve as a platform for uniform training and skills development within the nuclear energy industry. The next chapter gives a summary of recommendations of the research and conclusion to the whole report.

Chapter 6 : Recommendations

6.1 Introduction

This chapter provides a summary of the empirical findings. Recommendations, further research possibilities and limitations are identified. These are followed by a final conclusion.

6.2 Recommendations on the study

While there is training programmes at both Eskom and Necsa, these programmes are not coordinated, neither are they generic but are both tailored to the specific organisation. There is no industry wide, internationally benchmarked nuclear certification programme that can certify what level has been attained by a given candidate.

It is recommended that a coordination mechanism between these two important organisations in the nuclear sector be put in place. It is further recommended that NIASA as the industry representative body be the driver of this coordinated training mechanism through its education and training committee.

SANHARP and Thrip are the only two industry wide programmes that are aimed at addressing skills shortage, but these cover the whole science and engineering programmes and are not nuclear specific. NIASA does not have a specific programme aimed at developing skills for the nuclear industry as the industry body believes this will be a duplication of what is already being undertaken by their members.

It is recommended that NIASA plays a much stronger role in terms of training and development programme, even if it is just coordinating the programme as opposed to providing the training itself. South African must learn from other countries that have developed nuclear capability with success such as South Korea, instead of redesigning the wheel.

It is further recommended that a skills traceability and skill certification register be put in place. There must be a national guideline on nuclear training outcomes to ensure competence, capability and mobility of skills when so required. A skill risk register must be set up at national level to ensure proper planning and policy formulation as suggested in the Cogent publication, albeit with adaptation to South African conditions and also with more clarity on skills levels and certification.

While the Government have launched a number of laudable skills development and retention initiatives for the nuclear industry, both role players, i.e Government, Industry and Academia, must work together to address the shortage of critical skills in both capacity to deliver needed skills and capability to meet the likely demand which must be adequately addressed as a matter of urgency.

Up until it is known what technology will be chosen for the new-build programme, it will remain difficult to determine accurately what the exact numbers would be as the calculated numbers can only be based on averages. The use of average numbers can result in the underestimation of the required numbers.

Government therefore needs to come out strongly and clearly on what the future holds for nuclear energy, more so especially that nuclear has not been included in the National Development Plan (NDP2010) released recently by the National Planning Commission. The uncertainty surrounding nuclear energy also poses a problem in terms of attracting young people to the industry as most are uncertain whether it will be worth it to study in the area with job security not guaranteed. An aggressive marketing campaign must be put in place for the industry to market itself.

Commitment, both from Government and Industry must be provided, to capacity building, education and training as well as employment opportunities for South Africans. While Government does provide funding to students in a number of streams including technicians, no follow up is done to check the successful implementation of the programme. This must be addressed.

It is recommended that the skills register be the responsibility of the Department of Science and Technology (DST) in conjunction with the DoL. Frameworks must be developed to meet the needs of critical skills as identified in the skills register. The framework must be specifically tailored to maintaining the highest level of workmanship, quality assurance and safety awareness which are of extreme importance in nuclear construction and operation.

More funding must be made available to training institutions and training centres, Government must take the lead in this. There must be an employer driven entry level qualification within the nuclear sector with the support of industry bodies.

Government and its funding bodies must support funding for this training due to its importance to strategic areas of the economy and ability of reducing unemployment and poverty.

Necsa already have a good training facility and it is recommended that a way be found to equip this facility for larger groups training. There is a clear need for coordination between different Government departments, between industry and Government as well as within industry. This could provide the opportunity for other role players in the industry to collaborate in training initiatives.

It is recommended that a national nuclear training centre be established as well as an ECSA accredited nuclear qualification at technician level. In addition to providing training opportunities, more placement places for experiential training places need to be created to afford those with the theoretical knowledge practical experience. Industry must take the lead in this, perhaps Government can provide a financial incentive in this regard.

Certainty must be offered to those that are interested in choosing the nuclear career path. This certainty can only be provided by having a clear plan and commitment from Government on when the nuclear new-build will take off. Again, it is recommended that government take a lead in this. While nuclear courses have been introduced at a number of universities in the country, this has not happened at the Universities of Technology level and this must be addressed as a matter of urgency.

As education institutions are required to take initiative in terms of developing a course and apply to the Department of Higher Education (DoH) for approval, the nuclear industry must drive this as it will need the skills when the new-build take off. Given the long time it take for DoH to approve qualifications, this must be done as a matter of urgency.

The industry need to do more to attract the young people that have the necessary matric subjects to enter the field. The perceived lack of attraction of the career in technical fields needs to be addressed. The nuclear industry needs to be more visible in conventional media that young people use such as social media and educate the positives of following a nuclear career path. Young South Africans need to see a clear and exciting career path with full government backing in education and training with resources.

Supplier relationship leveraging must be a priority for Government by putting emphasis on the transfer of capacity to South Africa. A strategy similar to that used by Korea successfully need to be put in place. A generic nuclear course, similar to the one offered at Koeberg must be introduced into the Universities of Technology curriculum. It will be cost effective if elements of nuclear engineering are incorporated into traditional technician qualification.

6.3 Strengths and Limitations to the study

The number of responses contributed to valid results. The satisfactory response results confirmed the internal consistency or reliability of the items in the Skills Development Questionnaire.

There was limited literature on the training and skills development initiatives based on South Africa and of an academic nature. Literature available on skills development as well as skills certification is mainly on the United States of America. The USA was one of the first countries to implement nuclear specific training and qualification level certification more than 40 years ago. Limited research on other emerging nuclear power is also available, such as South Korea which has managed to localise about 95% of its nuclear programme in 1998.

The questionnaires were distributed to the main organisations operating in the nuclear energy sector and as such may be skewed towards the views of major organisations as opposed to for example the small consultancies. Generalisation of results should therefore be done with the required caution.

6.4 Possibilities for further research

This area of knowledge has revealed that there is a need for further research. There has not been a study dedicated to this area of study. Other researchers may want to research the following topics:

- As there is no national training guideline at technician level that is nuclear specific, this present a possible area of further research to establish a generic course that is developed between industry and academia.
- Further studies need to be conducted in terms of developing a business model for developing a nuclear specific curriculum at technician level at Universities of Technology.
- Another area that can be of possible further research is to look at what certification levels need to be in place that is internationally benchmarked to ensure uniformity.

References

1. Bailey, B. 1997, *Research for Technical Professionals*, 2nd ed. Philadelphia, Davis Company.
2. Cavallini, P. 24 February 2011. *Why energy will play a key role in the economy in the next decades*, Presentation at the nuclear expansion conference, Johannesburg.
3. Berg, BL. 1995. *Qualitative Research Methods*, Boston, Allyn and Bacon.
4. Chaturverdi, R.P. 1990, Issues related to nuclear energy transfer to develop countries, technology transfer in the developing countries, Macmillan Press, pp.249-261.
5. Choi K et. al, 2008, Fourteen lessons learned from the successful nuclear power program of the Republic of Korea, *Energy Policy* 37, pp.5494-5508
6. Cogent, 2008, *Next generation: Skills for new build nuclear*. Accessed from <http://www.cogent-ssc.com/research/nuclearresearch.php>, date accessed: 28 July 2011.
7. Cordoza, G, 2007, Learning innovation and growth: a comparative policy approach to East Asia and Latin America, *Science and Public Policy*, vol.24 no.6, pp.377-393
8. Csik B, 2004, Manpower development for nuclear power programmes, *IAEA Bulletin*, vol.21 No.2/3.
9. Creswell J.W, 2003, *Research design: qualitative and quantitative approaches*, Thousand Oaks, Sage printing.
10. David, M. & Sutton C.D. (2004). *Social Research the Basics*. London: SAGE Publications.
11. Deane, C. 15 September 2006. *National effort to tackle engineering shortage*. *Engineering News*, Print edition pg. 25
12. Department of Minerals and Energy, June 2008. *Nuclear energy policy for the Republic of South Africa*.

13. Department of Energy, Integrated Resource Plan for Electricity, 2010
14. Denscombe M, 2003, *The good research guide*, Maiden head, Open University press.
15. De Vos A.S, Schurink, E.M & Strydom H, 1998, The nature of research in the caring professionals, *Research at Grassroots: a primer for the caring profession*, pp239-251, Pretoria.
16. Goodfellow M.J, Williams H.R, Aza, P, Nuclear renaissance, public perception and design criteria: an exploratory review, *Energy Policy* 39(2011). Pp.6199-6210
17. Greyvenstein, G. 2008. The Critical Role of Educational Institutions in the Global Nuclear Renaissance. NIASA Deans' meeting, Pebble House 19 September 2008.
18. Haskins, S. 10 October 2008. *Energy minister promises 'emphatic' decisions on nuclear energy*. Engineering news, <http://www.engineeringnews.co.za/article/world-undergoes-nuclear-renaissance-2008-10-10> . Date accessed 2011/04/02
19. IAEA_a, 2002. *Management of Nuclear Knowledge*. Senior Level Meeting, International Atomic Energy Agency.
20. IAEA_b, 2007, Managing the 1st nuclear power plant project, Vienna
21. KAIF (*Korea Atomic Industry Forum*), 2005, Annual report
22. Krugman, K., 1994, *The myth of Asia 's miracle*, foreign affairs, pp. 62-78.
23. Kumar R. 2005, *Research methodology: a step by step guide for beginners*, London, Sage Publications.
24. Lorentzen, J., & Petersen, I., 2008, *Sectors and Skills: Three new technology platforms*, HSRC Press, Cape Town, 2008.
25. Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage Publications, Inc.
26. Mangena, J. 2007. *Investigating the Availability of Resources for Nuclear Power Plants in South Africa*. Masters of Engineering in Project Management, Faculty of Engineering, Built Environment and Information Technology, University of Pretoria.
27. Manpower Inc. 2007. *Industry sector skills requirement*. International survey
28. Matube, N. 30 May 2008, *South Africa's nuclear skills development initiatives*, WiN Global 2008 meeting, Marseille, France.
29. Merriam, S.B. (1998): *Qualitative Research and Case Studies Applications in Education*. San Francisco: Jossey-Bass Publications.

30. Molefe, P. 25 September 2007. *South Africa energy infrastructure development*, PowerPoint presentation to the Energy summit, Johannesburg.
31. NERSA, 2008. *National Integrated Resource Plan: NIRP 3*. National Electricity Regulator.
32. NIASA Subcommittee for Education Minutes, 13 April 2011, Available from: NIASA

33. NIASA, 2008. Status on Nuclear Education and Training in South Africa. Nuclear Industry Association of South Africa.

34. OECD_a, 2000. *Nuclear Education and Training: a cause for concern?* Organisation for Economic Cooperation and Development, Paris.
35. OECD_b, 2008, Nuclear power and sustainable development, Vienna
36. OECD_c, 2008, *Nuclear energy outlook*, NEA, Vienna
37. Potgieter LJ. 2010. A business model for the collaborative delivery of a master's degree in nuclear engineering by South African universities. MEng Thesis, NWU.
38. Pouris,A. 2009. *Demand for nuclear skills in South Africa*, Report for the Department of Minerals and energy, Pretoria.
39. Richie, J. & Lewis, J., 2003. *Qualitative research practise: A guide for social science students and researchers*. North America, 2004.
40. Rochin, GE, 1994, Broken plowshare: system failure and the nuclear power industry. Westview Press, pp. 231-61
41. Sanghera, B. 2009, Quantitative and qualitative research. Sage Oaks, London.
42. Sean, A., 2007, International Literature on skills training and the scope for South African application, Development Policy Research Unit, University of Cape Town.
43. Sonjica, B. 2007. *South Africa's Nuclear Energy and Uranium Renaissance Conference*. Address by the Minister of Minerals and Energy. 16 Feb 2007.
44. Thugwaneta, S.J, Mokhinea P.M., Raswesweb, M.A, Tiholakaea, B.Y., 2008. *SAYPS on Skills transfer, knowledge management and nuclear public education*. Kormorant 8(36):1, <http://www.cane.org.za/2008/05/07/nuclear-energy-related-brainwashing-at-taxpayers-expense/>. Accessed: 25 July 2011
45. Van Roojen, A., 2010, *Funding required to tackle skills shortages*, Engineering News, June 13.
46. Wolcott, H.E, 2009, *Writing up qualitative research*, 3rd edition, Sage Printing.
47. WNA, 2010. *Nuclear Technology Review*. Vienna: International Atomic Energy Agency.

Appendix



Survey of Nuclear Industry Human Resources Needs and Skills Development
Initiatives at Technician level
South Africa 2011

This Survey is undertaken as part of a Master's Degree research study in Nuclear Engineering at the Post-Graduate School of Nuclear Engineering, North-West University, Potchefstroom Campus. The survey is aimed at looking at skills available/shortage assuming the nuclear new-build goes ahead as planned.

Please complete the questionnaire with the best available information, and return it to the researcher, Titus Nampala at tnampala@gmail.com . it is highly appreciated if this survey is completed by a person who is involved in drawing up training program within the organisation at the highest level.

If more information or clarity is required, you may approach the researcher at North-West University (018-2994489/0724464730).

PERSONAL DATA OF PERSON COMPLETING THE QUESTIONNAIRE

Organisation	
Name of person completing the form	
Designation	

email		Telephone number	
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EMPLOYMENT AND VACANCIES IN THE ORGANISATION

(Please see definitions at the end of the questionnaire)

Employment category	Current employee s	Current vacancie s	Number of employee s to retire in the next 10 years
Managers & other professionals			
Engineers			
<ul style="list-style-type: none"> • With nuclear related expertise 			
<ul style="list-style-type: none"> • All other engineers 			
Scientists			
<ul style="list-style-type: none"> • Scientists with nuclear expertise (e.g. radiology) 			
<ul style="list-style-type: none"> • Scientists (other) 			
Technicians with nuclear related expertise			
Technicians (other)			
All other workers			
TOTAL NUMBER OF EMPLOYEES			

CURRENT HIGHEST QUALIFICATIONS OF EMPLOYEES

Employment category	Number of employees with Doctoral degrees	Number of employees with Masters degrees	Others with Higher Education qualifications
Managers & other professionals			
Scientists			
Engineers			

CRITICAL AND FUTURE NEEDS

(In RANKING, please indicate your critical needs for your operations by allocating priorities (1= highest – 5 = lowest)

Employment category	Ranking	Expected number of employees for new-build
Engineers with nuclear-related certification		
Other engineers		

Scientists (Nuclear med. physicians, Radiologists etc)		
Other scientists		
Health physics and radiation technicians		
Electrical & electronic technicians		
Other technicians		

(In RANKING, please indicate your critical needs for your operations by allocating priorities (1= highest – 5 = lowest)

Employment category	Ranking	Expected number of employees by 2019
Employees with Doctoral degrees		
Employees with Masters degrees		
Employees with first degrees		
Technicians		

GENERAL INFORMATION PERTAINING TO TECHNICIANS ONLY:

(Please insert an X where appropriate)

Do you have any initiatives for skills development, skills acquisition, retention etc	Yes	No
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If the answer is yes, please indicate the available funding during 2010 and the number of individuals who benefited from it at technician level.

Funding available for technician training	R
Number of individuals benefiting from this funding	

1. Please provide a short description of your initiatives for skills development/acquisition/retention.

(Please use additional space if needed).

2. Please list any strategies that are in place/planned for nuclear new-build.

3. Please list any activities/plans for capacity building and capability.

4. List/state/discuss methods used for skills traceability and certification

5. In your opinion who should take the lead in skills development, industry or Government?

6. Are there any gaps in training from the academic institution? If yes, how can these gaps be narrowed?

7. In your opinion is the country well poised to fully benefit from the nuclear localisation program?

8. How does your organisation intend on localizing its content(s) during new-build project?

Thank You for your participation!!!

I would appreciate it if I could receive your response by **16 September 2011**

DEFINITIONS

Managers:

Persons concerned with policy-making, planning, organizing, staffing, directing, and/or controlling the activities of an organization, usually through subordinate supervisors.

Engineers:

All persons actually engaged in engineering work at a level which requires knowledge of a field of engineering, equivalent at least to that acquired through completion of a 4-year university course. Typical job titles are electrical engineer, nuclear engineer and mechanical engineer.

Scientists:

All persons actually engaged in scientific work at a level which requires knowledge of mathematical, physical or life sciences, equivalent at least to that acquired through completion of a 4-year university course. Typical job titles are mathematician, computer scientist, chemist, physicist, biologist, and health physicist.

All other professional workers:

All persons (other than managers, engineers and scientists) engaged in work such as accounting, purchasing, personnel, and finance which requires knowledge at least equivalent to that acquired through completion of a 4-year university course. Typical job titles are accountant, purchasing agent, labour relations representative, and finance officer.

Technicians:

All persons actually engaged in technical work at a level which requires knowledge of engineering, mathematical, physical, or life sciences, comparable to two years of university study at technical colleges or other formal post-high school training or through equivalent on-the-job training or experience. Typical job titles are health physics/radiation protection technician, instrumentation and control technician, chemical technician and electronic technician.