

Localisation strategy for the South African nuclear power programme

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ABSTRACT

Through this study, a strategy for the localisation and development of the South African nuclear industry was developed. As background, the Korean localisation experience was investigated, along with international recommendations regarding nuclear localisation, and South African governmental policies. This research was used as foundation for the formulation of a localisation strategy. The possibility of using localisation and nuclear industry development as a means to address governmental socio-economic development goals was investigated. From the literature investigation localisation principles were identified. The focus areas of the localisation strategy were subsequently based on these principles. The principles are:

- Aggressive human resource development
- Governmental leadership and support
- International co-operation

The localisation strategy addresses general localisation recommendations, needed human resource development, structure of the Nuclear Energy Project Implementation Organization (NEPIO), roles of the participants of the NEPIO, and finally the supply-chain development and technology transfer guidelines. It was assumed that three nuclear power plants, consisting of two reactors each would be constructed. For localisation to be successful, a fleet approach must be followed to ensure economy of scale, and local participation must be incrementally increased with each power plant. The localisation strategy was circulated to industry for validation, and changes were made, based on industry feedback.

The needed human resource development amounts to the training of 4 012 labourers per year (see Table 1).

Table 1: Total human resource development requirements for construction, operation and localisation per year

Total Human Resource Requirement per Year	Number
Project Management	30
Scientists	22
Technicians	415
Engineers	230
Artisans	3 110
Safety & Licensing	95
Quality Personnel	110
Total per year	4 012

The local participation for each consecutive power plant is 30%, 50%-55% and 75%-80%, respectively. It was found that 100% localisation is not feasible. The planned nuclear power programme is too small to justify the development of globally leading components such as ultra-heavy forgings.

The structure of the NEPIO is shown in Figure 1.

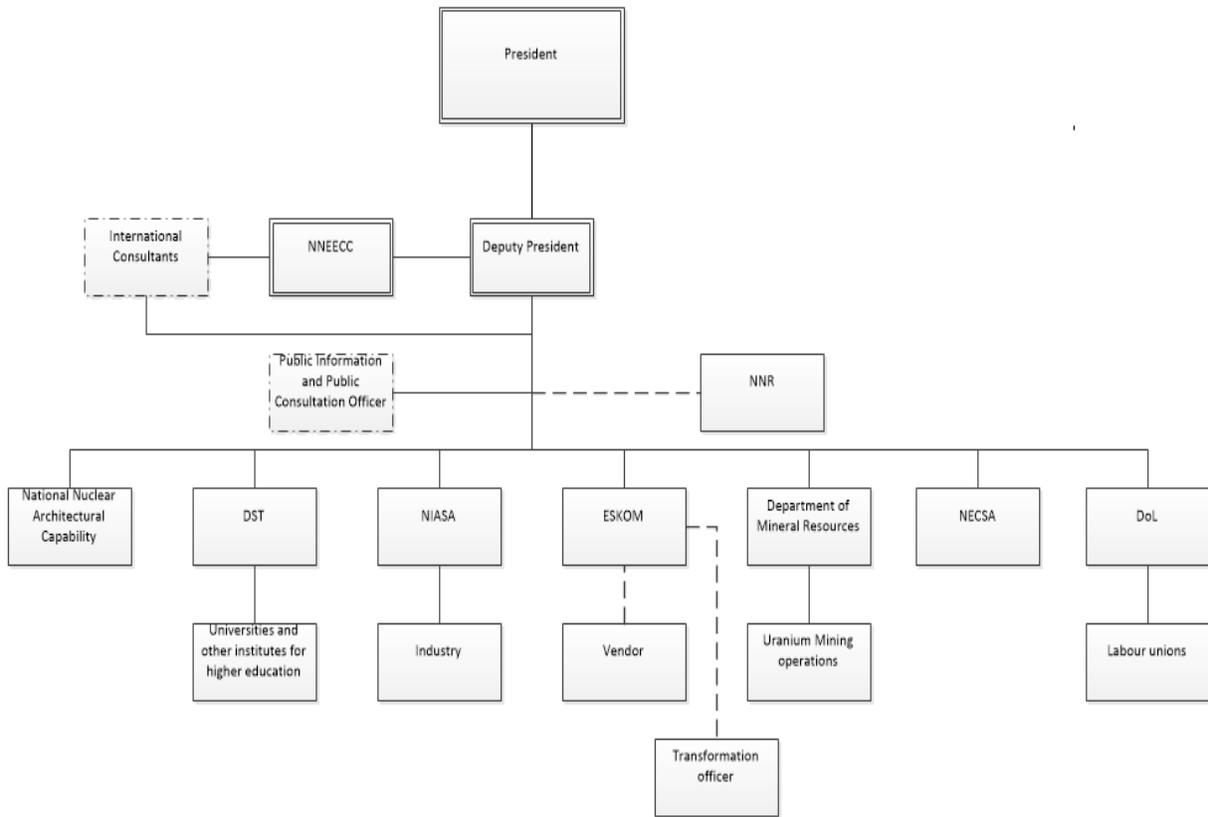


Figure 1: South African NEPIO structure

It was found that the localisation and nuclear industry development would serve as a vehicle to help achieve governmental socio-economic development programmes. It was finally concluded that South Africa has the potential for localisation, but obstacles such as a lack of governmental commitment, negative public perception, and lack of industry confidence will be detrimental to the localisation efforts. If these, and other obstacles are not urgently addressed, South Africa will miss out on a much needed development opportunity.

Keywords: nuclear localisation, human resource development, NEPIO, supply-chain development, South African nuclear power programme, localisation strategy.

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ABREVIATIONS

Abbreviation or Acronym	Definition
A/E	Architect/Engineer
AED	Atomic Energy Department
AERI	Atomic Energy Research Institute
AsgiSA	Accelerated and shared growth initiative for South Africa
ASME	American Society of Mechanical Engineers
BAA	British Airports Authority
B-BBEE	Broad-Based Black Economic Empowerment
BOP	Balance of Plant
BWO	Black Women Owned
CSDP	Competitive Supplier Development Programme
DMR	Department of Mineral Resources
DPE	Department of Public Enterprise
DST	Department of Science and Technology
DTI	Department of Trade and Industry
GDP	Gross Domestic Product
GW	Gigawatt

HVAC	Heating, Ventilation and Air Conditioning
IAEA	International Atomic Energy Agency
IP	Intellectual Property
IPAP	Industrial Policy Action Plan
IRP	Integrated Resource Plan
KEARI	Korean Atomic Energy Research Institute
KEPCO	Korea Electric Power Corporation
kW	Kilowatt
LBS	Large Black Supplier
LNG	Liquefied Natural Gas
MW	Megawatt
NECSA	South African Nuclear Energy Corporation
NEP	Nuclear Energy Policy
NEPIO	Nuclear Energy Project Implementation Organization
NIASA	Nuclear Industry Association of South Africa
NIPF	National Industrial Policy Framework
NNAC	National Nuclear Architectural Capability
NNEECC	National Nuclear Energy Executive Co-ordination Committee
NNR	National Nuclear Regulator

NPC	National Planning Committee
NPP	Nuclear Power Plant
OECD	Organisation for Economic Co-operation and Development
PBMR	Pebble Bed Modular Reactor
PIPCO	Public Information and Public Consultation Officer
PWR	Pressurised Water Reactor
R&D	Research and Development
SA	South Africa
SANAS	South African National Accreditation System
SBE	Small Black Enterprise
SDP	Supplier Development Plan
SOE	State Owned Enterprise
TSAPRO	The South African Power Project
UCOR	Uranium Enrichment Corporation
USA	United States of America
WNA	World Nuclear Association

1. INTRODUCTION, MOTIVATION, GOALS AND CHAPTER LAYOUT

1.1. Introduction

South Africa is the largest producer of electricity on the African continent. The local power utility, Eskom, is currently generating a total of 41 194 MW of installed capacity. The power generated by Eskom comprises 85% coal-fired power stations, 5% nuclear power stations and 10% from other sources (Eskom, 2011a).

In 2007, Eskom's surplus electricity supply ran out, and power outages became apparent. The demand for electricity was outgrowing Eskom's supply capabilities, and it became clear that Eskom urgently needed to expand its generation capabilities. In 2005 Eskom embarked on a capacity expansion programme and committed itself to increasing its baseload generation capabilities. The planned increase in total generation would amount to a total of 45 637 MW, of which a planned 9 600 MW would be from nuclear power plants (Department of Energy, 2011). The IRP was promulgated on 6 May 2011 by the Minister of Energy, thus cementing the implementation of the plan.

Although South Africa has only three operational nuclear reactors (2 reactors at Koeberg Nuclear Power Plant and the SAFARI-1 Nuclear Research Reactor), South Africa has very little established nuclear industrial capabilities, with only NECSA having ASME III nuclear certification. Thus, the expansion of Eskom's generation capacity through nuclear power poses both opportunities and obstacles for the South African economy and industry.

Past international experiences in nuclear power programmes showed that the host country could benefit greatly from a successful localisation of nuclear manufacturing capability and technology (Lee, Nam *et al.*, 2009). South Africa's vast natural resource supply, access to uranium and established construction, manufacturing and steel industries, create an opportunity for South Africa to develop a nuclear industry that holds great benefits for the South African economy. A localisation study for the first two units of the South African nuclear new-build programme was initiated by the Department of Trade and Industry. This report states that approximately 40% local content can be achieved and that South Africa should focus on establishing local capabilities to design, manage the project and deliver components and systems, not only manufacturing and construction for the new-build programme (Worley Parsons, 2011).

The Department of Trade and Industry identified nuclear energy as a sector with potential for development of long-term advanced capabilities, and the nuclear industry was mentioned as an

opportunity for new investments and joint ventures to supply both local and global markets (Department of Trade and Industry, 2010).

For South Africa to fully reap the benefits of commencing a nuclear power programme, a clearly defined strategy, including localisation goals and leadership structures, need to be formulated.

1.2. Problem Identification

Past international experience has shown that strong governmental leadership, and a clearly defined localisation strategy are crucial for the successful localisation of nuclear technology and development of a nuclear industry. To this end, a South African leadership structure needs to be defined, as well as a localisation strategy encompassing the goals of all the various role players, before the start of the nuclear power programme (IAEA, 2009b).

Some of the objectives for the nuclear power programme, as envisioned by the government, state the following (Department of Minerals and Energy, 2008):

- Establishment of a national industrial capability for the design, manufacture and construction of nuclear energy systems;
- Contribution to the country's national programme of social and economic transformation, growth and development;
- Attainment of global leadership and self-sufficiency in the nuclear energy sector in the long-term;
- Allow for the participation of public entities in the uranium value chain;
- Skills development related to nuclear energy.

To address the above-mentioned goals, organisations and associations have already been formed. The South African Nuclear Energy Corporation Limited (NECSA), for example, is mandated to undertake the promotion of research and development of nuclear and radiation sciences and technologies. Along with this, the Nuclear Energy Policy (NEP) mandate directs NECSA to develop viable nuclear fuel operations in South Africa.

Although the South African government has taken steps to address goals of the NEP, there is still a large amount of work to be done. In November 2011 the National Nuclear Energy Executive Co-ordination Committee was set up by cabinet, and the chairperson is deputy president Kgalema Motlanthe. This committee met for the first time in August 2012, 4 years after the NEP had been accepted. Lack of transparency into the functions, structure and work done

by the NNEECC undermines public and industry trust in the government. Other crucial role players such as the NNR and NECSA commented on the fact that funding constraints and lack of communication and consultation have left them in the dark, and that they had little idea as to what the nuclear build programme would entail (Preuss, 2012).

1.3. Problem Statement

Due to the fact that South Africa has no recent experience in a large-scale nuclear power project, and that there is no unified strategy encompassing government policies and industry goals, a localisation strategy needs to be created to ensure that all the economic and industrial benefits posed by such a programme can be achieved.

The aim of the research was to compile a localisation strategy for the nuclear power programme of South Africa. The work offers a unified strategy incorporating both governmental policies and industry development and localisation goals, and is based on past experience of countries that have successfully localised and on international recommendations. This strategy addresses key areas of focus regarding localisation and industry development, and proposes a possible implementation approach for the proposed 9.6 GW nuclear fleet. It will also propose a unified leadership structure to guide and regulate the localisation process.

The research objectives include investigations into:

- Applicable lessons learnt from past experience;
- Case study proving economic benefits of successful localisation and nuclear industry development;
- International recommendations addressing issues relevant to localisation;
- Local studies addressing localisation;
- Governmental policies addressing industry and human resource development, and the possible use of nuclear industry development to address these policies;
- Identification of the needed human resource development, and recommendations to achieve said development;
- Recommendations addressing localisation and industry development;
- The structure and functions of a South African Nuclear Energy Programme Implementation Organization.

These outcomes are based on existing governmental policies, industry goals and practices, past experiences and international recommendations.

1.4. Basic Hypothesis

The effectiveness of the localisation effort surrounding the South African nuclear power programme will be greatly improved when a localisation strategy clearly defining the needed leadership structures, human resource development, localisation requirements and industry development goals is compiled, and effectively executed.

The null hypothesis statement of the research is: The localisation strategy proposed by this research will *not* contribute to the effectiveness of the localisation effort with regard to the South African nuclear power programme.

1.5. Overview of dissertation

This dissertation consists of 5 chapters, structured in the following way:

Chapter 1	Chapter 1 serves as introduction to the dissertation and gives a brief overview of the problem statement and the planned outcomes.
Chapter 2	Chapter 2 is the literature study and focuses on the Korean experience regarding localisation and the economic impact thereof, the IAEA recommendations regarding the Nuclear Energy Project Implementation Organization (NEPIO) and infrastructure developments and a summary of the relevant government policies regarding the nuclear industry, localisation and industry development.
Chapter 3	Chapter 3 discusses the localisation model, and focuses on general recommendations, human resource development, the structure of a possible South African NEPIO and the roles of each organisation therein and recommendations for localisation and industry development.
Chapter 4	Chapter 4 summarises industry and government feedback on the proposed strategy, and addresses the needed changes that should be made to the strategy based on the feedback.
Chapter 5	Chapter 5 shall be the conclusion of the study

1.6. Conclusion

Nuclear power programmes pose large economic benefits and development opportunities for the host country, if managed correctly (IAEA, 2009a). The unified strategy and localisation approach should be documented, clearly showing the benefits from past experience that could be gained from a nuclear power programme, incorporating international experience and addressing the various governmental policies regarding localisation and industry development. Research regarding these aspects forms the basis of the proposed strategy, and is summarised in Chapter 2.

2. LITERATURE STUDY

As a basis for the localisation strategy, research into past localisation experience and international recommendations was done. The Korean experience was chosen as the case study, due to the success of their nuclear programme and the fact that their experience, and the impact of the nuclear industry on their economy, are very well documented. To structure better a unique strategy, South African human resource and industry development policies were included, as well as local capability studies. The Korean case study summarised the Korean localisation strategy, as well as the core localisation principles and focus areas, and the economic benefits of successful development of a nuclear industry. The international recommendations summarised the recommended leadership structures, and key issues regarding localisation through the various stages of the nuclear power programme. Local government policies were summarised, and shortfalls were discussed. Critical comment is integrated in the text, and further comment is made in paragraphs shown in *italics*.

2.1. The Korean experience

One of the best documented examples of nuclear localisation, and case study for the economic benefits associated with localisation, is provided by Korea. The Koreans were able to localise their entire nuclear industry, and thereby enter the international nuclear market on various levels. Today, Korea is an international leader in design and supply of various nuclear components.

2.1.1. Historical overview of Korean nuclear power programme

After World War II, the Korean peninsula was divided into North and South Korea. On 25 June 1950 the Korean War broke out between North Korea and South Korea, and lasted until 27 July 1953. After the war had ended, the country was left in a devastated and impoverished state. In 1954 the gross national product (GDP) of Korea was a mere \$70 per capita, roughly 0.35% of the gross national products per capita of Korea in 2009 (Choi *et al.*, 2009). Not only was the country left impoverished, but the industrial capability of Korea was largely destroyed, and especially the country's power generation capability. In 1961, the country had a generating capacity of a mere 367 254 kW. The Korean government decided to launch an ambitious capacity expansion programme, which included the use of nuclear power. In 1956 the Korean government sent a delegation to the first Conference on Peaceful uses of Atomic Energy, and signed a bilateral cooperation agreement with the USA. In 1957 Korea joined the IAEA, and in 1958 the Korean government launched the nuclear power programme by enacting the Atomic

Energy Act and establishing the Atomic Energy Department under the Ministry of Education. The first research reactor was built (a TRIGA Mark-II reactor) with the support of the USA, and with the introduction of the research reactor, the Atomic Energy Research Institute (AERI) was launched in 1959 as an affiliate of the OAE (later on known as the Department of Atomic Energy). In 1973 AERI, the Radiological Research Institute (RRI) and the Radiation Research in Agriculture (RRIA) merged to form Korean Atomic Energy Research Institute (KAERI) as it is known today (KAERI, 2011). In 1958, the first undergraduate nuclear engineering department was established. AERI and the OAE, with the use of the research reactor, up to 1964 focused on the medical and agricultural applications of nuclear power. In 1962, the three Korean power utilities were merged to create the Korea Electric Power Corporation (KEPCO). In 1964 Korea embarked on the site selection process for the first NPP. Construction on the first commercial nuclear reactor (Kori-1) started in 1972 and achieved commercial operation in 1978. After the successful Kori-1 NPP, there was a burst of activity with 8 reactors being built in the 1980s.

The first three reactors built, were turnkey projects, in which there was very limited participation from Korean government and manufacturers, and were used largely for research and development. The following 6 reactors were non-turnkey projects, where Korea took a much more prominent role throughout the entire project. Korean participation started to expand from non-safety balance of plant construction and component manufacturing, to construction and manufacturing of nuclear island components. Throughout this process, constant technology transfer, aggressive expansion and development of human resources, and a strong emphasis on research and development enabled Korea to partake in the design process, and they started standardising designs. In the beginning the Korean institutes focused on reverse engineering of the imported technologies, but, as this became more difficult to do legally under international trade laws, focus shifted to local research capabilities (IAEA, 2009a). By the 10th reactor, Korea standardized and localised the design and the manufacturers of NPPs.

In 2010 the country's total electricity generating capacity was 76 078 188 kW, of which 17 715 683 kW (thus 23.286%) was nuclear. There are currently 21 nuclear reactors in operation and a further 11 planned or under construction (WNA, 2011), making Korea one of the leading international role-players in the nuclear industry. Figure 2 shows the development schedule of nuclear power plants, and the role of Korean manufacturers.

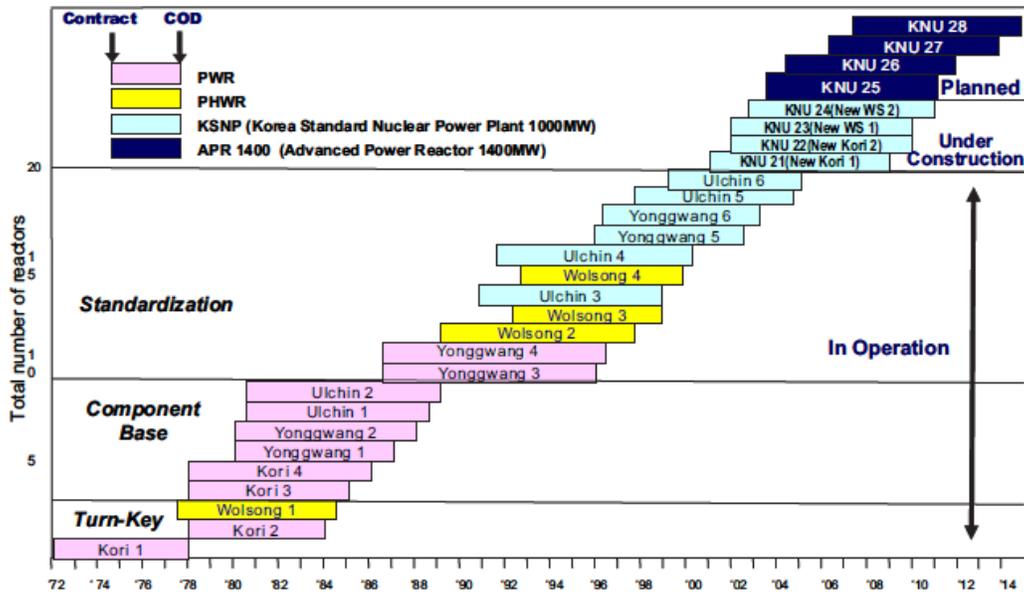


Figure 2: Development schedule for Korean nuclear power plants (source: IAEA)

2.1.2. Contributions of the nuclear programme to the economy of Korea

The IAEA, along with various departments from the Korean government, launched an extensive study to quantify the economic benefits of a nuclear programme to the host country (IAEA, 2009a). This study included the economic benefits of various elements of a nuclear program, such as nuclear power (with comparisons to other power sources such as coal), radio-isotope production, the contribution to the regional economy and the external benefits of nuclear power. To be able to do a quantitative analysis, an I-O model was used. The national I-O table was reorganized into 36 primary sectors, and each activity associated with a nuclear power project paired with its relevant industry. By doing this it is easy to isolate and analyse the effects of a nuclear power project on the various industries and on the country as a whole.

- Nuclear power

To study the quantitative economic benefits of nuclear power, the project was divided into its various phases, and each activity associated with those phases was linked to an industry in the national I-O table of Korea.

As Korean nuclear self-sufficiency evolved, the focus shifted from primarily construction to other industries. In a pre-1990 Korean nuclear industry where all nuclear projects were turnkey projects, the primary sectors involved in the construction of a nuclear power plant were electric power plant construction and finance and insurance. Later on, as local participation increased,

many other industries were involved with nuclear power plant construction, such as primary metal products, general machinery and equipment, electronic and other electric devices and business services (IAEA, 2009a).

Taking the overall contribution into account, nuclear power accounts for 1.3% of GDP. By comparison, the four major industries in the Republic of Korea are primary iron and steel products, semiconductors and related devices, motor vehicles and petroleum products contributed 1.3%, 2.1%, 2.2% and 2.9%, respectively to GDP in 2003 (IAEA, 2009a). The contribution to GDP by the nuclear power sector is summarised in Table 2. Note the growth in the contribution to GDP as local participation increased.

Table 2: Summary of the total nuclear power sector contribution to GDP (in billions of Won) (IAEA, 2009a)

		1980	1985	1990	1995	2000	2005
Gross output	Construction	287	938	748	1 514	2 665	3 585
	Operation	191	1 277	3 571	5 667	11 081	13 865
Value added	Construction	135	466	283	615	1 180	1 491
	Operation	148	1 018	2 414	3 581	7 281	9 163
GDP		37 116	78 848	178 317	375 803	599 645	810 516
Value Added Contribution to GDP		0.8%	1.9%	1.5%	1.1%	1.4%	1.3%

The next question is: What would the effects on the GDP have been if conventional thermal energy sources were used, such as coal and LNG plants? Domestic expenditures during the construction of a 1 000 MW nuclear power plant were estimated at 1 300 billion Won, 490 billion Won for the construction of a 500 MW bituminous coal power plant and 155 billion Won for a 450 MW LNG power plant. From these figures it can clearly be seen that the domestic expenditure of coal is 76% that of a nuclear power plant while LNG is a mere 26% compared to nuclear. For the sake of the comparison, the historical share of thermal power generation was adjusted to expand proportionally to replace all the power generated by nuclear. By using this assumption, the incremental value added to the GDP can be calculated. The results of the comparison are summarised in Table 3. It can clearly be seen that by using conventional thermal power sources, the GDP would have been lowered by as much as 0.4%.

Table 3: Incremental nuclear value added contribution to GDP (in billions of Won) (IAEA, 2009a)

	1980	1985	1990	1995	2000	2005
Total nuclear value-added	283	1 484	2 697	4 196	8 461	10 654
Total thermal value-added	123-191	841-1 074	1 837-1 978	2 851-3 158	5 512-6 102	7 711-8 456
Total value-added loss (Net nuclear contribution)	92-160	410-643	719-860	1 038-1 345	2 359-2 949	2 198-2 943
GDP	37 116	78 848	178 317	375 803	599 645	810 516
Share of incremental nuclear value-added contribution to GDP	0.3-0.4%	0.5-0.8%	0.4-0.5%	0.3-0.4%	0.4-0.5%	0.3-0.4%

- Radioisotope production

Radioisotopes are used in a broad spectrum of applications, such as use in medical applications, precision measurement instrumentation, agriculture, in non-destructive testing, etc. This broad spectrum of applications can create the opportunity to enter a very profitable market, generating large amount of revenue both locally and internationally via exports.

The use of radioisotopes has grown exponentially in the last two decades. In Korea is has grown from a value added contribution of 176 million Won in 1980 to approximately 6 223 billion Won in 2003 in manufacturing applications (IAEA, 2009a). This growth in the application of radioisotopes in the manufacturing sector constituted 0.4% of the GDP of Korea in 2005.

The use of radioisotopes in the medical sector also made major contributions to the national economy, constituting 0.23% of GDP in 2005, showing an increase of 0.17% from 1980.

The total contribution of radioisotopes to the GDP is shown in Table 4, in which it can be seen that radioisotopes contributed 0.67% to the GDP of Korea (IAEA, 2009a).

Table 4: Summary of the total radioisotope contribution to Korean GDP (in billions of Won) (IAEA, 2009a)

		1980	1985	1990	1995	2000	2005
Output	Manufacturing	391	1 054	2 009	4 214	7 547	10 787
	Medical	49	207	408	970	2 398	4 040
	R&D	-	-	-	-	-	-
	Sub total	440	1 261	2 417	5 184	9 945	14 827
Value added	Manufacturing	88	277	592	1 437	2 360	3 488
	Medical	22	102	196	504	1 101	1 904
	R&D	-	15	15	15	15	15
	Sub total		394	803	1 956	3 476	5 407
GDP		37 116	78 848	178 317	375 803	599 645	810 516
Value-Added Contribution to GDP		0.30%	0.50%	0.45%	0.52%	0.58%	0.67%

- Nuclear contribution to regional economy

Nuclear projects contribute profoundly to the local economy of the region in which the project is being built. The analysis used by the IAEA looks at the regional economic development, based again on an I-O analysis evaluating the direct, indirect and induced from increased output and expenditure of labour income, as well as plant expenditures for goods and services during the construction and operation of the plant. The Ulchin power plant is one of the best documented power plants with regard to regional contribution.

There are four nuclear power plant sites in Korea, one of which is the Ulchin power plant in the Ulchin region. This power plant has 6 reactor units in operation, with an installed capacity of 5.9 MWe, and is the sole supplier of power to the region.

The construction of the Ulchin nuclear power plant created a large economic growth spurt for the region. The creation of jobs in the construction phase, the operation phase and through the development of local infrastructure to support the project (such as the construction of schools, training and scholarship programmes, expansion of medical facilities, etc.) contributed greatly to the economic growth of the region. Another source of income to the region is from the tax associated with a nuclear power project. The contribution and other outlays for the Ulchin plant contributed some 70% of the total regional output, not including revenues from power generation. The plant has also contributed some 20% of regional labour income.

The total regional output and income of the Ulchin region due to the Ulchin nuclear power plant is summarised in Table 5 and 6 respectively.

Table 5: Total regional output effects of the Ulchin nuclear power plant (in billions of Won) (IAEA, 2009a)

	Nuclear Power		NPP Areas Regional Project	Local Taxes	Total	Shares to Total Regional Output
	Construction	Operation				
1990	n.a.	581.7	2.2	-	583.9	-
1995	n.a.	605.6	4.8	8.4	618.9	48%
2000	n.a.	1 559.8	10.1	26.2	1 596.1	69%
2001	n.a.	1 615.2	10.3	10.6	1 636.0	66%
2002	n.a.	1 445.4	9.8	17.9	1 473.1	60%
2003	n.a.	1 612.0	18.4	22.9	1 653.3	62%
2004	n.a.	1 835.2	11.4	25.9	1 872.5	72%
2005	n.a.	2 240.1	9.1	56.6	2 305.8	70%

Table 6: Total regional income effect of the Ulchin nuclear power plant (in billions of Won) (IAEA, 2009a)

	Nuclear Power		NPP Areas Regional Project	Local Taxes	Total	Shares to Total Regional Income
	Construction	Operation				
1990	-	20.0	0.6	-	20.5	-
1995	65.1	23.1	1.4	2.4	92.1	39%
2000	67.2	44.8	3.5	6.4	121.9	43%
2001	65.7	55.3	5.0	2.4	128.4	43%
2002	74.5	50.9	4.2	3.9	133.6	40%
2003	68.7	81.4	6.0	4.8	160.9	44%
2004	36.1	74.0	4.3	5.2	119.6	26%
2005	-	75.5	3.2	10.9	89.7	20%

From these figures it can be seen that a national nuclear power programme contributes immensely to the economy of the region. There are also benefits beyond what was discussed previously, such as the external cost implication of nuclear vs. conventional power sources, the environmental effects of nuclear and the security of supply. These are not direct costs/benefits, but can rather be seen as a positive by-product of using nuclear energy.

The external costs of energy refer to additional costs not included in the everyday operations and maintenance costs, such as the costs associated with pollution and other costs associated with the socio-economic impact of power generation. One of the best known studies of the external cost of power generation is the ExternE study, sponsored by the European Union and the Oak Ridge National Laboratory in the USA (European Commission, 2003). The study looked at the external cost of power generation in Europe,

and showed that nuclear had the third lowest external costs of all power generation methods available in Europe (IAEA, 2006).

2.1.3. Core localisation and technology transfer principles

Choi *et al.* documented the 14 lessons learnt from the Korean localisation experience. By incorporating the insights of other authors (de Prèneuf, 2004; Jiachen, Wenquan, *et al.* 2004; IAEA 2006; Lee, 2007), it becomes evident that the 3 core principles underlying the entire localisation process are:

- **Aggressive development of human resources**

From the start of the nuclear program, the Korean government focused heavily on human resource development. One of the first steps the Korean government took at the start of the programme was to create the Atomic Energy Department under the Ministry of Education, and start sending students on training programs abroad. Foreign expertise was brought in to assist in various phases of the nuclear projects, working alongside local students and in so doing ensuring that technology transfer was taking place. The establishment of KAERI created the opportunity for extensive research and development programmes and courses in the fields of nuclear energy were established at tertiary education institutes. Technology transfer was an essential part of the success of the Korean nuclear power programme, making it possible for Korea to start standardising nuclear power plant designs. The development of human resources in the various fields of nuclear power made it possible for the Koreans to start partaking in design, maintenance and operations of the nuclear power plants, gradually increasing local participation, which became a critical step on the road to self-sufficiency.

- **Governmental leadership and support**

The Korean government took the responsibility to implement and maintain the leadership structures for the Korean nuclear programme. The government not only supported the programme, but was a key participant through various departments. The governmental drive caused many industries to start focusing on nuclear as a key opportunity, and thus created nationwide support of the programme. Governmental leadership was also critical in public acceptance of the planned nuclear projects. No nuclear programme will succeed if the government does not accept the leadership role.

- International co-operation

At the very start of the nuclear programme, Korea entered into the international nuclear community. Knowing that they lack the expertise in the nuclear field, Korea capitalised on the knowledge and experience that were freely available the international nuclear organisations, such as the IAEA. International expertise was used in the creation of the Korean nuclear regulator, thus ensuring that all regulatory legislation and activities were on par with international standard. All planning and much of the designs of Korean nuclear components were sent abroad for comment from the international nuclear community (see Figure 3). This not only ensured the quality of the procedures and designs, it also built confidence within the Korean nuclear community.

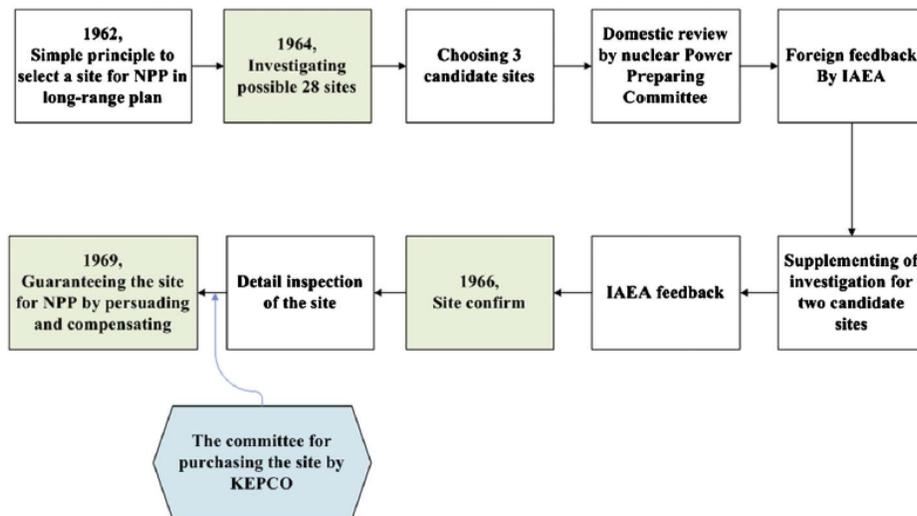


Figure 3: Site selection and evaluation in the 1960s (note foreign involvement) (Choi *et al.*, 2009)

2.1.4. Korean localisation model

With the manufacturing capability of Korea having been decimated after the war, and a lack of local expertise, the Korean government realised that they would not have the capacity for large involvement in the first nuclear projects. Thus, the first three reactors built were turnkey projects with very limited Korean participation. These projects were used as training tools and opportunities for technology transfer. With the successful completion of each project, local participation grew. The aim of the Korean localisation programme was to achieve nuclear self-reliance. To achieve this, technology transfer and standardisation were chosen as major vehicles for self-reliance (IAEA, 2009a).

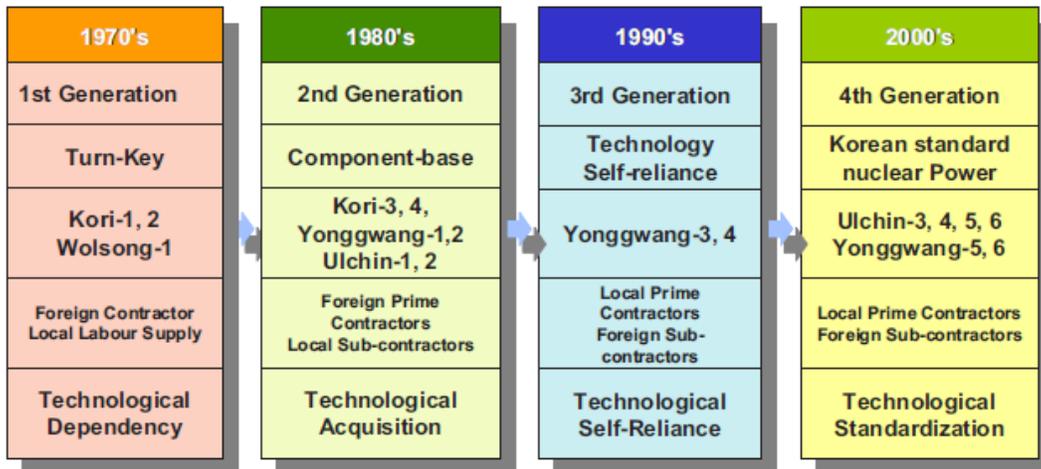


Figure 4: Progress of Korean participation in nuclear power projects (IAEA, 2009a)

KEARI recommended a gradual, progressive approach to localisation, and identified progressive level targets to be reached on the road to self-reliance (Mangena, 2007).

- Level 1: Minimal participation. Use of local labour and some construction materials are used for on-site, non-specialised purposes. Mainly civil engineering work;
- Level 2: Local contractors take partial/full responsibility for civil work, including the possibility for some design work;
- Level 3: Locally manufactured components are used for non-critical paths of the BOP;
- Level 4: Local manufacturers extend their capabilities to include nuclear design and standards;
- Level 5: Special manufacturing centres are set up locally to manufacture heavy and specialised nuclear components.

To achieve these levels of localisation, a NEPIO was formed, and certain responsibilities were assigned to the various key role-players. The structure of the Korean NEPIO is shown in Figure 5.

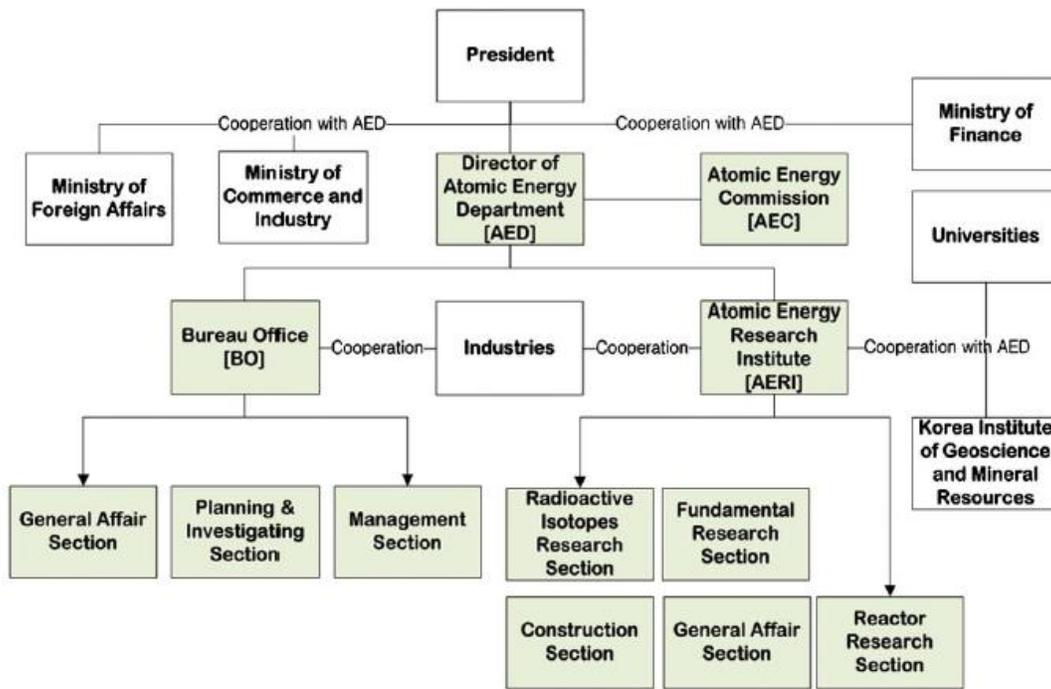


Figure 5: Organisation chart of Korean NEPIO in 1959 (Choi *et al.*, 2009)

The responsibilities of the various key role-players responsible for Korean self-reliance are shown in Table 7.

Table 7: Responsibilities of organisations for Korean self-reliance (Mangena, 2007)

Entity	Responsibilities
Korea Institute for Nuclear Safety	Regulatory and licensing support for the government
Korea Electric Power Corporation	Project management and operation
Korea Power Engineering Co., Inc.	Plant design (A/E) and development of A/E design technology
Korea Atomic Energy Research Institute	NSSS design, fuel design, and related R&D
Korea Heavy Industries & Construction Co., Ltd (HANJUNG)	Component design & manufacturing and development of fuel manufacturing technology
KEPCO Nuclear Fuel Co., Ltd.	Fuel manufacturing and development of fuel manufacturing technology
Universities	R&D of key technology

2.2. IAEA recommendations

From past experience, the IAEA compiled various documents to guide countries in the development and implementation of a nuclear power programme. These guidelines include:

- The development of national infrastructure for a nuclear power programme;
- Workforce planning for a nuclear power programme;
- Stakeholder involvement throughout the lifecycle of nuclear facilities;
- The responsibilities and capabilities of the NEPIO;
- General management of the first reactor.

These guidelines will be used to assess what will be needed for the successful implementation of a nuclear power programme

2.2.1. NEPIO Recommendations (IAEA, 2009b)

As can be seen from the Korean experience, the NEPIO plays a vital role in the success of the execution of a nuclear power programme. The overall responsibility of the NEPIO, as described by the IAEA, is to lead and manage the effort for consideration of a nuclear power plant, and the subsequent development of that programme. The NEPIO has various responsibilities with regard to each phase of the project, and the development infrastructure.

The IAEA makes various recommendations with regard to the NEPIO.

2.2.1.1. *Government Commitment*

From a localisation point of view, the NEPIO plays a vital role, and is responsible to drive the localisation effort. As seen in the generic NEPIO model of the IAEA, there is a specific role within the NEPIO focusing on economics and localisation. The role of the NEPIO and government involvement and commitment, are critical for successful localisation. It is recommended that the appointment of the NEPIO be made from a high level of government and, where applicable, government should form part of the NEPIO. The NEPIO's responsibilities should be clearly defined, and the NEPIO must be given the needed authority to enable it to effectively meet its responsibilities. This authority should include, but is not limited to:

- The ability to hire the needed competent staff;
- To enlist participation and co-operation of other government authorities where needed;
- Employ the needed consultants and specialists;

- Communication and interaction with international bodies, such as the IAEA.

The government's decision on appointing a NEPIO, and the structure thereof, should be made public, and a charter clearly defining the authority and deliverables of the NEPIO should be compiled. This ensures transparency regarding the functions of the NEPIO and aids in public awareness. The success of the NEPIO depends on government commitment.

2.2.1.2. Structure of a NEPIO

The structure of the NEPIO is mostly unique to each country. The structure should be such that the NEPIO is capable of addressing all leadership, management and implementation issues associated with a nuclear power programme, and should have clear interfaces with the various stakeholders.

The director of the NEPIO, and the leadership of all the major areas should be indigenous to the country, if possible, thereby insuring that all indigenous elements (such as cultural norms, governmental structure, national views, etc.) are taken into account. This also serves to develop local confidence.

Figure 6 shows the possible structure of a NEPIO. It is strongly recommended that the NEPIO has interfaces with the various stakeholders in the nuclear power project, such as the Department of Energy, the vendor and representatives from the nuclear industry. The responsibilities of the various staff members of the NEPIO may change over the course of the project, and the role and structure of the NEPIO itself will change as the project develops through the various phases. Thus, it is important for the project structure to be flexible enough to allow the transfer of responsibility to other organisations as the project progresses.

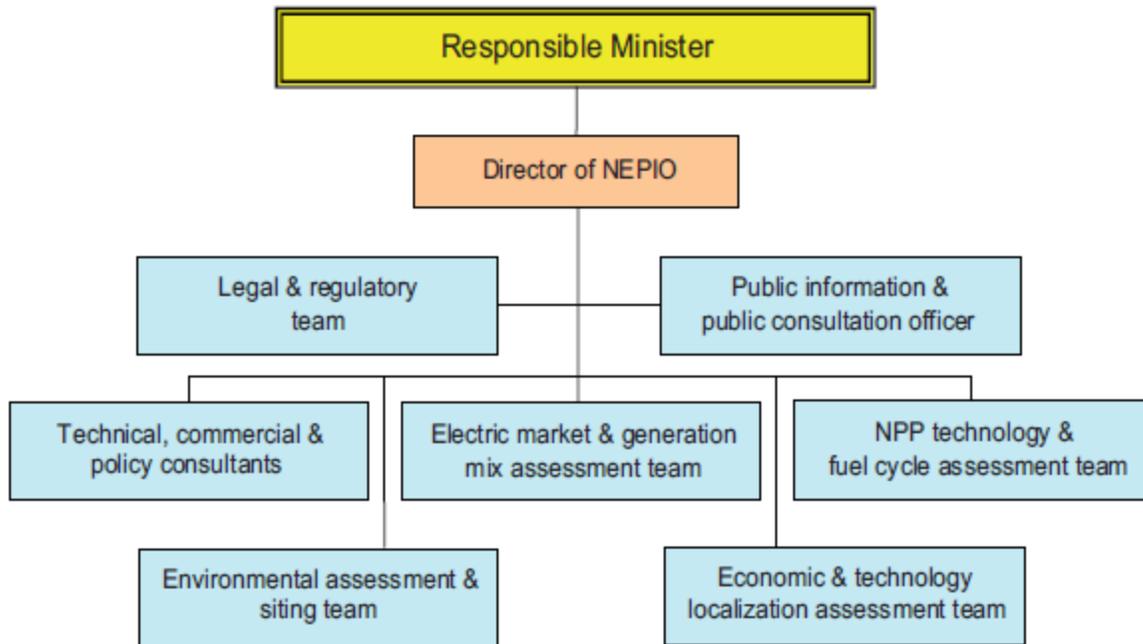


Figure 6: Example of possible NEPIO structure for Phase 1 (IAEA, 2007a)

2.2.1.3. Capabilities and lifespan of a NEPIO

Many of the capabilities of a NEPIO may come from within the government or other organisations, through personnel seconded to the NEPIO. As the project progresses, and thus the responsibilities of the NEPIO, the capability requirements may change, and the seconded personnel can return to their original organisations. Figure 7 shows this relationship, where the needed personnel and capability are used to structure the NEPIO in Phase 1, and then reabsorbed into their original, or other, organisations (the phases are based on the phases for infrastructure development discussed in section 2.2.2).

The director of the NEPIO plays a vital role in the success of the organisation. The director must have broad knowledge of the national culture of the host country, the governmental structures, and the current economic and industrial status of the country. Along with this, the director must have a broad understanding of nuclear power, along with the regulatory and technical aspects thereof.

The managers for each of the portfolios of the NEPIO should be capable and competent to manage their respective portfolios. Knowledge and insight into their given field, and the broad knowledge of nuclear power, are vital for the success of the organisation as a whole.

The NEPIO can be viewed as a preparatory body, which should ideally meld back into the institutions/organisations that will be responsible for the proper execution of the nuclear power programme. The NEPIO has a promotional role in championing the peaceful use of nuclear power, and in forming the infrastructure for a nuclear power programme. The responsibilities, and in some cases the entire NEPIO, will greatly diminish as the programme progresses, due to the fact that the responsibilities will shift back to the nuclear industry, the owner/operator and the regulatory body. Once the structures for proper conduct of nuclear power are in place, the NEPIO may be fully disbanded.

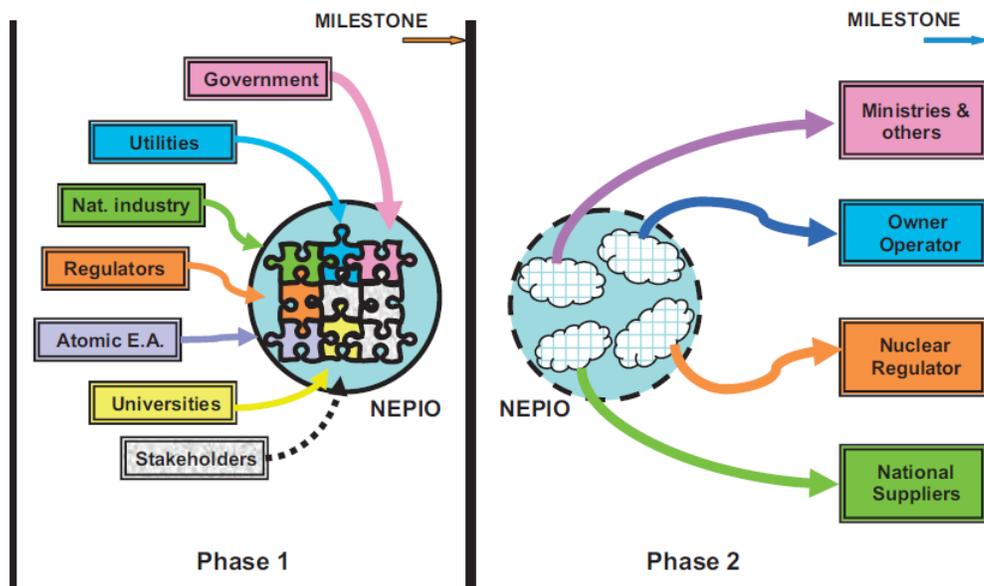


Figure 7: Buildup of NEPIO during Phase 1 and absorption into other organisations during Phase 2 (IAEA, 2009b)

The Korean NEPIO was structured using the Atomic Energy Department, a department within the Korean government. The director of their NEPIO directly reported to the presidency, giving the NEPIO the needed authorisation to successfully implement the nuclear power programme. The structure of the early NEPIO had a strong focus on research and development (see Figure 5). The Atomic Energy Research Institute focused, early on, on the development of local expertise to enable technology transfer and localisation, and later, the NEPIO shifted its primary focus to industrial development and the development of local fuel cycle capabilities. This approach, where the NEPIO is not only seen as a preparatory body, as stated by the IAEA, but rather as an organisation facilitating nuclear industry development throughout the entire programme, must be adopted by countries planning on hosting a large-scale nuclear power programme with ambitious nuclear industry development.

2.2.2. Milestones in infrastructure development (IAEA, 2007b)

The development of the needed infrastructure of a nuclear power programme includes the ‘hard’ (grid, facilities, etc.) and the ‘soft’ (legal, regulatory, training, etc.) aspects, and the development can be divided into three phases, each phase having a certain milestone to be reached. The phases can be described as follows (IAEA, 2007b):

- Phase 1: Considerations before a decision to launch a nuclear power programme is taken;
- Phase 2: Preparatory work for the construction of a nuclear power plant after a policy decision has been taken;
- Phase 3: Activities to implement the first nuclear power plant.

Each of these three phases includes various activities that need to be completed before the milestone for the phase can be met. The timeframe for the completion of each milestone will depend on the level of commitment of the host country to the programme, and it will also be greatly influenced by key decisions early in the project (e.g. turnkey purchase versus indigenous construction).

The milestones associated with the completion of each phase are:

- Milestone 1: Ready to make a knowledgeable commitment to a nuclear programme

At this milestone, the host country should have gathered sufficient information to make an informed decision regarding the implementation of a nuclear energy policy. It needs to fully realise its obligations and the full range of requirements which need to be met. The host country needs to have a clear understanding of its energy needs, and the role of nuclear energy in meeting those needs within the context of its national and socioeconomic development. Aspects that need to be considered are issues such as the fact that no single electric power producing unit should account for more than 5-10% of the installed capacity of the region. This could limit the choice of reactor. During this phase, the responsible entities would be the government and the NEPIO. The NEPIO should be responsible for ensuring the complete understanding of the commitments and responsibilities associated with a nuclear power programme.

- Milestone 2: Ready to invite bids for the first nuclear power plant

If the host country decided to commit itself to developing a nuclear power programme, much work has to be undertaken to achieve the needed technical and institutional competence. During this phase, the NEPIO is incorporated into the relevant government agencies, and

acts as a guiding organisation. The regulatory body needs to be developed to a level at which it is capable of fulfilling its oversight duties. The necessary infrastructure must be developed to the point of complete readiness to request a bid. The owner/operator must already have achieved a level of competence to manage a nuclear project and be able to meet regulatory requirements.

- Milestone 3: Ready to commission and operate the first nuclear power plant

During this phase the greatest capital expenditure takes place. At this point, much of the infrastructure development is at a very advanced stage. When milestone three has been reached, the owner/operator has to be able to commission and operate the facility. This necessitates staff training at all levels of the organisation.

Figure 8 gives a graphic representation of the phases, milestones and outcomes of each phase.

The IAEA identified 19 issues that need to be addressed at each phase of the nuclear power programme. The different organisations involved in the project will prioritise the issues according to their role/responsibility in the project. Thus, the different issues have different levels of importance, depending on the responsible organisation's perspective.

The issues listed are:

- National position;
- Nuclear safety;
- Management;
- Funding and financing;
- Legislative framework;
- Safeguards;
- Regulatory framework;
- Radiation protection;
- Electrical grid;
- Human resource development;
- Stakeholder involvement;
- Site and supporting facilities;

- Environmental protection;
- Emergency planning;
- Security and physical protection;
- Nuclear fuel cycle;
- Radioactive waste;
- Industrial Involvement;
- Procurement.

Of these issues, the ones having direct impact on localisation will be briefly discussed, with special attention to human resource development, nuclear fuel cycle and industrial involvement. It must be noted that the NEPIO plays a critical role in most of these issues, thus again highlighting the importance of a competent, well-structured NEPIO.

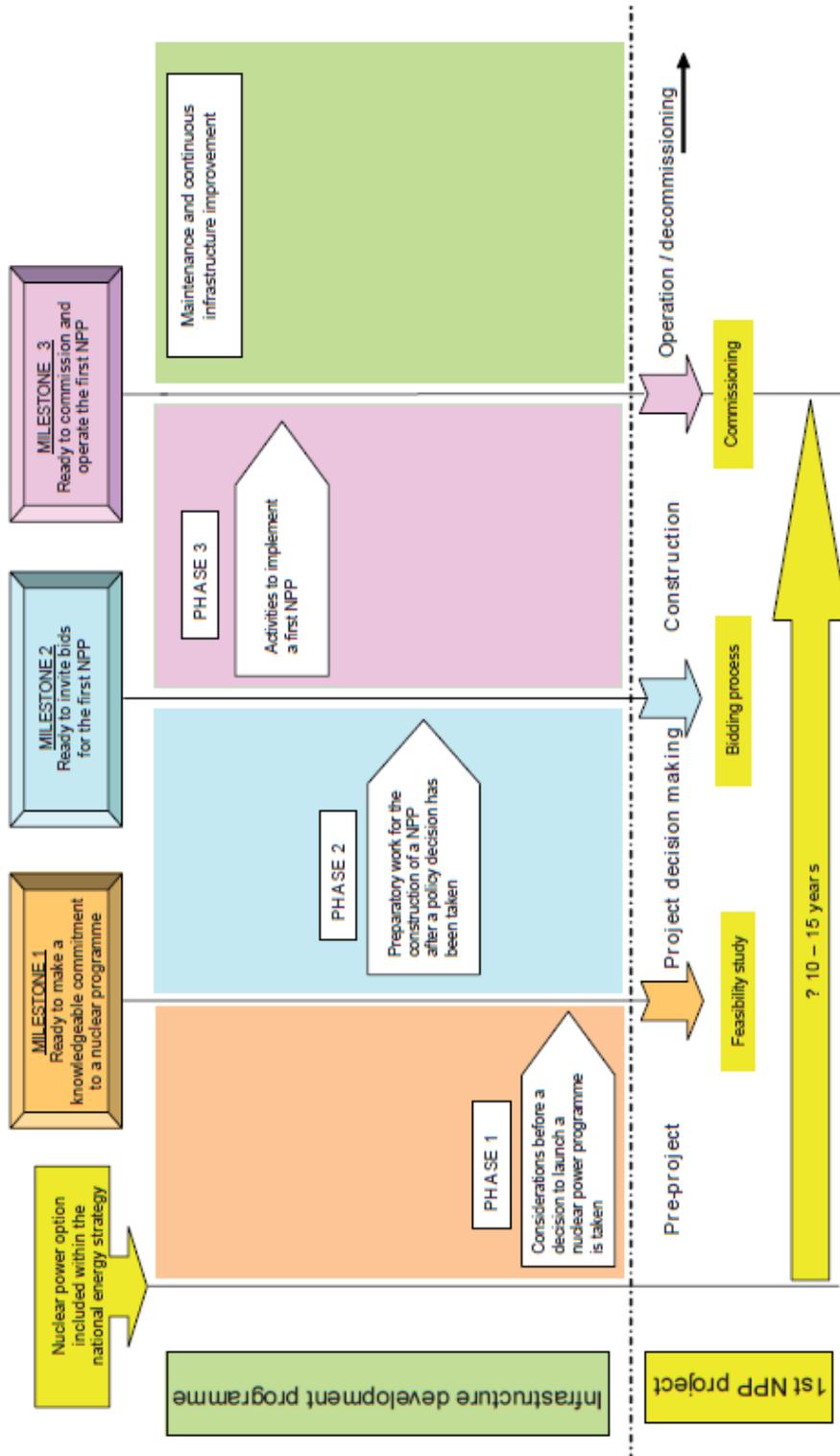


Figure 8: Infrastructure Development Programme (IAEA, 2007b)

2.2.2.1. National Position

The NEPIO plays a critical role in establishing the national position regarding a nuclear power programme. The organisation, as mentioned earlier, should report directly to a high level in government, such as the minister of energy or the minister of industry, or as was the case with Korea, directly to the president. During Phase 1, some of the key points that need to be investigated to fully understand commitments are:

- The need to develop national human resources, both within the government and the industry that will allow the successful construction, operation, maintenance, decommissioning and regulation of planned nuclear facilities;
- The need to provide industrial capability for equipment and services. This can be done either through international procurement or local development;
- The importance of national confidence. This can be achieved through open, transparent and timely interaction and communication regarding all the aspects of the planned nuclear power programme.

During Phase 2, decisions need to be made that have an enormous impact on the resource needs of the nuclear project, such as whether or not the first reactor would be a turnkey project. This dictates, for example, the human resources required. Some issues that need to be addressed by the government during this phase are:

- The establishment or expansion of an independent regulatory body that would be able to handle licensing and regulatory activities during design, operation and decommissioning of the nuclear installations, and ensure that this body has adequate staff, authority and financial resources;
- The need for the establishment of a nuclear fuel cycle policy. This policy must include arrangements for security of supply, transportation of new or used fuel, storage of fuel and long-term used-fuel management;
- Establishment of a policy addressing national and industrial participation in the nuclear programme and initiate programmes for human resource development, capability and capacity expansion, and physical resources needed to successfully implement the policy;
- A policy concerning research and development in the field of nuclear science and technology. This helps stimulate development of local experts and provides a good source of manpower in some important areas. The infrastructure for nuclear science and

technology R&D can be achieved by the use of private and national R&D institutes, higher education institutes, professional training centres, national industry and scientific academies and professional institutions.

The national participation plan must be compiled during Phase 2, and must address the following (IAEA, 2007b):

- Long-term nuclear power policy and commitment;
- Organisational structures;
- Management systems;
- Industry, and planned industry development;
- Human resource development;
- Legal framework;
- Funding and financing.

During Phase 3, the responsibility falls to the government to ensure that all funding, policies and programmes developed in the previous phase are effectively implemented and used, especially the programmes regarding human resource and local industry development.

2.2.2.2. Management

Competent management is vital for the success of the nuclear power programme. The roles and responsibilities of the management structures change drastically over time. For example, the primary management organisation during the first phases of the programme is the NEPIO, but the main management responsibility later shifts to government, the owner/operator and the independent regulator. During Phase 1, the NEPIO needs to investigate issues regarding the development of the national nuclear power programme. This is a daunting task, especially for countries attempting a nuclear power project for the first time. The NEPIO must be adequately staffed and funded, and all staff must be competent and qualified. Where there are gaps in expertise, external consultants can be used, but the leadership of the organisation, and the responsibility remains with local individuals. Some of the issues that need to be addressed in these investigations are:

- The availability of nuclear technologies, and their suitability for domestic application;
- The availability of long-term financial resources;

- The current availability of human resources and the needed human resource development;
- Current availability and needs of supporting industry.

During Phase 2, the management responsibility shifts, as stated earlier, to the government, the owner/operator and the regulatory body.

During this phase, the government should:

- Establish a plan for human and physical resource development that is in accordance to the policy for national participation in the manufacturing, construction, operation and support of the nuclear installation;
- Continue with an open and transparent public communication, education and consultation programme.

The regulatory body should:

- Establish and maintain a formal management system, and start formal staff training to create the needed safety and quality culture needed for the licensing and oversight of nuclear facilities.

The owner/operator should:

- Determine the appropriate/preferred nuclear technology for implementation;
- Develop a fuel supply strategy, develop and establish a fuel supply plan consistent with the contracting strategy;
- Develop a financing strategy and start the implementation of a financing plan that is in accordance to the contracting strategy.

During Phase 3 the government and regulatory body have to continue with the programmes started in Phase 2, and promote educational and industrial development. The owner/operator has to put into effect the strategies compiled during Phase 2.

2.2.2.3. Funding and Financing

When calculating the costs of the nuclear programme, there are three main costs to be considered, namely capital/investment costs, operation and maintenance costs and nuclear fuel cycle costs. Infrastructure development costs can be seen as part of capital/investment cost, and includes the costs for development of national infrastructure, transfer of technologies, national participation promotion and local industry development (IAEA, 2007a). If the localisation

desire is design capability, the required funding includes costs of R&D and research reactor, etc. If fuel is considered, then it includes mining, enrichment, production and possible reprocessing. The funding requirements for these costs should be considered, and aligned to the various policies regarding local participation. During the initial stages of the national nuclear power programme, the government is primarily responsible for funding the various activities associated with the programme, such as early infrastructure development, human resource and expertise development, etc. Here strong government commitment again becomes apparent, especially in the early stages of the programme, when, without proper government funding, the needed development will not be able to take place.

2.2.2.4. *Human resource development*

Human resource development is one of the key issues to be addressed, not only for successful localisation, but also for the overall success of the nuclear programme. The human resource needs, as mentioned earlier, vary drastically depending on the decision of whether the project is going to be a turnkey project or if local participation is going to be used, and if so, to what extent. If it is decided that the project will be a turnkey project, human resource development can still be considered for possible long-term use. The development of such local capabilities requires significant investment and attention to education and training. Although certain levels of fundamental training can be bought/obtained from the vendor, it is desirable for the host country to develop its own training and education capabilities to assure better long-term availability of crucial human resources. Investment into the development of human resources can be seen as an investment in the economic development of the host country.

During Phase 1 one of the key responsibilities of the NEPIO is to identify the knowledge and skills needed to develop the capability in human resources to enable the country to sustain a safe, secure and efficient nuclear power programme. This human resource development plan must be developed in conjunction with all the parties involved in the nuclear power programme. Some of the crucial areas of consideration by the NEPIO include:

- The evaluation of the attitudes of local industries towards nuclear, as well as the prevailing culture in the industries to ascertain whether or not the safety culture needed can be instilled in the given time;
- The full spectrum of scientific and technical disciplines needed for a fully functional nuclear power programme;
- Assessment of the current availability of those skills in the host country;

- The assessment of local educational capabilities, or the availability of foreign sources for training and education, including specialised training and education;
- The identification for specialised training, even for experienced personnel in the fields of nuclear safety, radiation protection, security, safeguards and management systems;
- The development of plans to obtain, either through development or purchasing, the initial resources that are needed;
- The development of a plan to ensure the flow of human resources throughout the entire lifecycle of the programme.

The above-mentioned development plans must reflect the choices made regarding localisation and technology transfer, and should include plans to sustain the resources.

When the host country reaches the decision to issue a bid request, the majority of the total human resources need to be in place. At this stage, the host country possesses the needed technical knowledge of the available technologies, and the regulatory body has to be developed to such an extent that it would be able to effectively regulate the licensing process. The initial training for the remaining resources to operate fully, the nuclear installation should also start at this time. Some of the specific resources needed at this stage include:

- Political and social expertise for public communication;
- Regulatory expertise for the implementation of regulations, codes and standards for all aspects of licensing;
- Business and technical expertise for fuel cycle procurement and management;
- Expertise in training, including training for project management and the management system, and training in the operation and maintenance of the nuclear installation;
- Plans to fully staff and train personnel for the regulatory body, for the operation and maintenance of the installation and the development of future expertise in all the relevant areas.

When Milestone 3 is reached, human resource development has taken place so that there are sufficient personnel available for the successful operation and maintenance of the power plant, including technical support organisations, and the regulatory body. Development should be maintained to insure the availability of human resources throughout the lifecycle of the nuclear power programme.

2.2.2.5. Stakeholder involvement

Strong, continuing government support is critical through all phases of the nuclear power programme. Government support can only be sustained through a positive political atmosphere. General public involvement is crucial throughout the programme. This can be achieved by open communication between the proponents of the nuclear programme (e.g. the government) and the other stakeholders. The most influential stakeholders are societal leaders such as local government officials, heads of industry and the media.

Government must realise the importance of national and international confidence. This can be achieved by open and timely interactions and communications regarding all the aspects of the nuclear power programme. Again, external expertise in the fields of public communication and education can be used, but local leaders can best understand and relate to the social and cultural norms, and thus will be key in providing the necessary guidance. Some of the activities that can be used during Phase 1 in this regard are:

- Public opinion surveys to determine understanding and acceptance of the nuclear power programme;
- The development of public information tools that address issues identified through the surveys, and clearly communicating the social and economic benefits from using nuclear power;
- Action plans to implement interactions with local leaders and opinion leaders.

Throughout the rest of the phases of the programme, government, the regulator and other proponents of nuclear power should continue to communicate openly and honestly to all the relevant stakeholders, focusing on the benefits of nuclear power, the issue of nuclear safety, and problems that are experienced.

2.2.2.6. Nuclear Fuel Cycle

Nuclear fuel cycle planning is an important consideration that has to be taken into account early in the planning stages of a nuclear power programme, due to the fact that this can influence the choice of technology to be used. The fuel cycle is divided into the front-end, consisting of all the activities prior to the fuel being used in the reactor, and the back-end, which consists of all the activities after the fuel has been burnt in the reactor, such as disposal and storage. Both the front- and back-end of the nuclear fuel cycle need to be properly planned early. A clearly-defined plan, especially with regard to the back-end activities, that is openly communicated to

the various stakeholders, will help develop confidence, and may assist in improving public perception of the nuclear programme.

The international nuclear market is sufficiently developed to the point that front-end services can be purchased with confidence, reducing the need for national development in nuclear fuel production and infrastructure.

During Phase 1, the NEPIO must develop a broad understanding of all the steps and activities of the nuclear fuel cycle, and make a choice regarding the national development of infrastructure for an indigenous nuclear fuel cycle. It is a daunting task to develop a completely indigenous fuel cycle concurrent with the first nuclear reactor, and would likely yield little to no economic benefits for the host country; however, if there is an abundance of uranium deposits in the host country, the decision can be made to embark on mining and milling of uranium, while purchasing conversion, enrichment and fabrication services. During Phase 1, the NEPIO needs to investigate:

- The individual steps in the nuclear fuel cycle;
- Sources of supply for the individual steps;
- National natural resources and capabilities with respect to each step;
- Feasible policies for the development of national fuel cycle capabilities;
- The impact on personnel and human resource requirements for the various proposed fuel cycle strategies.

During Phase 2, The NEPIO needs to take into consideration the following:

- The arrangements for purchasing the first core;
- The number of reload cores to be contracted with the first power plant;
- The specific fuel cycle services to be purchased or developed;
- A long-term strategy for the purchase or development of nuclear fuel cycle capabilities.

During Phase 3, plans regarding the back-end of the fuel cycle need to be finalised, and implementation started.

2.2.2.7. Industrial Involvement

A nuclear power project requires many commodities, components and services during construction and operation. These supporting activities can be a source of jobs and economic

growth for the country and the local region (IAEA, 2009a). Due to the stringent quality regulations of nuclear components, initial industry involvement, especially with regard to nuclear components may be very limited. During the early stages of the nuclear power programme, the host nation needs to adopt a policy of intent with respect to developing or enhancing industrial capabilities. This policy should evolve into firm plans to develop the facilities, programmes and skills to realise the desired level of involvement.

During Phase 1, the considerations by the NEPIO include the opportunity for national and local industrial involvement, and support of the nuclear power programme, with due cognizance to the qualifications needed for provision of nuclear components and services. The supplier of the nuclear power plant should be given assurance of the existence of local or national industrial capabilities that are adequate to support the mode of acquisition, before agreeing to yield any scope of participation to domestic industry (IAEA, 2007a). The following are crucial aspects that the NEPIO needs to take into account with regard to nuclear programme development:

- Assessment of national and local industrial capabilities;
- The assessment of business and industrial leaders in participating in the nuclear programme, with due consideration to the requirements that are necessary;
- Consideration of the ability to obtain the necessary investment for intended upgrading of industrial facilities and programmes;
- Development of short term and long-term policies to encourage a higher level of participation.

During Phase 2, a realistic assessment of local and national capabilities to supply components/services to the nuclear power programme must be done by the owner/operator before the creation of the bid specification and acceptance criteria. Planned local involvement must be called out in the bid specification, and should be negotiated with the vendor. Non-nuclear safety-related areas associated with the programme should also be considered for local participation. Plans, policies and programmes by government and industry must also be put in place for the transition to national and local suppliers in the future as their capabilities and capacity develop. At this stage, it is the responsibility of the owner/operator to consider:

- Which national or local supplier can reliably supply to nuclear or non-nuclear related portions of the project;

- What development in skills and capabilities, as well as facilities, is realistic in the time frame to support the nuclear project;
- Bid specification clarity with regard to the decisions made regarding planned local and national industry involvement.

During Phase 3, as construction of the nuclear facility nears completion, reassessment of suppliers need to be made, as well as possible amendments to planned future local and national involvement.

2.2.2.8. Procurement

The procurement of components and services for a nuclear facility is a complex task. If the decision is made to procure locally components that are deemed important to nuclear safety, the owner/operator needs to determine the quality requirements, and have the means to ensure that they are met. This should be done in conjunction with the regulatory body. The NEPIO needs to determine at an early stage the procurement policy that is consistent with the local industrial participation policy. An expertise development strategy should also be developed alongside the procurement policy.

Again, the three fundamental localisation principals become apparent. Enormous emphasis is placed on the role of the NEPIO, highlighting the need for an effective, competent leadership structure. The creation and support of the NEPIO aids in proving government commitment to the nuclear power programme. Government commitment, especially in funding industry and human resource development, plays a critical role in successful localisation, and government, along with the NEPIO determines the national position, and the extent of nuclear industry development. For a country rich in uranium deposits, the nuclear fuel cycle poses economic benefits, especially if a large nuclear power programme is planned. Creation of local fuel cycle capabilities poses long-term, sustainable benefits over the entire life-cycle of the operating plants. Human resource development plays a crucial role in all aspects and phases of the nuclear power programme. Not only is human resource development needed for the operation and maintenance of the power plants, but also serves as vehicle for technology transfer and local technology development. To achieve this, priority needs to be placed, especially in the early stages of the programme, on the creation and development of local research and development institutes. Universities and other institutes for higher education can be used in this regard.

2.3. South African nuclear and industrial policies

South Africa has been actively involved with nuclear R&D since the mid 1940s, with the formation of the Atomic Energy Board, that later developed into the Atomic Energy Corporation, in 1948. In 1965, the research reactor, Safari-1 at the Pelindaba site, went critical. In 1970, the Uranium Enrichment Corporation (UCOR) was established, and extensive nuclear fuel cycle and nuclear weapons R&D programs were established. This led to the construction of the Y-Plant enrichment facility at Valindaba, that produced enriched uranium for the SAFARI-1 reactor, and the Z-Plant enrichment facility that produced fuel for the Koeberg nuclear power plant. These enrichment facilities were decommissioned in 1990 and 1995, respectively (WNA, 2012a).

The Koeberg nuclear power plant is the only commercial nuclear power plant currently in operation in Africa. It consists of two 900 MWe reactors, which were commissioned in 1984 and 1985, respectively. In 2007 the Eskom board approved a plan to double its total generating capacity to 80 GWe. This capacity expansion programme called for the construction of 20 GWe nuclear power, thus increasing the contribution of nuclear power to over 25% of the total power mix. The initial plan was to start construction on the first nuclear power plant (Nuclear-1) in 2010, and to have the first unit commissioned in 2016. For this, the EPR (from AREVA) and the AP1000 (from Westinghouse) technologies were shortlisted. However, in December 2008, Eskom announced that it would not proceed with either bids from Areva or Westinghouse due to a lack of funding (WNA, 2012a).

After the announcement that the nuclear power programme would be delayed by several years, the Integrated Energy Plan was revised, forming the Integrated Resource Plan 2010-2030. The Department of Energy promulgated the Integrated Resource Plan for Electricity on 6 May 2011. This document outlined the planned energy expansion for South Africa from 2010-2030. It calls for the construction of 9.6 GWe nuclear power, with the first 1 600 MWe plant to be commissioned in 2023, and the following five 1 600 MWe reactors to be commissioned at 18 month intervals. Initially between 30%-40% local content is expected for this project (Worley Parsons, 2011). Various governmental policies exist in which the nuclear power programme is seen as an opportunity for industry development.

South Africa was also involved in the failed development of the Pebble Bed Modular Reactor (PBMR), a project that was financed by the Department of Public Enterprises, Eskom and other stakeholders from 1993 to 2010 (WNA, 2012a). The PBMR is a high-temperature, gas-cooled reactor design that could be used for either electricity generation or process heat applications.

2.3.1. Nuclear Energy Policy for the Republic of South Africa (Department of Minerals and Energy, 2008)

The NEP was compiled in 2008 by the Department of Minerals and Energy, and serves as the embodiment of the South African government's commitment to the further development of the nuclear energy sector. Nuclear energy is identified as a viable means of large-scale energy generation due to a number of factors such as:

- South Africa's sizable uranium deposits;
- Due to an established mining sector, the extraction and mining of uranium pose no major challenge;
- The beneficiation of the available uranium ore by the implementation of a strong nuclear power programme would lead to job creation and further development of a skilled workforce;
- A structured nuclear regulator, including legislation regarding nuclear energy, is already present in South Africa;
- The use of nuclear power would help reach lower carbon emission goals.

Some of the objectives of this policy include:

- The promotion of nuclear energy as an important electricity supply option by the establishment and development of national industrial capability for the design, manufacture and construction of nuclear energy sectors;
- The use of nuclear energy as contributor to the national programme of social and economic transformation, growth and development;
- To become a global leader in nuclear self-sufficiency;
- To allow and include public entities in the participation of the uranium value chain;
- Skills development.

There are 16 principles that guide the South African government's vision for nuclear energy. The principles relevant to localisation are:

- That nuclear energy shall contribute to economic growth and technological development in South Africa by investment in infrastructure, the creation of jobs and development of a skilled workforce;

- The use of uranium resources in a sustainable manner, and that the technologies chosen for nuclear energy shall be such that it allows for the optimal utilisation of resources;
- That government shall encourage the development of appropriate institutional arrangements and thereby ensure the development of human resources;
- The development of technological expertise and skills to enable design, development, construction and marketing of South Africa's own nuclear reactors and fuel cycle systems. To achieve this, an industrial support base shall be developed, and technology transfer shall be optimised for the procurement of any nuclear and nuclear-related equipment;
- Government shall support research and innovation in the use of nuclear technology and support the participation in international nuclear energy innovation programmes;
- Government shall ensure that proper funding is available in support of technology development initiatives that are essential for the successful implementation of the NEP;
- That government shall implement a fleet approach to nuclear power reactor procurement to optimise the industrialisation process and ensure economy of scale.

The NEP also recognises the importance of international cooperation, as well as bilateral and multilateral cooperation.

2.3.1.1. *Institutional arrangements*

The NEP discusses the institutional arrangements that are deemed necessary for the successful implementation of the policy.

- **National Nuclear Energy Executive Coordination Committee**

The policy calls for the formation of the NNEECC, a committee that coordinates all the activities of the nuclear fuel cycle, and ensures that they are aligned with national policies, properly structured and funded. This committee shall be at executive (cabinet) level.

- **National nuclear research, development and innovation**

NECSA, a national, government-supported organisation has been formed under the provisions of the Nuclear Energy Act to coordinate, and serve as anchor for nuclear research, development and innovation

- **National nuclear power generation organisation**

Eskom is assigned the role of the nuclear power generating organisation, and is responsible for ownership, operation and maintenance of nuclear power plants in South Africa. Ownership of nuclear power plants may take the form of Public Private Partnerships with Eskom, but with Eskom remaining the controlling shareholder.

- **National nuclear regulator**

The National Nuclear Regulator, as established under the provisions of the National Nuclear Regulator Act no. 47 of 1999, shall remain responsible for the protection of people, properties and the environment by the establishment of safety standards and regulatory practices applicable for the entire life-cycle of nuclear power plants, and activities associated with the nuclear fuel cycle.

- **National nuclear architectural capability**

For realisation of the South African government's intent to develop a national capacity to supply nuclear reactors and equipment, a national nuclear architectural engineering, component manufacturing and construction capability has to be established. To achieve this, a coordinated national approach for integrating government and private sector initiatives should be formed.

- **National radioactive waste management agency**

In terms of the national radioactive waste management policy and strategy, a national radioactive waste management agency should be formed, and shall be responsible for radioactive waste management.

2.3.1.2. Nuclear fuel cycle

To realise the full economic benefits of implementing a nuclear power programme, South Africa shall endeavour to implement or obtain interests in the complete nuclear fuel cycle.

- **Uranium mining and milling**

South Africa is ranked 12th in terms of uranium production (WNA, 2012c). The South African government shall ensure that national uranium resources are exploited and that long-term supply of uranium resources are balanced in a sustainable fashion, keeping in mind South Africa's own needs. The government shall promote investment in uranium exploration and mining, and in specific instances, make investment in these industries to ensure security of

nuclear fuel supply. NECSA shall participate in the uranium value chain and the beneficiation thereof, and shall be responsible for storing the government-attained uranium supplies.

- **Uranium conversion**

NECSA shall lead the development of uranium conversion facilities as part of the beneficiation of uranium. Private sector participation shall be promoted.

- **Uranium enrichment**

NECSA shall investigate the viability of developing national uranium enrichment capabilities, and shall simultaneously seek to obtain access to established uranium enrichment programmes to ensure security of supply.

- **Fuel fabrication**

Although there are currently sufficient diversity and capacity of nuclear fuel suppliers globally, the establishment of nuclear fuel fabrication capabilities within South Africa is part of the envisioned development of a globally competitive nuclear fuel industry, and securing the nuclear fuel supply chain. NECSA shall be responsible for the development of a strategy to develop nuclear fuel capabilities, whilst government shall seek to obtain access to established nuclear fuel fabrication programmes.

- **Used nuclear fuel and radioactive waste management**

Radioactive waste management shall be done in accordance to the radioactive waste management policy and strategy

- **Reprocessing of used fuel and recycling of fissile materials**

NECSA shall investigate the viability of developing local nuclear fuel reprocessing capabilities. Reprocessing of nuclear fuel is part of the sustainability objectives of the radioactive waste management policy and strategy. In the short-term, South Africa will use existing and established foreign reprocessing facilities.

2.3.1.3. *Nuclear construction and operation*

The South African government identified nuclear construction and operation as a means to meet national goals. An extensive pressurised water reactor (PWR) programme can substantially diversify the base generation, and lower carbon emissions. This programme would also help establish a modern nuclear technology industry, including manufacturing of nuclear

components, construction and service provision. The conventional nuclear build programme, where viable, should be associated with technology transfer, an investment programme and the expansion of national industrial capability.

It proposes that a phased approach be followed to meet the national objectives. The three phases consist of the following:

- **Phase 1 (2008-2010)**

- The maintenance and enhancement of the current nuclear infrastructure;
- Preparation for the expansion of the nuclear infrastructure across the entire nuclear fuel cycle, including funding and preparation for the construction of nuclear power plants;
- The continuance of research in advanced nuclear technologies;
- The acceleration of human resource development in line with the anticipated requirements, including increasing the capacity of institutions of higher education;
- The promotion of uranium exploration and mining;
- Roll-out aspects of radio-active waste management policy;
- Roll-out of a public information programme.

- **Phase 2 (2011-2015)**

- Construction of new nuclear infrastructure including a nuclear power plant;
- Continue maintenance of existing infrastructure;
- Demonstration of advanced nuclear energy systems;
- Initiation of localisation of nuclear equipment and component manufacturing;
- Building capacity for nuclear technology transfer.

- **Phase 3 (2016-2025)**

- The operation and maintenance of newly constructed nuclear power plants and nuclear infrastructure;
- Local manufacturing of nuclear equipment and components;
- Commercialisation of advanced nuclear energy systems;
- Accelerate research into further advanced nuclear energy systems.

2.3.1.4. General issues

The NEP envisions that 10 000 additional jobs will be created with the expansion of uranium mining and exploration alone, and that the expansion of nuclear infrastructure and the implementation of the nuclear power programme will have significant impact on human resource development. The nuclear power sector could also serve as a vehicle for workforce diversity, by increasing the representation of women, previously disadvantaged communities and, where applicable, people with disabilities.

A substantial level of funding is required by the various initiatives. These initiatives can be grouped by three categories, namely: Institutional, Technological and Industrial. Institutional funding focuses on the establishment of the entities as discussed in section 2.3.1.1. Technological funding includes funding for research, innovation and development, as well as enrichment, conversion fuel fabrication and radioactive waste management. Industrial funding finances industrial development, especially with regard to the processes and activities surrounding the nuclear fuel cycle.

The NEP mentions various initiatives and areas of interest, but only in very high-level descriptions. It states that a NNEECC be formed to “ensure implementation and exercise oversight over all aspects of this nuclear energy policy” (Department of Minerals and Energy 2008), but does not describe the structure of the NNEECC. The roles of the stakeholders in the NEP are also ambiguous. The NEP states that the Department of Minerals and Energy “has overall responsibility for nuclear energy in South Africa”, yet it is the NNEECC which addresses the implementation and oversight of the NEP. Thus, no clear entity is identified with the authority to address the issues stated in the NEP, such as who is responsible for the formation of the NNEECC. Although the NEP was accepted in June 2008, the NNEECC was formed at the end of 2011, even though nuclear projects such as PBMR, and the bid process for the construction of Nuclear-1, were active during the interim. The NEP just lightly touches on the issue of human resource development by mentioning “Government is committed to developing and maintaining technically competent workforce to accomplish the objectives of this policy”. Deeper insight into planned human resource development is needed for the successful development of a nuclear industry.

2.3.2. 2010/2011 – 2012/2013 Industrial Policy Action Plan (The department of Trade and Industry, 2010)

The IPAP is the implementation plan that addresses the National Industrial Policy Framework (NIPF). The NIPF was compiled in 2007 by the South African cabinet, and discusses the government's broad approach to industrialisation. Some of the core objectives captured within the NIPF include diversification beyond the reliance of traditional commodities and services, long-term intensification of the industrialization process and movement towards a knowledge economy, the promotion of more labour-absorbing industrialization, the promotion broader-based industrialisation with emphasis on historically disadvantaged peoples, and contribution to the industrial development of Africa. The DTI identified the nuclear industry as a means to address some of the issues in the NIPF.

The IPAP identifies nuclear as a sector with long-term advanced capability potential, and states that, if localisation of nuclear component and manufacturing does not take place effectively, the nuclear power programme will have dire consequences for the South African economy. The IPAP assumes that a fleet approach will be adopted, and that the first reactor will come into commercial operation in 2019. It also states that localisation will not be able to take place if a fleet approach is not taken to ensure economy of scale, with construction starting at 18 to 24 month intervals. Other possible constraints posed by the nuclear sector include meeting nuclear quality requirements, as well as regulations, and structuring of appropriate global partnerships and access to global supply chains.

The IPAP, as is the case with the NEP, is a very high-level description of opportunities, outcomes and key milestones. It clearly states the responsible department/organisation for each task, thus assigning a level of responsibility to various departments/organisations.

Within the nuclear sector, three main focus areas will be the nuclear build, conformity assessment framework for the South African nuclear industry and skills development support.

2.3.2.1. Nuclear build

The main focus for the DTI is to leverage procurement for the nuclear build programme, and through this ensure that localisation, as well as participation in the global supply chain is taking place. Localisation has to take place to protect the balance of trade, and would serve as a means for skills and technology transfer, the promotion and stimulation of new business opportunities with regard to the development of local nuclear manufacturing capability, possibility of entering the global supply chain, and the creation of jobs.

The outcomes would be:

- A long-term procurement plan, that addresses the objectives up-front, and specifies the mechanisms and regulations that will be used to ensure that the objectives are met;
- The identification of sequentially increasing local manufacturing opportunities;
- The structuring of an optimal funding mechanism for localisation.

The IPAP assumes that the first reactor will be in commercial operation by 2019, that 10 500 MW of installed nuclear capacity will be operational by 2028, and 21 000 MW of installed capacity by 2035. These figures are based on planned nuclear expansion prior to the IRP2010. The IRP calls for a total of 9 600 MW, accounting for less than half of the assumed nuclear expansion of the IPAP. This dramatically reduces viable manufacturing and localisation opportunities and must be taken into account when addressing the outcomes of the IPAP.

2.3.2.2. Conformity assessment framework for South African nuclear industry

Nuclear component manufacturers have to comply with ASME III or other internationally recognised nuclear quality and safety standards. Compliance and certification of these standards will allow local companies to enter the nuclear market. To stimulate the growth of a competitive, local nuclear manufacturing industry, nuclear certification, inspection and skills development should be localised with the aim of local accreditation capability. This accreditation system would be developed by the DTI in conjunction with SANAS.

2.3.2.3. Skills development

South Africa has a shortage of scarce skills. The calculated gap between the available skilled workers and the required skilled workers over the next five years amounts to 11 500 scientists and engineers, and 29 000 artisans. With the electricity capital expansion, an additional 3 000 scientists and engineers, as well as 24 000 artisans will be needed, thus bringing the needed skills development of scientists and engineers and artisans to a total of 14 500 and 53 000, respectively, over 5 years. With this drastic increase, large bottlenecks at SOEs and artisan testing facilities are anticipated. To alleviate this problem, the DTI will support and fund the upgrading of SOEs and certification funding, specifically at NECSA.

2.3.3. Accelerated and shared growth initiative for South Africa (AsgiSA) (The Presidency, 2006)

The AsgiSA is an initiative to fight poverty in South Africa by stimulating local development and economic growth. The aim of the AsgiSA is to half poverty and unemployment by 2014. This will

be achieved by reaching accelerated growth targets in terms of GDP. An envisioned 4.5% or higher growth rate is needed between 2005 and 2009 and 6% between 2010 and 2014. Although these are feasible targets, constraints have been identified that inhibit the reaching of these targets, such as:

- The volatility of the currency;
- The costs, efficiency and capacity of local logistics systems;
- Shortage of skilled labour;
- Limited opportunities and limits to competition;
- Regulatory environment and the burden on small and medium businesses;
- Deficiencies in state organisations and leadership.

To alleviate these problems, focus areas for development have been identified, such as infrastructure development, sector strategies (such as the CSDP), education and skills development, governance and institutional interventions, etc.

When looking at the effects of a nuclear power programme on the economy of the host country, as stated in section 2.1.2, it can be seen clearly that development of a local nuclear industry can address various issues raised in the AsgiSA, especially when taking into consideration the contribution that the nuclear industry has on GDP. Nuclear industry development and localisation can also alleviate some of the constraints of the AsgiSA, such as shortage of skilled labour and lack of opportunities.

2.3.4. The Competitive Supplier Development Programme (CSDP) (Department of Public Enterprises, 2007).

The CSDP is an initiative launched by the Department of Public Enterprise (DPE), and aims to develop a competitive local supply base and increase local capacity, and thus contributes to realising the goals of the AsgiSA.

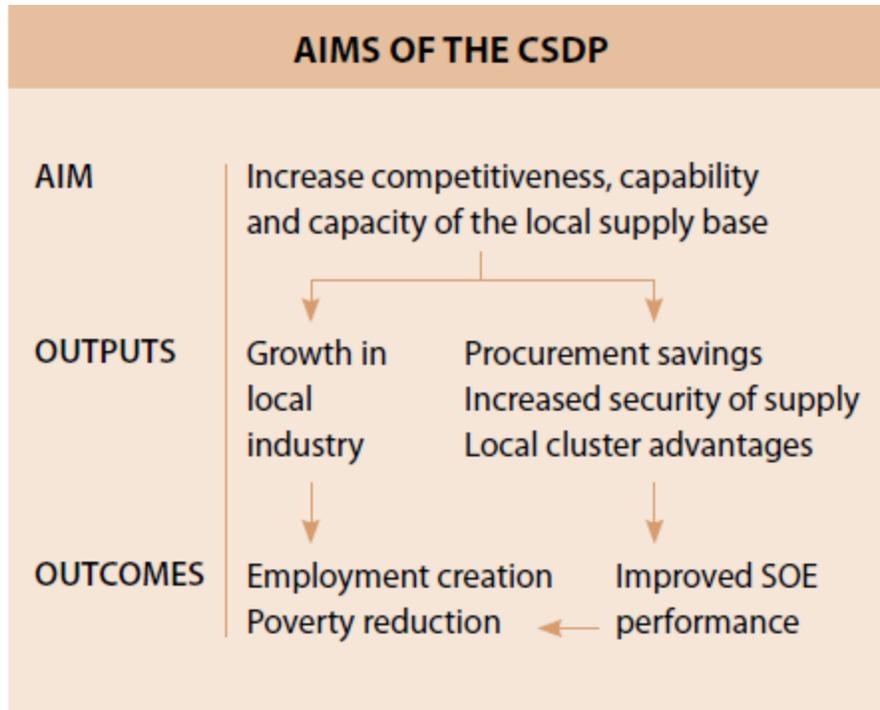


Figure 9: Aim, outputs and outcomes of the CSDP (Department of Public Enterprises, 2007)

The CSDP focuses on supply and demand side measures that can be taken to increase local competitiveness. State-owned Enterprises (such as Eskom) will be mostly responsible for demand, and by leveraging SOE expenditure, the development of competitive local supply can be stimulated. This will be done by fostering a culture within the SOE that focuses on the development of win-win partnerships, where value for money over the entire product life-cycle is considered, rather than low initial costs. SOEs are encouraged to compile Supplier Development Plans (SDPs) that will be updated and submitted for approval by the DPE annually. The SDP will identify areas where local suppliers can be used, and where incremental supplier development can take place. This will be achieved by expenditure analysis, as well as industry and market analysis. By focusing on local procurement, the local supply market can be stimulated to become competitive in international markets, and contribute to economic growth. SOEs will define measurable CSDP targets, and these targets will be reviewed annually.

Many actions can be taken by government and industry associations to assist the CSDP, such as the formation of industry associations, the intervention by the Competition Commission to eliminate monopolistic or anti-competitive behaviour, research, global marketing, funding and incentives for skills development, etc. Industry benchmarking will also assist SOEs in identifying possible local suppliers, and industry development focus areas.

Once the SOE starts implementing the SDP, it needs to be continuously evaluated. Key performance indicators for the evaluation of the SDP are:

- National value add/Total procurement spend. This will be measured against aggregated enterprise expenditures, capital expenditures and operational expenditures;
- Where applicable, skills development and job creation due to local procurement.

Eskom started implementing an SDP in 2008, and plans to invest a total of R131 bn over 5 years locally (Eskom, 2007). As part of their procurement process, potential suppliers are rated, based on a localisation scorecard, as well as their contribution to skills development (see Table 8 and Table 9 below). These evaluations have a significant impact on Eskom's choice of supplier.

Table 8: Eskom's localisation scorecard (Eskom, 2011b)

1	2	3	4	5
Criteria	Weight	Total Target	Total Proposed target	Score
LBS of Local Content Value	50%	10%		
BWO of Local Content Value	15%	5%		
SBE of Local Content Value	15%	8%		
Local Content % of Total Value	25%	100.00%		
Local-to-site % of Total Value	0.00%	0.00%		
Skills Development Total	25%	25.00%		
Total Score	100%			
			Localisation Score	

Table 9: Eskom's skills development scorecard (Eskom, 2011b)

1	2	3	4	5	6
Skills:	Weight	Target	Proposed	Weighted Score	Score (Adjusted by C21)
Systems Development	20%	2			
Database Design & Analysis	20%	2			
Operations Design	20%	2			
End-User Programming	20%	2			
Software Engineering	20%	2			
		10			

Eskom is one example of how the CSDP can be practically implemented, creating a favourable environment and opportunities, for the development of a local supply base.

Due to the unique nature of each project, the localisation goals need to be adjusted accordingly. Pre-defining an overall localisation score/target for all projects, may lead to unnecessarily high project costs, and may possibly be unreachable. The CSDP states that a SDP should focus on the value of the entire life-cycle rather than lowering initial costs, and thus create sustainable projects for local manufacturers. The Eskom implementation of the CSDP only focuses on a single project, and does not take into account future projects of the same type, and the continual use of the supplier for aforementioned projects. Situations may occur where lower initial localisation scores are achieved for the first project, but through planned use of the same supplier for projects of the same type, local supplier development will be stimulated. This becomes extremely relevant when a fleet of similar projects are planned.

2.3.5. South African localisation and human resource development studies

Human resource development, as stated in various sections and documents, is one of the main success factors for localisation. Many studies have been conducted to calculate the required human resources for the proposed nuclear build. Human resource development is discussed in two sections, firstly the basic human resource development needed to produce the planned nuclear reactors, and the additional human resources needed for localisation.

2.3.5.1. Assumptions

This document assumes that the 9.6 GW nuclear fleet, as proposed in the IRP will be built. It is assumed the fleet will consist of six 1 600 MW reactors that will be constructed according to the schedule of the IRP, in which the first reactor becomes operational in 2023. Thus, with a 5 year construction time, construction on the first reactor will start in 2017, with construction on the subsequent reactors starting at 18 month intervals. The construction schedule for reactors is shown in Figure 10.

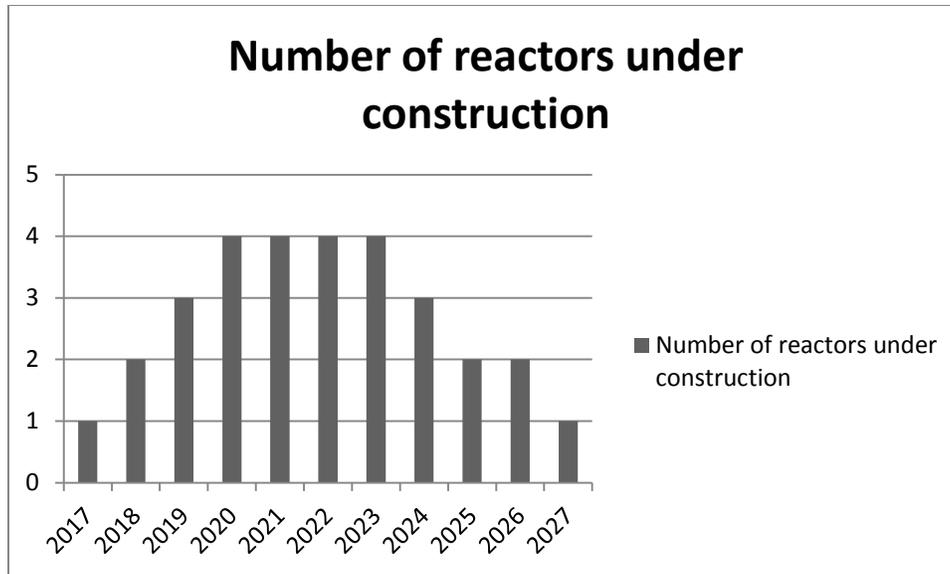


Figure 10: Planned nuclear reactor construction schedule

In Figure 10 it can be seen that the peak construction time and thus, the time requiring the largest amount of human resources is 2020 to 2023, where 4 reactors will be under construction simultaneously.

2.3.5.2. Basic human resource development needs

A study was done by NIASA to determine the skills needed for the construction and operation of three power stations, each consisting of two 1 600 MW reactors (Moduka, Smit *et al.*, 2012). These figures are seen as basic development requirements, thus excluding additional human resource development requirements for localisation. The figures are summarised in Table 10.

Table 10: Total human resource development requirements (Moduka, Smit *et al.*, 2012)

Total Human Resource Requirement	Number
Project Management	1 190
Security	480
Construction	26 700
Architect Engineering	1 830
Utility Engineering	260
Operation	2 300
Total	32 800

The human resource development required per year is shown in Table 11.

Table 11: Human resource development needed per year (per skill) (Moduka, Smit *et al.*, 2012)

Resource Required	Number per year
Engineers	110
Project Managers	30
Technicians	150
Artisans (O&M)	30
Artisans (Construction)	
Boilermakers	110
Carpenters	280
Electricians	510
Iron workers/Fitters/Welders	510
Insulators/Thermal insulators	50
Masons	50
Millwrights	90
Operating engineers/Crane operators	230
Painters	50
Pipefitters	470
Sheetmetal workers	90
Teamsters/Code 14 truck drivers	90
Total Artisans (Construction)	2530
Scientists	22
Total needed human resource development per year	2 872

2.3.5.3. Human resource development for localisation

A separate study was done by NIASA to identify gaps and development opportunities, based on current South African capability. This was done with the use of industry surveys, and various interviews. The human resources needed for successful localisation are shown in Table 12. It must be noted that these figures are based on the companies that participated in the survey by NIASA, and address human resource development required to reach a 40% localisation figure.

Table 12: Human resource development needed to reach 40% localisation goal (Mangena, 2012)

Skills Category	Current	Additional	Increase	Total
Mechanical Sector				
Engineers	1 040	107	10%	1 147
Technicians	302	189	63%	497
Safety & Licensing	548	185	34%	733
Quality Personnel	882	254	29%	1 136
Artisans	3 930	812	21%	4 742
Mechanical Sector Total	6 702	1 547	23%	8 249
Civil Works Sector				
Engineers	304	130	43%	434
Technicians	420	164	39%	584
Safety & Licensing	188	120	64%	308
Quality Personnel	152	107	70%	259
Artisans	1 963	490	25%	2 453
Civil Works Sector Total	3 027	1 011	33%	4 038
C&I and Electrical Sector				
Engineers	606	355	59%	961
Technicians	484	560	116%	1 044
Safety & Licensing	184	160	87%	344
Quality Personnel	216	180	83%	396
Artisans	524	1 435	274%	1 959
C&I and Electrical Sector Total	2 014	2 690	134%	4 704
Total				
Overall Total (all sectors)	11 743	5 248	45%	16 991

It must be noted that the choice of technology and the level of planned local participation will have a drastic effect on the human resources required. These figures again show the nuclear power programme will greatly assist in meeting socio-economic development goals, such as the AsgiSA and skilled labour shortages.

All the information gathered by the literature study was integrated, and a localisation strategy, specifically tailored for the South African environment was compiled. This strategy addresses the main focus areas identified in the literature, and is discussed in Chapter 3.

3. PROPOSED LOCALISATION STRATEGY

The proposed localisation strategy addresses general issues regarding the current situation of the nuclear industry in South Africa, the possible structure of the NEPIO and its fundamental roles and responsibilities, the needed human resource development, and finally the approach to be followed for local supply chain development and technology transfer. This strategy assumes that South Africa is reaching the IAEA Milestone 2 in infrastructure development, and that, as stated in the NEP and IRP, a fleet generating a total of 9.6 GW, is to be constructed.

3.1. General discussion

There are general issues that need to be addressed before starting the bid and procurement process. If left unchecked, these issues would not just adversely affect localisation, but the entire nuclear power programme.

3.1.1. Government commitment and public perception

The first major hurdle that needs to be overcome is governmental commitment and public perception. Government plays a critical role in any nuclear power programme, and if government does not make a firm decision to support a nuclear power programme, industry cannot invest in nuclear capability development. Industry and public perception surrounding nuclear have been negatively influenced during the past few years, especially when taking into account the termination of the PBMR project, the closure of the bidding process in 2008 without an outcome, and the events at Fukushima. Furthermore, publicity surrounding nuclear power in South Africa aids the creation of a negative public and industry perception of nuclear power, with published articles such as “Mothlanthe: Nuclear not a done deal” (Mothlanthe, 2012) and “NPC warns SA on cost of nuclear power” (National Planning Commission, 2012).

Clear government commitment is needed. When looking at the Korean experience (section 2.1.3), it is seen that continuous, long-term government commitment was a key factor in the success of the Korean nuclear power programme. Government commitment will prove to industry that nuclear power has a future in South Africa, and that nuclear development poses sustainable economic benefits, thus stimulating nuclear capability development. Development of certain nuclear manufacturing capabilities may take years to prepare and develop, especially when looking at heavy forging and specialised component manufacture (such as turbines, steam generators, etc.), and thus, if government takes too long to commit to the nuclear power programme, it will limit the spectrum of feasible localisation opportunities. The government and key stakeholders must also undertake public awareness and perception campaigns, to mitigate

against the negative image of nuclear in South Africa, and address any misconceptions regarding nuclear power.

3.1.2. Localisation and local content

The definitions of localisation and local content need to be clearly communicated to the vendor and potential suppliers. Local content represents value added in South Africa, using South African resources – thus the total spent minus the imported component. Localisation refers to the creation or development of local industrial capability. These two issues need to be addressed separately. High percentages of local content alone will not ensure successful localisation. When high levels of local content cannot be reached, the focus should shift to technology and knowledge transfer, thus creating the opportunity to develop the specific capability, and in so doing promote localisation. Currently Eskom requires an overall supplier development and localisation score of 60%, as part of their invitation to tender (see Tables 8 and 9). This may be, in many cases, unrealistic, especially with nuclear projects, due to the stringent quality requirements and limited availability of manufacturers able to produce nuclear components.

South Africa has access to vast natural resources, and has a moderately developed manufacturing capability, creating initial opportunities for the local sourcing of non-critical BOP components and services, and especially civil work. With the first reactors, South African participation in the manufacturing of nuclear-specific components or services will be very limited, due to a lack of expertise, experience and capability. These, however, create key opportunities for technology and knowledge transfer. Components and services should be graded by Eskom according to their possible local content contributions. The model proposed is shown in Figure 11:

61%-100%	Cat A
31%-60%	Cat B
0%-30%	Cat C

Figure 11: Proposed local content categorization based on the percentage of localisation

The categorisation of local content contribution should be based on current industry capabilities. Thus, Eskom has a responsibility to continuously benchmark local industry capability, and re-evaluate the component and service categories at the start of each new nuclear project. Components of categories B and C represent gaps in the industry, and thus pose opportunities for local industry development. For components of categories B and C, the localisation and supplier development programme needs to make provision for knowledge and technology transfer to assist the development of local capability of that specific component/service.

This in turn would make localisation easily measurable. The review of the number of category A, B and C components prior to construction of subsequent reactors will serve as an indication of industry development. If localisation is successfully taking place, clear decreases in the numbers of category B and C components, and thus a definitive increase in category A components should be seen. This categorisation can also be coupled with the industrial complexity categorisation as discussed in section 3.4.2. It must be noted, however, that it may take numerous nuclear projects to successfully localise some components, while other may never be fully localised within South Africa, and thus local content and localisation goals should be realistic.

Localisation and supplier development should also include opportunities for local participation in general operation and maintenance of the nuclear plants, as well as local participation in the front and back-end of the nuclear fuel cycle. These areas are sustainable, long-term local participation opportunities. Based on this, local content goals should be set up for the entire lifecycle of the nuclear power programme, and not merely for the construction phases.

3.2. South African NEPIO

Due to the history of nuclear energy in South Africa, there are many existing nuclear organisations that could be included in the South African NEPIO, such as the NNR, NECSA and NIASA. The Korean government created a ministerial department for atomic energy. This department served as the head of the NEPIO, coordinated with various other ministerial departments, and reported directly to the president (see Figure 5). South Africa has no such department, and thus it is proposed that the deputy president serves as the head of the NEPIO, as is the case with the NNEECC. This would give the NEPIO the needed authority to make policy decisions, and also give the NEPIO the needed knowledge regarding the socio-economic situation in South Africa. As recommended by the IAEA, the NEPIO should have a much more prominent role at the start of the programme, but the NEPIO should stay involved throughout the entire lifecycle of the programme. The NEPIO should include a small contingent of

permanent personnel responsible for ensuring that decisions and policies made by the NEPIO are being implemented. Due to the large spectrum of representation in the NEPIO structure, it would not be necessary to structure a large, full-time organisation.

The NNEECC was formed at the end of 2011, with the responsibility of implementing a phased decision-making approach to the nuclear programme (Njobeni, 2012). The NNEECC consists of the deputy president as chair, the minister of energy as deputy chair, and the ministers of finance, public enterprises, trade and industry, economic development, water and environmental affairs, science and technology, higher education and training, and the minister of planning (Njobeni, 2012). There is no industry representation, and Eskom, which is assumed to be the owner/operator of the plant, has also been excluded. Thus, the NEPIO and NNEECC are seen as separate organisations. The NNEECC is seen as a planning committee, while the NEPIO is viewed as an execution and implementation organisation. Before any decision or policy is finalised by the NNEECC, it should be presented to the NEPIO for comment to get the needed input from industry and other stakeholders.

3.2.1. Proposed Structure of the South African NEPIO

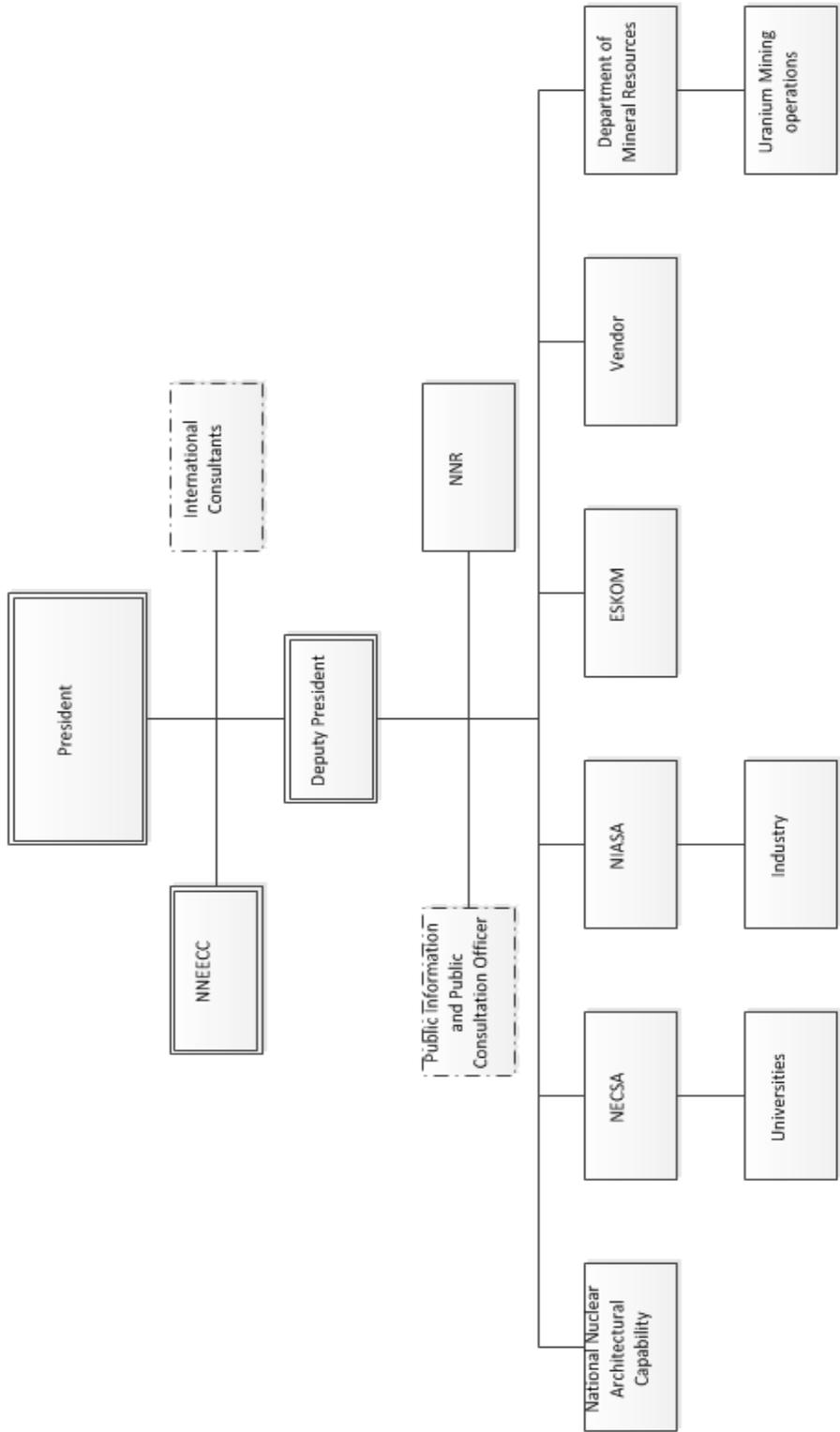


Figure 12: Proposed structure of the South African NEPIO

3.2.2. Roles and responsibilities of organisation in the proposed NEPIO

NNEECC	NNEECC serves as the primary planning and policy decision maker. Inputs to these policies must be done via the deputy president, who serves as chairperson for both NEPIO and NNEECC.
International consultants	International consultants are used to review and give external assessments with regard to nuclear issues. This will give the nuclear industry access to international expertise, and ensure that the nuclear power programme is on par with international standards. The primary international consultant is the IAEA. Other international consultants may include the expertise from the chosen vendor and countries that form part of bilateral cooperation agreements.
Deputy President	The deputy president serves as chairperson for NEPIO and NNEECC, and thus serves as primary liaison and communication channel between NEPIO and NNEECC. This insures that the chairperson has a broad overview and understanding of the activities of both NEPIO and NNEECC, and thus assist him in decision making and management of both. The deputy president reports directly to the president.
Public information and public consultation officer	As stated earlier in this document, one of the biggest hurdles to overcome is public perception and misconceptions of nuclear power. Addressing this issue is the responsibility of the public information and public consultation officer. Public consultation plays a critical role in the nuclear environment, and thus needs specialist attention. The PIPCO reports and gives inputs to the NEPIO on matters regarding public perception. The PIPCO is responsible to ensure transparency and honesty in all communication with the public. The PIPCO serves as media liaison for the NEPIO.
NNR	The NNR oversees the activities of NEPIO to ensure that all activities fall within the accepted regulatory and legislative practices. The NNR serves as an observer and adviser within NEPIO, but does not actively partake in the activities of the NEPIO, thus ensuring that the NNR remains impartial.

NECSA	NECSA serves, as mandated in the NEP, as the anchor for nuclear research, development and innovation. To achieve this, NECSA serves as primary liaison with the universities, and continuously communicating possible fields of needed research, and thus ensuring participation to the nuclear programme from institutes of higher education. By ensuring the participation of universities and other institutes for higher education, it creates opportunities for human resource and expertise development, and addresses skills development goals as stated in various government policies. Further, NECSA is directly responsible for the development of local nuclear fuel cycle capabilities. The development of these capabilities includes conversion, enrichment and fuel fabrication. If sufficient needs and benefits are identified, this development could be expanded to include reprocessing of used fuel. NECSA also assists in advanced manufacturing capability development, especially with regard to ASME III certification and nuclear quality standards.
NIASA	NIASA serves as nuclear industry representation on NEPIO, and is the primary liaison between NEPIO and industry. NIASA, along with Eskom is responsible for continuous benchmarking of the national nuclear industry, and is primarily responsible for identifying opportunities for nuclear development. NIASA also performs studies to help guide the development of the nuclear industry.
Eskom	Eskom, as owner/operator of the nuclear fleet, has a wide spectrum of responsibilities. Eskom, along with NIASA, is responsible for industry benchmarking. Eskom is also primarily responsible for supplier development and local participation, as discussed in section 3.1.2. This should be done by extensive negotiations with the vendor, and with accurate information regarding the current state of industry capability. It is Eskom's responsibility to include localisation and technology transfer goals in contracts, and monitor whether they are being met.
Vendor	The vendor shall report to NEPIO on the overall progress of the programme, and shall, within NEPIO, discuss issues regarding localisation

	and technology transfer. Open negotiations with the vendor regarding local participation and technology transfer as the programme progresses, would be crucial in successful localisation.
Department of Mineral Resources	The department of mineral resources represents South Africa's uranium interests. The DMR is primarily responsible for uranium beneficiation, and is the primary liaison and representation for South African uranium mines.
National Nuclear Architectural Capability	One of the goals of the NEP is to develop a national capacity to supply nuclear equipment, reactors and components. It may not be economically viable for private sector companies to invest the needed funds for the development of these specialised capabilities, and thus the national nuclear architectural capability can serve as a funding vessel for the development of specialised heavy forging and manufacturing capability. When looking at the Korean model, it is seen that they developed government-funded heavy industries that were later privatised, and it is proposed that the South African government, along with private sector investors, create the NNAC, as was done in Korea.

The department of energy was left out of the NEPIO structure due to the major role that it plays in the NNEECC. As mentioned earlier, the NNEECC will be seen as a planning committee, and with the minister of energy as the deputy chairperson for the NNEECC, it will not be necessary for the department of energy to have a dedicated role within the NEPIO.

3.3. Human resource development

Aggressive human resource development is one of the core success factors for localisation. Extensive human resource development is needed prior to the start of the nuclear power programme, as well as during the programme. The NIASA studies are used as basis for the calculation of the total needed human resource development.

3.3.1. Total human resource development needed

For the calculation of the total human resource development needed, the basic (Tables 10 and 11) and localisation human resource estimates (Table 12) are integrated. The localisation estimate is adapted and increased to encompass 80% localisation capability. The figures are

such that the goals as stated in Table 12 are reached when construction on the first reactor starts, and gradually increase to reach 80% localisation by start of construction of reactor six. Table 13 shows the needed human resource development for the next 10 years. This is only a rough estimate, and should be reviewed regularly, and only gives a broad overview of the needed human resources. It should also be noted that these estimates exclude human resources needed for the development of a local nuclear fuel cycle supply chain.

Table 13: Total human resource development requirements for construction, operation and localisation per year

Total Human Resource Requirement per Year	Number
Project Management	30
Scientists	22
Technicians	415
Engineers	230
Artisans	3 110
Safety & Licensing	95
Quality Personnel	110
Total per year	4 012

From the figures in Table 13, it can be seen that localisation has a major effect on the overall human resource development requirements (roughly increasing the needed human resource development per year by 28.5%). The human resource development for localisation is based on an 80% figure. It is assumed that, after the construction of the 6 nuclear reactors, many of the personnel used, are to be retained within the nuclear industry, and thus will assist in localisation.

3.3.2. Human resource development recommendations

As can be seen from the figures above, considerable human resource development is required over the following 15 years. Key role players for achieving the needed development are universities and other institutes of higher education, such as technical training facilities.

There are currently 7 universities in South Africa with nuclear-related programmes, focusing mainly on post-graduate studies (Moduka, Smit *et al.*, 2012). Enrolment for these programmes is low compared to other programmes, but this can be attributed to the uncertainty of the future of nuclear energy in South Africa. Government, along with industry stakeholders, should engage

education institutions to raise the profile of nuclear energy. This can also be accomplished through public awareness campaigns. It is recommended that a nuclear academy be established to coordinate nuclear training.

The figures show that large numbers of artisans need to be trained. Nuclear specific training is needed. Government has already taken pro-active steps to address the issue by funding the expansion and upgrading of artisan training facilities at NECSA. Many more nuclear-focused training and certification centres are needed if the artisan training targets are to be met. It is recommended that the vendor be contractually obligated to assist in the creation of such training facilities, and to make use of graduates from these facilities in the nuclear power programme.

Furthermore, the government and key industry stakeholders need to pro-actively start in the creation and development of human resources and nuclear expertise. This was achieved in Korea by means of foreign training. From 1955 to 1969, a total of 204 people were trained abroad at various institutions such as the IAEA (Choi, Jun *et al.*, 2009). This gave Korea the basic needed expertise to start human resource development locally. A similar approach should be used by South Africa, specifically with regard to nuclear quality standards and manufacturing practices, as well as nuclear reactor technology and nuclear engineering. These individuals can then be used to create local training centres, graduate and post-graduate programmes.

Once the choice of vendor and nuclear technology has been made, training and education focusing on the chosen technology should be started. This is done via the vendor, and will greatly assist in technology transfer, and the possible standardisation of the chosen technology.

The human resource development needed for the successful completion of the nuclear power programme and localisation will help address various government goals with regard to skills development, job creation and socio-economic growth, and is also a crucial factor in successful localisation and industry development. It is therefore recommended that human resource development, and especially the development of competent nuclear expertise, be made a priority by government and industry. If no immediate attention is given to human resource development, a nuclear power programme cannot be implemented successfully in South Africa, especially considering that the enrolment in universities (universities, comprehensive universities and universities of technology) total roughly 745 000 students, but with an average graduation rate of 16% (Council on Higher Education, 2009). The additional needed nuclear expertise places more strain on already stressed higher education institutions, but priority must be given to the nuclear power programme if it is to continue as planned.

3.4. Supply chain development and technology transfer guidelines

This section discusses the localisation and supply chain development for the proposed nuclear fleet. It briefly discusses the planned participation in the first reactor, and possible development of local capabilities.

3.4.1. South African participation in the first reactor

A study done by Worley Parsons and the DTI in 2011 found that, for the first two reactors, approximately 30% of the cost of the reactors will be spent on local content, and that South Africa has the technical capabilities to achieve 40% localisation (Worley Parsons, 2011). Natural candidates for localisation are:

- Civil Concrete;
- Rebar;
- Tanks;
- HVAC ductwork;
- HVAC Chillers, Heating coils etc;
- Formwork;
- Cranes.

With large power plant construction projects such as Mudupi and Kusile, the South African industry has some experience in the construction of conventional coal-fired power plants that will enable participation in the construction of a nuclear power plant, specifically when considering non-nuclear safety-related components, and civil works. This is seen as the basis for participation in the construction of the first nuclear power station. Participation in the construction of the first reactor must be very limited. The first nuclear power plant can be seen as a learning opportunity rather than an industry development opportunity. During the planning and construction phases, local expertise should be developed that can be used in the subsequent project, and thus a gradual increase in expertise is stimulated. It is also recommended, specifically with the first reactor, that localisation is not forced, especially not by expansion of the owner scope. This would greatly increase the risk to cost and duration of the project.

For the first reactors local industry capabilities must be assessed, and Eskom, along with the chosen vendor must decide what components and services can be sourced locally. For this 30% of total cost can be used as a guideline. The first power plant should be a turnkey project.

Construction and licensing of the first reactor should also serve as a test of the NNR capabilities to handle projects of this size, and an opportunity to iron out any problems early in the programme. Regulatory problems have been known to cause major project delays (Laaksonen, 2010), and thus it is of the utmost importance that the NNR proves their competency early on, and addresses any needs identified during planning and construction of the first power plant.

3.4.2. Proposed nuclear industry development

For the development of the local industry, components shall be categorised according to their degree of complexity. These categories are shown in Figure 13.

	Examples	Intervention requirements
Globally leading	<ul style="list-style-type: none"> • Ultra heavy forging • Turbine manufacture 	<ul style="list-style-type: none"> • Government driven investments for strategic economic purposes – not commercially viable in short-medium term
Advanced	<ul style="list-style-type: none"> • ASME III production facility • Fuel cycle 	<ul style="list-style-type: none"> • Commercially viable but high complexity - government investment required in specialised skills and technologies to enable investment
Inter-mediate	<ul style="list-style-type: none"> • Pipe prefabrication • Pumps, valves... 	<ul style="list-style-type: none"> • Investment requirements within capability of company balance sheets, but clear medium term commitment required
Shallow	<ul style="list-style-type: none"> • Construction • Structural steel 	<ul style="list-style-type: none"> • Within current industry capability • Sufficient notice required and information sharing to enable capacity expansion

Figure 13: TSAPRO component classification (South Africa Power Project Advisory Committee, 2008)

For the first power plant, shallow, and some intermediate components can be supplied from local manufacturers, as discussed in section 3.4.1.

At least 3-5 years prior to the start of construction of the second reactor, local industry must start with the process of nuclear certification (such as ASME III), in preparation for component supply for the second and third power plants. Vendor input and inspection can be used to

ensure that any initial nuclear, and safety-related components manufactured locally conform to the quality requirements.

With the start of construction of the third nuclear power plant, the South African industry should be able to manufacture advanced components. Due to the various delays to the start of the nuclear power programme, the rigid construction schedule and the size of the nuclear power programme, a globally leading component manufacturing capability may not be feasible. If commitments for a larger nuclear power programme are made, and enough time is given to develop the needed capabilities, along with sufficient government support, a globally leading component manufacturing capability may become viable.

Development of the nuclear fuel cycle must start as early as possible. The nuclear fuel cycle poses sustainable long-term benefits remaining long after construction of the plants have been completed. The vendor should give inputs into the development of the nuclear fuel cycle, especially regarding technology-specific issues.

It is proposed that for three power plants, each consisting of two nuclear reactors, the local expenditure should be:

- Plant 1: 30%;
- Plant 2: 50%-55%;
- Plant 3: 75%-80%.

A local expenditure of 100% will not be viable in South Africa if global leading components are not manufactured locally. These percentages are not the only indication of localisation, only the indication of local expenditure for the production of the nuclear power plants. Further localisation can be attained by the use of local companies in operation and maintenance activities, supporting services and local nuclear fuel cycle development.

Human resource development serves as the primary vehicle for technology transfer. Again, cooperation with the vendor in technology-specific training will stimulate technology transfer. Some other key elements to be transferred include drawings, computer code and simulation systems, processes, etc., but these elements are useless if the needed expertise is not developed to receive them. Initial focus areas for technology transfer are the nuclear fuel cycle, and nuclear critical components such as the reactor vessel, steam generators, pressurisers, etc. Along with this, an inter-organisational knowledge management system can be used as a tool to archive knowledge for future use. Taking into account that South Africa has an established,

though limited, nuclear knowledge base, it would be possible to develop nuclear technology self-reliance upon the completion of the 6th nuclear reactor. Figure 14 shows a proposed phased approach. The phases are parallel to the construction of the three power plants (thus Phase 1 coincides with the construction of the first nuclear power plant, Phase 2 with the construction of the second power plant, etc.)

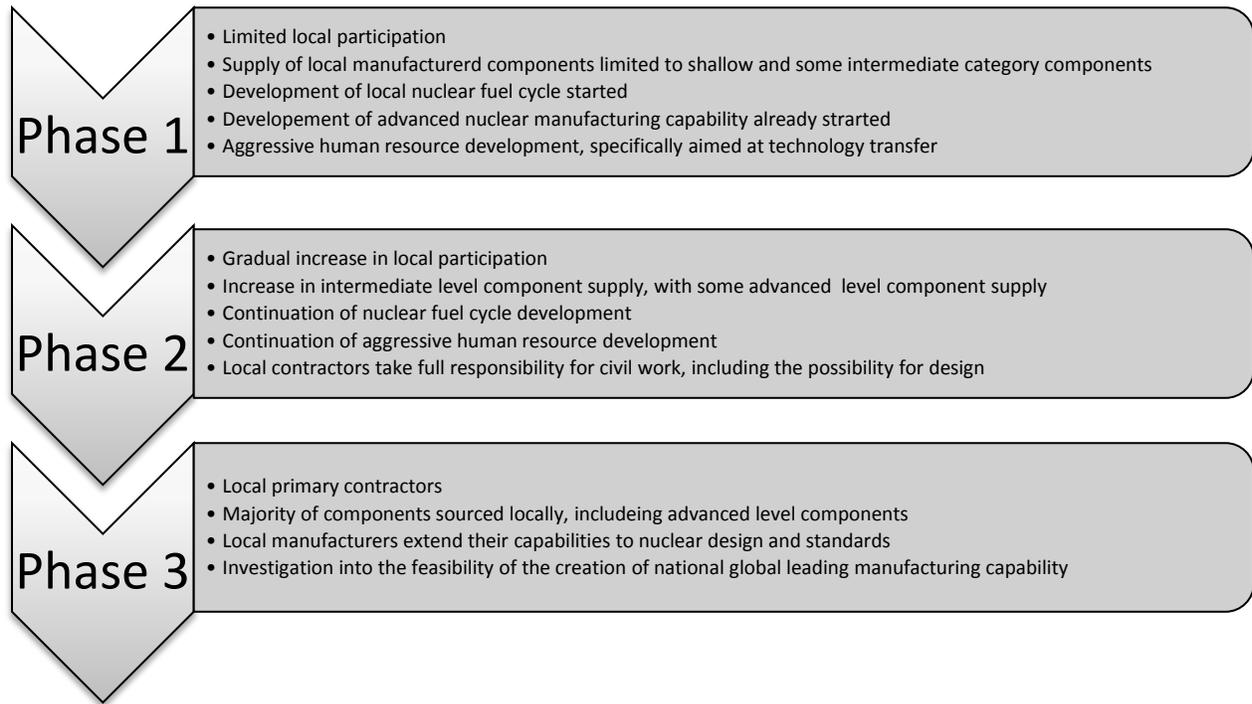


Figure 14: Recommended participation during the phases of the nuclear power programme

3.4.3. General recommendations

An advanced and globally leading class component manufacturing capability is not economically feasible if financed by private companies. Thus, as stated by TSAPRO, it would require government investment to be successful. TSAPRO calculated the needed investment as R17 bn over 17 years (from 2008-2025).

Co-operation with the vendors concerning localisation cannot be stressed enough. Vendors have experience in localisation and thus they have a better grasp of what is feasible, and what is not.

The focus of localisation, as stated in various sections, should not be on component supply and local expenditure alone. Various services and support functions, though not as lucrative as component manufacture, will create a sustainable source of revenue.

Localisation is a process that must be guided, not forced. Forced localisation greatly increases the cost and schedule risk of the project. Co-operation between the various stakeholders and clear guidance from the NEPIO will create an environment where localisation can happen naturally. Focus areas for localisation must be identified, and the process must focus on achieving goals, but with the certainty that those goals will not affect the outcome of the project. The South African nuclear industry cannot afford, especially with the general negative perception of nuclear energy, to have a project run late and over budget.

The nuclear power programme, if managed correctly, will make major strides in reaching government goals, and has a huge, beneficial, economic impact. This power programme creates the opportunity for South Africa to once again become a key role player in the global nuclear community.

To ensure the relevance and applicability of the localisation strategy, as discussed in this chapter, it needs to be validated by government and industry. To this end, the strategy was circulated to various stakeholders. These stakeholders, their feedback, changes and inclusions to the strategy are discussed in chapter 4.

4. INDUSTRY FEEDBACK ON PROPOSED STRATEGY

To validate the proposed localisation strategy, it was circulated to various nuclear industry stakeholders for comment. The chosen recipients of the strategy were selected based on activity and experience within the nuclear industry, and as members of the proposed NEPIO. Thus, the document was circulated to:

- NIASA;
- NECSA;
- The NNR;
- The DTI;
- The DST;
- The DOL;
- Large construction companies;
- Engineering companies;
- Heavy manufacturing companies;
- Potential vendors;
- Eskom;
- Steel producers.

The authors of the feedback will remain anonymous, so as not to infringe on any information affecting industry competitiveness, and it must be noted that the comments are those of individuals, and do not necessarily represent the views of the relevant company. The government departments who were approached, did not give any comments.

The feedback given by the potential vendors is given the most weight due to the fact that they have international experience in nuclear localisation. Feedback from NECSA, Eskom and the NNR is seen as more relevant when discussing the South African nuclear environment, labour arena, socio-political atmosphere and regulatory environment. Industry feedback is emphasised when discussing local industry capability and possible development, especially focusing on the feedback from companies involved with the Mudupi and Kusile power projects.

The comments and feedback are discussed, and changes and inclusions to the strategy are made. The chapter discusses general comments, areas where the strategy was found lacking, sections revised and a possible approach to contracting.

4.1. General comments

Feedback from a potential vendor, steel producers and heavy manufacturing companies, commented that government needs to play the leading role in localisation. The comments stated that a nuclear power programme is too big for privatised companies to champion. Government funding is needed to start the localisation process, especially with regard to the heavy manufacturing capability and nuclear fuel cycle development. Reference was made to South African case studies where this approach was successfully implemented, specifically Sasol and Iscor. Sasol (South African Coal and Oil), for example, was a government funded initiative that was later privatised, and is today an internationally competitive company contributing 4.7% to the South African GDP in 2008 (Sasol, 2008). Iscor can serve as another example where government funded the initiative, and later privatised the company. Governmental partnerships with the private sector can be made and used as vehicle to create the needed facilities and stimulate industry development. It takes years to create the needed facilities for global leading components, such as ultra-heavy forgings and turbines, and the longer it takes for South Africa to commit to the nuclear power programme, the less feasible these areas of localisation become.

It was noted that, when looking at the Korean experience, one of the key success factors was volume and consistency. Korea today operates 21 nuclear reactors, thus creating a favourable market for maintenance and local supply of nuclear components. The consistency with which the power plants were built from 1972 ensured that there is no loss of expertise, as is the case in South Africa. This highlights the importance of a fleet approach.

Other comments included that the localisation would initially add cost to the project, but would eventually show returns if a consistent local market is created. An economically viable venture must first be ensured before investment in localisation can be made, and the development of local capabilities must be such that nuclear is not over-emphasized. Thus the local developed capabilities must be able to partake in non-nuclear sectors as well. To make initial localisation efforts more viable, partnerships would a key factor.

4.2. Transformation

Eskom placed emphasis on transformation, and stated that they were pressured to implement transformation policies such as Broad-Based Black Economic Empowerment (B-BBEE). B-BBEE is a governmental socio-economic development initiative to address inequalities in the post-apartheid South African arena. This entails that black owned companies, or companies with favourable B-BBEE rating have preference during the tender process (Department of Trade and Industry, 2012). As can be seen in Table 8, B-BBEE constitutes a large percentage of the Eskom localisation scorecard, with Large Black Suppliers (LBS), Black Women Owned (BWO) enterprises and Small Black Enterprises accounting for 50%, 15% and 15% of the localisation score, respectively. The nuclear power programme represents a unique opportunity for the promotion of transformation.

The respondent stated that although transformation should be a focus area in the procurement process, it must not take priority above localisation. If there are sufficient, competent and capable local companies, transformation goals can be used as the deciding factor, but localisation and local industry development must always be the primary factor for the choice of suppliers. If only local companies that do not fulfill B-BBEE requirements are available, those companies should still be used, and partnerships with smaller black owned companies should be encouraged. This will stimulate the development of smaller black owned companies, and allow them to play a more prominent role later in the programme.

Based on this feedback, the NEPIO is amended to include a transformation officer, working with Eskom. The transformation officer is responsible for the oversight of transformation. The amended NEPIO is shown in Figure 15.

Transformation and the use of a local workforce also mitigate some of the risks associated with major projects in South Africa. Projects, such as Medupi power station, have been severely hampered by protests caused by the use of foreign workers. Issues such as these have enormous impact on the project schedule.

4.3. Revised NEPIO

Based on comment and feedback, changes to the NEPIO were made. These changes include both changes to the structure of the NEPIO, and to the roles and responsibilities.

The original proposed NEPIO was lacking in labour representation. Labour unions play a key role in the South African labour environment, and also in public perception. Transparent

communication with labour unions, proving the benefits of development of a local nuclear industry, would be key to ensuring stable provision of labour to the projects.

The NNR commented that their role in NEPIO needed to be revised. Initially, the role of the NEPIO is to ensure the creation of the needed infrastructure, including regulatory framework. Thus, the NNR can actively partake in the preparation for nuclear power programme, specifically with tasks relating to licensing and regulation.

The revised NEPIO is shown in Figure 15.

Note the inclusion of the DST and DoL. Due to the fact that NECSA is an industrial participant, its link to universities is deferred to the DST. If NECSA is to participate in supply areas other than the nuclear fuel cycle, its role as primary anchor for research and nuclear innovation should be shifted to the DST.

4.3.1. Revised NEPIO Structure

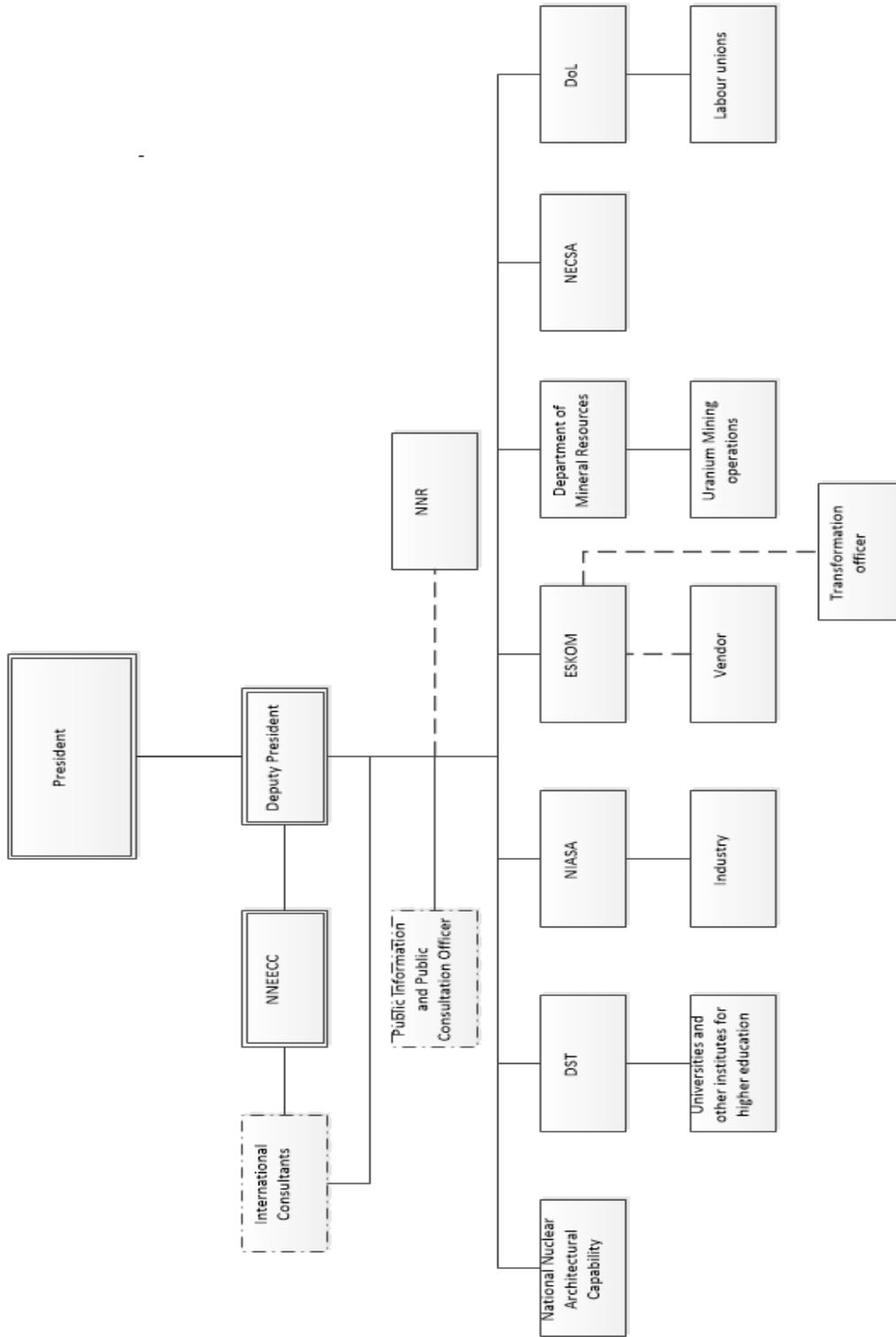


Figure 15: Revised NEPIO structure

4.3.2. Revised roles and responsibilities of organisations in the NEPIO

Changes to the roles and responsibilities based on feedback and comments are made in *Italics*. It must be noted that, although most of the feedback was used, not all comments were accepted due to impracticality, conflict with policies and other respondents.

NNEECC	NNEECC serves as the primary planning and policy decision maker. Inputs to these policies must be done via the deputy president, who serves as chairperson for both NEPIO and NNEECC. <i>International consultants must be used to ensure that the decisions made by NNEECC are on par with international best practice. It has the responsibility to co-ordinate the various governmental departments, and align government policy.</i>
International consultants	International consultants are used to review and give external assessments with regard to nuclear issues. This will give the nuclear industry access to international expertise, and ensure that the nuclear power programme is on par with international standards. The primary international consultant is the IAEA. Other international consultants may include the expertise from the chosen vendor and countries that form part of bilateral cooperation agreements. <i>International consultants will advise both NNEECC and NEPIO.</i>
Deputy President	The deputy president serves as chairperson for NEPIO and NNEECC, and thus serves as primary liaison and communication channel between NEPIO and NNEECC. This insures that the chairperson has a broad overview and understanding of the activities of both NEPIO and NNEECC, and thus assists him in decision-making and management of both. The deputy president reports directly to the president.
Public information and public consultation officer	As stated earlier in this document, one of the biggest hurdles to overcome is public perceptions and misconceptions of nuclear power. Addressing this issue is the responsibility of the public information and public consultation officer. Public consultation plays a critical role in the nuclear environment, and thus needs specialist attention. The PIPCO reports and gives inputs to NEPIO on matters regarding public perception. The PIPCO is responsible to ensure transparency and honesty in all communication with the public.

	The PIPCO serves as media liaison for NEPIO.
NNR	<i>The NNR actively takes part in activities of NEPIO, specifically regarding the creation of legislation, licensing and regulatory infrastructure. As the programme develops, the role of the NNR would shift to that of an observer and adviser. The NNR will, at all times, remain independent and impartial.</i>
NECSA	NECSA serves, as mandated in the NEP, as the anchor for nuclear research, development and innovation. Further, NECSA is directly responsible for the development of local nuclear fuel cycle capabilities. The development of these capabilities includes conversion, enrichment and fuel fabrication. If sufficient needs and benefits are identified, this development could be expanded to include reprocessing of used fuel. NECSA also assists in advanced manufacturing capability development, especially with regard to ASME III certification and nuclear quality standards. <i>If NECSA is to participate in more areas than just the development of fuel cycle capabilities, i.e. commercial manufacturing, the DST should be made the anchor for nuclear research and innovation.</i>
NIASA	NIASA serves as nuclear industry representation on NEPIO, and is the primary liaison between NEPIO and industry. NIASA, along with Eskom, is responsible for continuous benchmarking of the national nuclear industry, and is primarily responsible for identifying opportunities for nuclear development. NIASA also performs studies to help guide the development of the nuclear industry. <i>To this end, NIASA must shed its university, Eskom, vendor and government links, and represent only the industry to ensure there is no overlap of representation on the NEPIO and thus ensure balance of power.</i>
Eskom	Eskom, as owner/operator of the nuclear fleet, has a wide spectrum of responsibilities. Eskom, along with NIASA, is responsible for industry benchmarking. Eskom is also primarily responsible for supplier development and local participation, as discussed in section 3.1.2. This should be done through extensive negotiations with the vendor, and with accurate information regarding the current state of industry capability. It is

	<p>Eskom’s responsibility to include localisation and technology transfer goals in contracts, and monitor whether they are being met. <i>These goals need to be agreed upon by the vendor, and communicated to the NEPIO to ensure that the nuclear industry at large aligns itself to meet these goals.</i></p>
Vendor	<p><i>The vendor reports directly to Eskom, and Eskom shall report to the NEPIO any issues regarding localisation. Open negotiations with the vendor regarding local participation and technology transfer as the programme progresses would be crucial in successful localisation.</i></p>
Department of Mineral Resources	<p>The department of mineral resources represents South Africa’s uranium interests. The DMR is primarily responsible for uranium beneficiation, and is the primary liaison and representation for South African uranium mines.</p>
National Nuclear Architectural Capability	<p>One of the goals of the NEP is to develop a national capacity to supply nuclear equipment, reactors and components. It is not economically viable for private sector companies to invest the needed funds for the development of these specialised capabilities, and thus the national nuclear architectural capability can serve as a funding vessel for the development of specialised heavy forging and manufacturing capability. <i>Initially, NNAC will investigate the viability and feasibility of creating the aforementioned capabilities. This can only be done when a stable, consistent market has been created. The planned 9.6 GW will not be sufficient to create the aforementioned market, thus the focus of NNAC must be for a longer term than the planned programme. If found that the development of these capabilities is not viable, NNAC will be disbanded.</i></p>
DST	<p><i>The DST serves as primary liaison with the universities, and continuously communicates possible fields of needed research, and thus ensuring participation to the nuclear programme from institutes of higher education. By ensuring the participation of universities and other institutes for higher education, it creates opportunities for human resource and expertise development, and addresses skills development goals as stated in various government policies</i></p>

<i>DoL</i>	<i>The DoL serves as the primary liaison with the workers unions. The support of workers' unions will play a critical role in the successful completion of the programme. The DoL will advise, and where applicable, address any labour-related issues.</i>
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4.4. Human resource development

In section 3.3.2 it was stated that pro-active steps in human resource development need to be taken to ensure that the required development takes place. Based on feedback, Eskom has already started taking these steps.

Vendors are skeptical to invest in human resource development programmes without a clear indication from government that the nuclear programme is going to go ahead.

It was also commented that, if the effective recruitment takes place, it would not be necessary to raise the profile of nuclear, but that the flow of artisans, engineers and technicians will flow naturally to where needed. The bigger issue to address is issues regarding discipline and productivity. The average labour productivity in South Africa is much lower than that of other Organisation for Economic Co-Operation and Development (OECD) countries. South African productivity is on average 46.51% of the international standard (Moduka, Smit *et al.*, 2012). This more than doubles the local labour needs, and makes the use of local labour extremely expensive and uncompetitive.

4.5. Supply chain development and technology guidelines

In section 3.4.2 recommendations were made regarding nuclear technology transfer and industry development. It was indicated that initial focus areas for technology transfer should be the nuclear fuel cycle and nuclear critical components. Feedback from a potential vendor indicated that this was incorrect. Initial technology transfer should focus on areas with the highest potential for localisation, i.e. components that would require minimum industry development for local production. Only with very advanced manufacturing capability can nuclear-critical components be transferred, and even then it may not be possible to produce locally. The agreed maximum localisation percentage is 80%. This excludes the local production of steam generators, reactor pressure vessels and other globally leading components. Long-term partnerships will assist in the transfer of technology, and technology transfer should be agreed upon beforehand. It needs to be noted that many of the components in a nuclear power

plant are the Intellectual Property (IP) of the vendor, and will not be transferred, necessitating the need, where applicable, for local technology development.

4.6. Project management approach

Comment from a construction company stated that, for the successful realisation of the nuclear power programme, a different approach to project management and contracting needs to be followed, to ensure that the power stations are delivered on time and within budget. Reference was made to the T5 Agreement. The T5 Agreement was investigated, and although the use of the T5 Agreement as a whole might not be applicable to the South African environment, some of the principles, as discussed later, can be used. The T5 agreement is a contracting and project management approach adopted by BAA for the £4.3 billion construction of Terminal 5 at Heathrow Airport (Wolstenholme, Fugeman, *et al.*, 2008). Using principles of the T5 Agreement such as integrated teams, project culture and commitment to people, partnerships and incentive funds will assist in the successful delivery of the planned power stations. Successful delivery of the nuclear power plants would create national and international confidence, and thus stimulate localisation. Thus, these principles are discussed and modified to address localisation.

4.6.1. Integrated teams

To ensure that the projects are run by competent project managers, integrated teams can be used. These teams consist of members from various disciplines and organisations partaking in the nuclear projects, and are assembled, based on “customer products”. These teams comprise individuals with the necessary skill set for the activity at hand within the various organisations. The integrated teams are responsible for the management and final delivery of the assigned products (Wolstenholme, Fugeman, *et al.*, 2008). Eskom and/or the vendor still has a proactive leadership role, but as macro-managers rather than micro-managers.

For products with low current localisation opportunities, these teams can be used as a training ground. Companies with the potential to develop the needed capabilities locally can be included in these teams in an observational role at first, and as their capabilities develop, they can take a more prominent role within the team. This will be especially advantageous during planning and construction of the first nuclear power station.

4.6.2. Project culture and commitment to people

Companies partaking in nuclear projects are obligated to create, implement, maintain and improve cultures of quality and safety. Along with this, a culture of success must be cultivated within the organisation, where strong emphasis is placed on reaching milestones on or ahead of

schedule, and eliminating cost overruns, whilst still maintaining highest levels of quality and safety. This can be achieved by transparent, regular communication to the entire workforce, stating failures, but focusing on successes within the projects, and giving recognition to the teams and individuals responsible for those successes. Further, small financial incentives can also be used, rewarding individuals and teams, rather than the organisation at large. On-site marketing campaigns can be used to make employees aware that they are part of a historical project, creating a sense of pride, as well as communicating to employees their individual roles in the success of the project. Although difficult to legally enforce, agreements regarding this should be made prior to awarding contracts (Wolstenholme, Fugeman *et al.*, 2008).

In the volatile South African labour arena, a strong commitment to people would help mitigate risks of strikes. This can be achieved by ensuring high standards in office accommodation, the establishment of wellness facilities and continuous monitoring and, where needed, improvement of working conditions. Regular meeting and negotiations with labour unions to gauge the level of employee satisfaction will help assist in this regard.

4.6.3. Partnerships

One of the cornerstones of successful localisation is the creation of long-term, mutually beneficial partnerships, rather than the conventional view of contracted suppliers. The choice of supplier has to include the possibility for future use as supplier to another project, or for use in maintaining the supplied component/system. This creates confidence and trust between the supplier and the client. Opportunities to create international partnerships via the vendor should also be explored, thereby gradually stimulating entrance to the global nuclear market.

Win-win partnerships were also a focus area in the comments from a potential vendor. A long-term partnership for the delivery of a nuclear fleet would greatly assist in technology transfer and standardisation. Standardisation would lower costs, create familiarity with the technology and stimulate localisation.

4.6.4. Incentive fund

To assist performance management, an incentive fund should be used. This fund would be allocated to suppliers/teams/individuals that perform exceptionally. During the planning stages of the project, areas where the possibility for exceptional performance exist, must be identified, and funds allocated accordingly. By doing this, it creates a culture of excellence by leveraging commercial incentives to perform above expectation (Major Projects Association, 2007).

This principle should also be implemented on areas regarding localisation. For each project, localisation goals and targets are set (as can be seen in Tables 8 and 9) that the supplier/contractor is obligated to meet, but, when these goals/targets are exceeded, whilst still remaining within cost and schedule, the supplier/contractor can be awarded a commercial incentive. By using commercial incentives on localisation, it would help keep focus on localisation and stimulate local development.

Although the use of an incentive fund will increase the overall budget of the already expensive nuclear projects, it must be noted that the incentive fund would not necessarily be used. If companies do not perform above expectation, no incentives will be given, and in the case where performance is below expectation, resulting in projects falling behind schedule and incurring cost overruns, the incentive fund can be used to cover liabilities. The incentive fund must be stringently managed to ensure that the funds are not misused, and the allocation and use of the incentive fund must be fully transparent.

4.7. Knowledge management

The entire programme must be well-documented and recorded for future use. This includes all information regarding:

- Localisation;
- Project costs and all relevant financial information;
- Technology transfer;
- Suppliers used;
- Problems experienced.

If this system is automated and kept impartial, and by constantly monitoring the information flow between organisations, this information can be compared to documented best practice guidelines to ensure that the project is progressing according to national and international standards. This would allow the system to detect any deviation from best practice guidelines, and in so doing assist in early risk detection and mitigation, and therefore can be seen as a project assurance system. A system such as this can be compared to the “spider camera” system at a soccer game (Stoker, 2012). This system hovers above the players, monitoring the game without actively partaking in it. It knows the rules, and can immediately identify any infringements, and the parties responsible for it. Afterwards, the game can be analysed by the

teams from an overhead viewpoint, to identify areas where their game can be improved. A system such as this can, in principle, be applied to focus on localisation.

This information can be used to create South African nuclear best practice guidelines for future nuclear projects, and used as a monitoring tool to measure the overall development of the South African nuclear industry, as well as its impact on the South African economy at large. A knowledge management system will promote transparency, and information captured within this system, especially information regarding project costs should be made available, not only to those taking part in the programme, but to the general public.

At the onset of this study, certain research objectives were identified. By literature study the localisation strategy was developed, and through industry feedback, the proposed strategy was validated, and in so doing, the research objectives were addressed. Conclusions and final recommendations based on these findings are discussed in chapter 5.

5. CONCLUSIONS AND RECOMMENDATIONS

Based on the research done and feedback gathered, conclusions and recommendations can be made. These conclusions are discussed in the light of the research objectives stated in Chapter 1. Further recommendations are made concerning the localisation strategy and the implementation thereof, and finally recommendations for future research are made.

5.1. Conclusions

This study was done in such a way as to address the research objectives identified in Chapter 1. These objectives can be grouped into two distinct groups, namely objectives that are addressed by literature study and objectives that are addressed by applying information gathered in the literature study to the development of the localisation strategy. The objectives stated in Chapter 1, grouped as mentioned, are:

- Literature objectives
 - Applicable lessons learnt from past experience;
 - Case study proving economic benefits of successful localisation and nuclear industry development;
 - International recommendations addressing issues relevant to localisation;
 - Local studies addressing localisation;
 - Governmental policies addressing industry and human resource development, and the possible use of nuclear industry development to address these policies.
- Localisation strategy objectives
 - Identification of the needed human resource development, and recommendations to achieving said development;
 - Recommendations addressing localisation and industry development;
 - The structure and functions of a South African Nuclear Energy Programme Implementation Organisation.

The following conclusions are made for each of these objectives:

5.1.1. Literature objectives

5.1.1.1. *Applicable lessons learnt from past experience*

The Korean case study was investigated to use as example of past experience. The Korean localisation principles were integrated with that of other countries and authors to identify core localisation principles, and it is concluded that these principles are also applicable to the South African case. The core principles are:

- Aggressive human resource development;
- Government leadership and support;
- International co-operation.

Through the industry feedback, the relevance of these principles was verified, especially government leadership. The human resource development studies also proved the necessity for aggressive human resource development.

5.1.1.2. *Case study proving economic benefits of successful localisation and nuclear industry development*

The Korean nuclear industry is an excellent example of successful localisation, and the economic impact of localisation on the Korean economy, proving that successful localisation does hold economic benefits for the host country. Nuclear power contributes 1.3% to the Korean GDP, making it the fourth largest single contributor to Korean GDP. Further, it is shown that conventional thermal power sources would have lowered GDP by as much as 0.4%. It is concluded that successful localisation would, in a similar fashion, contribute greatly to the South African economy.

5.1.1.3. *International recommendations addressing issues relevant to localisation*

The IAEA was used as source for international recommendations. Recommendations addressing the core localisation principles identified were investigated. Although these recommendations were generic in nature, they were used as the foundation of the localisation strategy. It was found that the NEPIO played a pivotal role, not only in localisation, but in the successful realisation of a nuclear power programme.

5.1.1.4. *Local studies addressing localisation*

Local studies addressing localisation and the state of the nuclear industry were also taken into account. These studies address the capability of the nuclear industry and the needed human

resource development. These studies were used to calculate the total required human resource development for the realisation of the nuclear power programme and localisation goals. It was, however, found that there is a shortage of training facilities in South Africa that needs to be addressed urgently. The low productivity of South African labour is also extremely detrimental, and more than doubles the local labour needs. It is concluded that, if these issues are not addressed urgently, there will not be enough time for the required human resource development. Based on the studies it can also be concluded that South Africa has, at least to some degree, the capacity and capability to localise at least 30% of the first reactor, with incremental increases in local participation as the programme progresses, if the needed infrastructure is developed.

5.1.1.5. *Governmental policies addressing industry and human resource development, and the possible use of nuclear industry development to address these policies*

Governmental policies addressing industry and human resource development were investigated. It was found that the nuclear industry, if effectively developed, would address these policies. The nuclear power programme would create an estimated 32 800 jobs, thus addressing AsgiSA and skills development as stated in the IPAP. It was further found that industry development would address the CSDP, creating or developing local suppliers. Other aspects of the IPAP, as well as issues raised by the NEP, would also be addressed by localisation.

5.1.2. Localisation strategy objectives

5.1.2.1. *Identification of the needed human resource development, and recommendations to achieving said development*

Integration of the studies addressing the needed human resources resulted in an estimation of the needed yearly human resource development to not only successfully deliver the planned nuclear power plants, but also to achieve the planned localisation. It was shown that human resource development is one of the cornerstones of successful localisation, and it was found that South Africa has a shortage of skilled human resources. Aggressive development is needed, and if not prioritised, South Africa shall not be able to successfully localise.

5.1.2.2. *Recommendations addressing localisation and industry development*

Recommendations addressing localisation and industry development were made in section 3.4. It was found that 100% localisation would be unrealistic, and thus a maximum of between 75%

and 80% was used. Based on industry feedback, the incremental increase in localisation can be achieved, but local participation in the construction of the power stations is over-emphasized. Maintenance and support services pose another localisation opportunity, and must not be neglected when localisation is being planned. Furthermore, it was found that due to time constraints and economic feasibility, local development of globally leading component manufacturing capabilities is not viable.

5.1.2.3. *The structure and functions of a South African Nuclear Energy Programme Implementation Organisation*

The structure and functions of a South African NEPIO were discussed in section 3.2. It was concluded that the NNEECC does not satisfy the requirements for nuclear leadership due to a lack of industry representation. Thus, the NEPIO was structured in such a way as to align its functions to that of the NNEECC. Leadership is paramount to the success of localisation, and the proposed NEPIO with the changes based on industry feedback, encompasses the entire nuclear industry.

5.1.3. Final conclusion

Unfortunately, due to the failure of the PBMR and the first nuclear bid process, the lack of transparency in the South African nuclear industry and the mixed messages regarding nuclear in the media, industry is sceptical about the future of nuclear energy in South Africa. A major obstacle to overcome for successful localisation is to re-establish public and industry faith in the nuclear power programme. Without this, and government commitment, localisation will not take place, and a much needed development opportunity will be missed.

5.2. Recommendations

The localisation strategy was favourably received, and met with positive feedback from industry. This strategy will, if implemented effectively, contribute to the successful localisation and nuclear industry development. Through the research and industry feedback, the following recommendations were highlighted:

- Infrastructure and human resource development needs urgent attention. If development is started too late, localisation will not take place;
- Localisation needs to be driven by the government, and government commitment to the nuclear power programme is paramount to success;
- Localisation goals must be realistic and economically feasible;

- A fleet approach must be followed;
- For South Africa to fully reap the benefits of localisation, a consistent, stable local nuclear market is needed;
- Localisation is gradual a process that needs time to progress. Initial localisation goals must be such that they can be reached without any major impact to cost and schedule;
- The first two reactors must be seen as a learning experience for the South African nuclear industry, and thus localisation should not be the primary focus during construction of the first power station;
- Localisation will only be successful if localisation and industry development goals are aligned and co-ordinated. To achieve this, a well-structured leadership organisation, encompassing the entire nuclear industry is needed;
- Total localisation will not be possible in South Africa. The NEP is very ambitious in its goals, especially regarding the nuclear fuel cycle. The planned programme is too small to support the investment in the development of an entire front-end of the nuclear fuel cycle. The same can be argued for globally competitive components;
- Localisation and the development of the nuclear industry will address governmental socio-economic development goals, and will contribute to the economy of South Africa;
- Do not over-emphasise entry into the global nuclear market. First create a local market, and then the possibility of entering the global market can be investigated.

If the localisation effort is guided effectively, and the obstacles facing localisation are overcome, not only would it greatly assist in achieving socio-economic development goals, but it would once again make South Africa an international role-player in the nuclear arena.

5.3. Recommendations for further research

During the study, many other areas of research were identified. It is recommended that the following be researched:

- The feasibility of the NEP goals needs to be investigated, especially the envisioned development of the full fuel cycle;
- Investigation into the economic feasibility of the development of globally leading nuclear capabilities in South Africa;

- The development of a localisation project assurance system;
- The industry and public perception of nuclear energy, and their confidence level in the future of nuclear energy in South Africa;
- The cost and process of developing nuclear capability in local manufacturers;
- Development of a nuclear industry benchmarking tool;
- The South African nuclear readiness level with regard to embarking on a nuclear power programme.

Due to the complexity of nuclear projects, the South African government and industry must ensure that they understand the implications and requirements of a nuclear power programme. Only if all aspects of it is truly understood, can realistic localisation goals be set.

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