

Roadmap for new entrants into the South African nuclear manufacturing market

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I wish to thank our Heavenly Father who has given me the health and intelligence to do this study.

I dedicate this work to Janko van Zyl, born 26 June 2017. Thanks for sitting on my lap and help me 'type' this document. Remember, young man, 'tempus fugit'.

To my much younger study colleagues: thank you for accepting me as a fellow student (even though I am nearly twice your age). It was a privilege to experience your enthusiasm and guts.

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Yours sincerely

Rudie Theron

ABSTRACT

There are 3 opportunities for non-nuclear suppliers to become part of the nuclear supply chain in South Africa. These are the announced New Nuclear Build (although being put on hold until finalisation of the IRP 2018), life extension of Koeberg Nuclear Power Plant and maintenance at the same plant. The expectation exists that it is an opportunity to get businesses on all levels (SMME to large corporates) involved, because the total budgeted cost would be close to ZAR1 035billion.

This study determines the monetary value of localisation (the size of the local nuclear market) and how a company can become part of the nuclear supply chain.

The electricity supply of South Africa depends mainly on coal fired power stations. Other sources are solar, hydroelectricity and wind. Nuclear power makes out about 6% of the mix.

Climate change is forcing countries (including South Africa) to move to renewable energy sources. South Africa had licensed wind and solar plants and announced a New Nuclear Build (NNB) of 6 x 1600MW nuclear power stations.

The literature study covers nuclear quality and nuclear safety, as well as the responsible entities. Their requirements for a nuclear Quality Management System including applicable codes and standards have been researched. Research was done on the commercial and other role players in the SA nuclear market, because they will be either the mentors or the competition for the new entrants.

The UK NNB was studied because it followed a structured approach before announcing nuclear power plants (NPPs) to be built. The work packages of Hinkley Point C NPP were examined to establish the monetary value of each contract, and that was correlated with localisation values (%'s) from previous studies. The result is the estimated value of the manufacturing nuclear market. HPC has contracts to the value of GBP15 261m (ZAR259 437m) and an average localisation value of GBP1 254m (ZAR21 318m), being 8%. The complete NNB could be worth ZAR63 594m.

In conclusion, Quality Management is found to be the most important factor to become a nuclear supplier. A roadmap is provided describing the steps to be taken in becoming a nuclear supplier.

Keywords: nuclear, supply chain, new build, quality, codes, standards, safety, manufacturing

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ABBREVIATIONS (ENGLISH)

ABWR	Advanced Boiling Water Reactor
AHTR	Advanced High Temperature Reactor
ASME	American Society of Mechanical Engineers
ASQ	American Society for Quality
BBBEE	Broad Based Black Economic Empowerment
bn	billion (equal to 1 000 million)
BPVC	Boiler and Pressure Vessel Code (from ASME)
BUSA	Business Unity South Africa
CE	European certification marking for HSE
CI	Continuous Improvement
CIDB	Construction Industry Development Board (also 'cidb')
CMP11	11 th Meeting of Parties to the Kyoto Protocol (Dec 2015 in Paris)
CMO	Classified Materials Organisation (ASME)
CNS	Convention on Nuclear Safety
COP 21	21 st UNFCCC Conference of Parties (Dec 2015 in Paris)
CQI	Chartered Quality Institute
CRF	Water Circulation (Lubrication, Filtering and Separation)
CSDP	Competitive Supplier Development Plan
CSWG	Codes and Standards Working Group
DEA	Department of Environmental Affairs (SA)
DECC	Department of Energy and Climate Change (UK)
DoE	Department of Energy (SA)

DTI	Department of Trade and Industry (SA)
EDF Energy	A UK Energy company, subsidiary of EDF (see French abbreviations)
EN-1	Overarching National Policy Statement for Energy (UK)
EN-6	National Policy Statement for Nuclear Power Generation (UK)
ENSREG	European Nuclear Safety Regulators Group
EPR	European Pressurised Reactor (Areva design), or Evolutionary Pressurised Reactor
EPRI	Electric Power Research Institute
ESCS	Energy Security Cabinet Subcommittee (SA)
EVU	Containment Heat Removal
F4N	Fit for Nuclear
FIDIC	See French abbreviations
G8 Summit	Yearly summit for leaders of the 8 most powerful countries
GBP	British Pound Sterling (£, currency)
GDP	Gross Domestic Product
Gen IV	Generation 4
GSG	General Safety Guides (IAEA document)
GSR	General Safety Requirements (IAEA document)
HPC	Hinkley Point C (NPS under construction in the UK)
HSE	Health, Safety and Environment
HTR	High Temperature Reactor
IAEA	International Atomic Energy Agency
IEA	International Energy Agency

IEP	Integrated Energy Plan
INDC	Intended Nationally Determined Contribution
INIR	Integrated Nuclear Infrastructure Review
IPP	Independent Power Producers (that is non-Eskom, SA)
IRP	Integrated Resource Plan
ISO	Organisation Internationale de normalisation (French)
ITNS	Important to Nuclear Safety
JV	Joint Venture
KRC	Bodily Contamination and Dosimetry Control and Irradiation of Premises
KRT	Radiological Protection Measurement
ktoe	kilotonnes oil equivalent
MDEP	Multinational Design Evaluation Program
MSDG	Multistud Tensioner
MW	megawatt (power)
MWe	megawatt (electrical)
NAMRC	Nuclear Advanced Manufacturing Research Centre (UK)
NEC3	New Engineering Contract 3
NEC4	New Engineering Contract 4
NECSA	South African Nuclear Energy Corporation SOC (Ltd)
NEI	Nuclear Energy Institute (USA)
NERSA	National Energy Regulator of South Africa
NNEECC	National Nuclear Energy Executive Coordinating Committee (SA)
NIASA	Nuclear Industry Association of South Africa

NIL	Nuclear Installation License (SA)
NIPP	National Industrial Participation Plan
NNP	Nuclear Power Plant
NNPs	Nuclear Power Plants
NNR	National Nuclear Regulator (SA)
NPS	National Policy Statement
NPS	Nuclear Power Station
NPSs	Nuclear Power Stations
NQA-1	Nuclear Quality Assurance (from ASME)
NQSA	Nuclear Quality Standards Association
NRWDI	National Radioactive Waste Disposal Institute
NSQ-100	A QMS develop by NQSA
NUCLEAR AMRC	Nuclear Advanced Manufacturing Research Centre (also NAMRC)
OEM	Original Equipment Manufacturer
OHS Act	Occupational Health and Safety Act (SA)
ONR	Office for Nuclear Regulation (UK)
PER	Pressure Equipment Regulations (SA)
PRIS	Power Reactor Information System (of the IAEA)
QA	Quality Assurance
QC	Quality Control
QM	Quality Management
QMS	Quality Management System
R&D	Research and Development

RadCon	Directorate Radiation Control in the SA Department of Health
RCC-E	French nuclear construction code – Electrical
RCC-M	French nuclear construction code – Mechanical
RD	Requirements Document (from SA NNR)
REQs	Requirements (used in Figure 10)
RFI	Request for Information
RFP	Request for Proposal
RoC	Register of Contractors (cidb)
SA	South Africa
SAFARI-1	SA Fundamental Atomic Research Installation 1 (a research reactor)
SAN-Nest	South African Network – Nuclear Education, Science and Technology
SANS	South African National Standard
SANS 10227	SANS Criteria for the operation of inspection authorities performing inspection in terms of the Pressure Equipment Regulations
SANS 347	SANS Categorisation and Conformity Assessment for all Pressure Equipment
SF-1	Safety Fundamentals (IAEA document)
[sic]	'sic erat scriptum' which is Latin for 'thus it had been written'
SLR	Second Licence Renewal
SOC	State Owned Company (like NECSA and Eskom)
SOE	State Owned Enterprise (like NECSA and Eskom)
SSR	Specific Safety Requirements (IAEA document)
Stats SA	Statistics South Africa
TJ	terajoule (energy)

UCOR	Uranium Enrichment Corporation (SA)
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
US, USA	United States of America
USNRC	US Nuclear Regulatory Commission
WD	Waste Disposal
WNA	World Nuclear Association
ZAR	South African Rand (R, currency)

ABBREVIATIONS (FRENCH)

Since the EPR is of French design, a list of French abbreviations vs English abbreviations (where existing) vs English descriptions are published in a document titled 'UK-EPR Fundamental Safety Overview Chapter A, Introduction and Glossary' (Areva & EDF, 2007:22-35).

Examples:

French	English	Description
CE	CE	Conformité Européene (literally <i>European Conformity</i>)
EDF		Electricite de France
FIDIC		Fédération Internationale des Ingénieurs-Conseils
ISO		Organisation Internationale de Normalisation
PTR	FPPS/ FPCS	Fuel Pool Purification and Cooling Systems
TEP	CSTS	Primary Liquid Effluent

TECHNICAL TERMS USED IN HINKLEY C WORK PACKAGES

APA	Main Feed Pump Train (including Lubrication)
ASG	Steam Generators Emergency Feedwater System
CRF	Water Circulation (Lubrication, Filtering and Separation)
DER	Reactor Building Chilled Water Production
DEQ	Effluent Treatment Building Chilled Water Production
EVU	Containment Heat Removal
FCF	Fuel Cycle Facilities
HCB	Pre-discharge Pond
HF	Unclassified Electrical Buildings
HK	Fuel Building
HL	Electrical Building
HM	Turbine Hall
HP	Pump Station
HQ	Effluent Treatment
HR	Reactor Building
HV	High Voltage
HVAC	Heating, Ventilation and Air Conditioning
KRC	Bodily Contamination and Dosimetry Control and Irradiation of Premises
KRT	Radiological Protection Measurement
LV	Low Voltage
MSDG	Multistud Tensioner
OT	Open Tender

PB	Preferred Bidder
REQs	Requirements (used in Figure 10)
RRI	Component Cooling Water
SBO	Station Black Out
TEG	Gaseous Waste Processing
TEP	Primary Liquid Effluent
TES	Solid Waste Treatment
TEU	Non-recycled Liquid Waste Treatment
UPS	Uninterruptible Power Supply
WD	Waste Disposal

DEFINITIONS: GENERAL

Climate change (UNFCCC, 1992:2)	A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods
CO ₂ -equivalent (also CO ₂ e) (Brander, 2012)	Describes various greenhouse gases in a common unit. It signifies the amount CO ₂ that would have the same global warming effect that other greenhouse gases have. For instance, 1kg methane (CH ₄) is equal to 25kg CO ₂ e
Construction Start Date (of reactor) (IAEA PRIS, 2017:C)	It is the date when the first major placing of concrete for the base mat of the reactor building is made. From this date the reactor is under construction.
Energy intensity (EEA, 2017)	It is the ratio between the Gross Inland Energy Consumption (GIEC) and Gross Domestic Product (GDP) calculated for a calendar year.
Energy mix (planete energies, 2017)	The combination of the various primary energy sources used to meet energy needs in a defined geographic region.
Exchange rate (Investopedia, 2018)	The price of a nation's currency in terms of another currency.
Fossil fuels (planete energies, 2017)	Oil, natural- gas and coal.
Gross Inland Energy Consumption (EEA, 2017)	The sum of the gross inland consumption of the 5 sources of energy: solid fuels, oil, gas, nuclear and renewable sources
Power generation mix (planete energies, 2017)	It is the percentage of different energy sources (fossil fuels, nuclear and renewable energies) used to generate electricity.
Primary energy sources (planete energies, 2017)	It includes fossil fuels, nuclear energy, non-renewable waste and the various sources of renewable energy.
Fossil fuels (planete energies, 2017)	Oil, natural gas and coal.
Renewable energy sources (planete energies, 2017)	Wood, biofuel, hydro, wind, solar, geothermal, heat from heat pumps, renewable waste and biogas.
Wheeling (Eskom, 2017)	It is the movement of electricity between international customers through the Eskom network, without the power being available to customers on the SA grid
Overnight cost (Energy Education, 2018)	A hypothetical scenario where a power plant is built 'overnight'. It excludes the cost of interest, thus indicating the current cost of construction.
Greenpeace (Greenpeace, 2018)	Greenpeace is an independent campaigning organisation. Inter alia, they seek to end all nuclear threats.

DEFINITIONS: QUALITY RELATED

Quality (US Dept of Defense, 2003)	The composite of material attributes including performance features and characteristics of a production or service to satisfy a customer's given need.
Quality (Project Management Institute, 2013:228)	Quality as a delivered performance or result is “the degree to which a set of inherent characteristics requirements fulfill requirements”.
Quality Assurance (QA) (ASQ, 2018)	Quality assurance consists of that “part of quality management focused on providing confidence that quality requirements will be fulfilled.”
Quality Control (QC) (ASQ, 2018)	Quality Control is that “part of quality management focused on fulfilling quality requirements”.
Quality Management System (QMS) (ASQ, 2018)	“A quality management system (QMS) is a formalized system that documents processes, procedures, and responsibilities for achieving quality policies and objectives. A QMS helps coordinate and direct an organization's activities to meet customer and regulatory requirements and improve its effectiveness and efficiency on a continuous basis”.
ISO9001:2015 (ISO, 2018)	Quality Management System - Requirements
ISO19443:2018 (ISO, 2018)	QMS for “Specific requirements for the application of ISO 9001:2015 by organizations in the supply chain of the nuclear energy sector supplying products and services important to nuclear safety (ITNS)”.
NQA-1 (ASME, 2018)	The ASME Nuclear Quality Assurance is a standard providing requirements and guidelines for QA programs during the life cycle of nuclear facilities. It focuses on results, the contribution of individuals and management to achieve quality – consistent with the relative importance of the item or activity

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CHAPTER 1 – INTRODUCTION, PROBLEM STATEMENT, GOAL AND LAYOUT

1.1 Introduction

South Africa announced in 2013 that it will be building at least 6 x 1600MW nuclear power stations between 2020 and 2035. However, these plans were put on hold in August 2018, due to factors including questionable energy models, cost and financing models and anti-nuclear sentiment. This study looks at the factors that have the potential to influence the decision of new entrants to join the nuclear supply chain, should the NNB become a reality.

1.2 Structure of Chapter 1

The chapter starts with a snapshot of the South African energy picture, starting with the Energy Balance, followed by the Electricity Balance and the Nuclear Energy generation contribution, as shown in **Figure 1** below.

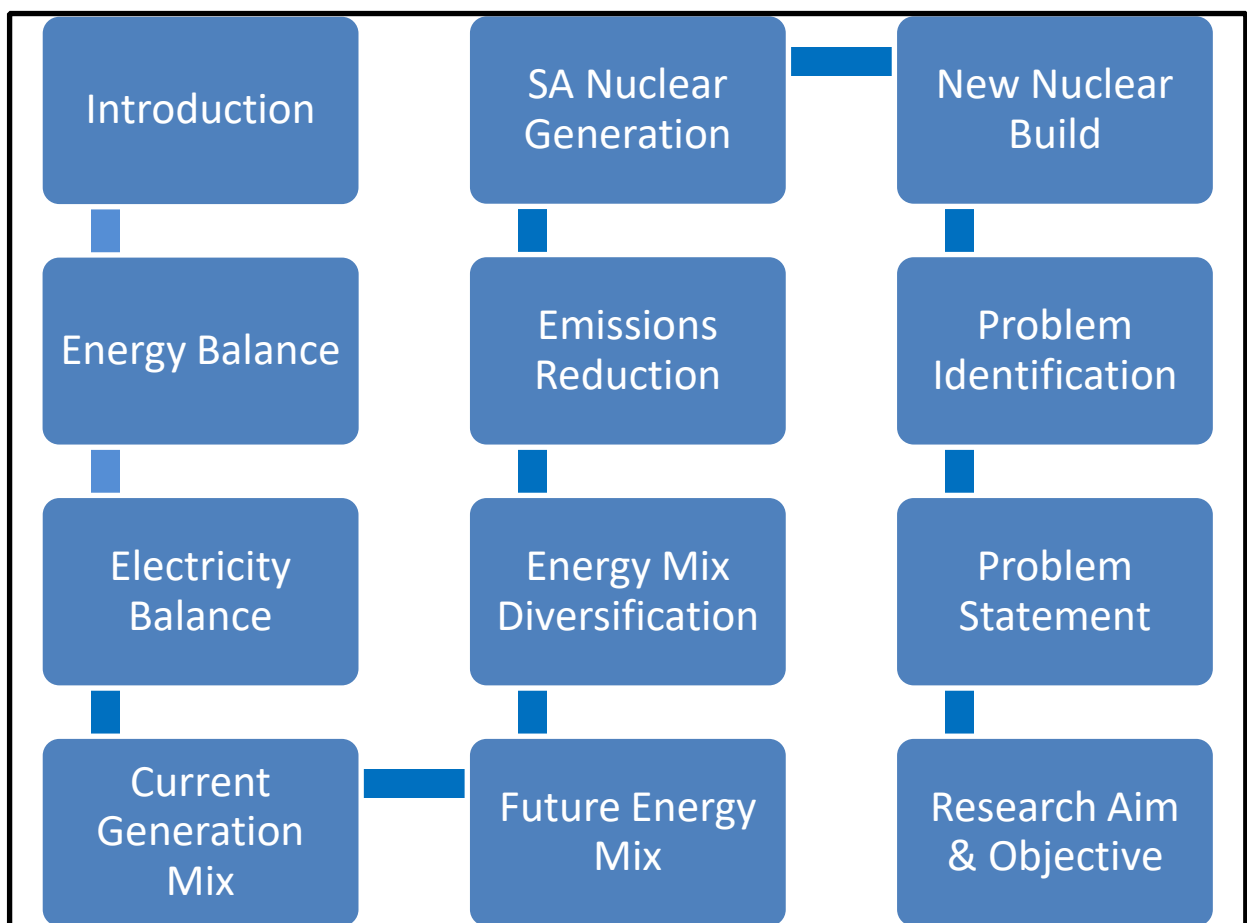


Figure 1: Structure of Chapter 1

Next are the environmental requirements to reduce emissions associated with coal fired power stations, forcing governments and power utilities to consider clean air technologies like nuclear and renewables, as components of their future diversified energy mixes.

Thirdly, the spotlight is put on SA nuclear builds, both historical and future. The historical SA nuclear builds include Koeberg NPS (2 reactors, commissioned in 1984 and 1985 respectively) and SAFARI-1, (opened in 1965) which are all still in production. Since 2010 several new nuclear builds (NNB) have been announced, but none has come to fruition yet. The most recent NNB has been announced in 2016 by the SA Government, creating the expectation of a large nuclear market (manufacturing, construction and supply of equipment and services) which would create opportunities for South African companies to participate.

This research is undertaken to determine

- the size of the potential nuclear market by analysing the work packages and costs an NPS currently under construction in the UK, and
- the requirements for the supply chain in terms of nuclear safety and quality compliances.

The result will be the list of steps that a prospective supplier needs to follow to become part of the future nuclear build.

It is important to note that the 2018 issue of the Draft Integrated Resource Plan (IRP 2018 Draft), does not mention NNB in the time window up to 2030. However, the outcome of this study will be applicable for future NNBs, life extension of KNPP and maintenance.

1.3 Energy Balance in South Africa

The International Energy Agency (IEA) published the 2015 South Africa Energy Balance on their website (IEA, 2017). It indicated the Total Primary Energy Supply (TPES) of South Africa in “kilotonnes of oil equivalent (ktoe)”.

The SA TPES consists of:

- Coal
- Crude oil
- Oil Products
- Natural Gas
- Nuclear

- Hydro
- Renewables
- Biofuel and Waste
- Nett Import/Export Electricity (NOT Generated Electricity)

The quantities for each type are given in **Table 1** on page 4.

The TPES is 142 028ktoe (indicated by 'a' in the table), with 67 236ktoe transformed (b) resulting in 74 792ktoe (c) nett available energy. For example, amongst others, 61 659ktoe of coal was transformed to generate 21 219ktoe of electricity (see the row marked with '>>' in the table). The nett available electricity was 17 068ktoe.

The data handling for the Energy balance table is beyond the scope of this study but is covered in an IEA document titled *From Basic Energy Statistics to Energy Balances* by Karin Treanton (Treanton, 2012).

South Africa Energy Balance 2015													
Items	Sub Items	Coal ¹	Crude oil ²	Oil products	Natural gas	Nuclear	Hydro	Renew-ables	Biofuels and waste	Electricity	Heat	Total ⁴	Tags
Total Primary Energy Supply		96,339	20,065	1,968	4,253	3,189	69	496	15,782	(133)	0	142,028 a = TPES	
Production		146,246	308	0	1,025	3,189	69	496	16,078	0	0	167,411	
Imports		584	19,757	10,399	3,228	0	0	0	0	1,123	0	35,091	
Exports		(50,509)	0	(3,834)	0	0	0	0	(296)	(1,256)	0	(55,895)	
International marine bunkers ³		0	0	(3,686)	0	0	0	0	0	0	0	(3,686)	
International aviation bunkers ³		0	0	(911)	0	0	0	0	0	0	0	(911)	
Stock changes		18	0	0	0	0	0	0	0	0	0	18	
Transformations		(78,050)	(20,065)	24,054	(2,510)	(3,189)	(69)	(383)	(4,225)	17,201	0	(67,236) b	
Transfers		0	(5,096)	5,454	0	0	0	0	0	0	0	358	
Statistical differences		4,825	0	13	0	0	0	0	0	0	0	4,838	
Electricity plants		>> (61,659)	0	(45)	0	(3,189)	(69)	(383)	(107)	21,219	0	(44,233)	
CHP plants		0	0	0	0	0	0	0	0	0	0	0	
Heat plants		0	0	0	0	0	0	0	0	0	0	0	
Gas works		(4,121)	0	0	0	0	0	0	0	0	0	(4,121)	
Oil refineries		0	(20,065)	19,584	0	0	0	0	0	0	0	(481)	
Coal transformation		(1,507)	0	0	0	0	0	0	0	0	0	(1,507)	
Liquefaction plants		(5,172)	5,096	0	(2,510)	0	0	0	0	0	0	(2,586)	
Other transformation		0	0	0	0	0	0	0	(4,118)	0	0	(4,118)	
Energy industry own use		(10,416)	0	(952)	0	0	0	0	0	(2,307)	0	(13,675)	
Losses		0	0	0	0	0	0	0	0	(1,711)	0	(1,711)	
Nett Available Energy		18,289	0	26,022	1,743	0	0	113	11,557	17,068	0	74,792 c = a + b	
Consumption		18,290	0	26,019	1,743	0	0	113	11,557	17,067	0	74,789 d	
Industry		11,369	0	2,318	1,741	0	0	0	2,002	10,454	0	27,884	
Transport		0	0	17,878	0	0	0	0	0	296	0	18,174	
Non-energy use		1,293	0	3,207	0	0	0	0	0	0	0	4,500	
Other		5,628	0	2,616	2	0	0	113	9,555	6,317	0	24,231	
Residential		3,463	0	572	0	0	0	0	9,555	3,222	0	16,812	
Commercial and public services		1,745	0	193	2	0	0	0	0	2,342	0	4,282	
Agriculture / forestry		340	0	1,272	0	0	0	0	0	474	0	2,086	
Fishing		0	0	98	0	0	0	0	0	0	0	98	
Non-specified		80	0	481	0	0	0	113	0	279	0	953	
Balances⁴		(1)	0	3	0	0	0	0	0	1	0	3 e = c - d	
Notes:													
Units: in thousand tonnes of oil equivalent (ktoe) on a net calorific value basis					1 000ktoe = 11 630GWh								
Note 1: The column of coal also includes peat and oil shale where relevant					Note 3: International marine and aviation bunkers are included in transport for world totals.								
Note 2: The column of crude oil, NGL, refinery feedstocks, additives and other hydrocarbons.					Note 4: Errors due to rounding in original table								
Source:					http://www.iea.org/statistics/statisticssearch/report/?year=2015&country=SOUTHAFRIC&product=Balances								
Accessed:					2017/09/19								

Table 1: SA Energy Balance 2015

1.4 Electricity Balance in South Africa

The IEA also published the Electricity Balance for South Africa, indicating all the sources and consumers of electricity. The 2015 Total Electricity Production was close to 250 000GWh (a), with Export/Export and Losses amounting close to 52 000GWh (b + d), resulting in the Nett Supply to the SA consumers of approximately 198 000GWh (reported as 198 461GWh, (e)).

These figures are reflected in Table 2 on the next page, indicating that the (electricity) Generation Mix consists of:

- Coal
- Oil products
- Nuclear
- Hydro
- Renewables and
- Biofuels.

The table also shows the Energy Consumption by various consumers classes namely:

- Industry
- Transport
- Residential
- Services
- Agriculture
- Fishing, and
- Non-allocated consumers.

The accompanying graph on page 7 (**Figure 2: SA Electricity Balance 2015**) shows the generation sources in blue, and the consumers in red.

SA Electricity Balance 2015

Generated from:		GWh
Coal		228,752
Oil		183
Gas		0
Biofuels		310
Waste		0
Nuclear		12,237
Hydro ¹		3,720
Geothermal		0
Solar PV		2,183
Wind		2,270
Total Production		249,655 a
Imports		13,059
Exports		(14,609)
		(1,550) b
Domestic supply		248,105 c = a + b
Energy Sector Own Use ²		(29,749)
Losses		(19,895)
		(49,644) d
Nett Supply		198,461 e = c + d
Consumption		
Industry	(121,562)	
Transport	(3,447)	
Residential	(37,463)	
Commercial and public services	(27,228)	
Agriculture/Forestry	(5,516)	
Fishing	0	
Other non specified	(3,245)	
		(198,461) f
Balance		0 g = e + f

Note 1: Includes production from pumped storage plants

Note 2: Includes own use by plant and electricity used for pumped storage

Source: <http://www.iea.org/statistics/statisticssearch/report/?year=2015&country=SOUTHAFRIC&product=ElectricityandHeat>

Table 2: SA Electricity Balance 2015

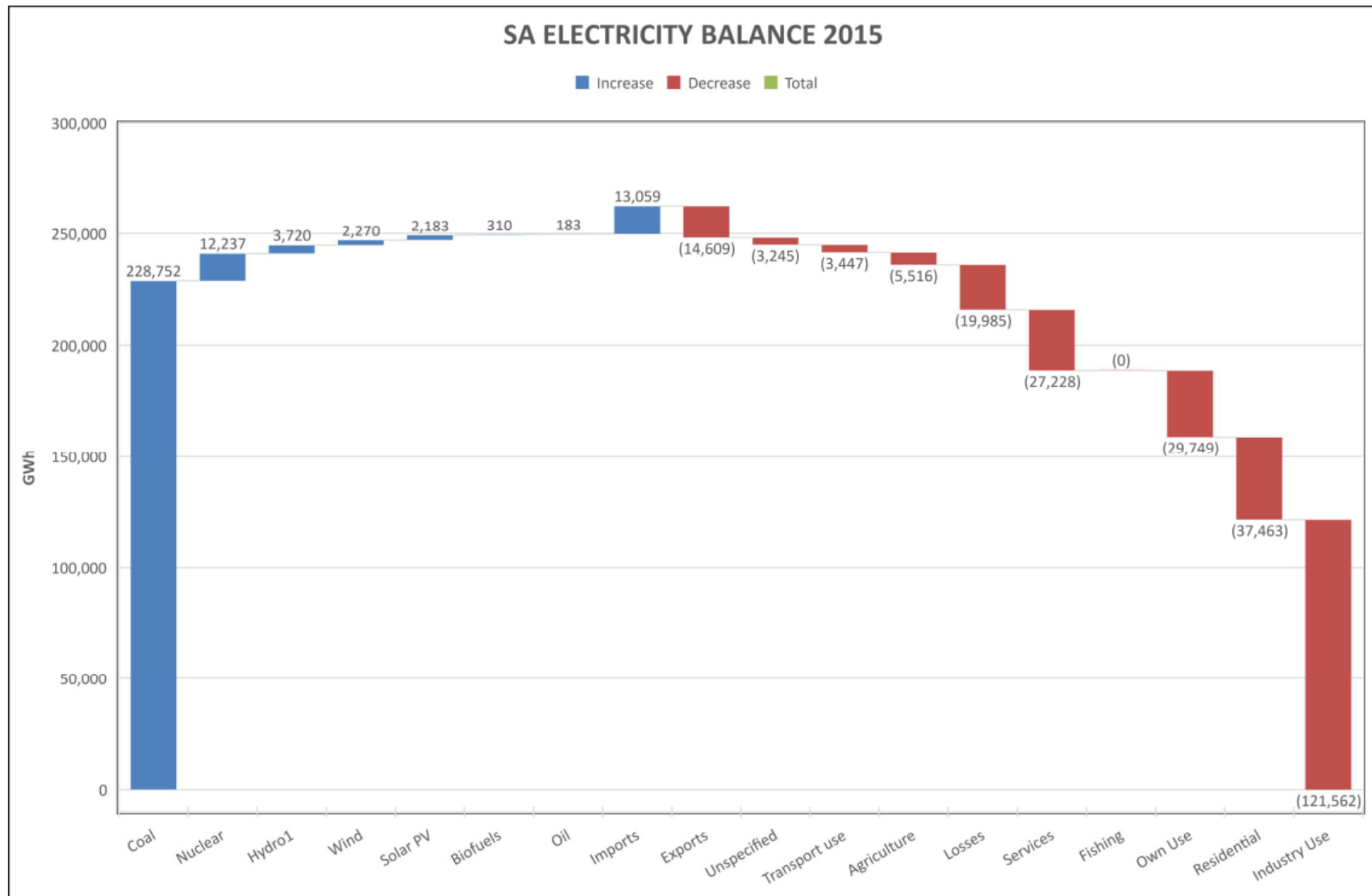


Figure 2: SA Electricity Balance 2015

1.5 SA Generation Mix

According to Eskom, it supplies approximately 95% of electricity used by the South African market (Eskom, 2017b), while IPPs supply the balance.

In Figure 3 the Total Available Electricity (bar graph) is shown together with cumulative % contribution per year of each generation source (coal, hydroelectric, pumped storage, gas turbines, wind, nuclear and IPP purchases) over the period 2005 to 2017. **Table 3** (page 9) and **Figure 3** (page 10) respectively, reflect the relative contributions (%) of each source to the yearly Total Available Electricity.

There are 14 operational Eskom-owned coal fired power stations with an installed capacity of 38 548MW (nominal 36 441MW due to ageing and auxiliary power consumption) in South Africa (Eskom, 2017:113-114). The installed nuclear capacity is 1 940MW (nominal 1 860MW). The installed capacity of other generation types (hydro, pumped storage, wind) totals to about 6 000MW, and contributions from IPPs are about 5 000MW.

From the table it is clear, that most of the electricity in SA is generated by coal fired power stations. The figures range between 93% in 2005/06 to 87% in 2016/17, with nuclear varying between 4.7% and 6.5% over the same period.

There was a rise in the IPP purchases (mostly solar and wind) from 0% in 2009/10 to 5.0% in 2016/17.

1.6 SA Nuclear Generation

All nuclear power in South Africa is generated by the Koeberg Nuclear Power Station (KNPS). As indicates in **Table 3** further on, the nuclear generation in SA for 2016/17 was 15 026MWh, about 6.5% of the total electricity generated in SA.

Worldwide, the Total Nett Electrical Capacity for all types of nuclear power stations is 393 843MW (IAEA PRIS, 2018c). The contribution of KNPS (1860MW) to this figure is 0.5%.

Eskom Generation Mix												
	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17
Source	GWh (nett)	GWh (nett)	GWh (nett)	GWh (nett)	GWh (nett)	GWh (nett)	GWh (nett)	GWh (nett)	GWh (nett)	GWh (nett)	GWh (nett)	GWh (nett)
Coal fired stations	206,606	215,211	222,908	211,941	215,940	220,219	218,210	214,807	209,483	204,838	199,888	200,893
Nuclear	11,293	11,780	11,317	13,004	12,806	12,099	13,502	11,954	14,106	13,794	12,237	15,026
Pumped storage	2,867	2,947	2,979	2,772	2,742	2,953	2,962	3,006	2,881	3,107	2,919	3,294
IPP Purchases	0	0	0	0	0	1,833	4,107	3,516	3,671	6,022	9,033	11,529
Hydroelectric	1,141	2,443	751	1,082	1,274	1,960	1,904	1,077	1,036	851	688	579
Gas turbine stations	78	62	1,153	143	49	197	709	1,904	3,621	3,709	3,936	29
Wind	3	2	1	2	1	2	2	1	2	1	311	345
Total available	221,988	232,445	239,109	228,944	232,812	239,263	241,396	236,265	234,800	232,322	229,012	231,695
Source												
Coal fired stations	93.1%	92.6%	93.2%	92.6%	92.8%	92.0%	90.4%	90.9%	89.2%	88.2%	87.3%	86.7%
Nuclear	5.1%	5.1%	4.7%	5.7%	5.5%	5.1%	5.6%	5.1%	6.0%	5.9%	5.3%	6.5%
Pumped storage	1.3%	1.3%	1.2%	1.2%	1.2%	1.2%	1.2%	1.3%	1.2%	1.3%	1.3%	1.4%
IPP Purchases	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%	1.7%	1.5%	1.6%	2.6%	3.9%	5.0%
Hydroelectric	0.5%	1.1%	0.3%	0.5%	0.5%	0.8%	0.8%	0.5%	0.4%	0.4%	0.3%	0.2%
Gas turbine stations	0.0%	0.0%	0.5%	0.1%	0.0%	0.1%	0.3%	0.8%	1.5%	1.6%	1.7%	0.0%
Wind	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
Total available	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Wheeling and Imports are excluded												
Sources: Eskom Integrated Reports for 2017, 2016 and 2015 respectively												

Table 3: SA Generation Mix

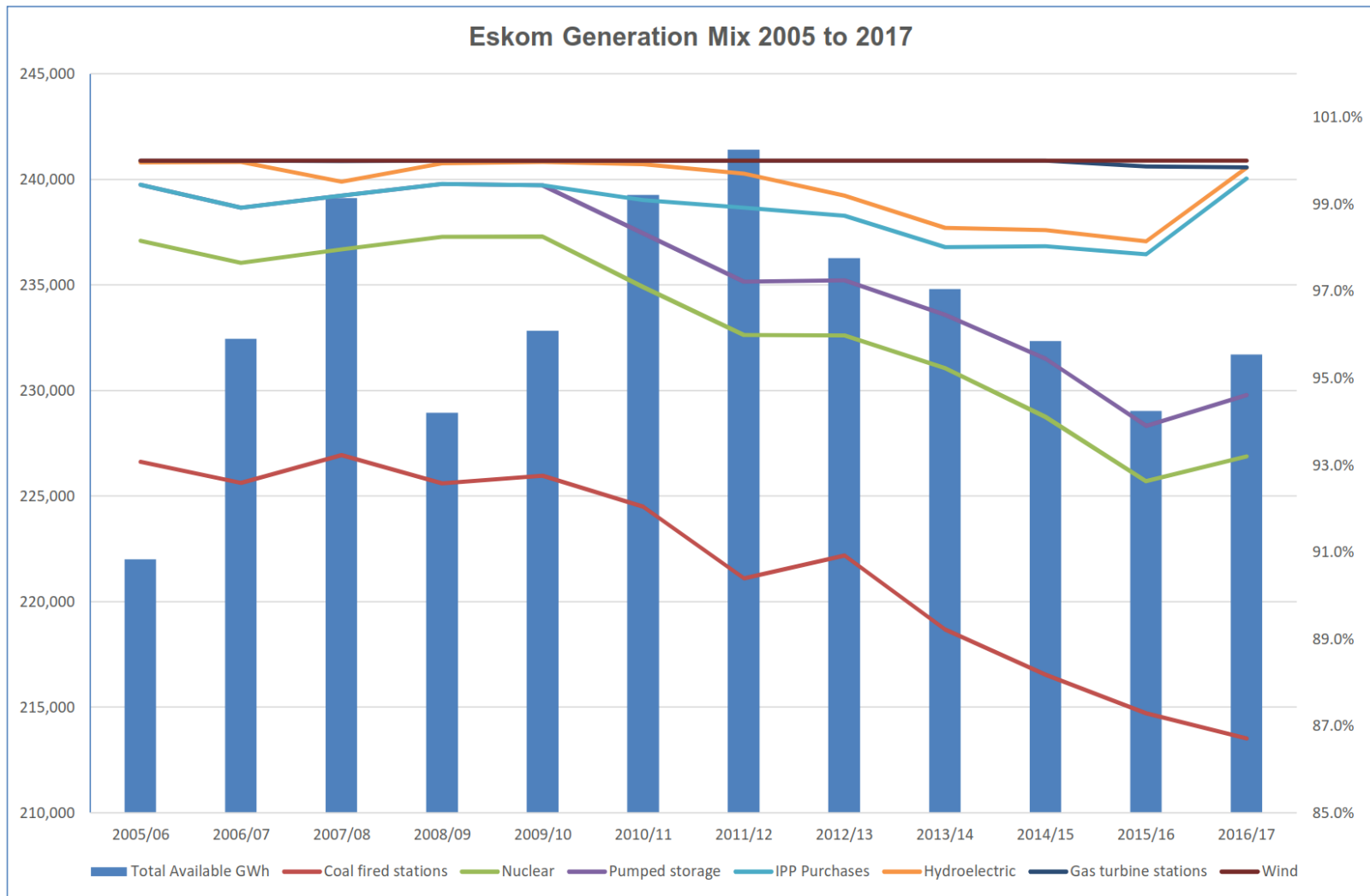


Figure 3: SA Generation Mix (based on Table 3)

1.7 Climate Change and Emissions Reduction

The COP 21 was held in Paris in 2015. The outcome was that 195 countries agreed to put actions in place to limit the global temperature rise well under 2°Celsius above pre-industrial levels. The reduction of greenhouse gas emissions was identified as essential to reach this goal (UNFCCC, 2015).

South Africa signed the Paris Agreement in April 2016 (Dept of Environmental Affairs, 2016). In a document called the INDC (Intended Nationally Determined Contribution) submitted to the UNFCCC's COP 21, South Africa inter alia committed to limit emissions during the period 2025 to 2030 to between 398 and 614 Mt CO₂-equivalent. These figures were set as the benchmark for the efficiency of mitigation actions (UNFCCC, 2015a:6).

According to the 2017 Eskom Integrated Report (Eskom, 2017:106, 119) the effect of their coal fired power stations on the environment is as listed in **Table 4** below (based on 214 121GWh, the total electricity sold).

Eskom does not yet publish the CO₂-equivalent values for its plants, since carbon budgets will only be applicable from 2020 (Eskom, 2017:127)

Type	Unit/GWh	Total in kt
Coal usage	0.53kt	113 484
Ash produced	152t	32 546
Particulate emissions	0.30t	64
CO ₂ emissions	0.99kt	211 100
SO _x emissions	8.25t	1 766
NO _x emissions	4.13t	885

Table 4: Eskom power stations emissions

1.8 Energy Mix Diversification

The effect of the Paris Agreement is the same for Eskom as for the country. Eskom reported in 2015 (Eskom, 2015:74) that their Climate Change Strategy had been put in place. One of the initiatives was to lower carbon-emission technologies through diversification of their generation mix, by purchasing renewable energy from IPPs and putting their own (Eskom) Sere wind farm (100MW) into operation

In 2016, Eskom reported that they remained under pressure to transition into a lower carbon electricity mix and reduce emissions. Eskom is not solely responsible to achieve the set targets but is dependent on the SA Government through energy regulations rulings, new build allocation, single buyer model electricity planning and price. (Eskom, 2016:67).

Carbon tax is another measure to be put in place to reduce greenhouse gas emissions by increasing the price of electricity and thereby decreasing electricity usage. In 2020 each company will receive a carbon budget based on measured values taken during 2016 to 2020. At first it will be a pilot project with companies being measured against their carbon targets but not financially penalised. However, they need to put pollution prevention plans in place (Eskom, 2016:68).

In summary, the main reason for energy mix diversification in South Africa is to reduce the use of coal as primary energy source for electricity generation to reduce carbon emissions. In other countries energy mix diversification might be done to lessen (for example) the use of nuclear power due to environmental risks or plant end of life.

Future energy planning for South Africa are addressed in inter alia the following documents:

- The Integrated Resource Plan 2010 – 2030 (Department of Energy, 2013a)
- The Integrated Resource Plan Update Nov 2016 (Department of Energy, 2016)
- The Integrated Resource Plan Draft Aug 2018 (Department of Energy, 2018)
- The Integrated Energy Plan (Department of Energy, 2012)
- The National Development Plan 2030 (National Planning Commission, 2011)

These documents contain scenarios for different type of energy mixes, with nuclear energy as a component thereof.

1.9 Future Energy Mix

In the documents mentioned above the SA Government indicated its commitment to alter the energy mix in future to reach the carbon emission targets, and to decrease the coal-based generation in favour of nuclear and renewable energy.

The IAEA states on their website that nuclear energy is expected to grow in future, because it is a substantial part of the world energy mix (IAEA, 2017).

1.10 SA Government Announced New Nuclear Builds

On 13 February 2014 Pres Jacob Zuma announced in the State of the Nation address that the Government was “to conclude the procurement of nine thousand six hundred megawatts of nuclear energy” (The Presidency, 2014).

He confirmed this in the State of the Nation addresses of 2015 (The Presidency, 2015) and 2016 respectively. In 2016 he stated that the 9 600MW would be a new build in addition to running the existing KNPS (The Presidency, 2016).

This NNB consisted of 6 x 1 600MW nuclear power stations, with the first one being connected to the grid in 2023 and the last one in 2035. See **Figure 4** on page 15.

For clarity, the abovementioned new nuclear builds (6 x 1 600MW) will be referred to as NNB1.

In November 2016 the DoE issued the IRP 2016 Update Rev1 for public comment. In this document, based on revised data, an alternative NNB was proposed. This entailed 15 x 1 359MW NPSs, totalling 20 385GW to be completed from 2037 to 2050 (NNB2) (Department of Energy, 2016). See **Figure 4** on page 15.

In December 2016, Eskom issued an RFI based on the 9 600MW NNB. Twenty-seven vendors confirmed that they would respond, but the process was halted by a court order, because the procurement processes were unlawful (Cordeur, 2017).

Eskom’s Final Environmental Impact Report received approval from the DEA in October 2017 (Dept of Environmental Affairs, 2017). This allows Eskom to develop NPSs with a total capacity of 4GW (IAEA, 2013:46) at Duynefontein, next to the existing Koeberg NPS.

In August 2018, the Department of Energy issued the Draft Integrated Resource Plan 2018 (IRP 2018 Draft), inviting interested and affected parties to comment (Department of Energy, 2018).

In this document, based on revised data, no NNB will be required before 2030.

Feedback on this document is out of scope of this dissertation due to its timing.

1.11 Cost of NNB

The costing calculations of the two possible NNBs mentioned earlier, are beyond the scope of this study, but costs published by various entities are used to determine the monetary value of the potential nuclear market.

1.12 Localisation

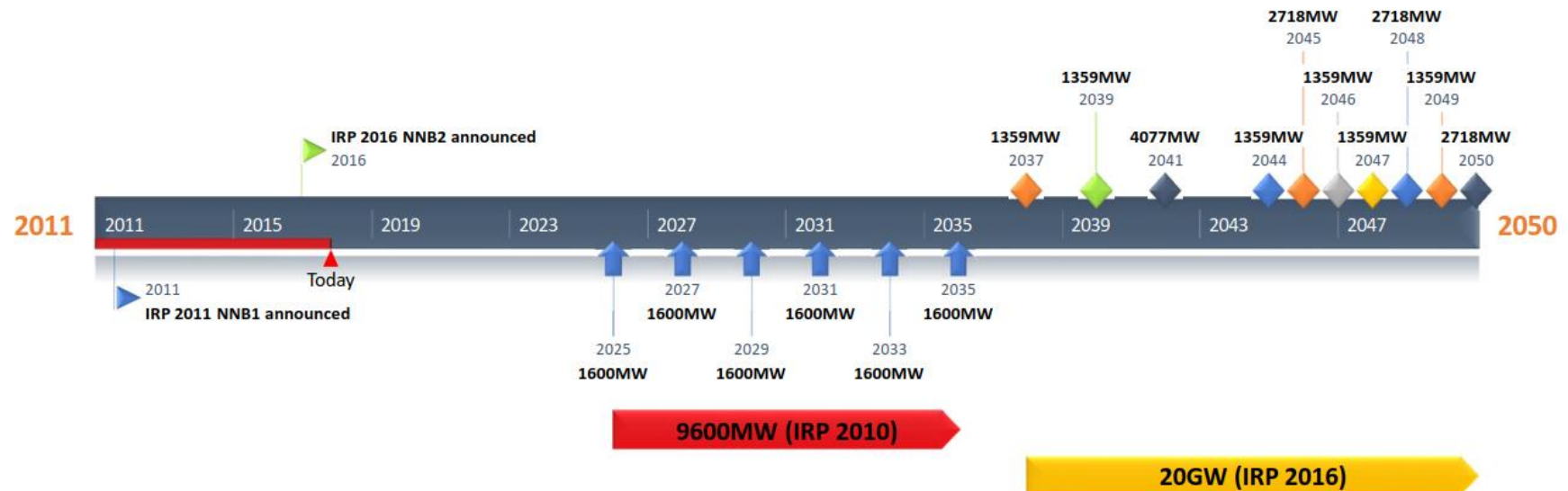
Eskom defines localisation in short as “spend on local suppliers including spend on black suppliers” (Eskom, 2011:13). Localisation can only take place if businesses exist locally that can fulfill the supply chain requirement.

1.13 Definition of New Entrant

A New Entrant (to the nuclear market) is defined as a business which will become part of the NNB supply chain for the first time.

All SA companies will be new entrants as defined above. However, there are a few companies that already render services and products to the Koeberg NPP for maintenance and improvement projects, like Lesedi Nuclear Services, Group 5 and Nuclear Consultants International. They will most probably become involved as higher tier suppliers, due to their experience on nuclear plants.

SA Proposed New Nuclear Builds



• Note: Estimated Commissioning Dates

Figure 4: SA Proposed New Nuclear Builds

1.14 Problem Identification

Given the announcements mentioned in a previous section, South Africa is now set to build either:

- NNB1: 6 x 1600MW NPPs between 2023 and 2030 in the IRP 2013 scenario, or
- NNB2: 15 x 1359MW (20 385 GW in total) from 2037 to 2050 (IRP 2016 Draft), or
- No NNB before 2030 according to IRP 2108 Draft.

When it happens, the prospect of a new market exists – a nuclear build market with a large economic impact – ZAR855billion to ZAR1 000billion. At an estimated 50% localisation, the local manufacturing market may be as large as ZAR427billion to ZAR500million.

And South African businesses indicated that they want to be involved in the NNB. In 2016, the president of the Black Business Council (BBC) said the BBC and its members were “ready to take up the opportunities that will arise from the nuclear new build programme” (Black Business Council, 2016).

But do they know what they are in for? “They” in this case does not only refer to the members of the BBC, but also to all prospect suppliers who have not been involved in the nuclear supply chain before.

Do they know what an NPP consists of in terms of the work packages that need to go out on tender? Some of the tenders will only be issued to preferred bidders, while the rest will go out on open tender.

Are they aware of the contract requirements, like NEC3 or NEC4, FIDIC or bespoke contracts?

The safety and quality requirements for manufacturing and supply of nuclear components are very strict. For example, for a USA-supplied NPP the mechanical components in the nuclear island need to comply with the ASME Boiler and Pressure Vessel Code Section III with Nuclear compliance – the so-called N-stamp. By 2017 only one company in South Africa had N-stamp accreditation, namely NECSA (ASME, 2018).

For a European NPS, the AFCEN RCC-x codes apply, with RCC-M for mechanical components, and RCC-E for electrical installations (AFCEN, 2017).

The South African nuclear quality system is based on ISO 9001:2008, with RD0034 as basis. All participating companies shall have to comply with nuclear accreditations and codes as to be determined by the NNR. That might include ASME, RCC-x, SANS, Russian, Chinese, Korean or Japanese codes and standards (National Nuclear Regulator, 2015).

South African companies have been involved in maintenance or equipment replacement projects at Koeberg over the years, but where nuclear equipment is involved, Eskom made use of OEMs like Areva in conjunction with South African companies. This is evident in the recent *PTR Tank Replacement Project* and *Steam Generator Replacement Project* where Areva, Group Five and J&J Holding formed Lesedi Nuclear Services, which is now a BBBEE company. Lesedi successfully completed several nuclear related projects mainly at Koeberg (Lesedi Nuclear Services, 2015).

The problem is identified as follows:

Depending on the monetary value of the NNB and the prescribed percentage for localisation, current non-nuclear suppliers might expect unqualified access to the supply chain by virtue of their BBBEE supplier status.

1.15 Problem Statement

The problem statement is as follows:

Only a few select South African manufacturing companies are currently able to take part in the planned new nuclear build in South Africa. The rest of the interested companies need to be guided on how to become a player in the new emerging nuclear market.

1.16 Research Aim and Objectives

The Objectives of this study is to identify the requirements (which might be possible obstacles) for manufacturing companies to participate in a nuclear build.

The Aim of the research is to propose solutions to overcome the identified barriers and turn them into opportunities for nuclear build participation.

1.17 Dissertation Contents

This dissertation consists of the following:

- | | |
|-----------|--|
| Chapter 1 | Introduction, overview, problem identification and problem statement |
| Chapter 2 | Literature studies |
| Chapter 3 | Research Methodology |

Chapter 4 Research Results

Chapter 5 Conclusion

1.18 Conclusion to Chapter 1

The researched information enabled the researcher to identify the problem, to define the problem statement and produce the research aim and objectives.

1.19 Contents of Chapter 2

Chapter 2 deals with literature studies regarding:

- Technology roadmaps
- The announced SA new nuclear builds
- Commercial nuclear activities
- Nuclear safety (SA and international)
- Nuclear quality
- Status of nuclear power stations worldwide
- NNB in UK
- Hinkley Point C costs
- Localisation,

to provide background for this study.

CHAPTER 2 – LITERATURE STUDY

2.1 Previous Chapter

The previous chapter describes the current energy supply scenario in South Africa, with coal fired sources topping the list. Carbon emissions are the main cause for climate change, and nations are forced to change their respective generation mixes to include more renewable sources, including nuclear power.

2.2 This Chapter

The use of nuclear energy is strictly governed by various nuclear authorities and international treaties to firstly ensure the safe use thereof in applications for the benefit of mankind (like nuclear medicine or generating electricity) and secondly to prevent nuclear proliferation (excessive growth in applications including the use of nuclear weapons). New participants in this industry need to take notice of these terms and conditions in order to get access to the market.

For the structure of this chapter, please refer to **Figure 5** below.

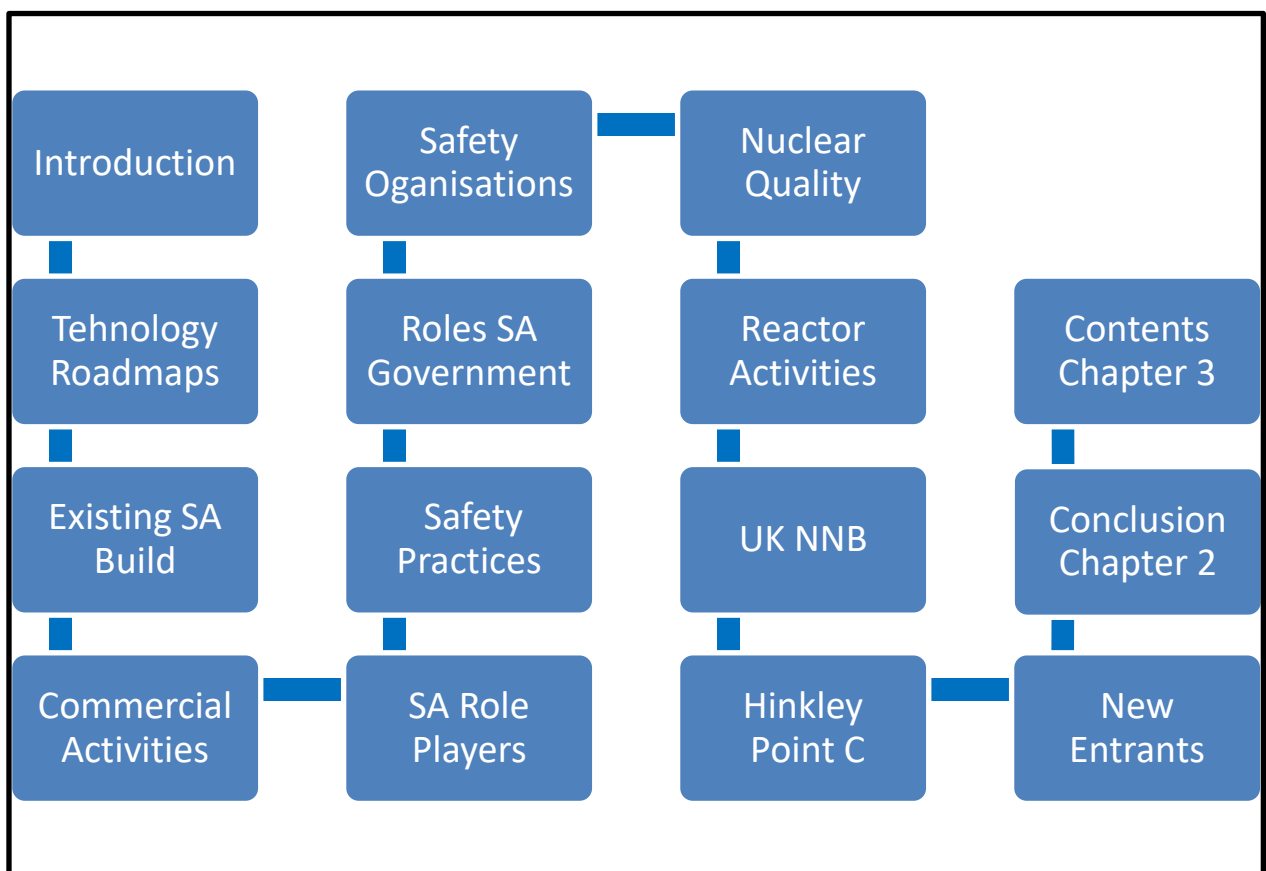


Figure 5: Structure of Chapter 2

The announced NNB will not be the first nuclear builds in South Africa. The SAFARI-1 research reactor (since 1965) and the Koeberg NPP (since 1984 and 1985 respectively) are nuclear installations that have been in operation up to now. This chapter covers their history to prove that SA has (had) nuclear build expertise (albeit that most of the nuclear gurus from the 70s had retired) and currently has operational and maintenance proficiency for the existing plants.

Nuclear safety is an international affair in the true sense of the word. This chapter touches on the safety policy roles of the IAEA, the SA Government, SA Licensees and manufacturers. Whatever happens on the highest level, filters through all levels to the lowest, including the suppliers.

Locally, South Africa has a hierarchy of role players to execute the requirements for nuclear safety. They include the commercial nuclear operators who sell products derived from the utilisation of nuclear energy, regulators to keep a watchful eye on the operators, advisory bodies for the improvement of the industry and the supply chain.

2.2.1 Scope of this dissertation

The following are included due to their impact on manufacturing

- Nuclear power generation
- the 9 600MW (NNB1) timeline and quantities
- EPR reactors
- the manufacturing supply chain.

The following are excluded (not manufacturing related)

- Military applications
- Non-proliferation
- Nuclear security

2.3 Energy Technology Roadmaps

At the G8 2008 summit, the ministers requested the International Energy Agency (IEA) to prepare roadmaps for the advancement of innovative energy technology.

The IEA describes a *roadmap* as a strategic plan describing the steps to be taken by an organisation to achieve stated outcomes and objectives. It clearly outlines the interdependencies of tasks and priorities for action on a timescale (IEA, 2014:p4).

Figure 6 on page 22 is an example of such a roadmap.

This is a very high-level document which applies to the role that governments will have to play in reaching the goal as stipulated. The researcher will present the outcome of this study in similar way.

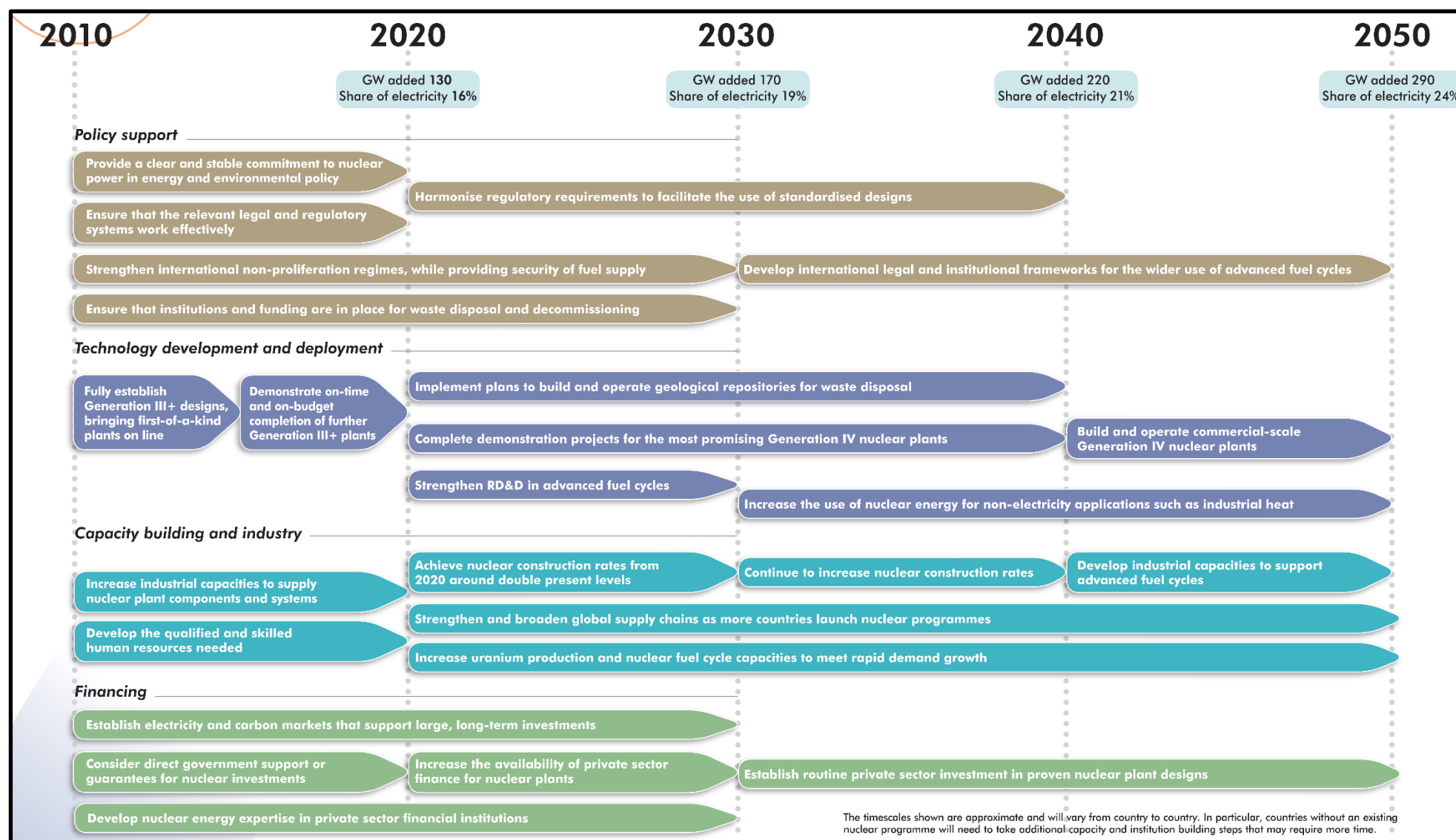


Figure 6: A nuclear roadmap

2.4 Existing Nuclear Build in South Africa

Nuclear power is supplied by the Koeberg Nuclear Power Plant (KNPP) near Cape Town. The two units of KNPP were connected to the grid in 1984 and 1985 respectively, with a total nominal output of 1 860MW (1 940MW installed). Building Koeberg was announced in 1976, but South Africa's involvement in nuclear energy went way back to the times of the Second World War.

2.4.1 SA Nuclear History

South Africa had been involved in the nuclear programmes since the 1940s. The activities included

- 1940s Supply uranium to the UK and USA
- 1950s Atoms for Peace program and founding of IAEA
- 1960s SAFARI-1 research reactor was installed and commissioned
- 1970s UCOR was established for uranium enrichment (Y-plant, Valindaba)

This included a period (1970's and 1980's) of developing nuclear weapons to provide a limited nuclear deterrent. However, State President FW de Klerk announced on 24 March 1993 the program had been halted, all weapons had been dismantled and South Africa had signed the Non-Proliferation Treaty on 10 July 1991. The IAEA verified the process by September 1991 (Stumpf, 1995).

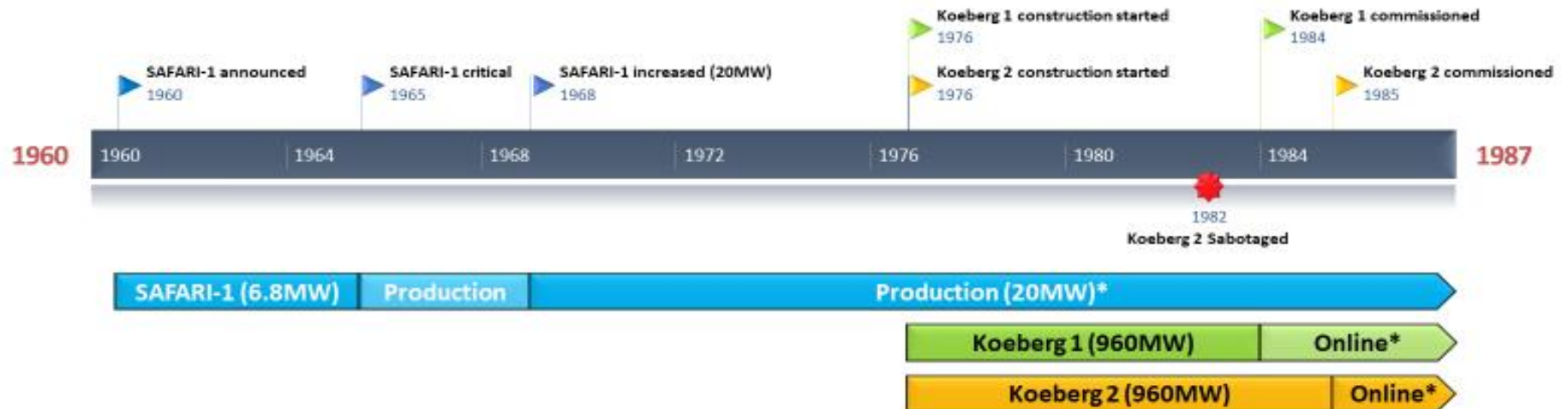
Actions regarding development and use of nuclear weapons are beyond the scope of this study.

For the peaceful application of nuclear energy and nuclear R&D in South Africa, the following are dates for existing and planned nuclear builds:

- 1965 – SAFARI-1 research reactor commissioned (6.8MW)
- 1974 – SAFARI-1 capacity increased (20MW)
- 1976 - Koeberg NPP construction started
- 1984 – Koeberg Unit 1 commissioned
- 1985 – Koeberg Unit 2 commissioned

See **Figure 7** on page 24.

SA Nuclear Builds - Existing



*Still online at time of report – Nov 2018

Figure 7: Existing Nuclear Builds in South Africa

Other previously announced builds:

- 1991 – PBMR announced*
- 2008 – Eskom Nuclear 1 announced**
- 2010 – PBMR mothballed*
- 2012 – Eskom Nuclear 1 halted**

See **Figure 8** on page 26.

Most recently announced NNBs:

- 2016 – Steenkampskraal Thorium Reactor announced
- 2017 – Eskom AHTR announced 2013 – SA Government 9 600MW (NNB1) announced
- 2016 – SA Government 9 600MW halted ^[1]
- 2016 – SA Government 20 385MW (NNB2) announced*
- 2018 - SA Government publish IRP 2018 Draft, with no reference to an NNB up to 2030

See **Figure 9** on page 27.

Only Koeberg NPP and SAFARI-1 exist - more than 40 years after their respective commissioning.

^[1] Depending on IRP 2016 Draft and IRP 2018 Draft

SA Nuclear Builds – Announced (1)

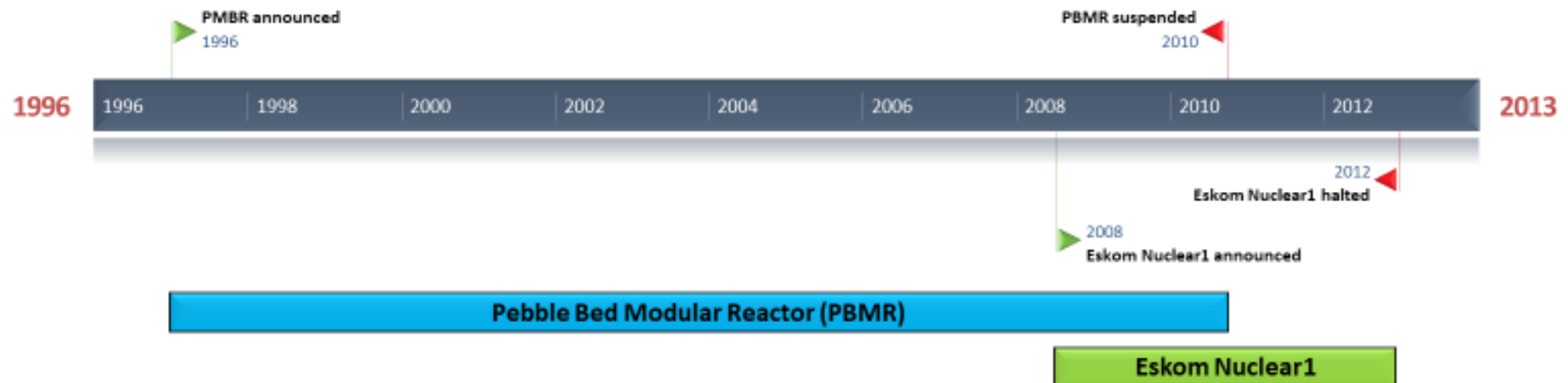


Figure 8: Previously announced builds

SA Nuclear Builds – Announced(2)

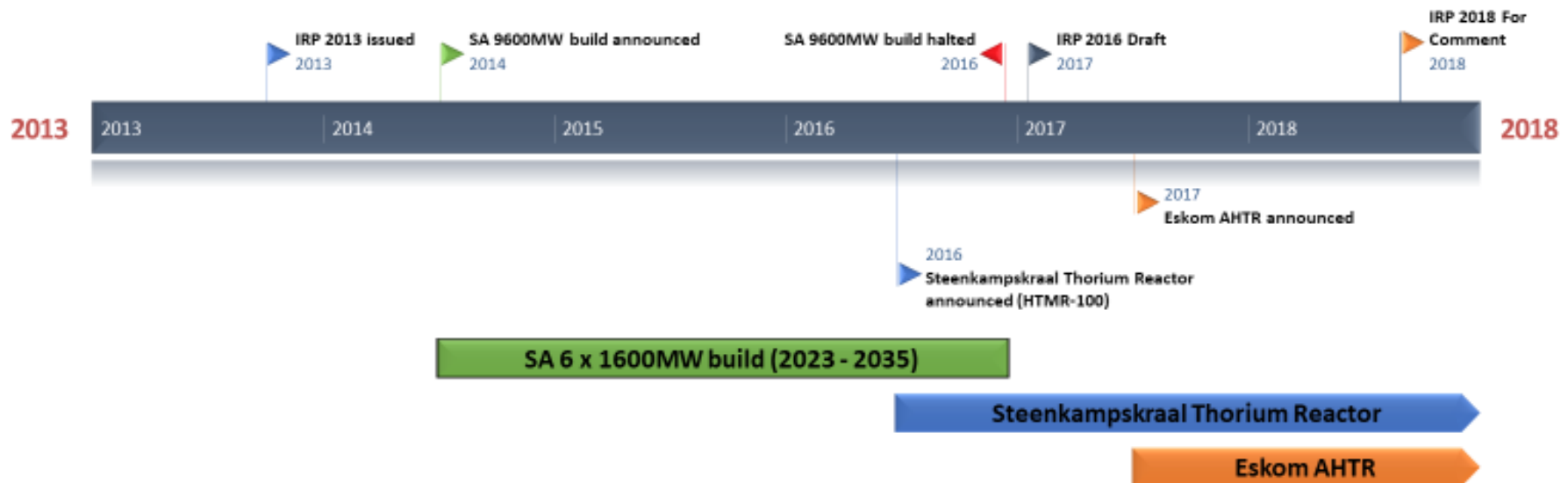


Figure 9: Recently Announced NNBs

2.5 Commercial Nuclear Activities in South Africa

Commercial nuclear activities in South Africa include the following:

- Power generation
- Research and isotope manufacturing
- Uranium mining (primary input for nuclear fuel manufacturing)
- Nuclear waste transport and storage
- Use of isotopes for medical and industrial purposes.

Nuclear power in South Africa is supplied by the Koeberg Nuclear Power Station (KNPS) near Cape Town in the Western Cape. The KNPS is owned and operated by Eskom.

Nuclear research and isotope production take place in the SAFARI-1 reactor situated at Pelindaba near Pretoria in the Gauteng Province, where NECSA is the responsible entity.

Nuclear waste is the responsibility of the National Radioactive Waste Disposal Institute (NRWDI) and NECSA (under NIL-28 issued by the NNR), with the main disposal site at Vaalputs in the Northern Cape Province.

It is reported that South Africa has the 5th largest uranium (any isotope, recoverable) reserves in the world (449 300t), whilst Australia tops the list with 1 780 800t (World Atlas, 2018). SibanyeStillwater is one of the SA uranium (and gold) producers.

2.6 Nuclear Safety Organisations

There is a worldwide network of nuclear regulatory and safety organisations, with the International Atomic Energy Agency (IAEA) serving as the umbrella organisation.

2.6.1 International Atomic Energy Agency (IAEA)

The IAEA was founded by the United Nations in 1957 (Fischer, 1997:1), with the objectives to increase nuclear use for peaceful purposes, and to prevent its use for military purposes.

As far as nuclear safety is concerned, the IAEA is authorised by its statute (Article III A 6) “to establish or adopt ... standards of safety ... and to provide for the application of these standards” (IAEA, 2016a).

Sixty years of experience and focus on continuous improvement “have led to a global recognition of the high quality and relevance of the safety standards and have generated wide interest in their

use”. Furthermore, “the principal users of IAEA safety standards are regulatory bodies and other relevant national authorities” (ENSREG, 2017).

The IAEA membership was 170 countries as of 30 April 2018 (IAEA, 2018d), with South Africa a Member State since its inception in 1956 (IAEA, 2018d), and a Board Member for the period 2018-2019 (IAEA, 2018).

2.6.1.1 The IAEA and Nuclear Safety

The IAEA Department for Nuclear Safety and Security is responsible for the Safety Standards, which address these safety components:

- SF-1: Safety Fundamentals, describing the fundamental objective, namely protection against ionising radiation
- GSR Part 1 to 7: General Safety Requirements – applicable to all nuclear activities
- SSR Part 1 to 6: Specific Safety Requirements - additionally applicable to identified nuclear activities, like Nuclear Power Plants (NPPs), Research Reactors (RR) and Radioactive Waste Disposal Facilities (WD).
- GSG: Collection of General Safety Guides – how to comply with the requirements.

2.6.1.2 SF-1 Fundamental Safety Principles

This Safety Standard (SF-1) (IAEA, 2006) sets the scene for nuclear safety. It describes the fundamental safety objective, which is “to protect people and the environment from harmful effects of ionizing radiation” (IAEA, 2006:4-5), and the ten safety principles required to accomplish the objective.

Two of the ten safety principles (IAEA, 2006:5-16) place the onus for nuclear safety firstly on the user of nuclear energy and secondly on the government of the country in which these activities take place.

2.6.1.3 GSR Part1 Governmental, Legal and Regulatory Framework for Safety

This Safety Standard dictates to countries what the nuclear responsibilities of their respective governments are (IAEA, 2016g:1).

The responsibilities and functions of a government (IAEA, 2016g:3-16) are to establish a national policy and safety strategy, a safety framework and an independent regulatory body. In addition, they are to keep to international obligations by cooperation and assistance, as well as to share nuclear experiences (operating and regulatory).

In **Figure 10** the researcher indicates how the IAEA safety requirements are applied to countries and their governments (SA as an example), by promulgating laws, founding nuclear regulators and establishing Quality Management Standards, as well as codes and standards.

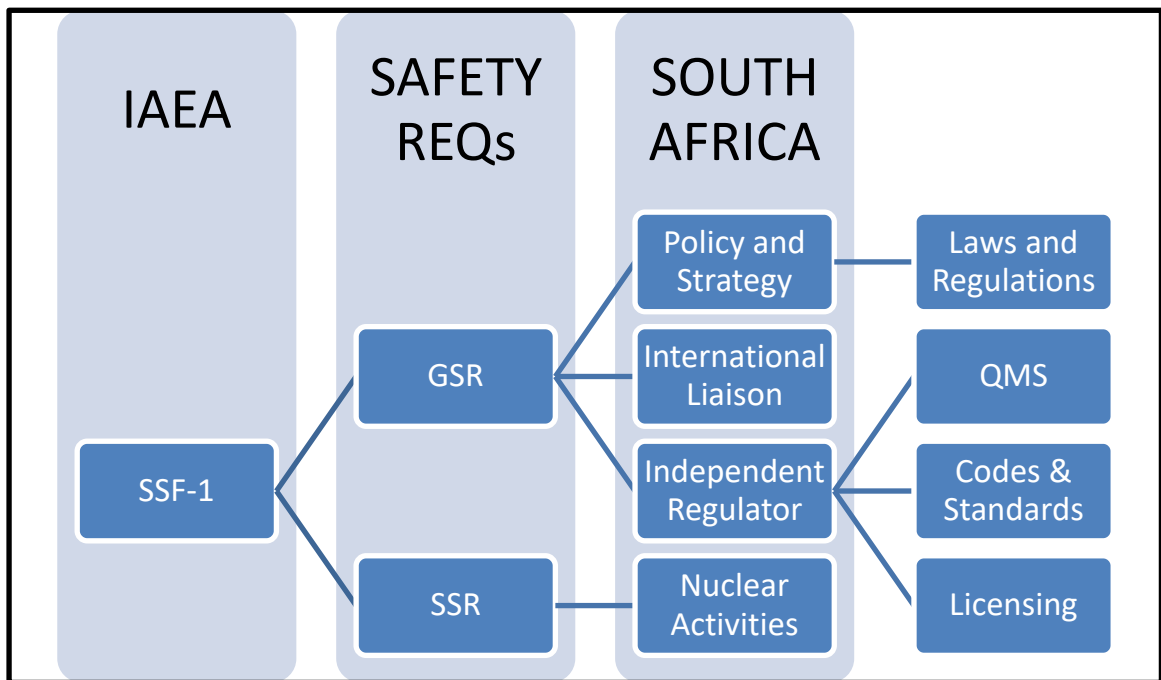


Figure 10: IAEA Safety Deployment

2.6.2 Others

Some of the other international organisations involved in nuclear matters, are:

- WANO: World Association of Nuclear Operators (WANO, 2018)
- IEA: International Energy Agency (IEA, 2018)
- OECD-NEA: Organisation for Economic Co-operation and Development - Nuclear Energy Agency (OECD NEA, 2018)
- ENSREG: European Nuclear Safety Regulators Group (ENSREG, 2018)

The Regulator of each IAEA member country has local regulatory functions, as well as international liaison regarding nuclear matters.

2.7 Nuclear Safety Role of SA Government

To conform to the IAEA safety requirements, SA had to promulgate laws in this regard. This includes the Constitution and several nuclear related acts.

2.7.1 The Constitution of South Africa

Section 231 of the SA Constitution describes how International Agreements are to be treated by South Africa (SA Government, 1997).

It states that the national executive (the Government) is responsible for negotiating and signing all international agreements. Such agreements become law in South Africa when they are enacted into law by national legislation. International agreements which had been in place before the 1997 Constitution took effect, are still binding.

Even though the IAEA statute had been signed by South Africa in 1956, the current government is still bound by it and has the obligation to fulfil the requirements thereof.

2.7.2 Nuclear Laws of South Africa

In accordance with GSR Part 1, the South African government promulgated three laws to comply, namely:

- National Nuclear Energy Act (Act 46 of 1999),
- National Nuclear Regulator Act (Act 47 of 1999), and
- National Radioactive Waste Disposal Institute Act (Act 53 of 2008)

2.7.2.1 National Nuclear Regulator Act

The National Nuclear Regulator Act (Act 47 of 1999) appointed the National Nuclear Regulator (NNR) as the highest nuclear safety authority in South Africa (South Africa, 1999b).

This act established the NNR, to regulate the nuclear activities in SA. In practice the NNR is responsible for the issue of licences for every activity relating to nuclear. Furthermore, it needs to provide applicable safety standards and regulatory practices to protect people, assets and the environment (South Africa, 1999b).

Figure 11: SA Nuclear Safety Hierarchy on page 33 shows the safety hierarchy in SA. Only the standards required for manufacturing of nuclear equipment are indicated (last column).

2.7.2.2 National Nuclear Energy Act

The **National Nuclear Energy Act (Act 46 of 1999)** (South Africa, 1999a) established the SA Nuclear Energy Corporation Limited (NECSA) and its management structures.

NECSA (a state-owned company, SOC) is to:

- Ensure that the necessary measures are put in place for SA to adhere to the IAEA Nuclear Non-Proliferation Treaty
- Regulate the procurement (export and import) and ownership of nuclear fuel, related nuclear material and equipment, as such that SA complies with international requirements.
- Prescribe the handling and storage of radioactive waste and irradiated nuclear fuel
- Provide for incidental matters.

It also has a commercial role in the nuclear market as described in Section 2.9.5 of this document.

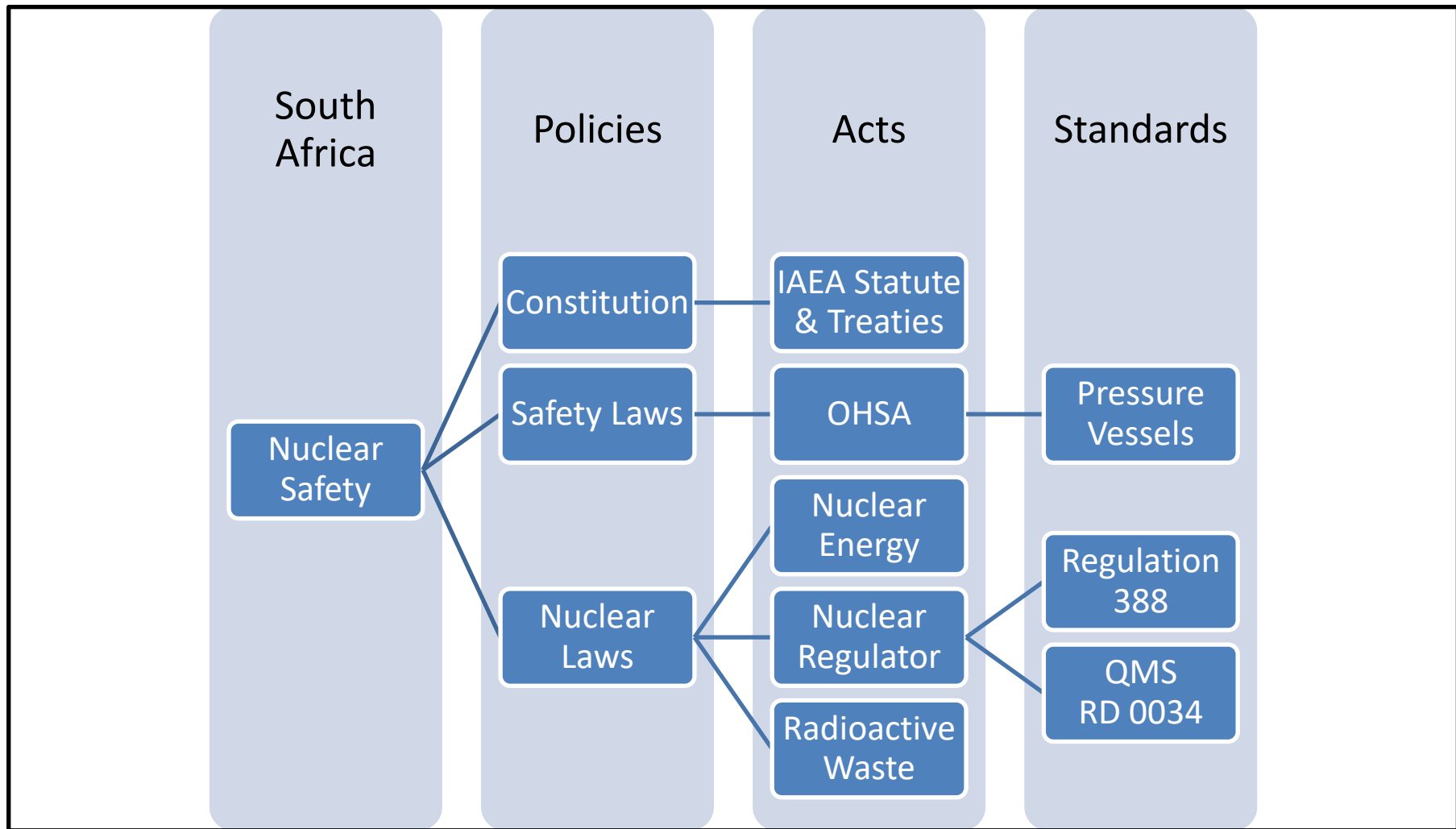


Figure 11: SA Nuclear Safety Hierarchy

2.7.2.3 South African Nuclear Regulations R388

To enforce the Safety Standards and Regulatory Practices referenced in Articles 36 and 47 of the National Nuclear Regulator Act, the Minister published Regulation 388 in the Government Gazette 28755 on 28 April 2006.

Among regulations regarding inter alia licensing, dose limits, etc. it is stated in Section 3.4 that “installations, equipment or plant requiring a nuclear installation license, a nuclear vessel license or certificate of registration and having an impact on radiation or nuclear safety, must be designed, built and operated in accordance with good engineering practice” (South Africa, 2006)

Section 3.10 stated that “a Quality Management programme must be established, implemented and maintained in order to ensure compliance with the nuclear authorisation”.

To comply with R388 Section 3.10 mentioned above, the NNR issued RD0034 Quality and Safety Management Requirements for Nuclear Installation (NNR, 2008). This describes the QMS requirements, prescribed in GSR3 Part 1, for SA nuclear activities.

2.7.3 Other SA Safety Laws

Another law that has an impact on nuclear safety is the Occupational Health and Safety Act together with the Pressure Equipment Regulations.

2.7.3.1 Occupational Health and Safety Act

The main purpose of the Occupational Health and Safety Act (Act 85 of 1993) as amended, is to inter alia provide for

- “the health and safety of persons:
 - at work
 - in connection with the use of plant and machinery,”
- “the protection of persons other than persons at work against hazards to health and safety arising out of or in connection with the activities of persons at work.”

The OHS Act provides the minimum conditions for health and safety that are to be provided at the workplace. (South Africa, 1993).

2.7.3.2 Pressure Equipment Regulations

The OHS Act Pressure Equipment Regulations (PER) apply to “the design, manufacture, operation, repair, modification, maintenance, inspection and testing of pressure equipment with a design pressure equal to or greater than 50 kPa in terms of the relevant health and safety standard incorporated into these Regulations under section 44 of the Act” (South Africa, 2009).

In 2017 the Department of Labour published *Guidance Notes to Pressure Equipment Regulations July 2009 Rev 2* (South Africa, 2017). The aim of this document is to assist in the understanding and implementation of the PER.

These regulations also contain references to relevant international manufacturing codes and standards like ASME, CE and SANS.

2.7.4 Other NNR Documents

The NNR issued various documents regarding nuclear issues. In addition to RD-0034 already mentioned, three more are related to this study, namely:

- RG-0012: Interim Guidance on Construction Management (NNR, 2018a),
- PP-0012: Manufacturing of Components for Nuclear Installations (NNR, 2018b), and
- PP-0016: Conformity Assessment of Pressure Equipment in Nuclear Service (NNR, 2018c)

2.7.4.1 Construction Management

In Section 7.6 of RG-0012 the NNR provides guidance on *Management of Suppliers and the Supply Chain*. It covers the requirements for the procurement of products, the selection of and supervision of suppliers and quality management.

Section 8.1.3 *Starting Component Manufacturing and Preparing the Site Before the Granting of a Construction Licence* covers preconditions of manufacturing., which are in addition to complying with the management system and process compliance.

Section 12 *Mechanical – Pressure Vessels and Piping* describes mechanical work packages (like turbo generator, reactor, steam generators), HVAC packages and piping packages. Section 12.2 is dedicated to requirements for pressure vessels.

2.7.4.2 Component Manufacturing

PP-0012 describes laws and regulations applicable to nuclear component manufacturing of Long Lead Items (before issuance of the Construction Licence). It covers the pre-conditions for authorisation to manufacture, as well as Supplier and Component Qualification. It also states that the NNR will do inspections and audits on all levels of manufacturing.

2.7.4.3 Pressure Equipment

With PP-0016 the NNR dedicates a whole document on the Conformity Assessment of Pressure Equipment (PE). It describes applicable laws and regulations like SANS 347, PE Regulations and SANS 10227. Finally, it covers the application of design codes and standards (ASME BPV, RCC-M and NNR Requirements for Quality and Safety Management).

2.7.5 Conclusion on Safety Role of the SA Government

The SA Government fulfils its obligation for nuclear safety as prescribed by the IAEA by promulgating laws and regulation.

2.8 SA Nuclear Safety in Practice

As stated before, the NNR is responsible for nuclear safety in South Africa and must report nationally (NNR Annual Report) and internationally (Commission of Nuclear Safety, amongst others). South Africa also undergoes audits and/or reviews by international bodies. An Integrated Nuclear Infrastructure Review (INIR) was carried out in 2013.

Some of the reports are described below.

2.8.1 NNR Yearly Report

The NNR *Annual Report 2015-2016* is the latest published report, consisting of 152 pages (NNR, 2017).

In addition to Corporate matters (including structure, goals, finances, risk assessments, etc), it reports in detail on the nuclear installations under NNR control - Koeberg, Necsa and Vaalputs respectively.

The Koeberg report mentions that Eskom has an inspection programme to ensure it complies with its NIL conditions. The NNR in turn does independent inspections as proof of the Koeberg NIL compliance.

The report provides feedback on:

- Occupational exposure to radiation, projected public exposure and dose from effluent discharges (both gaseous and liquid)
- Nuclear Safety items:
 - Fukushima requirements
 - PTR Tank Replacement Project
 - Long Term Operations Project
 - Spent fuel dry storage
 - Structural integrity of containment structures
- Operator workforce competent and sufficient to work safely
- Safe transport of nuclear material
- Safety regarding radioactive waste
- Environmental protection
- Nuclear emergency planning and preparedness
- Physical security
- Reporting of nuclear incidents and/or accidents
- Compliance inspections by the NNR
- Warnings and directives to suspend activities as issued by NNR
- Appeals to the Chief Executive Officer

The detailed Koeberg feedback is to be found in the report (NNR, 2017a:53-66).

The sections on NECSA Pelindaba and Vaalputs are structured in a similar way.

2.8.2 The SA Report to the Convention on Nuclear Safety (2016)

South Africa also reports on nuclear safety to more than one international forum. One of them is the IAEA Convention on Nuclear Safety (CNS). The latest one was held in 2017, where the SA National Report (NNR, 2016) was presented. One of the objectives of the Convention as stated in Article 1 is to:

“Achieve and maintain a high level of nuclear safety worldwide through the enhancement of national measures and international cooperation including, where appropriate, safety-related technical cooperation.”

This report is too comprehensive to cover in this dissertation. An extract of the topics covered, are:

- Existing nuclear installations (Koeberg)
- Legislative and regulatory framework (SA Government)
- Regulatory Body (National Nuclear Regulator, NNR)
- Responsibility of the license holder (Eskom)
- Priority to Safety
- And more.

This report reflects all the nuclear related activities that took place during the reporting window.

2.8.3 Integrated Nuclear Infrastructure Review (INIR 2013)

On South Africa's request, the IAEA performed an Integrated Nuclear Infrastructure Review (INIR) in early 2013. SA had been the first IAEA member with an operational NPP to request an INIR, to establish the status of its nuclear power infrastructure for NNB.

The INIR mission evaluated the progress on the nineteen infrastructure topics as per the "Milestones in the Development of a National Infrastructure for Nuclear Power", IAEA Nuclear Energy Series No. NG-G-3.1, to identify areas needing improvement to reach the respective milestones in the building of national infrastructure in South Africa; and to provide recommendations and suggestions regarding infrastructure development.

The INIR noted strengths in several nuclear infrastructure areas supporting both the current and planned new build. But it also found that SA still "has work to do before it will be ready for to invite bids for new build."

The team also made 10 Recommendations and 11 Suggestions in the following key areas to enhance the South Africa's infrastructure development (IAEA, 2018):

- Amendments to the relevant legislation, especially the NNR Act to be completed and promulgated
- The Regulatory Framework should be enhanced
- Finalise the Contracting Strategy for the NNB
- The need for an integrated approach to Human Resource Development in the NNB

The researcher could not find any official progress feedback to the IAEA in response to the findings. For example, the NNR Act has still not been amended.

2.8.4 Conclusion on Nuclear Safety in Practice

Section 2.8 covers examples of various actions taking place in reporting on the status of nuclear safety, both internationally and in SA.

2.8.5 Conclusion on Nuclear Safety

Nuclear safety is paramount. Safety shall be engineered into the design of any nuclear equipment, which directly dictates the quality of manufactured products.

2.9 SA Nuclear Market Role Players

There are other entities in South Africa which are relevant in the SA nuclear market. These include the SA Government, nuclear licensees, Koeberg, OEMs, specialist manufacturing and maintenance businesses, nuclear interested bodies (like NIASA) and training facilitators (like SAN-NEST).

On the other end of the spectrum is the anti-nuclear lobbyists including, but not limited to, Greenpeace, Earthlife Africa and the South African Faith Communities Environment Institute.

See **Figure 12** and **Figure 13**, respectively.

2.9.1 SA Government

In addition to making the required laws as described in the previous section, the Government is an active role player in the nuclear market in the country and is responsible for the nuclear policy and funding.

The national nuclear energy policy provides for an energy mix with a larger nuclear energy component. The policy is founded upon the Integrated Energy Plan for the Republic of South Africa (2003), the White Paper on Energy Policy for the Republic of South Africa (2008), and the Nuclear Energy Policy and Strategy for the Republic of South Africa (2008).

The SA nuclear policy is aimed at the advancement of energy diversification and security of supply, best utilisation of the country's uranium resources, visible contribution to economic growth, technology and infrastructure expansion, job creation, and skills development (NNR, 2016:8).

The Government also published other planning documents (following below) to support its energy drive, and each one has a reference to nuclear energy expansion.

2.9.1.1 The Integrated Resource Plan 2010-2030

The IRP 2010 was promulgated in the Government Gazette of 6 May 2011 as Regulation R400 of the Electricity Regulation Act No 4 of 2006 (South Africa: , 2011). The report was updated in 2013 (Department of Energy, 2013a).

In the report, different scenarios were examined to determine the optimal energy mix. One of the scenarios included a nuclear fleet of 6 x 1 600MWe (total 9 600MWe) nuclear power plants (NNB1) (Department of Energy, 2013a:62).

In 2016 the DoE put the IRP out for revision, with public consultation. The nuclear scenario had been changed to 20 385MWe by the year 2050 (Department of Energy, 2016:26). (This revision was commented on but has not been finalised yet).

In August 2018 the DoE published IRP 2018 Draft, awaiting public feedback by 25 October 2018. In this revision no mention is made of additional nuclear power in the period up to 2030.

2.9.1.2 National Development Plan 2030

On 19 February 2013 the Government published the *National Development Plan 2030* (NDP2030) which contained references to a diversified energy supply by the year 2030, including nuclear energy.

The document states: “While some of these issues were investigated in the IRP, a potential nuclear fleet will involve a level of investment unprecedented in South Africa. An in-depth investigation into the financial viability of nuclear energy is thus vital. The National Nuclear Energy Executive Coordinating Committee (NNEECC), chaired by the Deputy- President, will have to make a final “stop-go” decision on South Africa’s nuclear future, especially after actual costs and financing options are revealed” (National Planning Commission, 2011:172)

2.9.1.3 Integrated Energy Plan

The Integrated Energy Plan (IEP) was issued in 2012. “The purpose and objectives of the Integrated Energy Plan (IEP) are anchored in the National Energy Act, 2008 (Act No. 34 of 2008). Integrated energy planning is undertaken to determine the best way to meet current and future energy service needs in the most efficient and socially beneficial manner” (Department of Energy, 2012:5).

The IEP states that the “optimal use of energy may at times require a shift in the use of a particular energy resource. For example, with the challenge of carbon emissions related to the use of coal in the generation of electricity, alternative supply options such as renewable and nuclear energy should be considered, as they provide a cleaner source of energy” (Department of Energy, 2012).

2.9.2 National Nuclear Energy Executive Coordinating Committee

In the Nuclear Policy document, it was stated that a “National Nuclear Energy Executive Coordination Committee, which shall ensure implementation and exercise oversight over all aspects of this nuclear energy policy implementation shall be formed, appropriately structured and funded” (Department of Minerals and Energy, 2008:22)

On 9 November 2011 the “Cabinet approved the establishment of the National Nuclear Energy Executive Coordination Committee (NNEECC) to implement a phased decision-making approach to the nuclear programme. Cabinet further approved the establishment of the nuclear energy technical committee (NETC) to support the NNEECC” (SA Cabinet, 2011).

However, in 2015 State President Jacob Zuma announced that “the NNEECC had been converted into the Energy Security Cabinet Subcommittee (ESCS) responsible for oversight, coordination and direction for the activities for the entire energy sector. This committee reports to Cabinet and its proceedings and documents are classified under the Minimum Information Security Standard Act (MISS Act) as TOP SECRET. As a result, I am unable to share the agenda and minutes of the meetings held by the Energy Security Cabinet Subcommittee” (The Presidency, 2015).

The result was that no information on the new nuclear build was made available – not even to Parliament.

2.9.3 Eskom

In addition to NECSA, Eskom is the other main user of nuclear energy in South Africa through its Koeberg Nuclear Power Plant.

Eskom (originally known as the Electricity Supply Commission) was established in 1923 by the Electricity Act of 1922. Koeberg construction started in 1976 and the two 900MW units were connected to the grid in 1984 and 1985 respectively.

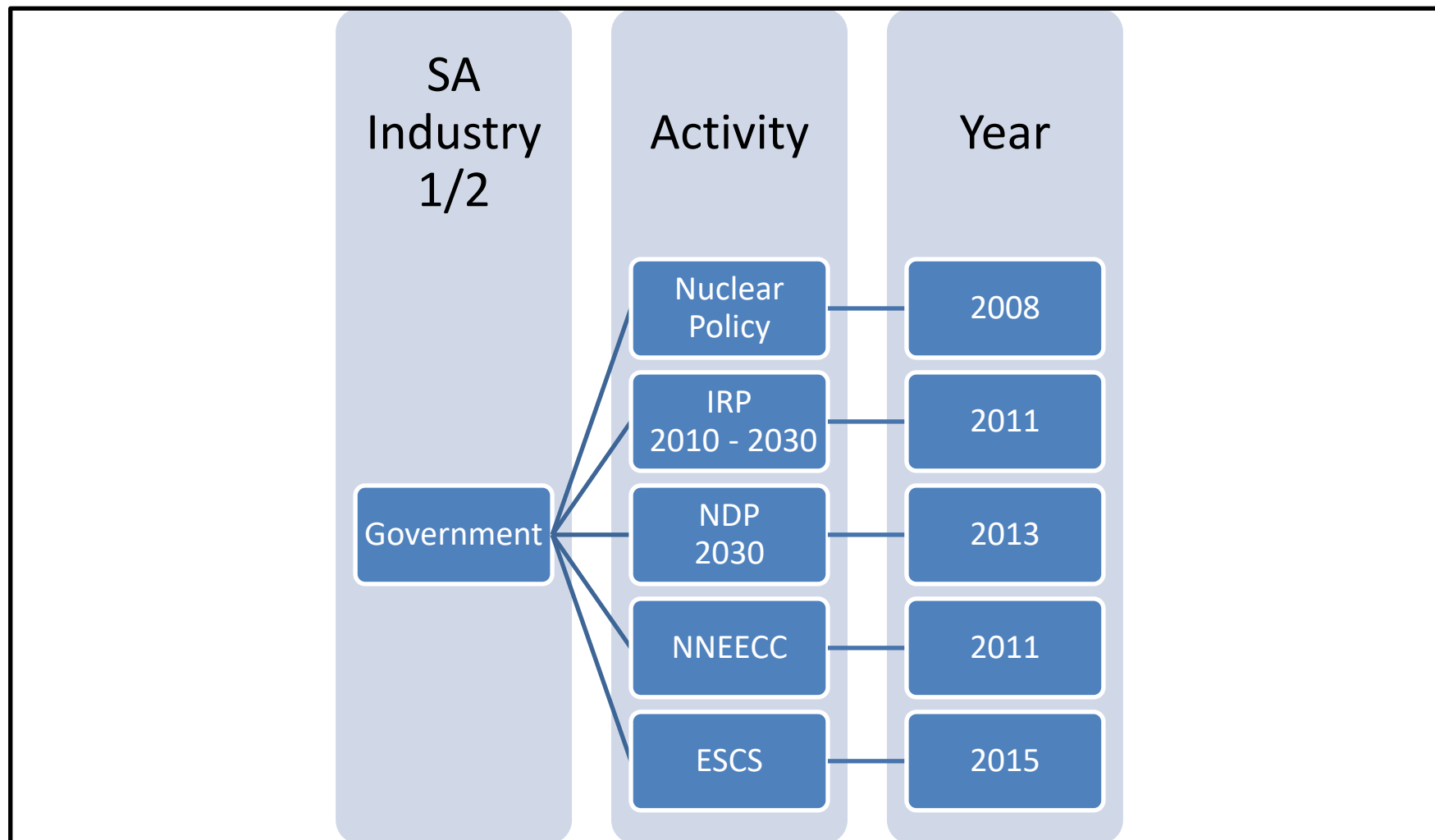


Figure 12: SA Nuclear Market (1 of 2)

The NNR has issued Koeberg with a Nuclear Installation License (NIL 01). According to the NNR Act, Section 21(1) a NIL is required for “any person wishing to site, construct, operate, decontaminate or decommission a nuclear installation” (South Africa, 1999b). A “nuclear installation” per definition includes a nuclear reactor (fission or fusion) and spent fuel storage facility, both of which are present at Koeberg.

The responsibilities of Eskom as a licensee regarding public safety, financial stability, nuclear damage responsibility and inspections are described in the same act.

2.9.3.1.1 Eskom as Nuclear Procurer

The SA Government issued a Section 34(1) determination in December 2016 (South Africa, 2016), stating that SA needs to procure 9 600MW of nuclear energy through a “fair equitable, transparent, competitive and cost-effective tender process”, also allowing for private sector participation. The timeline of the nuclear programme shall be aligned with IRP 2010-2030 (or as updated).

As a result, Eskom Holdings (SOC) Limited or its subsidiaries was appointed as the NNB procurer.

2.9.4 National Energy Regulator of South Africa (NERSA)

NERSA through the Electricity Regulation Act (2006) (South Africa, 2006) governs Eskom (and other electricity suppliers) by issuing licenses and regulating the way in which generation, transmission, distribution, trading and the import and export of electricity takes place. These activities are outside the scope of this study.

2.9.5 NECSA

According to their website (Necsa, 2016), NECSA does on the one hand R&D on nuclear energy and radiation sciences and technologies.

On the other hand, NECSA is also a business entity being responsible for the maintenance and operation of the SAFARI-1 Research Reactor at Pelindaba, manufacturing of and dealing in isotopes for use in health care, science and industry.

In addition, NECSA manages and operates the Vaalputs National Radioactive Waste Disposal Facility on behalf of the NRWDI.

For these two nuclear installations the NNR has issued NECSA with a Nuclear Installation License (NIL 02).

Their Nuclear Manufacturing division designs, repairs and manufactures pressure vessels, heat exchangers, tanks and piping systems according to ASME III N stamp requirements.

In fact, according to the ASME website, NECSA is the only manufacturing company in South Africa that has N Stamp accreditation (ASME, 2018).

2.9.5.1 Other Licensees

In total 42 Nuclear Installation Licenses have been issued – all except NIL01 (for Koeberg), are for different NECSA facilities at Pelindaba.

Certificates of Registration (COR) have been issued to over 260 entities – mostly in the business of Mining and Mineral Processing, Service Providers and Scrap Processors (NNR, 2017).

2.9.6 Directorate Radiation Control

RadCon is the Directorate Radiation Control in the SA Department of Health. They are responsible for regulating the use of radiation sources in medicine and industry.

RadCon is beyond the scope of this study.

2.9.7 Nuclear Industry Association of South Africa (NIASA)

The aim of NIASA is to “represent the nuclear industry in SA, and to support, promote and champion the collective interests of its members” (NIASA, 2008).

NIASA has 5 sub-committees, namely:

- Manufacturing for advancing nuclear manufacturing
- Education performing skills surveys and
- Communications for communications strategies and plans for stakeholders
- Regulatory to facilitate contributions to improved regulatory framework
- Finance to handle internal financial issues

Members are from the industry, and include Westinghouse, Areva, Necsa and Eskom.

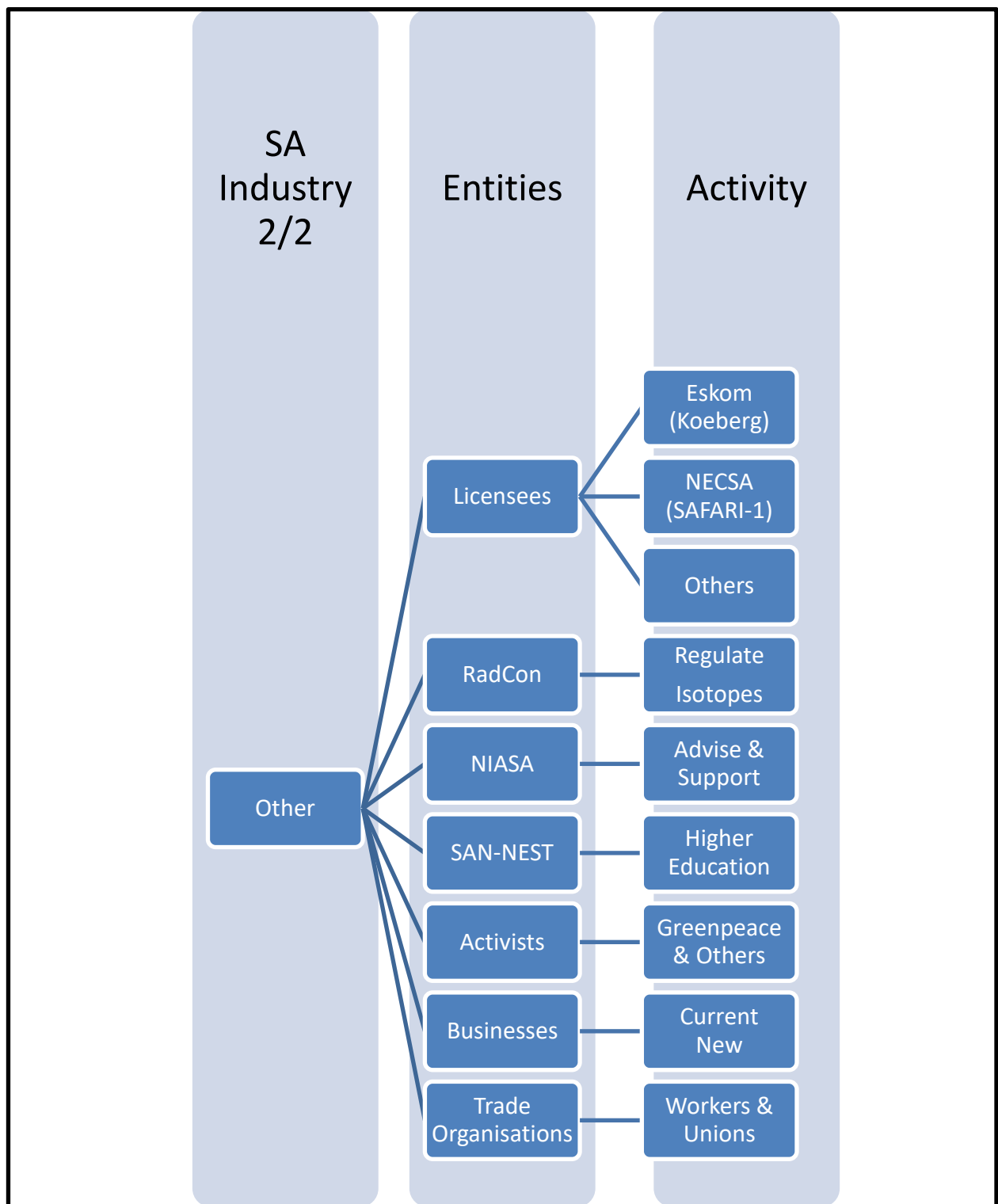


Figure 13: SA Nuclear Market (2 of 2)

2.9.8 SAN-NEST

SAN-NEST is the South African Network for Nuclear Education, Science and Technology (SAN-NEST, 2016:6). Its objective is that “suitably qualified and experienced nuclear personnel employed by nuclear science and technology programmes in South Africa are predominantly produced by the South African education system.”

The IAEA Board of Governors approved SAN-NEST in December 2015 (SAN-NEST, 2016:7). The members are:

- 7 SA universities through their respective nuclear and/or physics departments
- 3 other SA universities
- NECSA
- NNR
- NIASA
- SA Government (Department of Energy, Department of Science and Technology)

2.9.9 Existing SA Nuclear Suppliers

South African businesses are currently rendering services for Eskom at the Koeberg Nuclear Power Station (KPNS). One of these businesses is Lesedi Nuclear Services (Lesedi NS, 2017). According to their website, their shareholding consists of Areva, Group Five (a construction company) and J & J Holdings.

Areva constructed and commissioned the KPNS in the 1980's. Lesedi states on their website that it was founded to provide services to the SA nuclear power industry. Furthermore, they have completed numerous (>150) projects at Eskom's KNPS (Lesedi NS, 2016:9 - 10). One of the most recent projects is the Steam Generators Replacement (Lesedi NS, 2016:12). They also have international exposure, which “enables them to retain and maintain certified and authorised nuclear skills for Koeberg” (Lesedi NS, 2016:11).

Lesedi (and other businesses) have higher tier expertise that might be utilised in the SA New Nuclear Build.

2.9.10 Construction Industry Development Board (cidb)

The cidb [sic] was established by the CIDB Act (Act 38 of 2000), with the mandate to provide guidance for construction development. It needs to facilitate and promote the better-quality share of construction to the economy of SA (cidb, 2018).

The cidb promotes construction procurement uniformity, optimal infrastructure delivery, and performance improvement.

It further needs to improve industry transformation and the emerging industry segment, including skills development. Public sector projects above R200 000, and above R10m for SOE and private sector projects need to be registered on the cidb database. The Register of Contractors (RoC) grades (1 to 9) and categorises contractors in accordance with their financial and works capability in carrying out construction projects.

The grading requirements are shown in **Table 5** on page 48.

Excluding SM (Timber buildings) the rest of the 20 the Classes of Work are applicable to NPP construction, with 2 pertaining to this study. They are EP (Electrical Engineering Works – Infrastructure) and ME (Mechanical Engineering) (cidb, 2018).

2.9.11 Workers and Trade unions

With an unemployment rate of 27.7% in 2017, expectations could be high amongst the unemployed that an NNB would create the opportunity for them to be employed. It is important to understand that the potential workforce in the immediate vicinity of a new NNP has an even higher expectation that they should be given the highest priority. Training and skills development need to be taken account.

At the end of March 2018 there were 190 registered trade unions in SA (Department of Labour, 2018). A select group of them will be involved in the NNB, ensuring good employment and health and safety conditions. They might also become involved in skills training.

Grade	CIDB Max Tender Value		HPC Works Package Ranges	Best Turnover Last 5yrs	Largest Contract Last 5yrs	Available Capital	Registered Professionals		Classes of Work	
							GB & CE	EB, EP, ME, SE		
1	R200,000	>	£11,765	---	---	---	---	---	GB	General Building
2	R650,000	>	£38,235	---	R150,000	---	---	---	CE	Civil Engineering
3	R2,000,000	>	£117,647	R1,000,000	R500,000	R100,000	---	---	EB	Electrical Engineering Works – Building
4	R4,000,000	>	£235,294	R2,000,000	R1,000,000	R200,000	---	---	EP	Electrical Engineering Works – Infrastructure
5	R6,500,000	>	£382,353	R3,250,000	R1,600,000	R650,000	---	---	ME	Mechanical Engineering
6	R13,000,000	>	£764,706	R7,800,000	R3,250,000	R1,300,000	---	1	SB	Asphalt works (supply and lay)
7	R17,000,000	<	£1,000,000	R24,000,000	R10,000,000	R4,000,000	1	2	SC	Building excavations, shaft sinking, lateral earth support
7	R40,000,000	>	£2,352,941	R24,000,000	R10,000,000	R13,000,000	1	2	SD	Corrosion protection (cathodic, anodic, and electrolytic)
7	R85,000,000	<	£5,000,000	R90,000,000	R10,000,000	R13,000,000	1	2	SE	Demolition and blasting
8	R130,000,000	>	£7,647,059	R90,000,000	R32,500,000	R40,000,000	2	3	SF	Fire prevention and protection systems
9	R425,000,000	<	£25,000,000	R270,000,000	R100,000,000	R40,000,000	3	4	SG	Glazing, curtain walls and shop fronts
9	R850,000,000	<	£50,000,000	R270,000,000	R100,000,000	R40,000,000	3	4	SH	Landscaping, irrigation and horticulture works
9	R1,700,000,000	<	£100,000,000	R270,000,000	R100,000,000	R40,000,000	3	4	SI	Lifts, escalators and travellers
9	R4,250,000,000	<	£250,000,000	R270,000,000	R100,000,000	R40,000,000	3	4	SJ	Piling and specialised foundations
9	R8,500,000,000	<	£500,000,000	R270,000,000	R100,000,000	R40,000,000	3	4	SK	Road markings and signage
9	R17,000,000,000	<	£1,000,000,000	R270,000,000	R100,000,000	R40,000,000	3	4	SL	Structural steelwork fabrication and erection
9	R99,999,999,999	>	£5,882,352,941	R270,000,000	R100,000,000	R40,000,000	3	4	SM	Timber buildings and structures
RoE R17/£1 https://registers.cidb.org.za/PublicContractors/Table1 https://registers.cidb.org.za/PublicContractors/Table2 https://registers.cidb.org.za/PublicContractors/Table3 Ex: CIDB R-value > GBP CIDB ranges ZAR < HPC value HPC ranges fitting									SN	Waterproofing of using specialist systems
									SO	Water supply and drainage for buildings
									SQ	Steel security fencing or precast concrete

Table 5: HPC ranges mapped on cidb requirements

2.9.12 Anti-nuclear lobbyists

Greenpeace writes on the cover of the 2016 Annual Report that they are an “independent global campaigning organisation that acts to change attitudes and behaviour, to protect and conserve the environment and to promote peace” (Greenpeace, 2016).

Greenpeace has offices in at least 39 countries, with the ones for Africa and South Africa situated in Johannesburg and Randburg respectively.

In August 2002 twelve Greenpeace anti-nuclear demonstrators landed on the jetty at the Koeberg nuclear plant, then 6 of them climbed onto the roof of a containment building to unfurl a banner protesting against the use of nuclear power in Africa (News24, 2002).

Earthlife Africa (ELA) is “a non-profit organisation, ... that seeks a better life for all people without exploiting other people or degrading their environment. We want to encourage and support individuals, businesses and industries to reduce pollution, minimise waste and protect our natural resources” (Earthlife Africa, 2017). They are against the building of new nuclear power stations in Africa because they are dangerous and not economically viable.

South African Faith Communities Environment Institute (SAFCEI) “as a multi-faith organisation SAFCEI is committed to supporting faith leaders and their communities in Southern Africa to increase awareness, understanding and action-taking on eco-justice, sustainable living and climate change issues” (SAFCEI, 2017).

In 2017 the Western Cape High Court ruled in favour of ELA and SAFCEI “to block the unlawful and unconstitutional actions of the South African government in its nuclear deal” (SAFCEI, 2017b).

These actions indicate that the lobbyists should not be taken lightly – they do have an impact on the nuclear activities in South Africa.

2.9.13 Public and Local Communities

Citizens need to be informed of the benefits and risks that accompany (proposed) nuclear activities in their country and immediate vicinity (there will always be somebody living close to a nuclear facility). They need to understand the technical aspects, as well as energy policies to create trust between them and the nuclear entities.

2.9.14 Conclusion on Nuclear Role Players in SA

Section 2.9 provides information of the major role players and their inputs into the SA nuclear market.

2.10 Nuclear Quality

Nuclear safety and quality are intertwined. The UK Chartered Quality Institute goes as far as to say that “Quality = Nuclear Safety” (Chartered Quality Institute, 2013:Ch 4 p4).

The NIA issued a document titled “The Essential Guide for The Nuclear New Build Supply Chain Stage Two” (Nuclear Industry Association, 2013). Chapter 5 describes the Quality Requirements for an NPP concerning project specifications and related codes and standards:

- followed rigorously will deliver a safe, high integrity power station
- entails substantial human effort and interpretation
- compliance is ensured by a Quality Management System, which describes
 - definite plan for work to be done
 - roles, responsibilities and authorities for execution thereof
 - instructions and guidance
 - personnel qualifications, experience
 - correlation between inspections and nuclear importance of equipment

2.10.1 Quality Management Systems (QMS)

There are various nuclear QMSs that exist in different countries.

Depending on the technology (and thus country of origin) and the relevant national Regulator, one of the following QM Systems could be applied in an NNB:

- ISO9001: 2015 (for EPR contracts)
- ASME NQA-1 (for ABWR and Westinghouse AP1000 contracts)
- NSQ-100 (based on ISO 9001: 2008, integrating NQA-1 and IAEA GSR Part 1, expected to be the future standard).
- IAEA GSR Part 1 (*“issued by the IAEA which defines the quality requirements it deems as being necessary to work in the nuclear industry.”*)

Due to the various reactor technology suppliers and the different QMSs that existed, the Codes and Standards Working Group (CSWG) of the Nuclear Energy Agency published a technical report in 2013 titled “Regulatory Frameworks for the Use of Nuclear Pressure Boundary Codes and Standards in MDEP Countries” (Nuclear Energy Agency, 2014). The long-term goal of the CSWG is to integrate the regulatory and code requirements of different countries.

2.10.1.1 ISO 19443:2018

ISO 19443:2018 is a QMS with “specific requirements for the application of ISO9001:2015 by organisations in the supply chain of the nuclear energy sector supplying products and services important to nuclear safety (ITNS)” (ISO, 2018).

This standard is based on ISO9001: 2015, with additional sections regarding nuclear safety. This researcher has not found any reference to this standard on the IAEA website. A note on the ISO website indicates that organisations rendering services or delivering products on a licensed nuclear site, is subject to prior approval of the licensee. This standard only complements customer, applicable statutory and regulatory requirements, and is not an alternative.

This researcher expects that ISO19443:2018 will in future become prominent in nuclear quality management, based on the NQSA’s optimism regarding this standard as a ‘first step towards international standardisation of nuclear supplier assessment’ (NQSA, 2018).

2.10.2 Nuclear Components

According to the NNR (NNR, 2008) Nuclear safety components are classified as follows:

- Class 1 Components failure could cause substantial radiation release
- Class 2 Component failure could disrupt or endanger plant stability
- Class 3 Low nuclear safety impact – failure would have limited impact on plant stability

2.10.3 Nuclear Supply Chain

The nuclear supply chain is divided into different tiers to ensure the safety requirements can be met by the capabilities of a supplier. Between 4 and 6 tiers are defined, namely:

- Tier 1: Technology Vendor
- Tier 2: Systems Integrators
- Tier 3: Original Equipment Manufacturers (OEM)
- Tier 4: Sub component suppliers
- Tier 5: Fabricators, and
- Tier 6: Raw material suppliers.

Figure 14 on page 53 gives an example of the types of product to be supplied by the different tiers.

Each tier is directly responsible for the quality and safety management of the tier below it, but also responsible for all the tiers further below in the same supply chain. For example, Tier 5 is directly responsible only for Tier 6, while Tier 4 is responsible for both Tiers 5 and 6.

2.10.4 Eskom QMS Requirements

As nuclear procurer, Eskom has its own requirements for a QMS, based on the safety classification according to RD0034 (e.g. Class 2 components are defined as Q2 by Eskom).

These requirements are issued as a specification with every tender, and it covers the Eskom, NNR and other relevant management system requirements applicable to suppliers and sub-suppliers of Q2 (specifically in the case of the PTR Tanks) nuclear products and/or services for application in nuclear installations in SA. One of the purposes of the specification is to give Eskom confidence in a supplier's ability to comply with these required nuclear quality requirements when implemented.

This specification (Eskom, 2011c), refers to 18 quality management documents, including:

- ASME NQA-1 2008 (still in use although 2017 was issued)
- IAEA GSR-3
- ISO9001: 2008 (now 2015)
- OHS Act
- Pressure Equipment Regulations
- Other ISO standards regarding QMS
- Other Eskom internal QMS specifications

Eskom further requires from its suppliers the maintain a certified ISO9001: 2015 QMS, fulfilling nuclear safety and quality requirements in general, and for Eskom specifically.

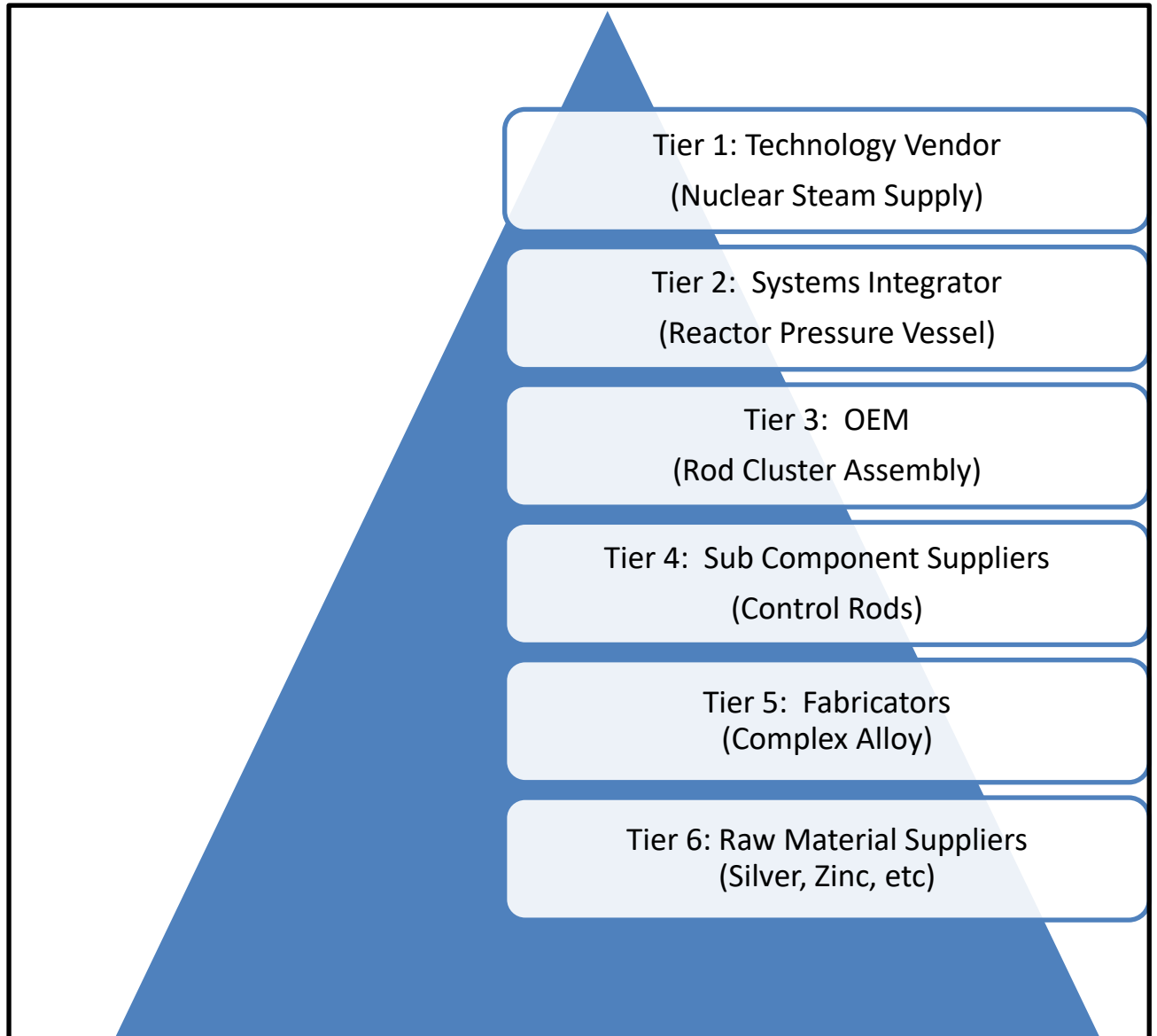


Figure 14: Supply Chain Tiers

Source: (Department of Energy and Climate Change, 2012)

A typical supply chain map with 5 tiers in practice is given in **Figure 15**, indicating multiple tiers on the same level under a higher tier. For example, Tier 2 (red) manages 2 x Tier 3 (with associated Tiers 4 and Tier 5, while Tier 2 (green) manages only 1x Tier 2.

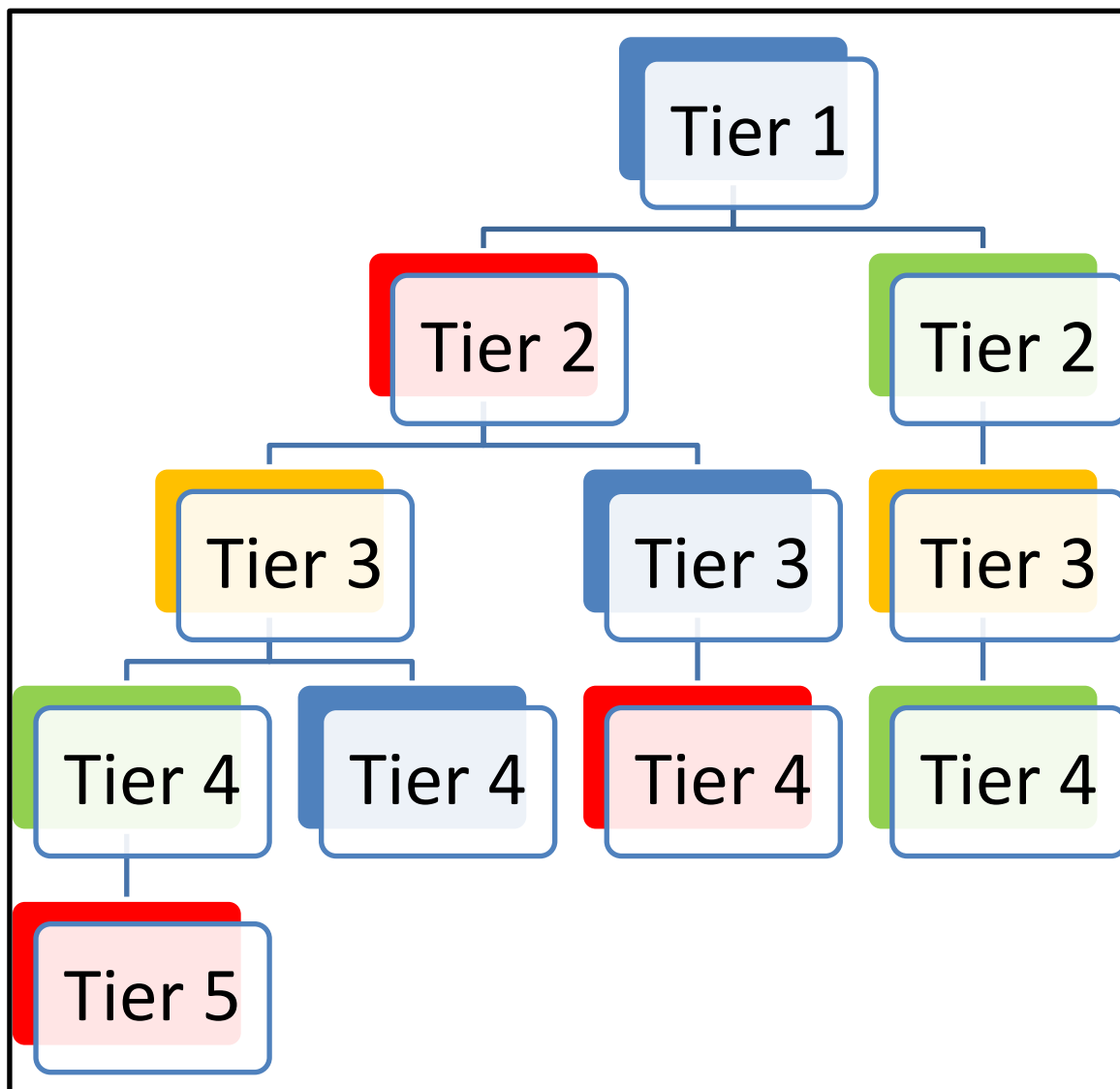


Figure 15: Example of Hierarchy of Tiers

2.10.5 Codes and Standards

The RCC-M Code was written by the French Association for Design, Construction and In-Service Inspection Rules for Nuclear Island Components for use in France (Nuclear Industry Association, 2013). The RCC-E code was a set of technical rules for the design and construction of electrical equipment in a nuclear power station.

The ASME III Boiler and Pressure Vessel Code Division 1 was written by the American Society of Mechanical Engineers (ASME). It is reported to be the most widely used nuclear pressure vessel code around the world (Nuclear Industry Association, 2013).

The same document warned that although RCC-M and ASME apparently have similarities it should not be assumed that the design requirements are the same. Below is a table depicting the use of different codes for the respective safety classes.

The following table compares the structures of the two mechanical codes:

Designation	Type of Company	Applicable Codes	Tier of Supplier
Class 1	Technology Provider, e.g. AREVA, Westinghouse or Hitachi	Nuclear Codes such as ASME III, RCC-M, RCC-E, plus additional customer requirements	Technology Provider and specialist manufacturers
Class 2	Nuclear experienced companies with proven QS certified to ISO 9001	Nuclear Codes such as ASME III, RCC-M, RCC-E, PER plus additional customer requirements	Tier 1 and 2
Class 3	Companies with experience of pressure systems with proven QS certified to ISO 9001	National standards (PER) plus additional customer requirements.	Tier 2 and 3
Commercial	Companies with QMS according to ISO 9001	National Standards (SANS) and PER	Tier 2 and 3

Table 6: Safety Classes vs Standards vs Tiers

In addition to ASME and RCC-M, other equivalent nuclear codes exist for different countries (Nuclear Energy Agency, 2014), for example:

- JSME (Japan Society of Mechanical Engineers)
- PNAE G-7(Russia)
- N285.0 (Canada)
- KEPIC (Korea Electric Power Industry Code)

2.10.6 SA and Nuclear Codes

The ASME website (ASME, 2018) reported that 9 South African companies had ASME certification in October 2018. Only one company namely *Nuclear Manufacturing* from Pelindaba (being a subsidiary of NECSA) had N-certification (NPT, NS, NA and N).

South African codes and standards applicable to nuclear components are mentioned in Section 2.7.3 of this document.

2.10.7 Cost of Codes and Standards

Manufacturing Codes and Standards are not freely available on the Internet, and Controlled Copies (either paper or electronic) need to be bought from the respective publishers. Furthermore, certification and/or accreditation also carry a cost for the account of the suppliers.

From ASME, the “Boiler and Pressure Vessel Code 2017 Complete Set with Binders” costs USD16 920 (ZAR253 000 at ZAR15/USD). On its own, “BPVC Section X1 – Rules for Inservice Inspection of Nuclear Power Plant Components (BPVC-X1-207)” costs USD740 (ZAR11 100). In similar fashion BPVC Section VIII – Rules for Construction of Pressure Vessels Division I (BPVC-VIII-2017) carries a price tag of USD735 (ASME Shop, 2018b). ASME standards are due for revision every 2 years.

ASME courses cost between USD1 500 and USD 3 400 each, depending on the subject. Every BPV Code has its own course.

At ISO the following applies:

- | | | | | |
|-----------------------|---------|--------|------------|----------|
| • ISO9001:2015 | QMS | CHF138 | @ZAR15/CHF | ZAR2 070 |
| • ISO3834:2015-1 to 5 | Welding | CHF225 | | ZAR3 375 |
| • ISO19443:2018 | ITNS QM | CHF158 | | ZAR2 370 |

In South Africa, the following applies:

- SANS347 Pressure Equipment ZAR580
- SANS10227 Pressure Equipment Inspection ZAR325

In general, the international codes and standards are more expensive than local publications by a factor 10 to 20.

2.10.8 QMS implementation Timelines

The duration for implementing ISO9001:2015 depends on the company size. A medium sized company with 500 employees might take 8-12 months for implementation (Advisera, 2018). Implementing ISO19443, RD0034 and Eskom QMS requirements might double the time.

Depending on the type of contract, a new entrant have to start up to 3 years before the contract placement times indicated in Figure 29 on page 87 to prepare for admission to the nuclear supply chain.

2.10.9 Conclusion on Nuclear Quality

Section 2.10 covers the nuclear QMS requirements, including the applicable codes and standards.

2.11 Worldwide Nuclear Reactor Activities

The IAEA PRIS (Power Reactor Information System) is a complete database, focusing on nuclear power plants all over the world. On 16 May 2108 it reported on power reactors being:

- in operation (450)
- under construction (59)
- on long term shutdown (0)
- permanently shut down (166) (IAEA PRIS, 2018a).

The IAEA collects data via data providers nominated by the Member States (IAEA PRIS, 2017).

Reactors are only reported upon when the Construction Start Date has been reached. As per the PRIS Glossary (IAEA PRIS, 2017) that is only when the “first major placing of concrete for the base mat of the reactor building is made”.

This means that site work on new nuclear power plants could already be in progress, but the reactors are not under construction yet, and therefore not reported by PRIS. An example is

Hinkley Point C in the UK, where site work has begun in 2016, but the first nuclear concrete will only be poured in 2019 (Reuters, 2017).

2.11.1 Reactors Status

Figure 16 (page 59) is a graph, indicating the respective statuses per country. The USA (99), France (58) and Japan (39) are the countries with the most operational reactors (red). China (18), India (7) and Russia (6) have the most reactors under construction (green). The USA (34), UK (30) and Germany (29) are way ahead of the other countries regarding reactors that have been shut down.

The UK (30 vs 15) and Germany (29 vs 7) have more reactors shut down than in production, with both countries having none reported under construction. Germany has taken a conscious decision in 2011 to close all its nuclear power plants by 2022, following the Fukushima disaster in 2010 (BBC, 2011). On the other hand, the UK announced their intention to build new NPPs at Hinkley Point C (3.2GW), Sizewell C (3.2GW), Wylfa (3GW) and Oldbury (3GW) (Nuclear Industry Association, 2012a:4 - 6) to name but a few of the 8 identified sites (with a total of 11 reactors), , to replace their aging fleet.

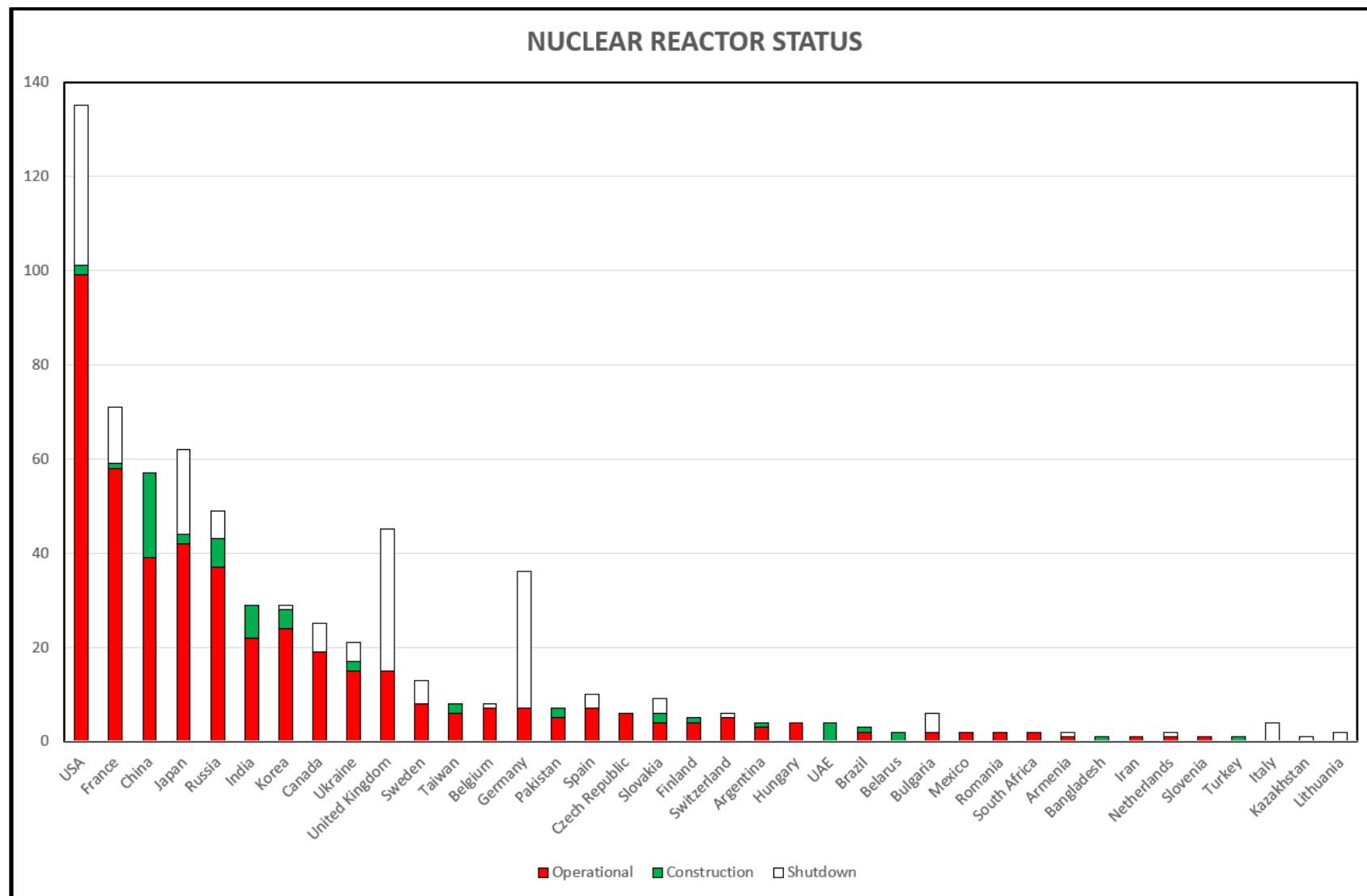


Figure 16: Nuclear Reactors Status (May 2018)

2.11.2 Reactor Ages

Figure 17 (page 61) indicates the age of reactors currently in operation (IAEA PRIS, 2018d). Reactors with an age of 0 years have been connected to the grid in 2018 before 20th May. Ages with a negative value indicate how far reactors under construction are from grid connection (e.g. the 4 reactors with an age of -5y are planned for 2023).

The graph has two peaks – one on the left at ages -1y and 0y, which indicates the number of younger reactors, while there is another higher peak at 34 years and 35 years which points to the older reactors. The latter is nearing their designed decommissioning age of 40 years.

Some reactors have already been licensed to extend their operational life. In 2017 the NEI reported that 85% of the US reactors had been relicensed for life extension by the USNRC (Nuclear Energy Institute, 2017). The Koeberg NPP will reach its design life of 40y in 2025. The SLR process for 60y is already underway (Eskom, 2016).

The WNA reports that an estimated 154 reactors are 'Planned' to come into operation before 2030, while 333 more are 'Proposed' (plans, sites, start-up unknown) (World Nuclear Association, 2018b).

2.11.3 Conclusion on Reactor Activities

Section 2.11 reported on the Worldwide Status of Reactors (active, under construction and long-term shutdown). The age report gives an indication of when life extension of reactors will be requested, or new nuclear builds need to be initiated.

NNBs are ongoing all over world, for different reasons like reactors reaching end of life, energy mix diversification (by reducing coal fired power stations) and economic growth in countries (preferring to go the nuclear and/or renewables route instead of coal).

2.12 New Nuclear Build in the UK

PRIS reported in May 2018 that the United Kingdom has 15 reactors operational and 30 permanently shut down (IAEA PRIS, 2018b).

The oldest of the operational reactors were connected to the grid in February 1976. They are GB-16A Hinkley Point B-2 and GB-17A Hunterston B-2, their ages being 42 years in 2018. Their original decommissioning date was 2016, but in 2012 EDF announced that they both are expected to be in operation until 2023 (EDF Energy, 2012).

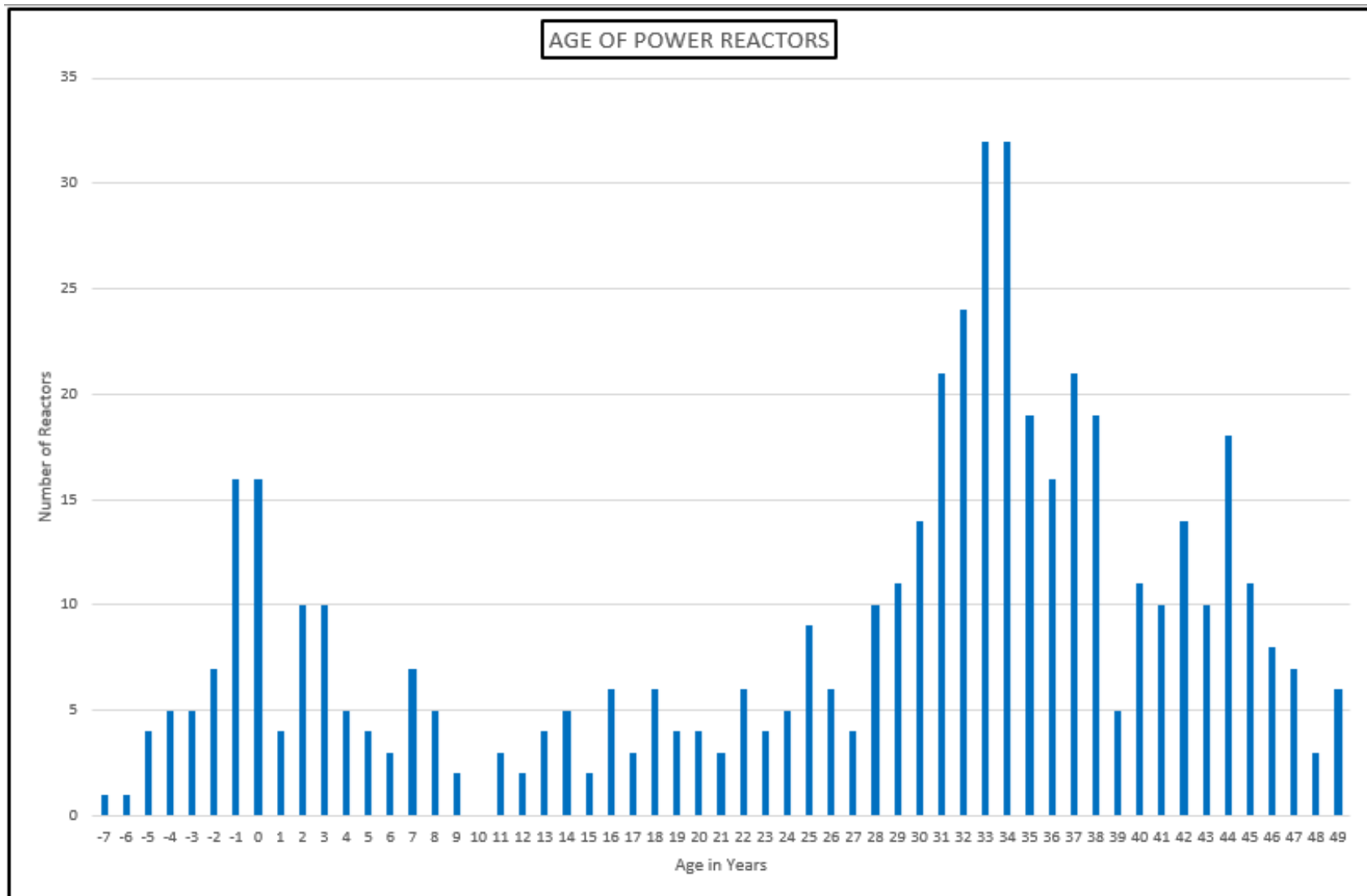


Figure 17: Age of Nuclear Reactors (May 2018)

The last one to be connected to the grid was GB-24 Sizewell B in February 1995 – now aged 23 years (in 2018). It is the only Pressurised Water Reactor in the UK. Its expected decommissioning date is 2035 (EDF Energy, 2018b), but a life extension of 20 years is foreseen. (EDF Energy, 2012).

Furthermore, it is reported that in 2016 the UK produced 336 888 GWh electricity in total, with 65 149 GWh (19.34%) being nuclear produced electricity.

2.12.1 UK New Build History

Due to the age of the UK nuclear reactors, the UK Government decided to embark on a New Nuclear Build and has gone through various steps regarding nuclear energy since 2003. That included Energy Reviews, White Papers and Policies. Some of the salient events are listed below. Also, please see a concise timeline, with some Hinkley Point C activities in **Figure 18** on page 63.

2.12.1.1 Energy White Paper 2003

In the *2003 Energy White Paper* the Government recognised that a new nuclear build might be necessary if the UK was to meet its carbon targets, but it concluded that it was not economically viable at that point in time. Furthermore, they committed to consult publicly in depth with and publish a further White Paper to spell out the proposals (Dept of Trade & Industry, 2003:61).

2.12.1.2 Energy Review 2006

The *Energy Review July 2006* was issued by the Department of Trade and Industry, regarding two major long-term challenges regarding the energy mix in the UK by that time, namely reducing carbon emissions -and energy security. It concluded that nuclear power was to be included in the future UK energy mix, with the private sector being responsible for the cost of both the total life cycle (design, construction, operation and decommissioning) of the NPP and waste management in the long term. The UK Government would assist the developers to identify sites, provide for the necessary pre-licensing and design approval procedures (Dept of Trade and Industry, 2006b).

UK NNB Strategy & HPC

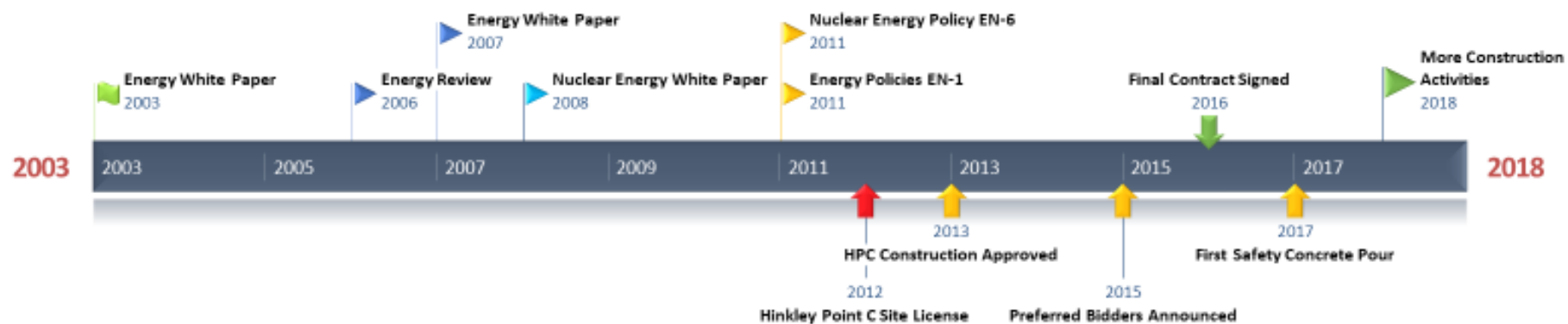


Figure 18: UK NNB Strategy & HPC Timeline

2.12.1.3 High Court Ruling 2007

It was not all plain sailing, and Greenpeace went to court, challenging the *2006 Energy Review* report. At the beginning of 2007, the High Court delivered judgement in their favour that “with regard to the issue of nuclear waste arising from new build” (Monckton Chambers, 2007).

2.12.1.4 White Paper 2007: Meeting the Energy Challenge

In May 2007 the Department of Trade and Industry issued a White Paper titled *Meeting the Energy Challenge* (Dept of Trade and Industry, 2007a) putting forward their international and domestic energy strategies, as well as address their long-term energy challenges.

2.12.1.5 The White Paper on Nuclear Energy 2008

In January 2008, the UK Government published *The White Paper on Nuclear Energy*, announcing that new nuclear power stations be built given the climate change and energy security challenges (Dept for Business Enterprise and Regulatory Reform, 2008a).

2.12.1.6 National Policy Statements for Energy 2011

In July 2011 the UK Government published a suite of National Policies regarding energy and climate change titled “*Planning for a new energy infrastructure*”.

The *Overarching National Policy Statement for Energy (EN-1)* (Department of Energy and Climate Change, 2011a) sets out the Government’s policy for delivery of major energy infrastructure. Altogether, five technology-specific NPSs for the energy sector were published.

The documents EN-6 National Policy Statement for Nuclear Power Generation Volume 1 (Department of Environment and Climate Change, 2011b) and Volume 2 (Department of Environment and Climate Change, 2011c) describes nuclear specific principles which need to be taken into account when evaluating applications for NPPs. It also listed 8 possible suitable sites (including Hinkley Point) where the NNB could be rolled out (Department of Environment and Climate Change, 2011b:33).

2.12.1.7 Industrial Strategy: The UK’s Nuclear Future 2013

In 2013 the UK Government published their *Nuclear Industrial Strategy* (the *Strategy*), stating that “nuclear will play a significant role in the UK energy mix in the future” (Department for Business, Innovation and Skills, 2013a).

The documents underpinning the Strategy include inter alia the following:

- NIA Capability Report 2012, evaluating “the capability and capacity of the UK industry to deliver a programme of new nuclear power stations” (Nuclear Industry Association, 2012a)
- The Nuclear Supply Chain Action Plan 2012, which included the following key objectives like enhancing job creation in the nuclear and to maintain and develop an active supply chain (Dept of Energy and Climate Change, 2012).

2.12.1.8 The NUCLEAR-Advanced Manufacturing Research Centre

The NUCLEAR-Advanced Manufacturing Research Centre (Nuclear AMRC), mentioned in the Nuclear Industrial Strategy, works “with manufacturers to gain clarity and knowledge on nuclear codes and standards, helping them to meet the demanding requirements of this industry” (Department for Business, Innovation and Skills, 2013b).

The official website describes the Nuclear AMRC as being “collaboration of academic and industrial partners from across the nuclear supply chain, with the mission of helping UK manufacturers win work at home and worldwide” (Nuclear AMRC, 2018).

According to the Nuclear AMRC brochure (Nuclear AMRC, 2018b:5) companies are assisted by two core programmes, namely:

- Manufacturing innovation, whereby companies are supported to solve their manufacturing problems, and
- Supply Chain Development, whereby suppliers are assisted to identify performance and capability gaps.

Furthermore, Nuclear AMRC supplies support for skills development in collaboration with the National Skills Academy for Nuclear, providing a one-stop shop for manufacturers included in the nuclear supply chain. In addition, the AMRC Training Centre provides practical skills covering the spectrum from apprenticeships through to doctorate and MBA for manufacturing companies.

2.12.1.9 The Fit for Nuclear Program (F4N)

A major initiative under AMRC Supply Chain Development, is the Fit For Nuclear (F4N) program of the Nuclear AMRC. It provides UK manufacturers the ability to measure their businesses against the required standards for suppliers to the nuclear industry, and close gaps to reach a higher performance level (Nuclear AMRC, 2018b).

The program has been developed in cooperation with industry partners like reactor vendors, new build developers, the UK Nuclear Decommissioning Authority and their top-tier suppliers. These

industry frontrunners use F4N to identify potential companies to be utilised in their own supply chains.

The F4N journey is being described as follows:

- Complete the Nuclear capability questionnaire to establish needed support
- Online assessment is done, covering 6 categories (each with 10 multiple-choice questions) concerning business operation and performance
- A site visit is done to verify the initial assessment results.
- An action plan is created to close any performance gaps
- Programme is reviewed to evaluate progress, and provide news on new opportunities
- The capabilities of the business are measured against the nuclear checklist to establish level of nuclear readiness
- An advisor assists the company in preparing a final presentation to the F4N granting panel.
- Upon meeting the standards, 3 years F4N is granted, the company is put on the NAMRC online directories to give visibility to nuclear buyers, and continuous support is given to ensure compliance

By January 2018 more than 640 companies have been assessed. Of those, 130 have successfully completed the program (Nuclear AMRC, 2018b:14).

2.12.2 Conclusion on UK NNB approach

Section 2.12 describes the active steps that was taken by UK Government and Industry to prepare for their new nuclear build.

2.13 Hinkley Point C Nuclear Power Station

In 2018, the Hinkley Point C (HPC) NPS is under construction at one of the eight sites that the UK Government had identified. The owner is EDF Energy, and the 3260 MWe NPS consists of 2 x 1630 EPR reactors (EDF Energy, 2018).

The ONR granted a site license in November 2012 (EDF Energy, 2018a: 26 Nov 2012), and construction of cabling and piping tunnels, as well as a jetty and seawall started in 2017 (Reuters, 2017).

Although already 15 months late, the first nuclear concrete pour is planned to take place in 2019, and connection to the grid in 2025. The cost has also risen to £20.3bn (originally £18.0bn), as reported by The Guardian (The Guardian, 2017).

The construction, financing and operation of Hinkley Point C are beyond the scope of this study.

2.13.1 Hinkley Point C NPS Supply Chain

In accordance with the UK Nuclear Industrial Strategy (Department for Business, Innovation and Skills, 2013a), EDF Energy is committed on utilising the UK nuclear market in general, and local businesses around HPC, especially for the supply chain.

They published a booklet titled “Building our industrial future Hinkley Point C supply chain - be part of it” in which they describe the background of nuclear supply, requirements in terms of quality and safety, as well as the steps that potential suppliers need to take to become part of HPC supply chain (EDF Energy, 2015).

EDF Energy describes the steps (the “HPC supply chain journey”) as follows:

- HPC Design Work Packages and Contract Templates
- EDF Energy Procurement
- Supplier Design
- Supplier Procurement
- Manufacturing
- Site Installation and Commissioning
- Operational Power Station

During Manufacturing the suppliers must conform to the following codes and standards:

- Quality Control System - the “General Quality Assurance Specification “(GQAS) Ref ECUK100053”, based on IAEA required ISO 9001: 2008 (now 2015), including nuclear industry requirements (now ISO19443:2018).
- Nuclear Island Codes - design and manufacturing are to take place in accordance with the RCC-M (for mechanical components) and RCC-E (for electrical components). Sub-codes (e.g. RCC-M1) use depends on the Component Safety Class (1 to 3) and where it is to be installed (Reactor Coolant Boundary or High Integrity Component). The conventional pressure equipment codes also apply.

In the booklet, further reference is made to:

- Product Quality (to ensure nuclear safety)
- Records (to proof compliance)
- Manufacturing Surveillance & Inspection (in accordance with ONR and IAEA rules)
- Management of non-conformances (identification, reporting and resolution)

Furthermore, it provides information regarding “post manufacturing quality protection and controls”. This is necessary to ensure that equipment is delivered to site in the same condition as accepted after manufacturing.

2.13.2 Hinkley Point C Work Packages and Contracts

EDF Energy maintains a database on their website, which lists all the work packages and contracts (EDF Energy, 2018c). This database is open to public (general information) and registered users (detailed information).

Information made available includes the following:

- Category (part of plant, e.g. Nuclear Island, Valves)
- Package name (e.g. Cranes, Catering, Civils) and short description
- Status (e.g. Preferred bidder, Awarded, Completed)
- Cost (as price ranges - <£1m, £25m to £50m, >£1bn)
- Successful bidder and contact details (e.g. Rolls Royce, Areva, Schneider Electric)

2.13.3 Database analysis

The following monetary figures and quantities regarding the tenders were extracted from the database.

2.13.3.1 Project budget

The original budget for HPC had been £18bn but it rose to £20.3bn by mid-2017 (The Guardian, 2017).

2.13.3.2 Works packages

EDF Energy issued 164 work packages for HPC. The work packages are divided into 12 categories. A summary of the total number of packages and the maximum value (in GBP million) per category, as well as the number of packages are shown in **Figure 19** on page 70.

For example, the Nuclear Island consist of 15 packages (4 issued to Preferred Bidders and 11 issued on Open Tender) to the value of GBP5328m

The green shapes on the left represents (civil) construction and services, while the red and black shapes on the right cover the manufacturing and installation of equipment. This includes the nuclear island, conventional island, balance of plant, ICE, valves and mechanical equipment.

2.13.3.3 Cost reflected in Database

Since the cost per contract is reflected as price range in the database (e.g. <£1m, £25m to £50m, >£1bn), the researcher calculated the cost of the project based on the minimum and maximum values respectively of the cost range for each contract.

The following assumptions were made:

- For contracts “<£1m”, the minimum cost was taken as £0.5m, since £0m is an unrealistic amount for a contract.
- For the 3 contracts “>£1bn” the researcher used the actual contract values (totalling £7 370bn) which was obtained from the websites of the respective companies.

The minimum cost for HPC is £10 658bn which is £9 615bn less than the newest budget, while the maximum cost is calculated at £15 261bn which is £5 039bn below the £20.3bn budget. Maximum costs are reflected in this document, because the researcher believes nuclear contracts would rather be closer to the maximum, as illustrated by the 3 largest contracts, being 2,5x more than the minimum total of £3 000bn.

The difference between the budget and the indicated work package figures is not part of this study.

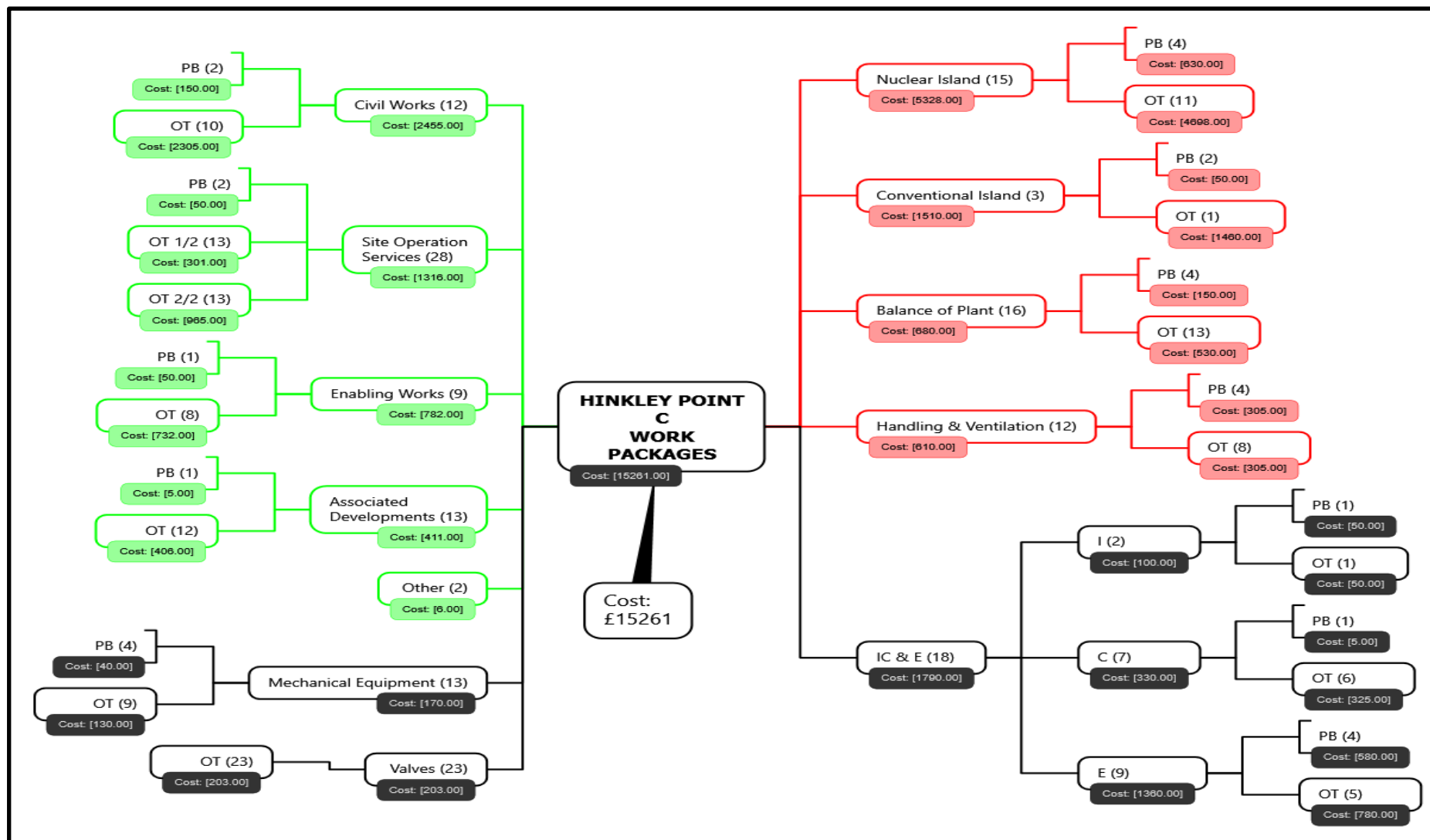


Figure 19: Hinkley Point C: Work Packages Summary

2.13.3.4 Preferred Bidders vs Open Tenders

In Figure 19 the number of work packages assigned for Open Tender are indicated with the letters 'OT', while the number in brackets indicates the number of OT packages. The number in the coloured shapes is the total monetary value of the OT packages. Groups of packages without either 'PB' or 'OT' labels are 'OT' by default. **Table 7** is a summary of the database indicating respective OT and PB packages and values.

The Preferred Bidder ['PB'] packages are indicated in a similar way. The Preferred Bidders are Tier 1 suppliers on their own, or Joint Ventures. According to the database, 29 work packages out of the total 164 were assigned to Preferred Bidders. The monetary value of the PB work packages is £2 065bn out of the total contract value of £15 261bn.

Converting the values to ZAR at an exchange rate of ZAR17/GBP1, the total (maximum) cost of HPC is ZAR259 437bn, with ZAR35 105bn allocated to Preferred Bidders. That leaves ZAR224 322bn for the owner to go out on Open Tender.

The researcher acknowledges that there are several other factors that will have an influence on the ZAR value of an HPC equivalent plant (based on EPR) in SA. Those factors might include siting, availability of higher end skills in SA, manufacturing and construction skills, the availability of Areva specialists and engineers, other ex-pat skills, the exchange rate and cost of financing.

GROUPS		PB	OT	TOTAL
Construction & Services	Number	6	58	64
	Value	£255m	£4 715m	£4 970m
Manufacturing & Supply	Number	23	77	100
	Value	£1 810m	£8 481m	£10 291m
TOTALS	Number	29	135	164
	Value	£2 065m	£13 196m	£15 261m

Table 7: HPC Preferred Bidders vs Open Tenders

2.13.3.5 Contract types

HPC contracts are mostly based on NEC and FIDIC. The implementation of these contracts is beyond the scope of this study, but prospect suppliers need to be aware that different contract types apply to different packages.

2.13.3.6 HPC contract ranges and the cidb

In **Table 5** on page 48 the HPC contract ranges are superimposed on the maximum tender value for the cidb grades. The purpose was to establish whether which cidb grade could tender for work packages in the HPC ranges:

Grade 9 is in position to tender on any works package in its class (ME, CE, EP, etc), having no limit on the upper tender value. There are 164 Grade 9 of various classes registered at the cidb (cidb, 2018b).

Grade 8 could tender on work packages below R130m on the packages in £5m to £ 25m (R85m to R425m) range since that is its cidb contract limit. The packages above R130m (£7.6m) in this range need to be covered by Grade 9. There are 484 Grade 8 of various classes registered at the cidb (cidb, 2018b).

Grade 7 could tender on work packages below R40m on the packages in £1m to £5m (R17m to R425m) range since that is its cidb contract limit. The packages above R40m (£2.4m) in this range need to be covered by Grades 8 and 9. There are 1 233 Grade 7 of various classes registered at the cidb (cidb, 2018b).

When it comes to the work packages below R17m (£1m), all the cidb grades from 7 down to 1 would be allowed to tender. Since the exact costs for package in this range are unknown but estimated to be closer the maximum value of R17m, it is safe to say that Grade 7 (R40m limit), Grade 6 (R13m), Grade 5 (R6.5m) and Grade 4 (R4m) will be allowed to tender. There are 2064 Grade 6, 1758 Grade 5 and 2794 Grade 4 of various classes registered at the cidb (cidb, 2018b).

The above registration figures are for contractors spread all over South Africa. Localisation will have an influence on which contractors will be allowed based on their location. For instance, if a new NNP is to be built next to the existing Koeberg NNP, then only contractors from Cape Town and surroundings would be allowed to tender. Grades 1 to 3 (max R2000k or £117k) are most unlikely to participate in the NNB.

EDF Energy announced 7 preferred suppliers before the final investment decision had been taken for the following packages:

- Turbine Hall (1)
- NSSS
- Civil Works
- Marine Works
- Electrical cabling and equipment installation
- Mechanical pipework and equipment installation
- Heating, ventilation and air conditioning

This might also happen in SA, depending on the available technical expertise available. However, NSSS will most likely be sourced from overseas.

Information regarding HPC is presented in **Figures 20 to 28** (from next page onwards).

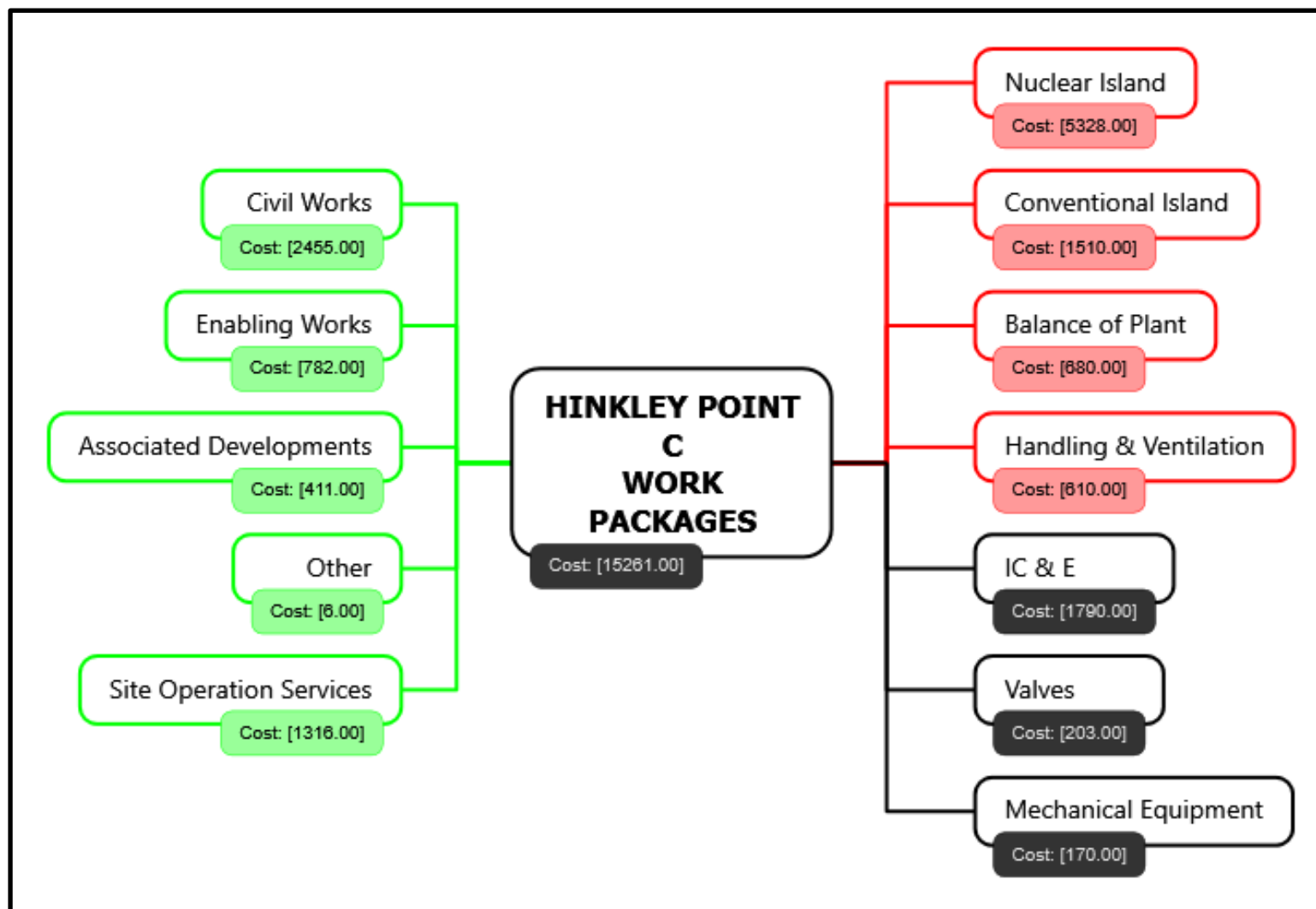


Figure 20: Hinkley Point C Work Packages Summary (cost in £m) [(EDF Energy, 2018c)]

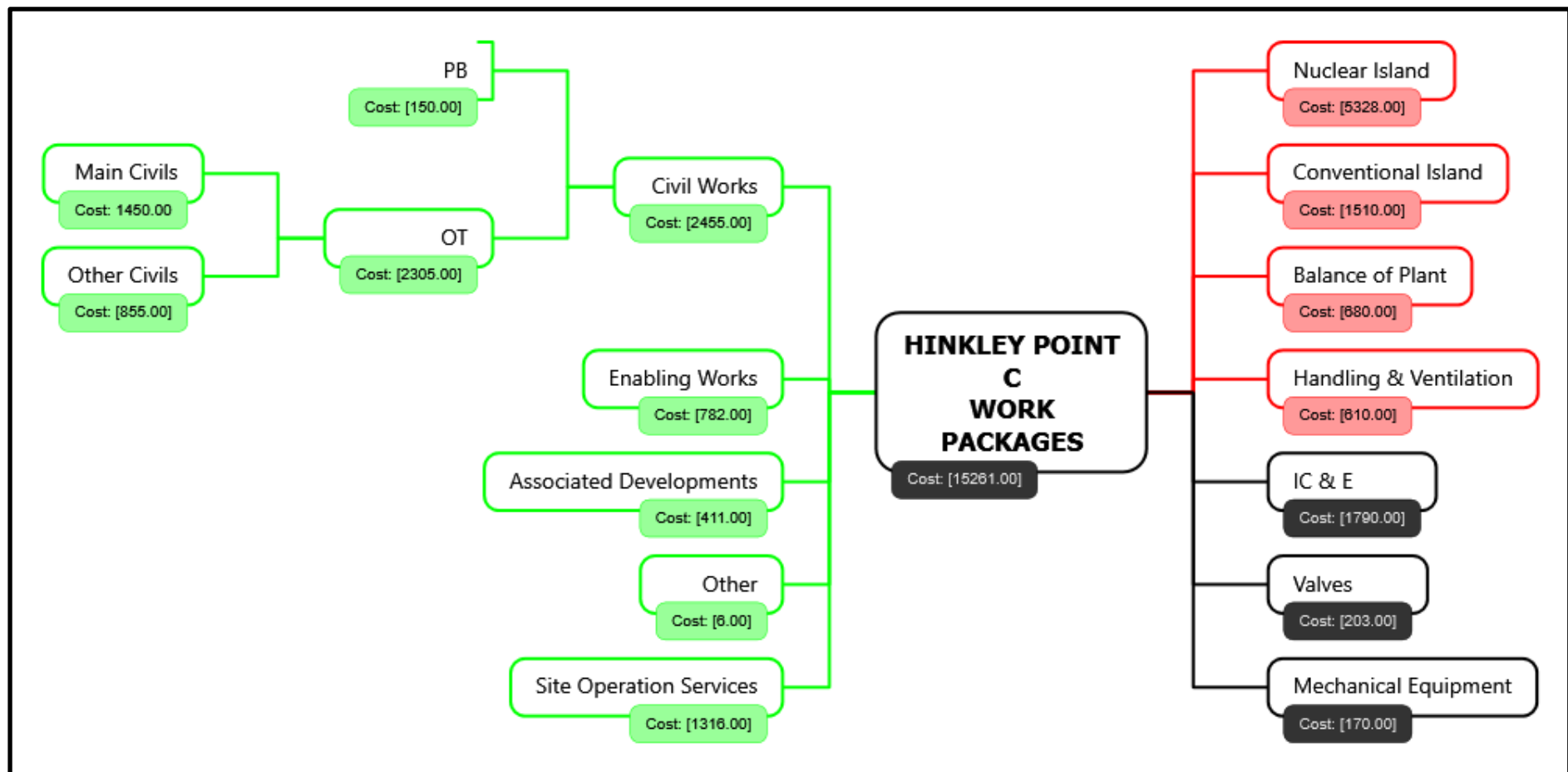


Figure 21: Hinkley Point C Focus on Civil Works

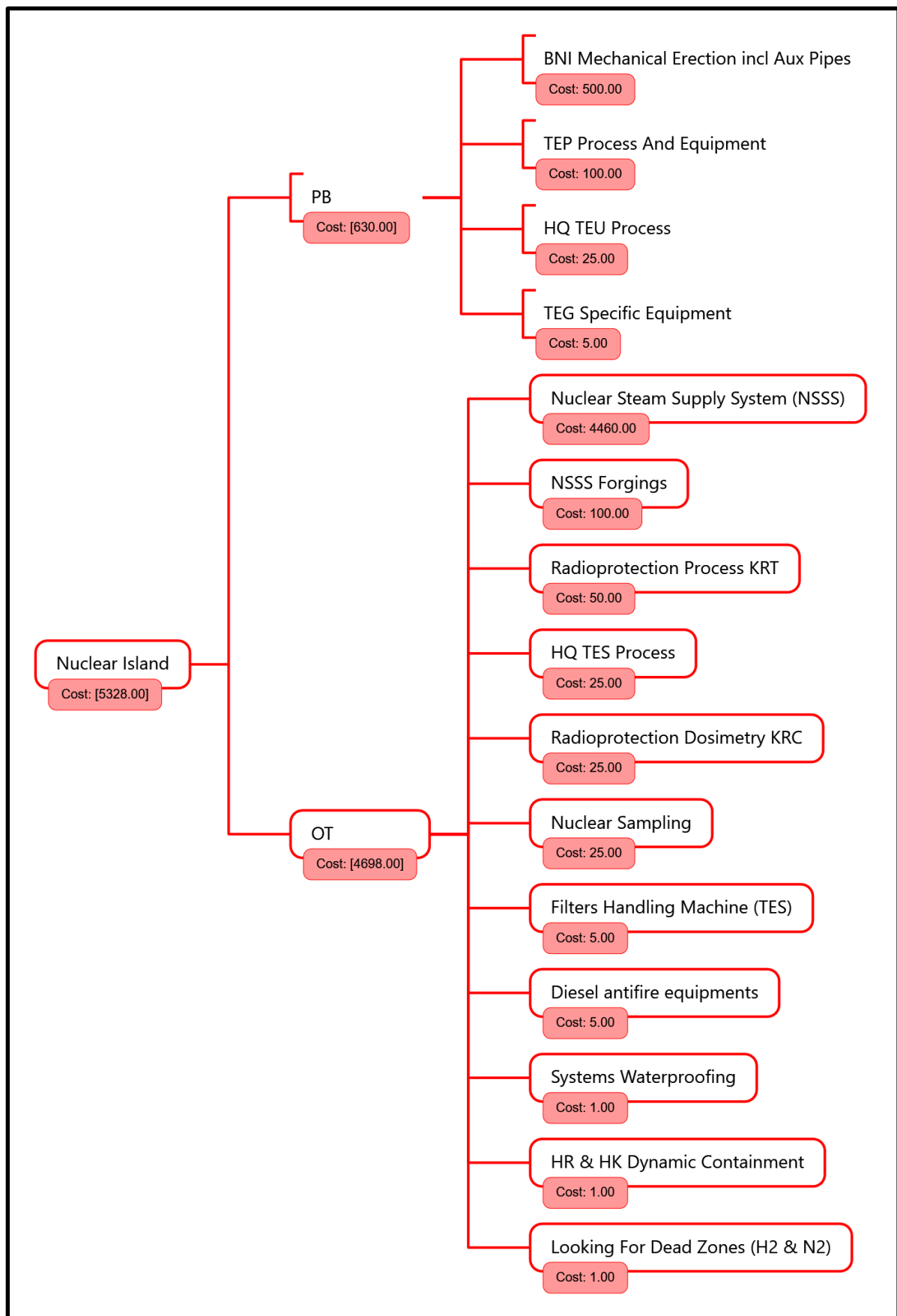


Figure 22: Hinkley Point C Nuclear Island

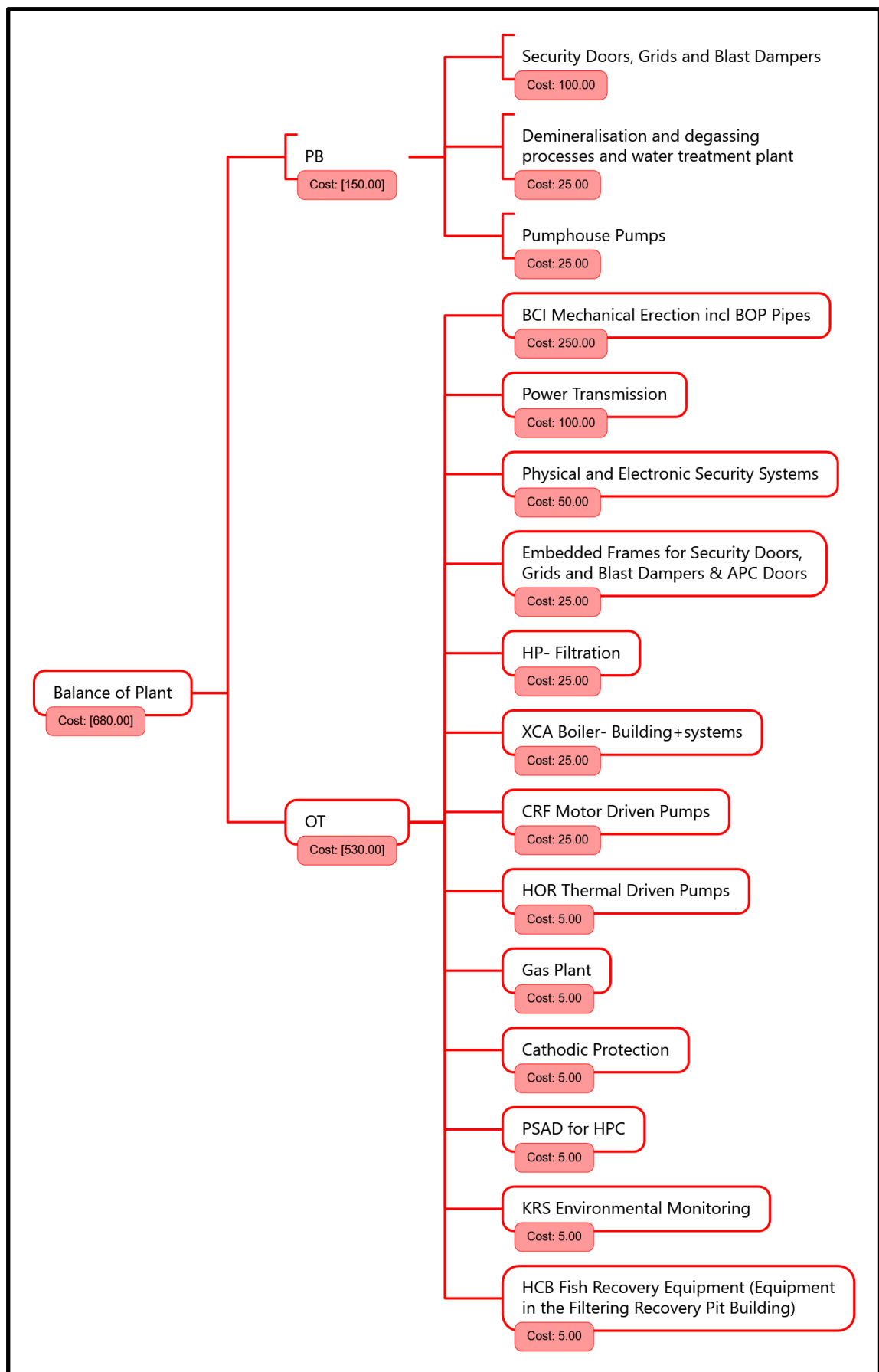


Figure 23: Hinkley Point C Balance of Plant

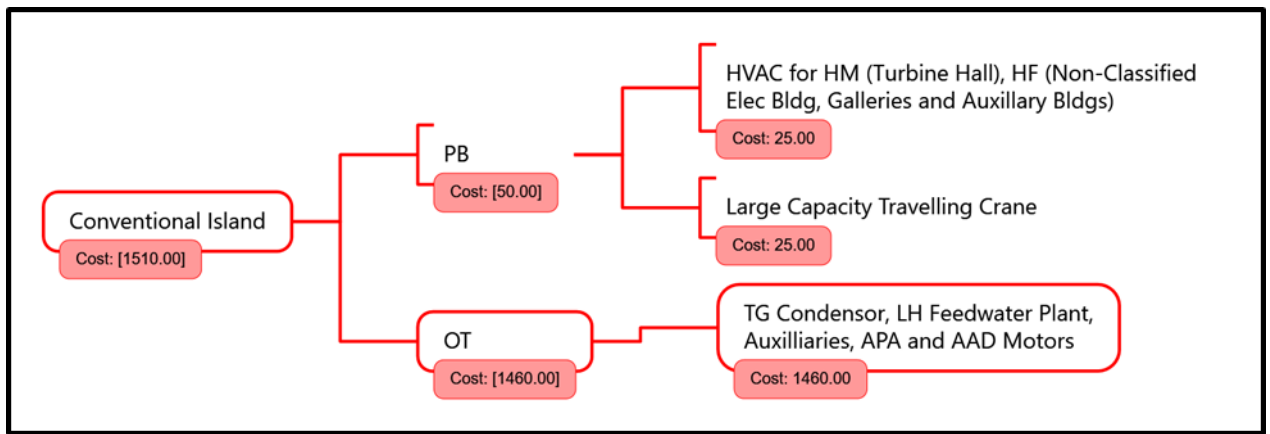


Figure 24: Hinkley Point C Conventional Island

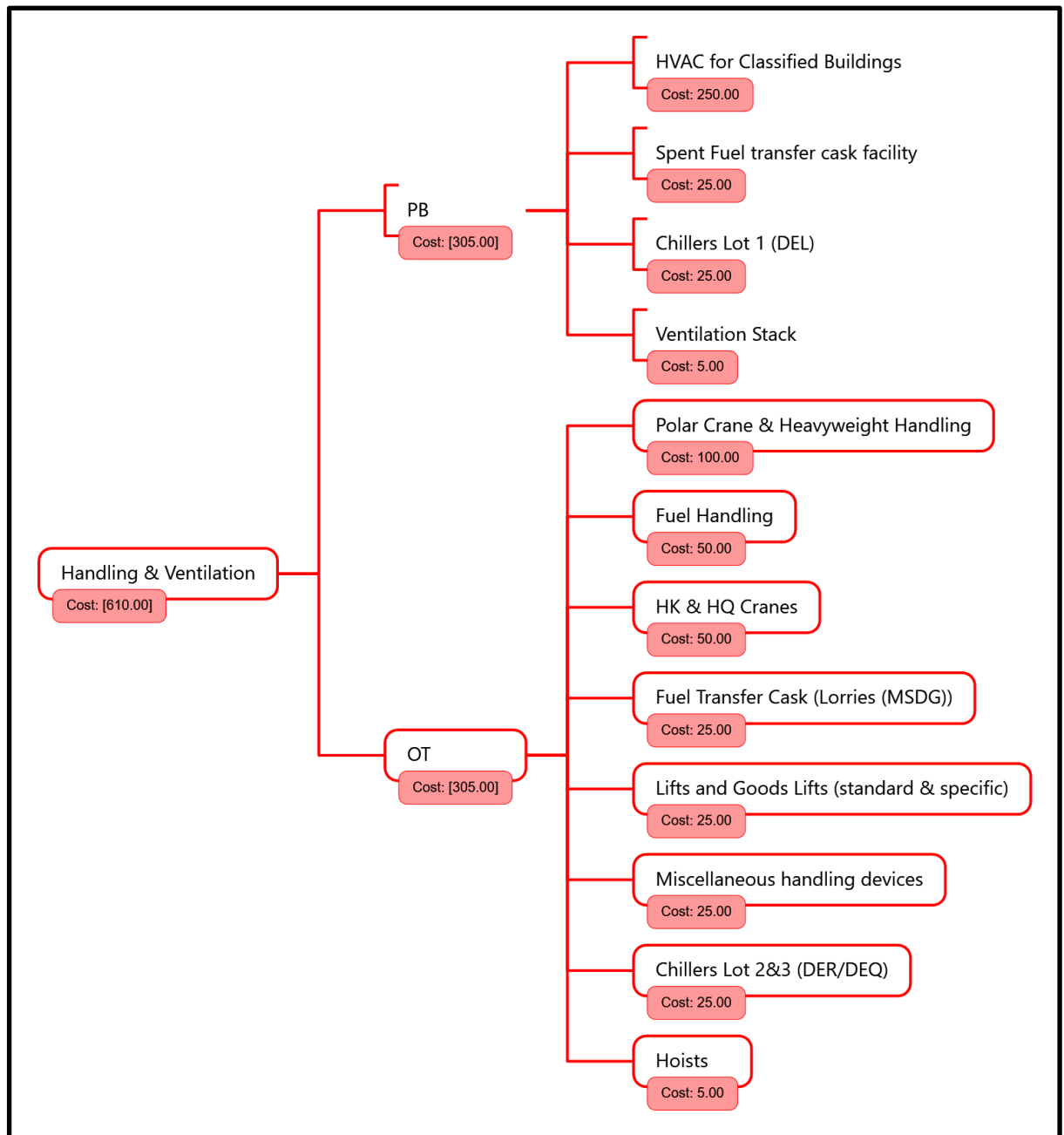


Figure 25: Hinkley Point C Handling and Ventilation

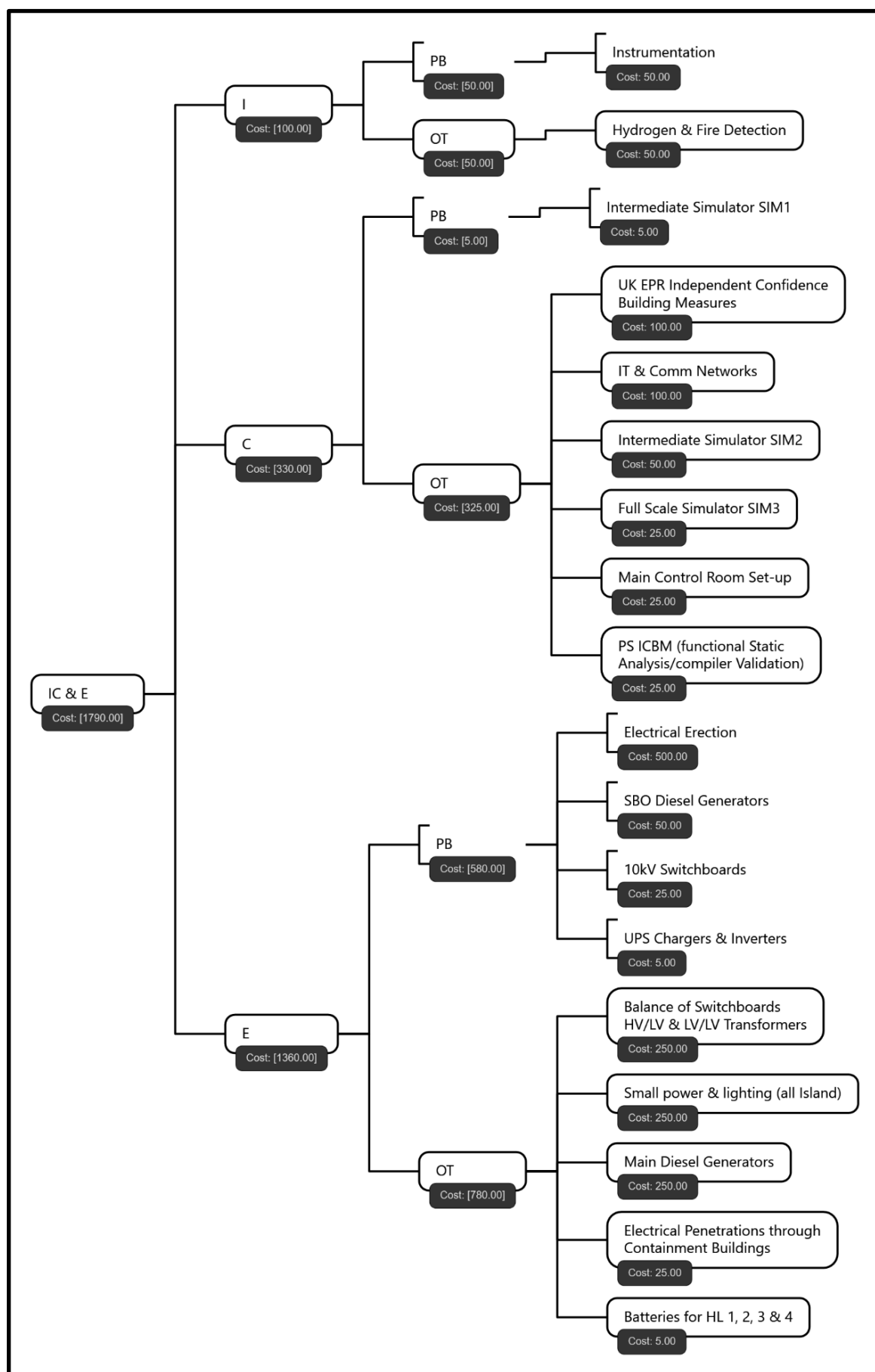


Figure 26: Hinkley Point C - IC & E

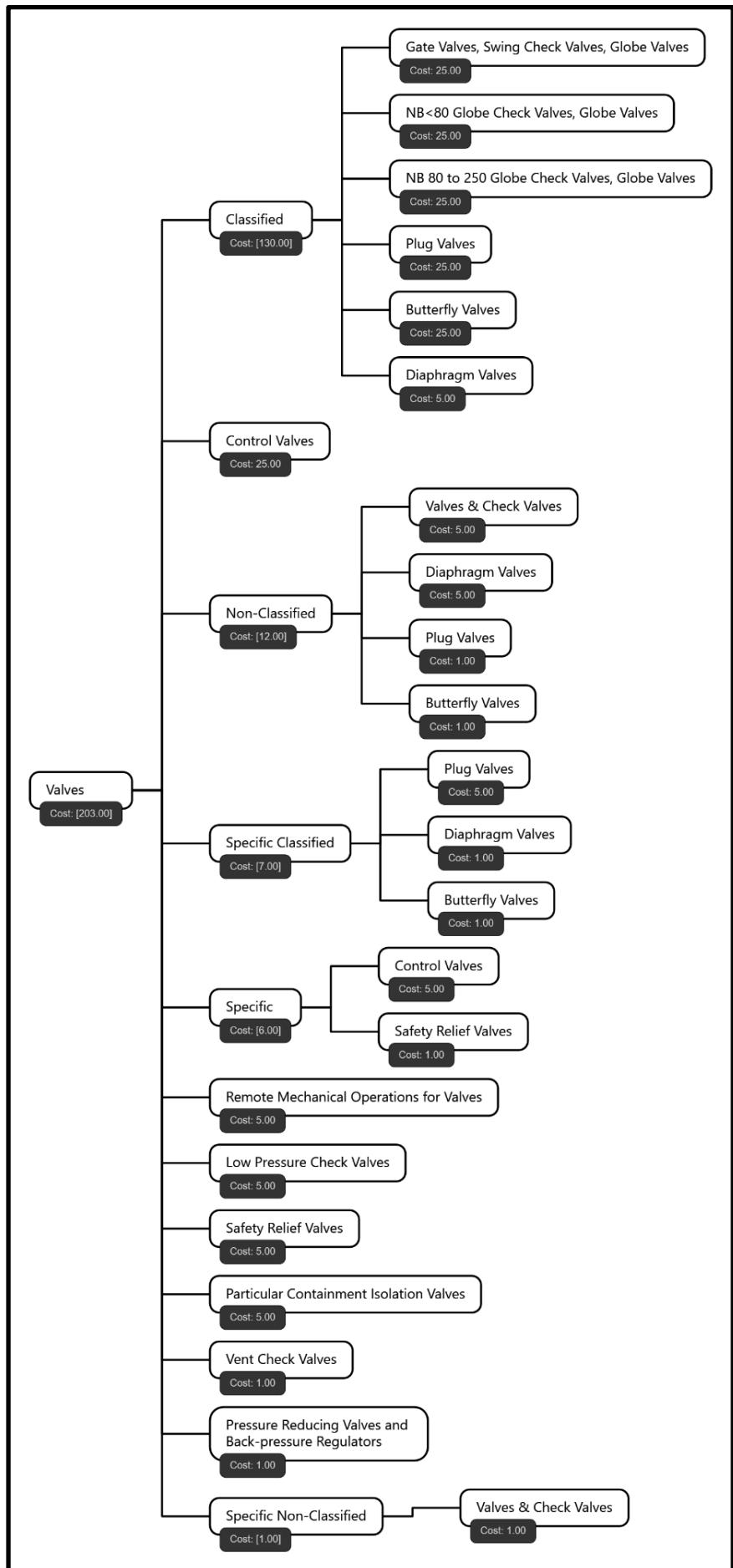


Figure 27: HPC Valves

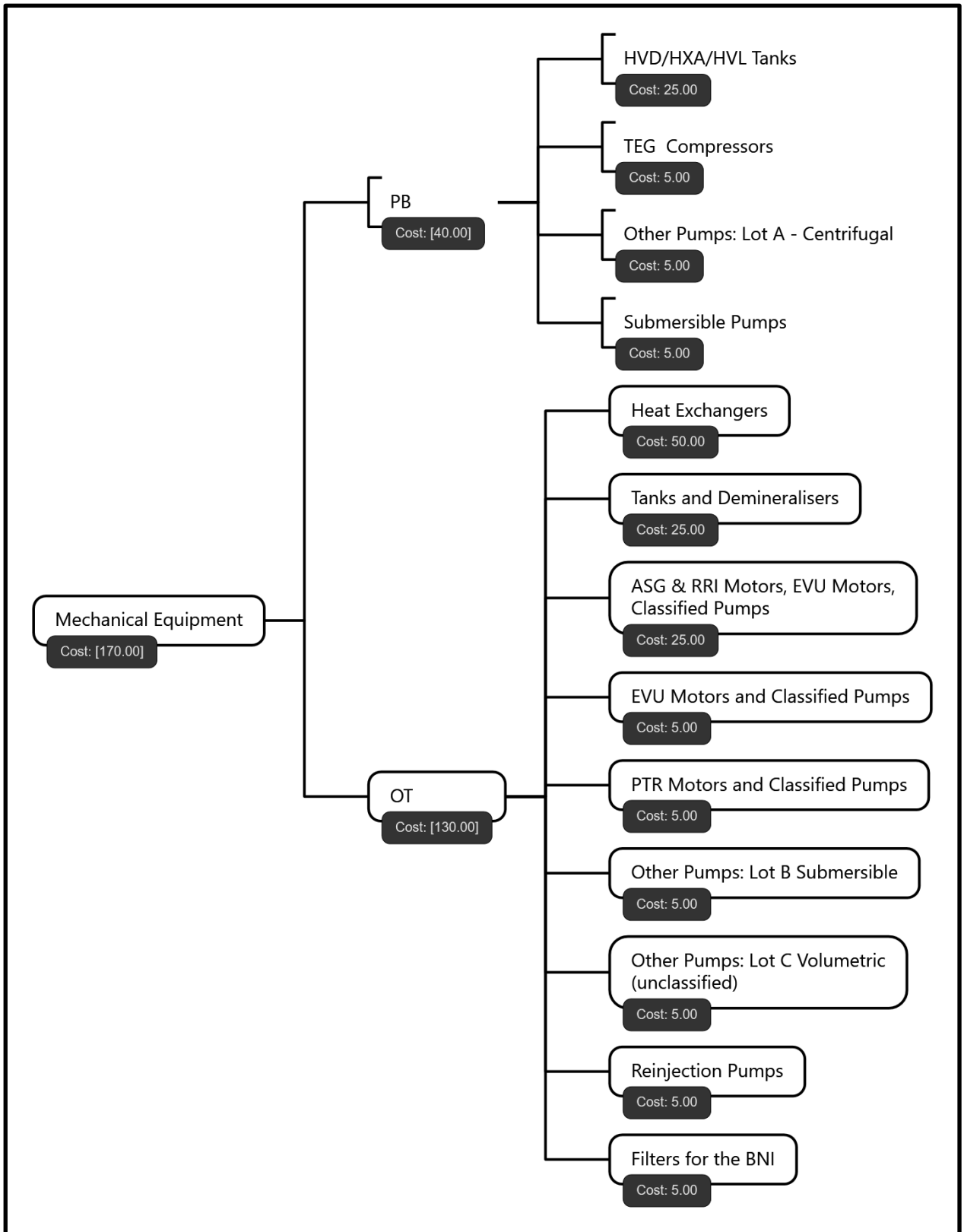


Figure 28: Hinkley Point C Mechanical Equipment

2.13.4 Monetary Value of Localisation

Localisation determines the amount of money to be spent on local business during the NNB.

2.13.4.1 Localisation in General

Various localisation figures (estimates) exist for NNB1. See **Table 8** on page 83. The table shows localisation values (% of total cost) that were obtained from research by others (indicated in the last column of the table) and by the researcher.

It is also important that localisation be defined in terms of the NNB work packages. For example, it might be unrealistic to put a 100% localisation requirement on the manufacturing of the Nuclear Steam Supply System. Although it has a very high economic value, it might be impossible to manufacture it in SA, due to complexity and nuclear quality requirements.

A good balance needs to exist between localisation and globalisation, being a result of the extent of past and future nuclear programme in the relevant country. Defining a new nuclear supply chain has challenges and might be more difficult in countries with a nuclear past (like SA). Within 10 or 20 years, precious know-how and manufacturing capabilities are lost due to inactivity (IEA, 2015:50).

In 2009 the Italian government requested Enel (an energy company, equivalent to Eskom) determine if it was possible to achieve 70% localisation. This initiative was halted after the Fukushima incident.

Enough work was done before the project was abandoned, and Enel concluded that a series of action steps were needed to increase the localisation value:

- Government incentive programmes
- Partnerships with qualified nuclear suppliers (international and local)
- Implement programmes for nuclear equipment qualification
- Intensify knowledge of nuclear codes and standards
- Intensify knowledge of document configuration management

For Hinkley Point C, there are no legal basis for percentage UK content, but supply chain benefits (read “localisation”) is paramount for the national economy, local economy and public support. The UK Government and Industry encourage prospect suppliers to become involved in the NARMC Fit for Nuclear (F4N) program, and with National Skills Academy for Nuclear to enhance their performance through teamwork and action on skills.

LOCALISATION	SOURCE	COMMENTS	REFERENCE
Units 1 & 2: 30% obtained naturally; 40% desired	Worley Parsons and DTI	For first two units. Based on specific elements	(WorleyParsons, 2011:76)
Units 1 & 2: 30%; Units 3 & 4: 50 - 55%; Units 5 & 6: 75 - 80%	Van Wyk dissertation at North-West University	Phased approach. Focus on component supply and long-term services support	(van Wyk, 2012:63-65)
60%	Eskom overall supplier development and localisation	May be unrealistic for nuclear projects	(van Wyk, 2012:52)
70%	Koeberg PTR Tanks Replacement Project	Work in progress	(Eskom, 2011)
Unit 1: >50% Unit 2: >70%	Framatome and China Ling Ao Phase II	>80% planned, but not realised	(NTI, 2018)
Hinkley Point C	EDF	64% of project spend	(Dept for Business, Energy and Industrial Strategy, 2017)

Table 8: Localisation Values

2.13.4.2 WorleyParsons Report on Localisation

WorleyParsons tabled a report on localisation for the (then) Department of Trade and Industry on localisation (WorleyParsons, 2011). They concluded that an average localisation of 40% of Capex value could be achieved.

Their calculations are shown in **Table 9** on page 86.

By excluding Civil and Services, the localisation of Manufacturing comes down to 8%. Based the maximum contract value of Hinkley Point C of GBP15 261m, localisation is worth GBP1 221m. Converted into SA currency at ZAR17/GBP, the result is ZAR20 755m.

Note: this report consists of 92 pages and is not included in this document.

2.13.4.3 NNB Costs

In August 2016 EE Publishers published the results of their own study and stated an overnight cost of USD50billion for eight Russian VVER 1200 reactors. At an exchange rate of USD1 = ZAR14 it converts to R776billion (EE Publishers, 2016).

Eyewitness News reported in April 2017 that the Eskom Chief Nuclear Operator estimated the cost of the 9 600MW NNB to be around ZAR600billion (Eyewitness News, 2017).

On 8 November 2017 Dr Antonie Cilliers (national coordinator of SAN-NEST) wrote that the 9 600MW NNB with 8 reactors would cost about USD60billion, which is ZAR855billion at USD1 = USD14.5 (Cilliers, 2017).

There are also reports that the 9 600MW NNB1 might carry a price tag of ZAR1trillion. BusinessTech carried an article with the heading *“Eskom will finance South Africa’s R1 trillion nuclear plans: minister”* in October 2016. The article mentions that the conservative estimate was ZAR500million, but it was expected to rise to double the value at ZAR1trillion, based on the Medupi and Kusile experiences with both having overrun on both budget and time (BusinessTech, 2016).

The Electric Power Research Institute (EPRI) commissioned a report titled Power Generation Technology Data for Integrated Resource Plan of South Africa (Electric Power Research Institute, 2017). This is a highly techno-economics report, which was used in the compilation of IRP2018 Draft.

In the United Kingdom the construction of the Hinkley Point C NPS started in 2016. The budget (in 2017) for the twin AREVA EPR (3 200MW total) is GBP20.3billion (The Guardian, 2017). At an exchange rate of GBP1 = ZAR17 the budgeted cost of HPC is therefore ZAR345billion. Through linear extrapolation the cost for 9 600MW NNB1 would amount to GBP60.9billion, equal to ZAR1 035billion (ZAR1 035 000million).

This researcher will use the Hinkley Point C costs as reflected in Section 2.13.4.2 of this document to establish the value of the nuclear manufacturing market in South Africa.

2.13.4.4 Hinkley Point C

The WP Report was based on a bill of materials, while the information on Hinkley Point C is based on work packages and a cost range for every contract. This researcher will do a localisation value calculation based on the ranges defined by WP.

The following assumptions were made in the calculation, based on personal industrial (non-nuclear) experience (since 1982) and expert opinions from interviews:

a) Contracts NOT to be localised:

- All contracts for the Nuclear Island (GBP5 328m, or 35%) due to the ASMEIII-N requirements.
- On the Conventional Island, Turbines, Generators, etc (GBP1460, or 10%)
- Balance of Plant
 - Security Doors, Blast Dampers (GBP100m, or 0.65%)
 - Embedded frames for above (GBP25m, or 0.16%)
 - HP Filtration and Fish Removal (total GBP30m, or 0.20%)
- Control
 - Simulators 1, 2, 3 and Main Control Room (GBP105m, or 0.69%)
 - PS ICBM (GBP25m, or 0.16%)
- Electrical
 - Penetrations through Containment Buildings (GBP25m, or 0.16%)
 - Main Generators and Batteries (GBP255m, 1.67%)
- Handling and Ventilation (total GBP205m, or 1.34%)
 - Spent Fuel Transfer Cask Facility (GBP25)
 - Ventilation Stack (GBP5m)
 - Polar Crane (GBP100m)
 - Fuel Handling (GBP50)
 - Fuel Transfer Cask Lorries (GBP25)

b) Apply WP localization values to the rest of the contracts.

Alternatively, items like valves, pumps and motors might be sourced from respective single suppliers, and free issued to contractors for installation in other work packages.

Type	Equipment	WP Localization Index					
		Value	LI Low	LI High	LI Low	LI High	LI Avg
		%Capex	% Value	% Value	%Capex	% Capex	%Capex
Mechanical Equipment		a	b	c	d = a x b	e = a x c	
	Pressure Vessels	0.5%	30.0%	60.0%	0.2%	0.3%	
	Tanks	2.3%	30.0%	75.0%	0.7%	1.7%	
	Valves	1.4%	33.0%	48.0%	0.5%	0.7%	
	Pumps	0.9%	36.0%	59.0%	0.3%	0.5%	
	Compressors	0.5%	0.0%	10.0%	0.0%	0.1%	
	Fans (HVAC)	0.5%	85.0%	100.0%	0.4%	0.5%	
	Chillers, Heating coils, etc (HVAC)	0.5%	0.0%	50.0%	0.0%	0.3%	
	Heat Exchangers	3.6%	47.0%	50.0%	1.7%	1.8%	
	Filters	0.7%	0.0%	10.0%	0.0%	0.1%	
	Ion Exchangers	0.5%	0.0%	10.0%	0.0%	0.1%	
	Turbines	2.3%	0.0%	0.0%	0.0%	0.0%	
	Pipes	3.2%	28.0%	52.0%	0.9%	1.7%	
	HVAC Ductwork	1.4%	0.0%	50.0%	0.0%	0.7%	
	Cranes	0.2%	0.0%	80.0%	0.0%	0.2%	
	Total	18.5%			4.6%	8.5%	6.6%
Electrical Equipment	Generators	0.5%	0.0%	0.0%	0.0%	0.0%	
	Transformers	0.5%	0.0%	30.0%	0.0%	0.2%	
	Motors	0.5%	67.0%	92.0%	0.3%	0.5%	
	Switchgear	0.5%	0.0%	25.0%	0.0%	0.1%	
	Motor Control Centre (MCC)	0.5%	0.0%	10.0%	0.0%	0.1%	
	Electrical Panels	0.5%	26.0%	50.0%	0.1%	0.3%	
	Cables	0.5%	39.0%	48.0%	0.2%	0.2%	
	Total	3.5%			0.7%	1.3%	1.0%
I & C Equipment	DCS	2.0%	0.0%	10.0%	0.0%	0.2%	
	Transmitters	2.0%	0.0%	10.0%	0.0%	0.2%	
	Gauge/Indicators	2.0%	0.0%	10.0%	0.0%	0.2%	
	Sensors/Elements	2.0%	0.0%	10.0%	0.0%	0.2%	
		8.0%			0.0%	0.8%	0.4%
Grand Total 1		30.0%			5.3%	10.5%	7.9%
Civil and Construction	Civil Concrete	25.3%	50.0%	90.0%	12.7%	22.8%	
	Formwork	0.3%	25.0%	75.0%	0.1%	0.2%	
	Rebar	2.4%	25.0%	75.0%	0.6%	1.8%	
	Tendons	0.3%	0.0%	0.0%	0.0%	0.0%	
	Structural and Reinforcing Steel	14.2%	50.0%	90.0%	7.1%	12.8%	
	Containment Assemblies	1.6%	0.0%	10.0%	0.0%	0.2%	
		44.1%			20.4%	37.7%	29.1%
Services	Design	5.0%	25.0%	75.0%	1.3%	3.8%	
	Services	2.0%	25.0%	75.0%	0.5%	1.5%	
		7.0%			1.8%	5.3%	3.5%
Grand Total 2		51.1%			22.2%	43.0%	32.6%
Grand Total		p76	81.1%		27.5%	53.5%	40.5%
RPV, SG & Misc		p61	18.9%				

Source:

Localization Study for First Two Units
of the South African Nuclear New-Build
Programme Final Report

1210 – PM-REP-0001
09-Jun-11

Table 9: WorleyParsons Localisation Estimates

2.13.5 Monetary Value of Localisation based on Work Packages

The value of localisation for Hinkley Point C based on work packages is GBP1 287m, which is about GBP66m more than the WP (GBP1 221m) bill of material approach. The average of the two numbers is GBP1 254m, which is ZAR21 318m at ZAR17/GBP.

Figure 30 (page 89) and **Figure 31** (page 90) respectively show the packages and their localisation values.

To put this ZAR21 318m in perspective, the researcher investigated the revenue of large SA manufacturing companies. For their financial year ending on 30 June 2018, Murray and Roberts had a revenue of ZAR21 847m (and a profit of ZAR268m) (Murray & Roberts, 2018). In turn, Group 5, reported a revenue of ZAR7 349m (and a loss of ZAR1 365m) (Group 5, 2018). Lastly, WBHO posted a revenue of ZAR35 028m (and a profit of ZAR859m) for 2017/18 (WBHO, 2018).

A proposed contract placement timeline is below in **Figure 29**. This will have the effect that the ZAR21 328m will be spread over several years (up to three 3 years before first nuclear concrete (FNC). The placement after FNC are not clear from this graph (Nuclear Industry Association, 2013:8).

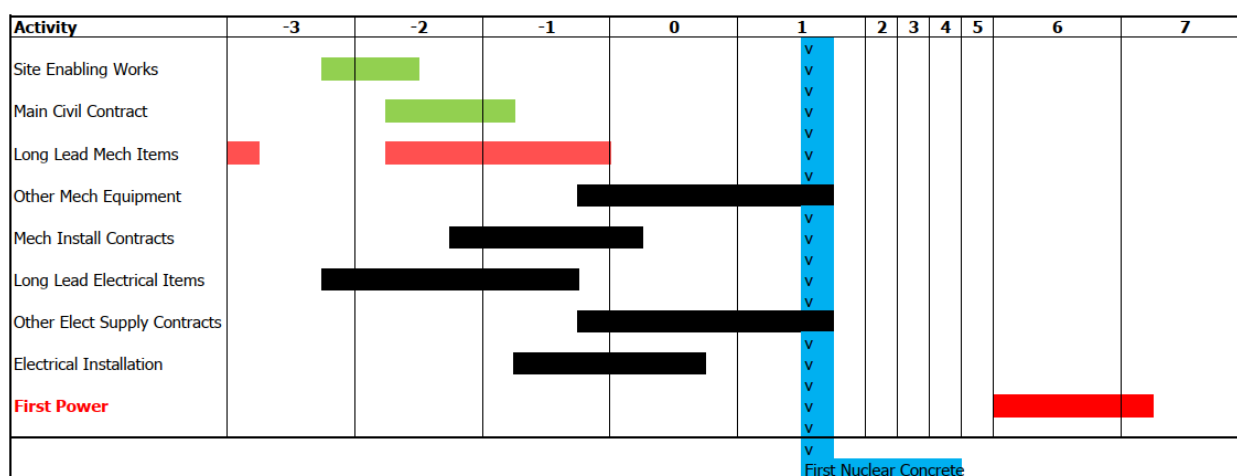


Figure 29: Contracts Placement

The time value of money is outside the scope of this study, but the consecutive builds of NNP might alleviate the cashflow situation for prospect suppliers. The Researcher has had no access to the financial terms and conditions (like advances, and compensation events).

2.14 Opportunities for New Entrants

New entrants are defined in Section 1.13 of this report, as 'n first time participant of a nuclear supply chain.

The figures in the previous section are for tenders to be issued to Tier 1 suppliers (OEM). New entrants will most likely be involved from Tier 2 downwards, which means that they could become JV partners of, or subcontractors to Tier 1 suppliers, depending on their current supplier status in the open market.

Current suppliers to fossil fuel power plants (Eskom as owner), and petroleum industry (Sasol as owner) are already in better position than others to become suppliers of:

- Smaller forgings, castings and spool pieces
- Auxiliary pipework
- Automated weld inspections
- Independent Third-Party Inspection
- Electrical site installation
- MV/LV Switchgear
- ICE Control and Distribution panels (Nuclear Industry Association, 2012b).

That is because they already know how to work in environments requiring high quality products and services, and they have audited quality systems in place. However, this does not imply that they are on nuclear quality level, and this may prevent them from the NNB.

And more so for the smaller suppliers who might become involved due to localisation, as per the Eskom definition (Section 1.12) “spend on local suppliers including spend on black suppliers”, to reach localisation targets.

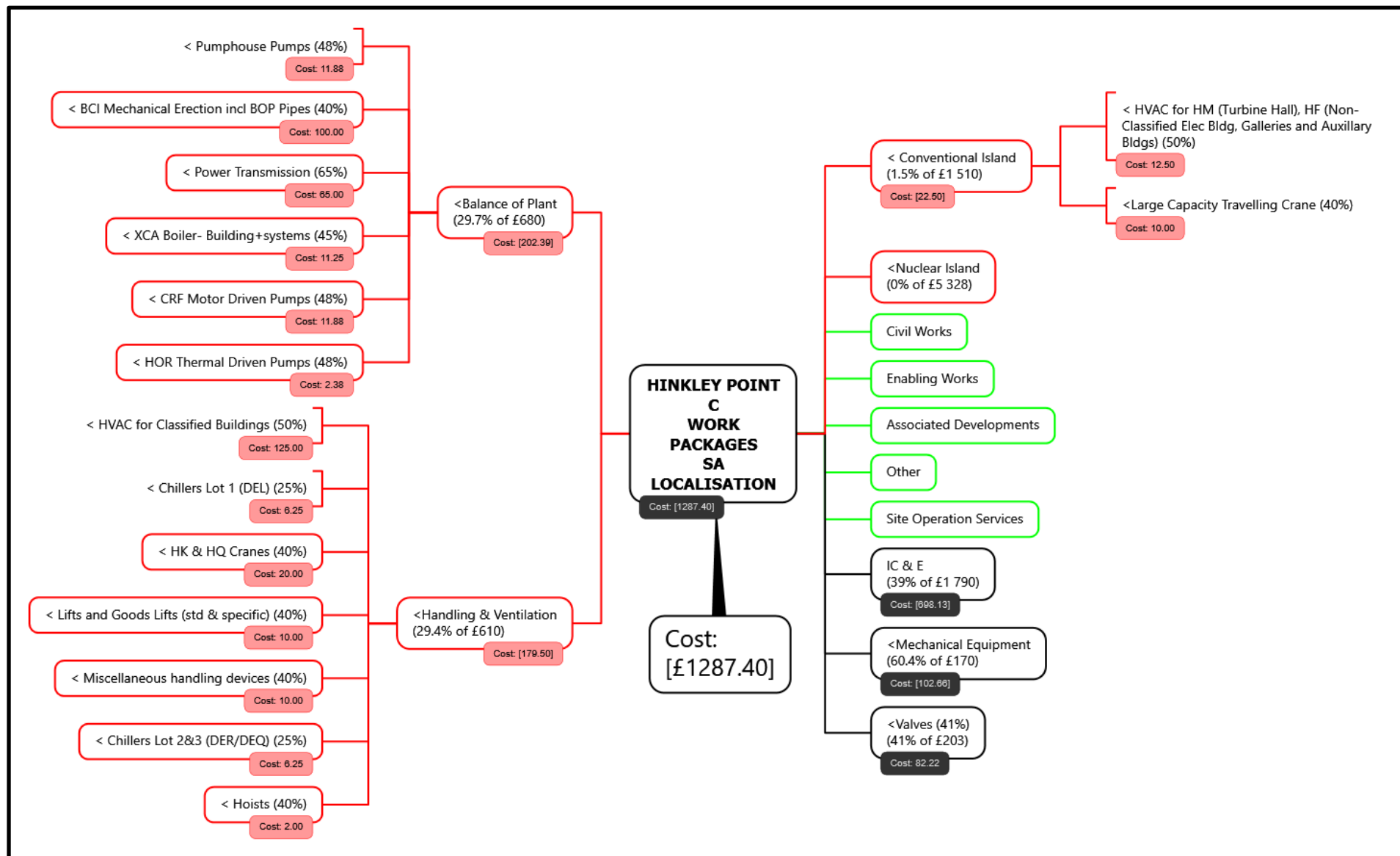


Figure 30: SA Localisation based on HPC and WP (details of red items)

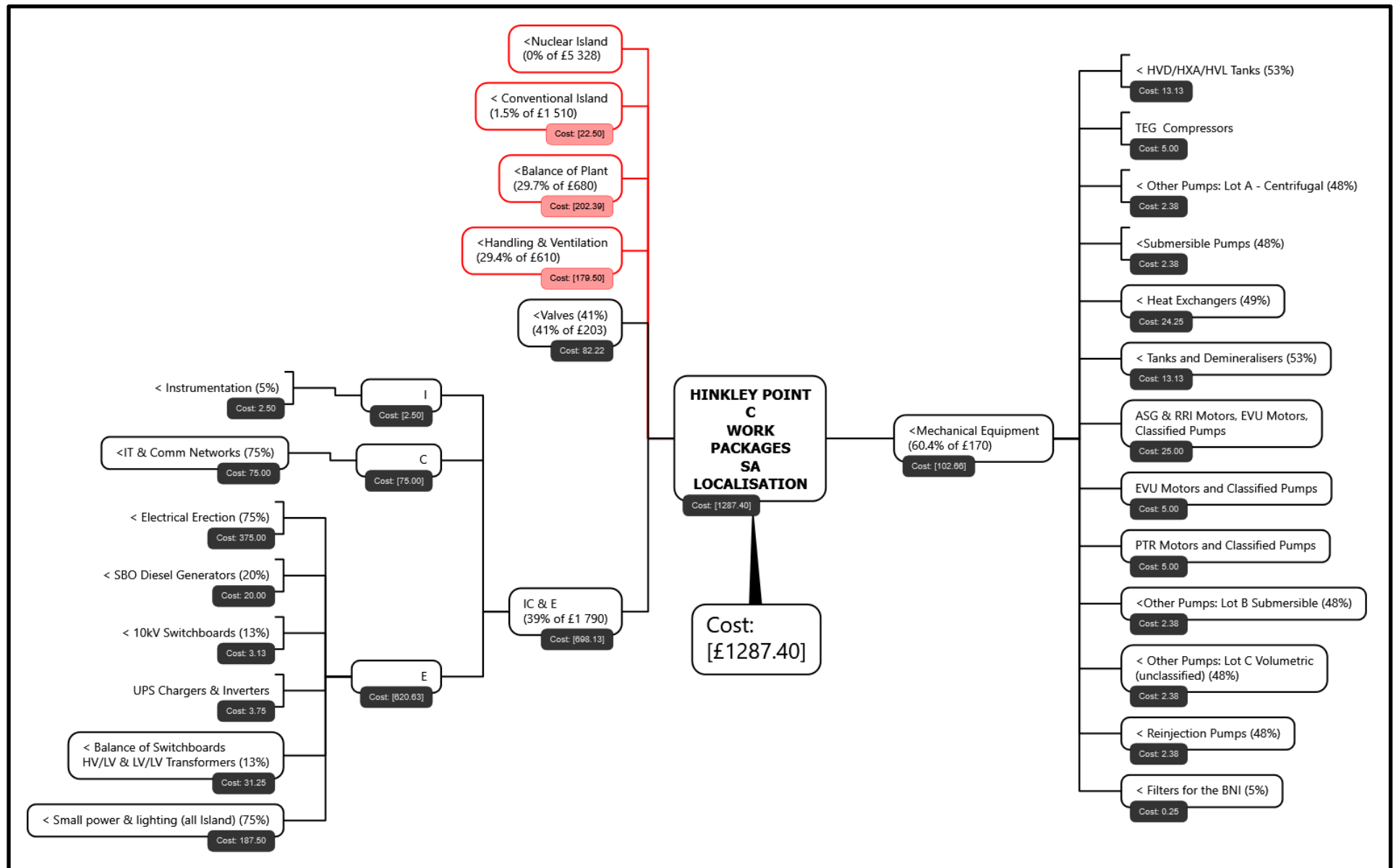


Figure 31: SA Localisation based on HPC and WP (details of black items)

2.15 Conclusion to Chapter 2

Chapter 2 entails the literature study of the factors that have an influence on the nuclear market in South Africa.

Firstly, it covers nuclear safety and nuclear quality, internationally and locally. The influence of the IAEA on all countries and particularly SA had been researched.

Secondly, the economic factors and role players in SA was researched. This provides qualitative information what new entrants could find in the market – laws, standards, rules and competition.

Thirdly, the Hinkley Point C NNB was researched to find a realistic price for a nuclear power plant, based on the contract values per work package. This also provides a monetary value for localisation, to establish the potential nuclear market value in SA for the first two reactors.

However, the challenge of how to become part of the nuclear supply chain is still unanswered.

2.16 Contents of Chapter 3

Chapter 3 describes the Research Methodology used to determine what the abovementioned challenges are.

CHAPTER 3 - RESEARCH METHODOLOGY

3.1 Previous Chapter

Chapter 2 is a literature study to determine the international and local factors that would influence the new entrant to become a member of the nuclear supply chain.

3.2 This chapter

This chapter covers the research methodologies used to obtain data for the roadmap, which is the aim of the study.

Based on the characteristics of data, there are 2 research methodologies, namely:

- Quantitative, and
- Qualitative.

3.3 Quantitative Research Methodology

According to Walliman (Walliman, 2011:71), when numbers are used to record information regarding science (speed, mass, etc) and society (indices, wealth, poverty) it is called quantitative data. Quantitative data can be measured, since it has magnitude (usually a number).

Numbers are analysed by statistical tools and techniques.

3.4 Qualitative Research Methodology

On the other hand, the same author states that “a lot of useful information cannot be reduced to numbers” (Walliman, 2011:71). The emotions, ideas, values of people are only described in words, that’s why they are qualitative data. These data are descriptive in nature. Qualitative data is dependent on human understanding and evaluation.

Words needs different analytical techniques, because they cannot be manipulated or evaluated mathematically.

3.5 Common approaches to data collection

Young & Hren (Young & Hren, 2017:22) described 4 methods of data collection, as listed in **Table 10** on the next page.

Approach	Goal or Application
Interviews	Explore individual experiences, perceptions or practices in rich detail
Textual data	Various like surveys, stories, documents, etc.
Focus Groups	Through group discussions generate insights in shared experiences and social norms
Observation	Learn about behaviours in a natural environment

Table 10: Data Collection Methods

3.5.1 Interviews

Young & Hren described an interview as “a conversation with a purpose, and it is useful for individual perspectives and experiences, sensitive topics and gathering in-depth information about a topic” (Young & Hren, 2017).

Walliman states that “interviews are more suitable for questions that require probing to obtain adequate information. There are 3 types of interviews commonly used, (Walliman, 2011:99):

- Structured, with standard questions, asked by the interviewer
- Unstructured, where the interviewer allows the interviewee to elaborate on his answers, to get more insight into his standpoint.
- Semi-structured, which is a combination of the abovementioned.

Interviews can be done face-to-face, in focus groups or telephonically, depending on the situation at hand (time available, travel, etc).

3.5.2 Textual data

Data are collected by using any type of documentation (printed or electronic), including quantitative surveys.

3.6 Simplicity

Young & Hren quoted David Silverman (2006) as to have said: “If you have a simple approach that is working well for you, don’t try to dress up your work in fancy terms” (Young & Hren, 2017).

3.7 Pilot Study

To select the best research methodology, the Researcher did a pilot study on a small number of respondents.

Depending on the contact information, either an e-mail or WhatsApp message was sent, or a telephone call was made to the 4 initial respondents, describing the purpose of the survey, and if they would prefer an interview or questionnaire.

In two out of the 4 cases the respondents granted the Researcher an interview (due to time constraints and uncertainty about the subject) and requested the questionnaire to be sent as agenda (for the interview). All four respondents were the owners of their respective non-nuclear manufacturing companies. Two messages were not replied to.

During the interviews, the questionnaire was not used as a ‘tick list’, and the Researcher switched to an Unstructured Interview, which allowed for a friendly and more receptive atmosphere. Given the ages of the parties (around 60) and the fact that 2 of the 4 respondents attended the same university as the Researcher around 1980, albeit in mechanical engineering while the Researcher studied electrical engineering, resulted in common ground and great rapport.

Young & Hren write that the Interviewer may deviate from the agenda and follow a different but related idea offered by the interviewee. The Interviewer may also change the contents of agenda by adding, removing or changing questions (Young & Hren, 2017).

3.7.1 Outcome of Pilot Study

Because of the pilot study, the Researcher decided on the following methodology:

- Qualitative with Unstructured Interviews, and
- Qualitative Open Format Questionnaires,

as depicted in **Figure 32** on page 95.

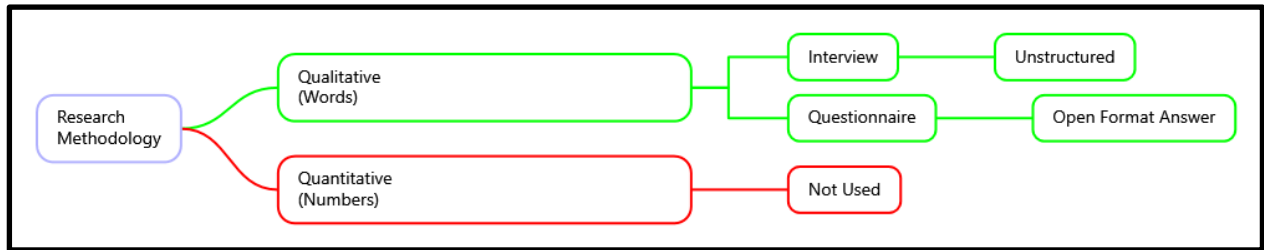


Figure 32: Research Methodology

3.7.2 Selection of Respondents

Respondents for the study were chosen on the following basis:

- Manufacturers in the Vaal Triangle (Researcher's home base)
- Manufacturer in Secunda (previous project capabilities known to Researcher)
- Contact details acquired during literature study
- Networking

See **Figure 33**.

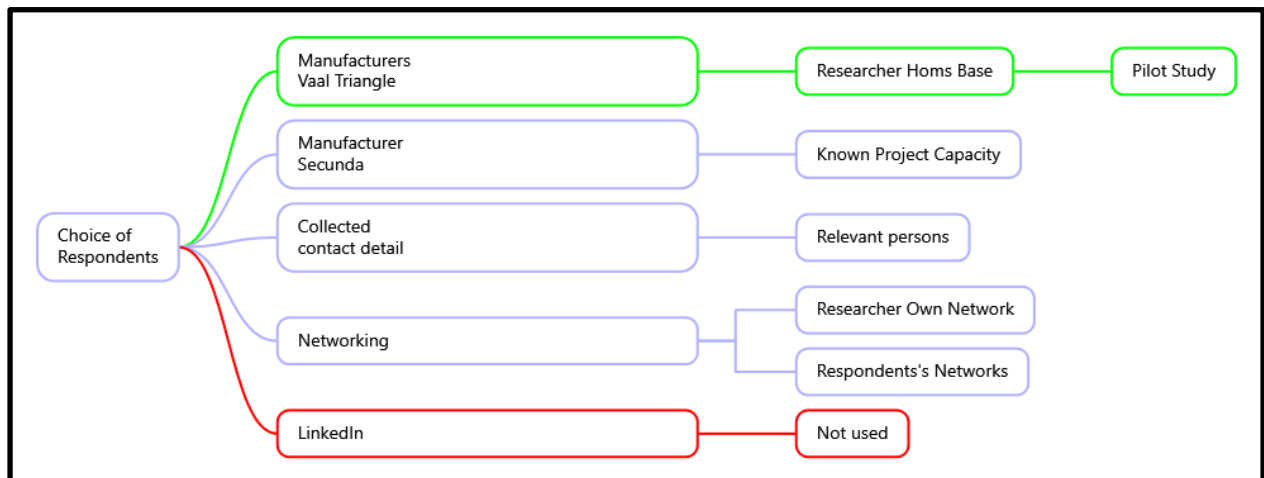


Figure 33: Choice of Respondents

3.7.2.1 Networking

Networking is defined as “a supportive system of sharing information and services among individuals and groups having a common interest” (Dictionary.com, 2018). The Researcher differentiates between different networks:

- Primary networking: Researcher contacted Respondents within his own frame of reference, to arrange interviews.
- Secondary networking: Researcher was referred to potential Respondents by initial Respondents from their own (primary) networks during the interviews.
- Work related: in some cases, senior management who received the initial request for an interview, referred the Researcher to senior personnel within their company.

3.7.2.2 LinkedIn

The Researcher did not make use of LinkedIn, since it is impersonal. Most of the referrals to other Respondents had the friendly undertone of “tell him or her that I gave you their contact details.”

3.7.3 Respondents in the Market Sectors

The Respondents were selected to be in the following market sectors:

- Manufacturing or services: non-nuclear
- Manufacturing or services: nuclear
- Consultants: non-nuclear
- Consultants: nuclear
- Eskom: nuclear (at Koeberg)

See **Figure 34**.

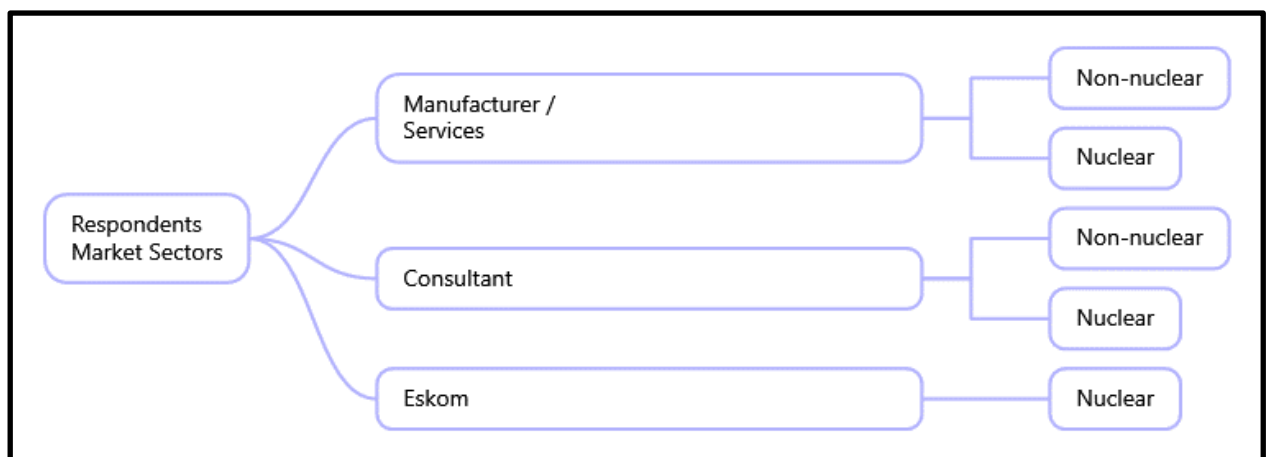


Figure 34: Respondents Market Sectors

3.8 Questionnaire for Non-Nuclear Interviewees

The Questionnaire for Non-Nuclear Companies is shown below.

Company Name	
Interviewee/Respondent, role, qualifications	
Introduction	PR Theron (Pr Eng Electrical) enrolled for M Eng at NWU
Confidentiality, Ethics	The information only be used for academical purposes
Company Info	Location / Big / Medium / Small
New Nuclear Build (6 x 1600MW)	Are you aware of the announced New Nuclear Build?
What products do you currently manufacture?	
To what codes and Standards	
For Eskom and petrochemical companies?	
Do you have a Quality Management System?	
Do you have accreditation?	
Do you know what the nuclear quality and safety requirements are	NQA-1 QMS, Safety classes for components, ASME III, NNR's RD0034
Skills and training situation	
What are your facilities?	
Are you interested to become a nuclear supplier?	
Would you need assistance	
Any questions	
Thank you	

Table 11: Questionnaire Non-nuclear

3.9 Questionnaire for Nuclear Supplier

The Questionnaire for the Nuclear Suppliers is as follows:

Company Name	
Interviewee/Respondent, role, qualifications	
Introduction	PR Theron (Pr Eng Electrical) enrolled for M Eng at NWU
Confidentiality, Ethics	The information only be used for academical purposes
Company Info	Location / Big / Medium / Small
Eskom Nuclear Supplier	Yes
What products do you currently manufacture?	
What services do you supply?	
Does your Quality Management System comply to RD0034?	
How do you experience the role of the NNR as additional AIA?	NQA-1 QMS, Safety classes, ASME III, NNR's RD0034
Do you sub contract to third parties?	
Would you contract current non-nuclear suppliers? How would you assist them to become a nuclear supplier?	
What components of a Nuclear Power Plant would be manufactured in SA?	
Is it possible for a company to become a nuclear supplier purely on his BBBEE status to reach localisation target?	
Any questions	
Thank you	

Table 12: Questionnaire Nuclear

3.10 Questionnaire for Eskom

The questionnaire presented to 3 Senior Eskom personnel:

Company Name	Eskom
Interviewee/Respondent, role, qualifications	
Introduction	PR Theron (Pr Eng Electrical) enrolled for M Eng at NWU
Confidentiality, Ethics	The information only be used for academical purposes
Recent Projects involved in	
Did the researcher identify the correct factors influencing a new entrant to the nuclear supply chain?	
What components of a Nuclear Power Plant would be manufactured in SA?	
Is it possible for a company to become a nuclear supplier purely on his BBBEE status to reach localisation target?	
Any Question	
Thank you	

Table 13: Questionnaire Eskom

3.11 Conclusion to Chapter 3

The theory behind Research Methodology is described in this chapter. Depending on the Respondent, the Researcher opted either for Unstructured Interviews with an agenda or Questionnaires with Open Format Answers.

3.12 Next Chapter

The results (outcomes of the interviews and questionnaires) of the Research are described in Chapter 4

CHAPTER 4 - RESEARCH RESULTS

4.1 Previous Chapter

In the previous chapter, the Researcher studied the Research Methodology, and decided on the applicable ones to be used in the survey.

Qualitative Unstructured Interviews was the preferred choice, but Qualitative Questionnaires with open format answers were used where it was required.

4.2 This Chapter

In this chapter, the survey results are discussed. Since Qualitative methods were applied, it is not possible to do statistical analyses on the data to reach a conclusion. Qualitative analysis will be applied.

4.3 The Numbers

4.3.1 Respondents

The complete table of Respondents is listed as Appendix A. The Researcher contacted 29 respondents and received feedback in the form of Unstructured Interviews (14), e-mail answers (3) or referral e-mails. Please see **Figure 35** on page 103 and **Figure 36** on page 104.

4.3.2 Pilot Study

In the pilot study, the Researcher contacted 4 potential respondents by e-mail and phone respectively. The results were as follows:

Method	Number	Interview	No reply	Referrals
e-mail	2	1 1	1	
WhatsApp	1	1		3
Call	1		1	

Table 14: Pilot Study

Based on the pilot study, the Researcher decided to opt for Interviews to gather information. A further advantage of interviews is referral to colleagues and/or associates of the Interviewees.

4.3.3 Contact Methods

The Researcher used mainly e-mails, but also phone calls and WhatsApp to initially contact potential Respondents. The outcomes were as follows:

Method	Subject	Number	Inter-views	No reply	Info supplied	Declined but referred	Referrals from Interview
Call	Request for Interview	2	2				1
	Initial contact (pilot)	1		1			
WhatsApp	Initial contact (pilot)	1	1				3
e-mail	Initial contact (pilot)	2	1	1			
	Request for information	4		1	2	1	1
	Request for interview (B)	6		6			
	Request for interview (A)	13	10		1	2	6
Total		29	14	9	3	3	11

Table 15: Contact Methods

The figures in red are the 11 referrals made during interview and are included in total 29 above.

4.3.4 Interpretation of Figure 35 and Figure 36

All the action steps taken to do the research are represented in **Figure 35** (page 103) and **Figure 36** (page 104).

The two figures are the two halves of a wide mindmap, split (for legibility) into two halves, around the central theme labelled **RESEARCH**.

4.3.4.1 Figure 35: Respondents and Responses (1)

Figure 35 contains the elements to the right of the central theme, with sub-headings **Pilot Study**, **e-mails** and **Request for Interview (B)**. **Figure 36** contains the elements to the left, with 1 sub-heading.

In **Figure 35**, the next level of the **Pilot Study** indicates which methods was followed to initiate first contact, namely **e-mail**, **Phone calls**, and **WhatsApp** messages. Next to those, are either the **names** of individuals, position or companies contacted. Then follows the outcome of the contact, which was either a **No reply** or **Interviewed**. In the **Interviewed** block the letter O, B, M, D and E indicates information about the interviewee as described in Section 4.4.2. Lastly **Referrals** to other persons are indicated (indicated with an equal-sign '=').

Under **e-mails**, the respondents to which questionnaires had been e-mailed are indicated, followed by their respective responses.

Under **Request for Interview (B)**, are listed contacted interviewees who did not reply.

Numbers next to Respondents refers to their number in the list from **Appendix A**.

4.3.4.2 Figure 36: Respondents and Responses (2)

Figure 36 summarises the other interviews (in addition to the Pilot study) that took place. The figure is the mirror image of **Figure 35**, and contains the same information.

Two interviews were requested by phone calls, while the rest per e-mail.

In one case, there was a Request for Interview, but information was supplied per e-mail (27 at the top).

In two cases to Senior Management, the original Request for Interview was declined, but directly referred to technical personnel (no 25 and 24).

An indirect referral (company to company on behalf of the Researcher) was declined (no 6).

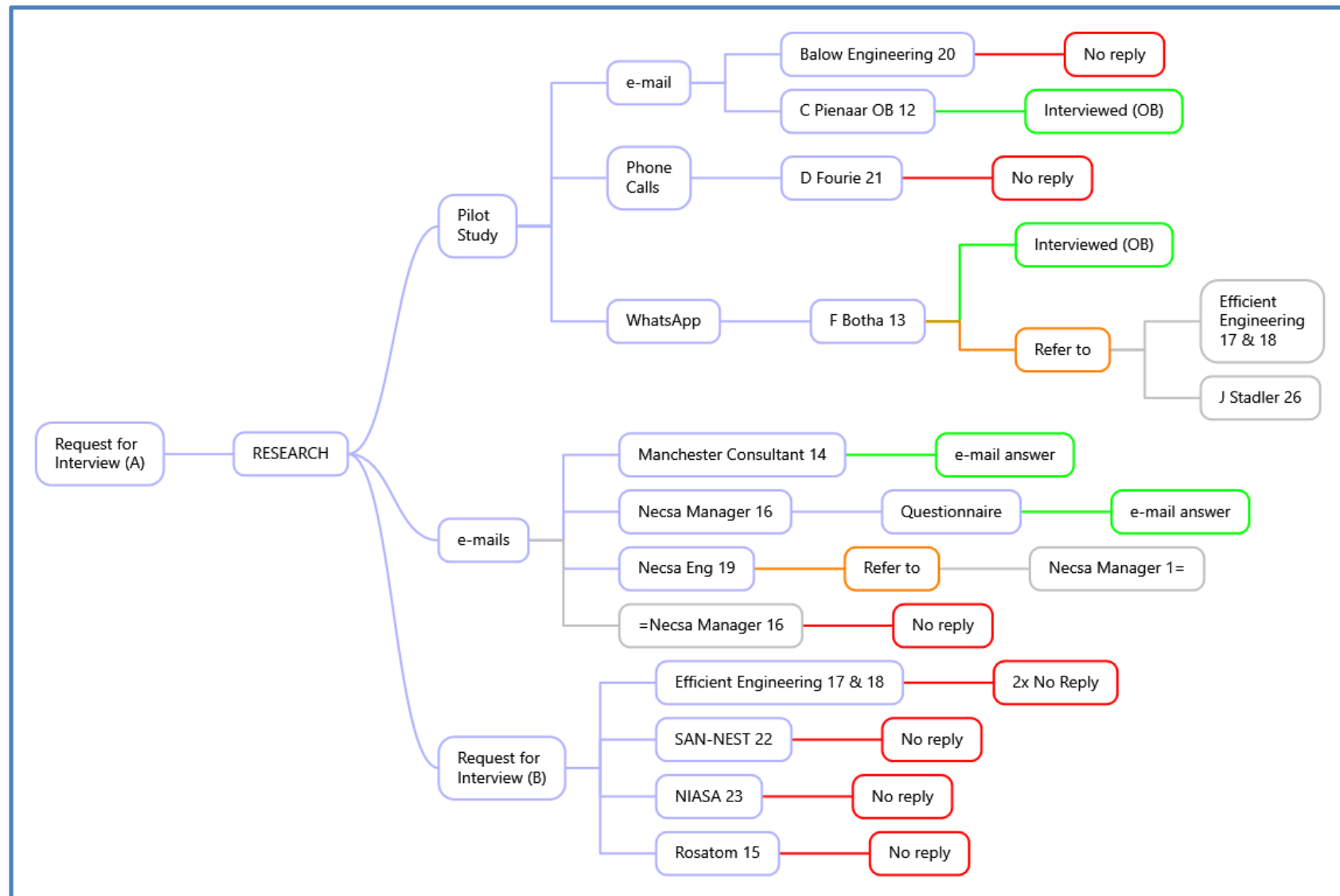


Figure 35: Respondents and Responses (1)

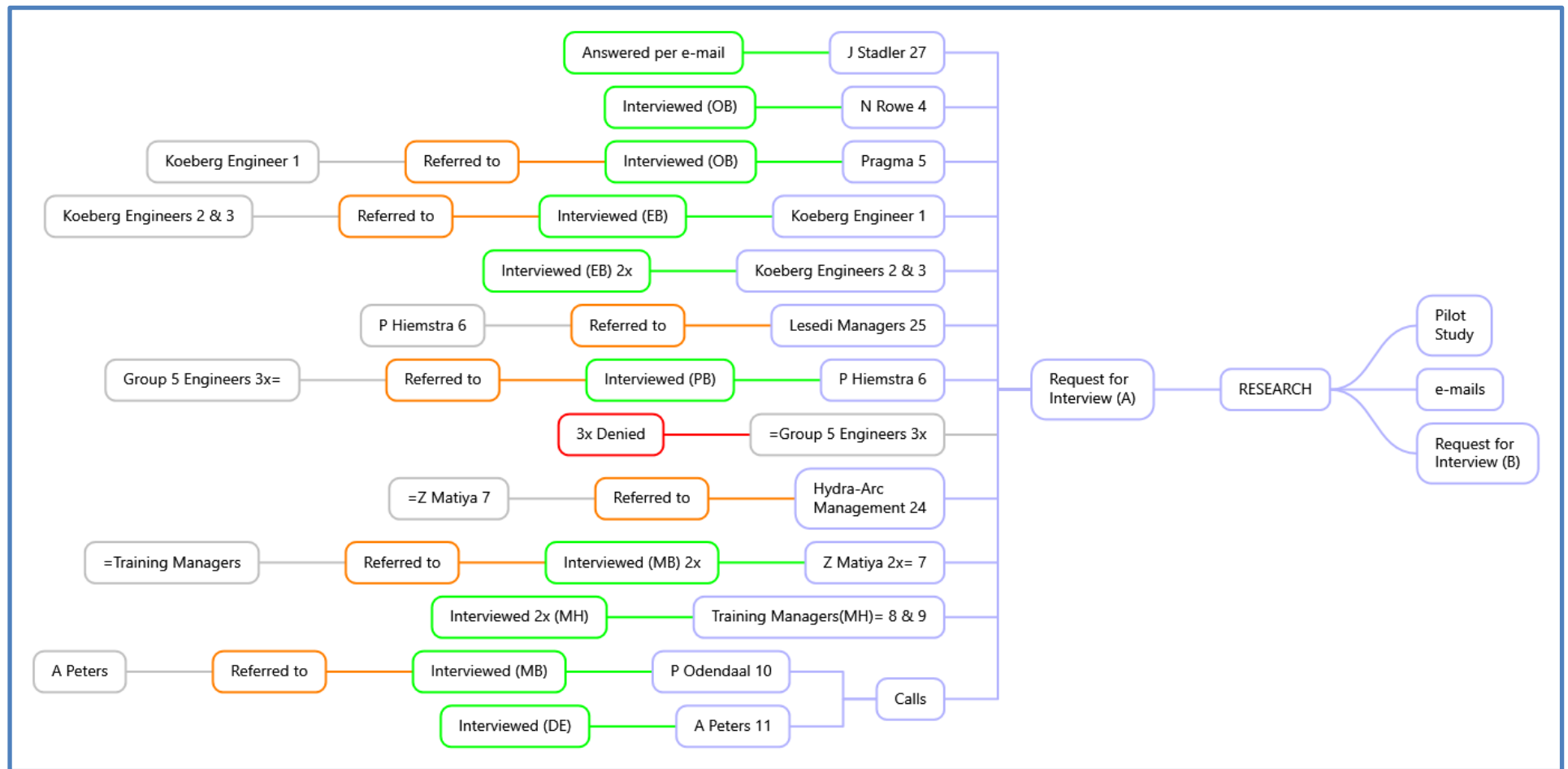


Figure 36: Respondents and Responses (2)

4.3.5 Referrals

A most useful advantage of having the interviews, is the fact that the Researcher was referred to other possible reviewees. There were 11 referrals from interviews.

Three requests for interviews with Group 5 were done directly by Lesedi, but interviews were declined.

4.4 Interviews

The following were discussed during the interviews, with the questionnaire/agenda as guideline. The answers are questions and responses are combined in the paragraphs to follow.

4.4.1 Introduction

Greeting and names were exchanged.

4.4.2 Position in Company

The Respondents occupied the following positions respectively

- Owners or Directors of company (O): 4
- Senior Technical Managers* (M): 2
- Senior Design Engineers (D): 1
- Senior Project Manager (P): 1
- Senior Project Engineers (E): 3
- Senior Training Managers (T): 2

The abbreviations are used in the green boxes in **Figure 35** and **Figure 36** respectively.

4.4.3 Qualifications

All the technical interviewees (i.e. O, M, D and P above) are engineers and have at least a B Eng degree (B).

The Researcher did not obtain the qualifications of the Training Managers (T).

4.4.4 Experience

The industry experience of:

- each of the owners of companies (O) is at least 35 years,

- the senior project managers (P) is at least 25 years
- the senior technical managers (T) is at least 35 years
- the senior design engineer (D) is at least 20years
- the senior training officers (M) is average 15 years.

4.4.5 Size and Type of Company

Question regarding size and type of company (details on their websites):

- Onsite Services: Medium Manufacturing non-nuclear (www.onsiteservices.co.za)
- Turnmill: Medium Manufacturing non-nuclear (www.turnmill.co.za)
- Hydra-Arc: Large Manufacturing and Large Training Facility non-nuclear (www.hydra-arc.com)
- Lesedi Nuclear Services: Large Nuclear Consulting and Component Supply (www.lesedins.co.za)
- Nuclear Consulting International: Large Nuclear Consulting and Component Supply (<https://nci-sa.co.za>)
- Pragma: Large maintenance management non-nuclear (www.pragmaworld.net)

4.4.6 NNB awareness

Question to non-nuclear manufacturers: are you aware of the NNB that was announced (6 x 1600MW)?

Yes, we are aware of the plans to build new nuclear power stations, but we are of the opinion that it will not realise.

Question: are you interested in becoming a nuclear supplier?

Yes, but no investment will be made before a firm go ahead was given, together with Government and/or the Owner's commitment.

Hydra-Arc answered they had prepared for the nuclear supply chain but stopped after spending ZAR3m without any return on investment.

Question to current nuclear suppliers: are you ready for the announced NNB?

Yes, we are looking forward to the challenges.

Question: what about skills and training?

Currently it is possible to find skills all over South Africa and internationally, since the market is on a downturn. When the NNB goes ahead, it will become a crisis, without a national nuclear skills program.

4.4.7 Quality Management System (QMS)

All the non-nuclear manufacturers stated that they are ISO9001:2015 accredited.

Question: are you aware of the requirements of nuclear quality and nuclear safety?

Yes, but not in detail. It will be addressed if and when required.

Question to nuclear suppliers: how do you handle a case where a non-nuclear supplier has the skill set and product or service that you require to win a nuclear contract?

Lesedi and NCI both answered that they are responsible by law to ensure that their sub-contractors have the correct QMS for nuclear components and/or services. Eskom and the NNR (as per RD0034) will also audit the subcontractor until they are satisfied with the QMS.

Question to nuclear suppliers: what are the biggest differences between nuclear and non-nuclear quality control?

Lesedi and NCI both answered that the extent of nuclear QC is much wider than for non-nuclear. For instance the specification for non-nuclear pressure vessel might require only 10% of the welds to be checked, while a nuclear specification would require 100%

Furthermore, every quality defect found needs to be reported to all the tiers of suppliers and the NNR. If reported, assistance from all levels could be expected, but the NNR shall suspend the manufacturing, until such time that the process is corrected. This is also stated in Section 8 of the NNR document titled "PP0012 Manufacture of Components for Nuclear Installations " (NNR, 2018b).

4.4.8 Training

Question: do you do training, and if so, to what extent?

Except for Hydra-Arc, all manufacturers answered that they train personnel (welders, fitters, boiler makers and inspectors) on an as-required basis.

Hydra-Arc, however, has a large training subsidiary (Jomele). They train 1000 artisans (boiler makers and coded welders) per year. The syllabus consists of 9 months theoretical and 6 months in service training. They also provide for the training of riggers, quality officers (90 trained in 2017) and safety officers. In all cases it is a one-stop service – accommodation, transport and food are supplied to the learners, so that they can concentrate on learning. They also do training courses and accreditation on behalf of the SA Welding Institute.

Vacancies in their own operations are filled by appointing qualified learners from the training academy.

They are the largest training facility of its kind in SA. They have a ratio of coaches and moderators to learners of 1:30, and workplace to learner ratio of 1:3, with 250 welding cubicles available.

Their goal is to have 2 100 trainees enrolled at any time of the year. At the time of the interview the figure stood at 1 353.

They are confident that they will be able to further grow their capacity and adapt to the NNB skills requirements.

Note: the interview was done in good spirit, but questions regarding the monetary value of the training, and the involvement of Government were cordially declined.

4.4.9 Resources and Material

A Consultant who had been on the PMBR team, remarked that local sourcing of material (special grade steel, for example) required for the NNB might not be readily available, and might need to be imported or specially manufactured.

4.5 F4N e-mail

A **Questionnaire** was sent to a Nuclear Consultant at the University of Manchester, enquiring about the F4N program in the UK. His answer is summarised as follows:

It is most important for the UK economy, public and Government that jobs be created at NPP sites and throughout the nuclear supply chain. The NAMRC was established to support (through the F4N program) smaller companies in the supply chain to ensure that they are proficient in and adhere to all nuclear codes, safety protocols and procedures. The NIA nuclear supply chain also plays a role in this regard.

4.6 NECSA Questionnaire

A **Questionnaire** was sent to a Senior Manager at NECSA, and the following (edited) answer received per e-mail:

NECSA is interested in and will be involved in the NNB as per the Nuclear Energy Policy and the Nuclear Energy Act respectively

All the nuclear quality requirements as previously mentioned in this study are applicable. NECSA is a Certified Material Organisation (CMO), enabling them to qualify suppliers, NECSA in a position enabling suppliers to supply ASME III material under their (NECSA) supervision.

As far as skills are concerned there will unquestionably be challenges in the engineering fields of mechanical and manufacturing, electrical, control and instrumentation, civils and construction at engineering and artisan levels.

Training will be needed on the mentioned categories. Training initiatives are already taking place in collaboration with vendor countries such as China and Russia.

Localisation shall be a requirement already at the stage of contracting the technology vendors (OEMs). The Government will use instruments like the CSDP, NIPP and BBBEE on the NNB, providing for training by the vendor countries and transfer of skills.

The Government shall see to it that vendor countries and companies compete in the bid process and include localisation, skills development and skills transfer across the value chain. Eskom and NECSA as SOEs need to fulfill significant roles in the NNB, since they are ideal vehicles for the government to prepare and ensure that skills are in place to give the program a head start.

In most countries, procurement has always been led by or guaranteed by government. SA needs to take advantage of lessons learnt on NNBs being undertaken elsewhere. Eskom will be the owner operator of the NNB reactors since it already has experience in operating an NPP. NECSA on the other hand could lead the fuel program, since it has experience in this regard.

NECSA already has facilities or capabilities to undertake nuclear R&D, engineering, manufacturing, procurement, and installation at Pelindaba. Since the location of the service or product provider or supplier is a factor which has an impact on the cost of NNB products and services, strategic decisions need to be taken on relocating suppliers closer to or onto the NNB sites (like Duynefontein).

4.7 ESKOM Interviews

The Researcher had interviews with 3 Senior Nuclear Project Engineers. They have been fulltime involved in the Koeberg Steam Generator Replacement Project.

On the question on which of the Hinkley Point C work packages could be executed by SA companies, they agreed with the selections in **Figure 30** and **Figure 31**, and that the percentage of localisation might be even higher than the WorleyParsons report (qualitative statement). Although out of scope of this study, they also mentioned that the green elements in the figures (civils, site services and operational services) have a high localisation value.

Secondly, with reference to **Figure 37** on page 113, they **confirmed** that the Researcher had chosen the correct factors that will have an influence on the New Entrant's decision to become a nuclear supplier.

On the third and last question, if it is possible for a company to become a nuclear supplier purely on his BBBEE status to reach localisation targets, the answer was negative - it is impossible.

There are just too many nuclear quality requirements that must be satisfied. Nuclear safety cannot be compromised by politics or economics.

If Eskom would require specific skills or products or services from a non-nuclear supplier, they and the existing Tier 1 suppliers are committed to assist the prospective supplier to establish the required QMS. If the equipment is Class 1 or 2, the NNR will also be involved in the process through audits.

4.8 Conclusion to Chapter 4

This chapter reflects the answers on the research questions. Since it was a qualitative research, no statistics are involved.

The non-nuclear suppliers are aware of the nuclear QMS requirements, but they will focus on their current supply chains until such time that the NNB is fixed and firm, and they receive a real commitment from Government that the effort would be worth their while.

NECSA points out the roles of SOEs before the NNB starts, in order to have core skills ready beforehand.

Eskom verified the researched factors that will influence the decision of non-nuclear suppliers to venture into the NNB. The requirements for joining the nuclear supply chain will remain strict.

4.9 Next Chapter

In the next chapter, a roadmap will be presented, and the quality steps described, which a non-nuclear supplier needs to take to become a member of the nuclear supply chain.

CHAPTER 5: CONCLUSION

5.1 Chapter 4 outcomes

Chapter 4 contains the results and interpretation of the survey described in Chapter 3.

5.2 This Chapter

In this chapter the Researcher uses the results from Chapter 4, to draw a conclusion and propose a possible solution on how a New Entrant could become part of the nuclear supply chain for the planned SA NNBS.

5.3 The New Entrants Conundrum

A graphical representation of most of the subjects from the Literature Study in chapter 2 is to be found in **Figure 37** on page 113.

At first glance, it resembles a glossary at the end of a book – a book on the elements of the SA nuclear supply chain.

Getting involved in the nuclear supply chain is not impossible, but it will take commitment to become a supplier.

It is important that the above elements not be considered as obstacles, but as challenges. In some instances, the success factor is 'compliance' (in response to 'thou shalt' instructions, like complying to the Pressure Equipment Regulations).

Other challenges, like establishing a Quality Management System, gives a company the freedom to present the business processes it has in place in order to achieve the quality requirements for the nuclear components. It is a two-way process – the company tells the client how it wants to do the work to achieve his requirements. The client, in turn, wants proof that the work is done accordingly. This is done through repeated scheduled audits, until the parties have reached agreement.

It is a journey that cannot be undertaken alone, but the NNB main procurer (project manager or owner) is prepared to assist businesses to qualify eventually for work package contracts. The Tier 1 suppliers will also be involved in the process.

A proposal of how this could be achieved is shown in a roadmap in **Figure 38** (page 114), with the discussion in Section 5.4.

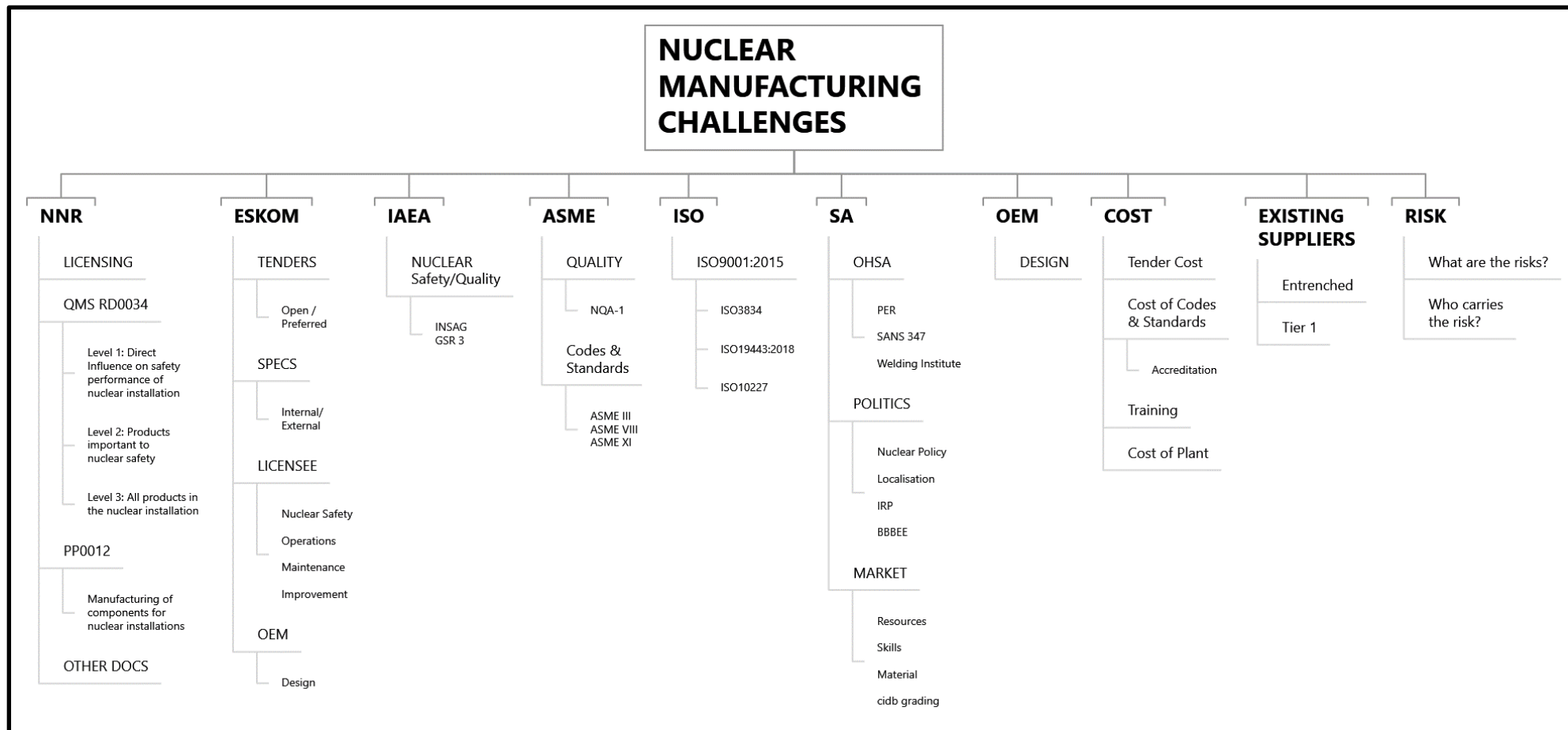


Figure 37: New Entrants Conundrum

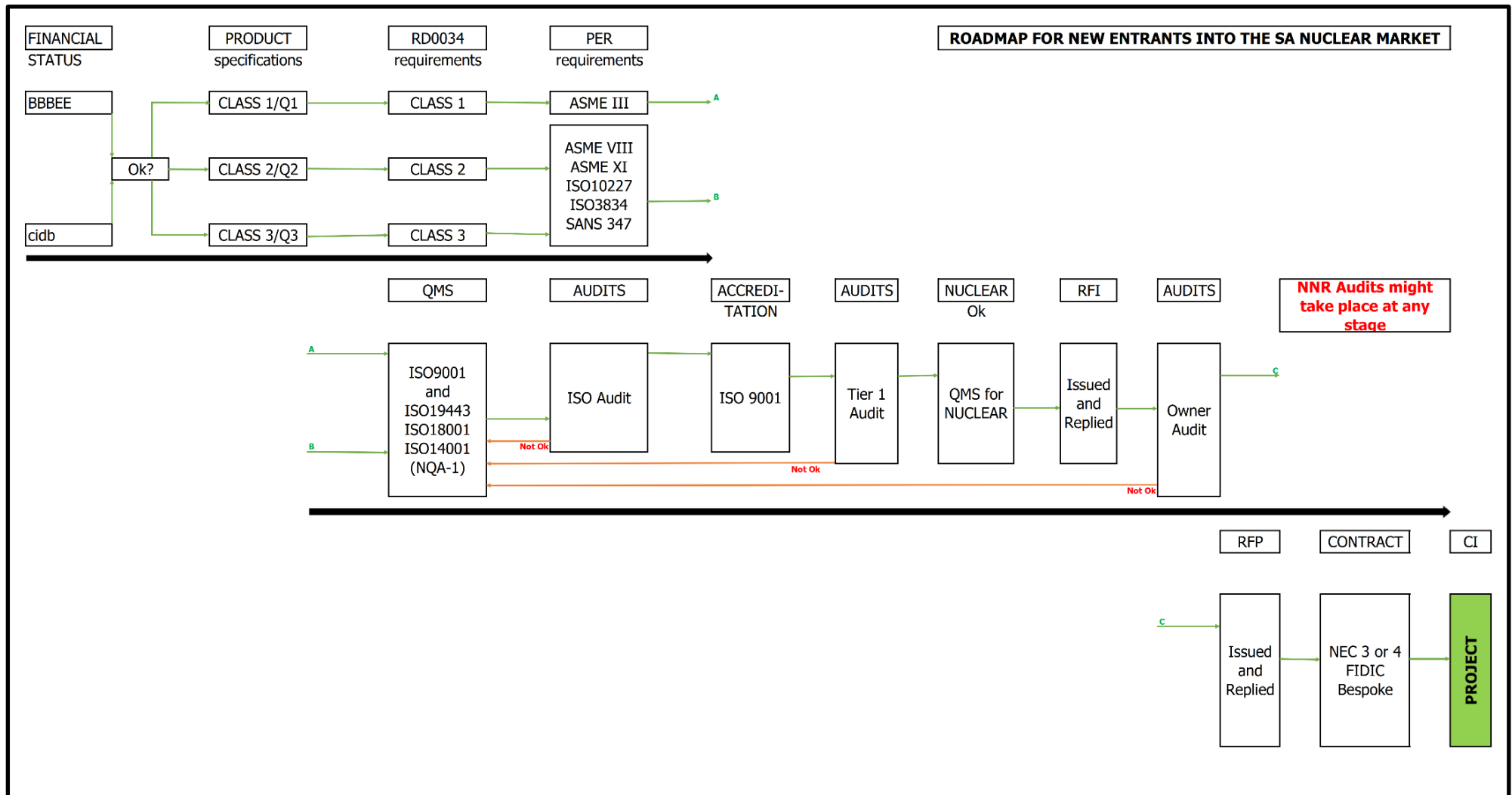


Figure 38: Roadmap to Nuclear Supply Chain

5.4 The Roadmap

Figure 38 on page 114 depicts the Roadmap that a non-nuclear supplier must follow to become part of the nuclear supply chain. It reflects the steps that he has control over. It is assumed that skills and facilities are already in place.

5.4.1 The Top Row

The maps start on left with a question asked regarding the financial status of the company. If either the cidb rating or the BBBEE status is not in place, it is no use in pursuing this venture any further.

If the financial status is in accordance with the expected contract value, the product specifications come into play. Class 1 is critical to nuclear safety, Class 2 is important to nuclear safety and Class 3 is neither of the two.

This specification needs to be in line with RD0034 of the NNR. This will determine which sections of RDA0034 need to go into the company's QMS.

Since the PER is in fact the law pertaining to pressure equipment is South Africa, all its requirements need also be taken up into the QMS. Class1 equipment will be subject to ASME III, while Class 2 & 3 will be subject to ASME VIII, ASME XI, ISO10227, ISO3834 and SANS 347.

The two green arrows tagged A and B continue to the second row and end up in the QMS.

5.4.2 The Second Row

All the technical and quality requirements are taken up in the QMS. The QMS is in accordance with ISO9001:2015, together with ISO14001 (Environmental) and ISO18001(OHS).

The QMS contains information of the company, how it plans to execute the project, and how it will manage the quality of its product (nuclear component or service). Although the company has some freedom in specifying what will be done (due to availability and capacity of equipment, for example) it must comply to nuclear quality guidelines.

After the QMS Draft has been compiled, it is necessary to obtain accreditation. The ISO process is two-way: the company tells what it wants to do and how it is going to do it. The ISO auditor comes around and check that the company has indeed done the work accordingly. If the audit has been successful, the company is now ISO accredited. Non-conformances need to be addressed.

The next audit is done by the Tier 1 company to verify that the lower tier company is indeed conforming to the Tier 1 QMS. If, so the company is now 'Nuclear Ready' (or Fit 4 Nuclear as described in the UK).

The company can now receive an RFI and respond to it. Questions regarding its QMS need to be answered to the satisfaction of the Owner. The Owner in turn also need to audit the company's QMS, to ensure compliance.

The NNR has the right to enforce its own audits at any stage to exercise its authority as regulator.

5.4.3 The Third Row

If the Owner's audit is passed, the company will receive the RFP. If the bid is successful, a contract will be signed (usually with the Tier 1 supplier),

The project execution then starts. During execution the quality audits at all levels continue, and Continuous Improvement is now the critical item.

5.4.4 Timeline

The Roadmap might take up to 3 years to complete, depending on the QMS status of the new entrant.

5.5 Finally

No company will become a nuclear supplier unless it goes through the nuclear quality process. This needs to be a concerted effort by Government, the manufacturing as well as the nuclear industries. The UK F4N is an excellent example to follow, but it needs to be adapted for SA.

From the Roadmap the process might seem to be trivial, but it is a complex, time consuming and expensive process.

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APPENDIX A

List of Respondents

No	TYPE	NAME	COMPANY	QUALIFICATION	JOB DESCRIPTION	CONTACT DATE	CONTACT DETAILS
1	Interview	Tommy Booysen	Eskom (Koeberg)	Pr Eng	Nuclear Engineering	2018/09/18	booyset@eskom.co.za
2	Interview	Louise Nieuwoudt	Eskom (Koeberg)	Pr Eng	Nuclear Engineering	2018/08/31	nieuwdtl@eskom.co.za
3	Interview	Kurt Jurgens	Eskom (Koeberg)	Pr Eng	Nuclear Engineering	2018/09/18	unknown
4	Interview	Neil Rowe	Nuclear Consultants Internat	Pr Eng	Managing Director	2018/06/22	neil.rowe@woodplc.com
5	Interview	Ronnie Taljaard	Pragma	Pr Eng	Director	2018/06/21	ronnie.taljaard@pragmaworld.net
6	Interview	Piet Hiemstra	Lesedi Nuclear Services	Engineer	Project Manager (PTR)	2018/06/21	piet.hiemstra@lesedins.co.za
7	Interview	Zbyszek Matyja	Hydra-Arc, Secunda	Pr Eng	Director	2017/09/14, 10/24	zfm@petref-consulting.com
8	Interview	Loren	Hydra-Arc, Secunda	Unknown	Training Manager	2017/10/26	lorenc@westhouse.co.za
9	Interview	Jacek Matyja	Hydra-Arc, Secunda	Unknown	Training Manager	2017/10/16	jacek.matyja@hydra-arc.com
10	Interview	Piet Odendaal	Turnmill, Vanderbijlpark	Pr Eng	Quality Manager	2018/08/29	083 304 017x
11	Interview	Alfred Peters	Private, Vanderbijlpark	Pr Eng	Design Engineer	2018/09/07	083 442 235x List Continues

12	Interview	Carel Pienaar	Turnmill, Vanderbijlpark	Pr Eng	Managing Director	2016/09/20	carel@turnmill.co.za
13	Interview	Fanus Botha	Onsiteservices, Vanderbijlpark	Pr Eng	Managing Director	2017/09/01	fanus@onsiteservices.co.za
14	e-mail	Consultant	Manchester University	Ph D	Nuclear Fellow	2016/09/22	xyz@manchester.ac.uk
15	e-mail	Ryan Collyer	Rosatom	Unknown	Communication Director	2017/09/06	info@rosatom.co.za
16	e-mail	Jabu Mangena	NECSA	Unknown	Localisation Consultant	2017/09/13	jabux.mangena@gmail.com
17	e-mail	Gerhard van Zyl	Efficient Engineering	Unknown	No response	2017/09/06	info@efficient.co.za
18	e-mail	Mike vd Walt	Efficient Engineering	Unknown	No response	2017/09/06	info@efficient.co.za
19	e-mail	Petrus Steyn	NECSA	Mechanical Eng	Candidate Engineer	2017/09/06	Referred me to Manager - no reply
20	e-mail	Lionel v Vuuren	Balow Engineering, Sasolburg	Unknown	No response	2017/08/30	balow@worldonline.com
21	Voicemail	Dawie Fourie	Engineer Firm	Unknown	Owner	2017/08/31	082 807 072x
22	e-mail	Anthonie Cilliers	NorthWest University	Ph D	No response	2017/09/22	anthonie.cilliers@nwu.co.za
23	e-mail	Des Miller	NIASA	Unknown	No response	2017/09/06	niasaservices@vdm.co.za List Continues
24	e-mail	Jose Maciel	Hydra-Arc	Unknown	Managing Director	2017/09/05	Referred me to Zbyszek Matyia

25	e-mail	Gerard du Plessis	Lesedi Nuclear Services	Pr Eng	Sr Mechanical Engineer	2018/06/08	Referred me to Piet Hiemstra
26	e-mail	Shane Pereira	Lesedi Nuclear Services				
27	e-mail	Johan Stadler	Guideline Construction	Pr Eng	Managing Director	2017/09/08	Referred by F Botha End

