

A licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL Secunda as a case study

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Declaration

I declare that: "***A licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL Secunda as a case study***" is entirely my own original work, I am the sole author and all sources applied have been acknowledged by way of reference. This dissertation was not previously submitted at North-West University or any another educational institution.

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Signature

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Date

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Abstract

A licensing plan for coupling a nuclear energy source to a chemical process plant. SASOL Secunda as a case study

The purpose of the research study was to identify the implications of the licensing process-related costs for coupling high temperature reactor(s) (HTR) to the SASOL coal-to-liquid (CTL) process (hereafter known as nuclear coal-to-liquid (NCTL)). This was achieved by formulating a licensing plan using SASOL Secunda as a case study. The secondary objectives of the study were: To analyse the national nuclear regulatory (NNR) act, regulation and authorisation, relevant to the licensing of the NCTL production plant; identify variables influencing licensing and evaluating the relative significance from the perspective of relevant stakeholders; and evaluate the magnitude of the activity-base costs. In order to achieve these goals, an in-depth literature review was conducted to understand the application of nuclear licensing and related concepts. These concepts consisted of several key elements, ranging from South Africa's legal requirements from the perspective of the national energy regulator; environmental impact assessment; NNR's nuclear installation site license, nuclear installation license – including commissioning and decommissioning. A mixed experimental approach consisting of qualitative (explorative) and quantitative (descriptive) survey designs were utilised in this study to achieve the primary aim and secondary objectives. Three (3) structured measuring instruments such as a telephonic interview, in-depth interviews and self-administered surveys were utilised in this study to collect data. The data collected revealed three (3) short comings. Short comings were addressed thereafter; ten (10) problems were also identified, to which solutions were suggested. From the results of the study and empirical evidence, a quantified assessment of the risk of time and cost of licensing the NCTL production plant was achieved; it was shown that the overall timelines of the licensing plan for the NCTL production plant was estimated at 8 years as suggested by international best practise; total licensing costs was estimated at ZAR 918,599,904.00 in 2013 value. This study concluded with several recommendations in respect of engagement with the NNR, of which the following are important: To gain clarity on the requirements on the content of site safety reports; provide direction on how to apply for multiple nuclear installation licenses for installations for construction on a common site after granting multiple nuclear installation site licenses and public participation process; and distinguish whether the safety authority has the required human resource capable of handling two (2) license applications per year.

Keywords: ARCHER Project, NCTL Production Plant, Licensing Plan, Licensing Risks, Regulatory System.

List of Acronyms

Acronym	Description
ARCHER	Advanced High-Temperature Reactors for Cogeneration of Heat and Electricity R&D
CEO	Chief Executive Officer
CHP	Combined Heat and Power
CO ₂	Carbon Dioxide
CTL	Coal-To-Liquids
DiD	Defence-In-Depth
DME	Department of Mineral and Energy
DoE	Department of Energy
EAP	Environmental Assessment Practitioner
EIA	Environmental Impact Assessment
EIR	Environmental Impact Report
EMP	Environmental Management Plan
EUROPAIRS	End-User Requirements for industrial Process heat Applications with Innovative nuclear Reactors for Sustainable energy supply
HTR	High-Temperature Reactor
IAEA	International Atomic Energy Association
INL	Idaho National Laboratory
KNPS	Koeberg nuclear power station
LD	Licensing Document
LWR	Light-Water Reactor
MW(t)	Megawatt Thermal Power
NCTL	Nuclear Coal-To-Liquid
NEA	Nuclear Energy Act
Necsa	The South African Nuclear Energy Corporation Limited
NERA	National Energy Regulator Act

NERP	National Electricity Response Plan
NERSA	National Energy Regulator of South Africa
NGNP	Next Generation Nuclear Power Plant
NGP	New Growth Path
NIL	Nuclear Installation License
NISL	Nuclear Installation Site License
NNR	National Nuclear Regulator
NNRA	National Nuclear Regulatory Act
PBMR	Pebble Bed Modular Reactor
POS	Plan of Study
RD	Requirements Document (Regulatory)
SA	Safety Analysis
SAR	Safety Analysis Report
SHE	Safety, Health and Environment
SR	Scoping Report
SSR	Site Safety Report
SSRP	Regulations on Safety Standards and Practices
VAT	Value Added Tax
WBS	Work Breakdown Structure
WNA	World Nuclear Association
ZAR	South African Rand

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Chapter 1: Introduction

In 2009, at the Copenhagen climate change conference, South Africa committed itself to a 34% reduction below 'Business As Usual' levels of greenhouse gas emissions by 2020 and a 42% reduction by 2025 (Francesco Sindico, 2010). These reductions are subject to the provision of financial resources, technology transfer and capacity building by developed countries (Article 4.7 of the Convention).

Yet, energy demand was projected to increase from 2007 to 2030 globally due to the fact that electricity consumption levels were doubling through population and industrial development growth (WNA, 2011). On the other hand, refining industry will also increase in energy intensity (such as SASOL). The utilisation of the coal-to-liquid (CTL) process increases globally after 2022 while energy usage increases by 13% through 2040 (AEO, 2013, pp. 47-66).

Over the last decade, electricity demand in South Africa (SA) has also steadily grown due to strong economic growth and changing socio-economic conditions. Lately, the South African government has committed to a new growth path (NGP) to prioritise the creation of employment in all economic policies – including energy, communication, transport, water and housing – as being critical to growing South Africa's economy (RSA DoE, June 2013). Due to this constant growth, the reserve generation capacity will become exhausted and thus reduce Eskom's reserve margin with time (Eskom, 2010).

In light of South Africa's commitments to reduce its greenhouse gas emissions; and new NGP of energy, inspires the exploration of an alternative energy source other than coal-fired energy for combined heat and power (CHP) for the production of synthetic fuels using SASOL's CTL process. The utilisation of carbon in this process can be improved through the introduction of a high temperature reactor (HTR) as a heat source, steam and hydrogen for carbon neutral production. Thus, the coupling of an HTR with a chemical process plant (such as CTL) offers the prospect of improving the overall carbon and thermal efficiency.

The use of HTR in chemical processes has been explored by a number of international organisations. An example is the Advanced High-Temperature Reactors for Cogeneration of

Heat and Electricity R&D (ARCHER) project, which is focused on the coupling of the European HTR to a chemical process plant in the European Union. It extended its advanced European HTR technology with consortiums consisting of industry, technical support groups, research and development (R&D) institutes and universities; such as North-West in South Africa (hereafter known as South African (SA) ARCHER team). SA ARCHER team aims at modelling the SASOL CTL process to demonstrate the possible financial viability of coupling HTR energy to the SASOL CTL process, hence the need of a licensing plan.

1.1. Problem Statement

The ARCHER Project's objective is to demonstrate the viability of HTR and VHTR technology (ARCHER, 2013), while SA ARCHER team endeavours to utilise the SASOL scenario "to evaluate the economic viability of Nuclear Coal-To-Liquids (NCTL) production plant" in South Africa (NWU, 2013). They also have a researcher (consultant) assigned to their research project, which aims at identifying the implications of the licensing process on the project.

Building HTR modules to supply CHP to SASOL would require a nuclear installation license. This license should be applied for prior to engaging in any nuclear activities, in terms of section 20 of the National Nuclear Regulatory Act of South Africa (NNR Act No. 47 of 1999). Similarly, mandatory site assessment should be conducted first, followed by the optional design authorisation, then mandatory authorisation to manufacture and construct, and mandatory authorisation for operation, decontamination and decommissioning. These license activities are under the auspices of the NNR.

To be able to model the financial viability of introducing HTR energy to the SASOL CTL process, the SA ARCHER team needs a quantified assessment of the risk of time and cost of licensing the scenario in South Africa. Therefore, research is required by formulating "[a] *licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL Secunda as a case study*", to be able to quantify the economic risk of licensing and its delays (Bredimas, A & Nuttall, W, c. 2010, p. 2).

1.2. Aim and Objectives of the Study

The researcher's primary aim is to identify the implications of the licensing process-related costs for coupling high temperature reactor(s) (HTR) to the SASOL coal-to-liquid (CTL) process by formulating a licensing plan using SASOL Secunda as a case study.

In this context, the content of the licensing plan will be organised in phases from pre-operation and commissioning through to decommissioning (i.e. after life-time of plant) within Microsoft Project. The researcher will also identify critical milestone for project advancement, activity-based cost (ABC) estimates and accountability of the safety authority.

In order to realise the primary aim, the following secondary objectives must be met:

1. To define the hierarchy of the NNR act, regulation and authorisation, relevant to the licensing of the NCTL production plant.
2. To identify variables influencing licensing and evaluating the relative significance from the perspective of relevant stakeholders.
3. To evaluate the magnitude of the activity-base costs relating to the licensing plan.

1.3. Assumptions and Limitations

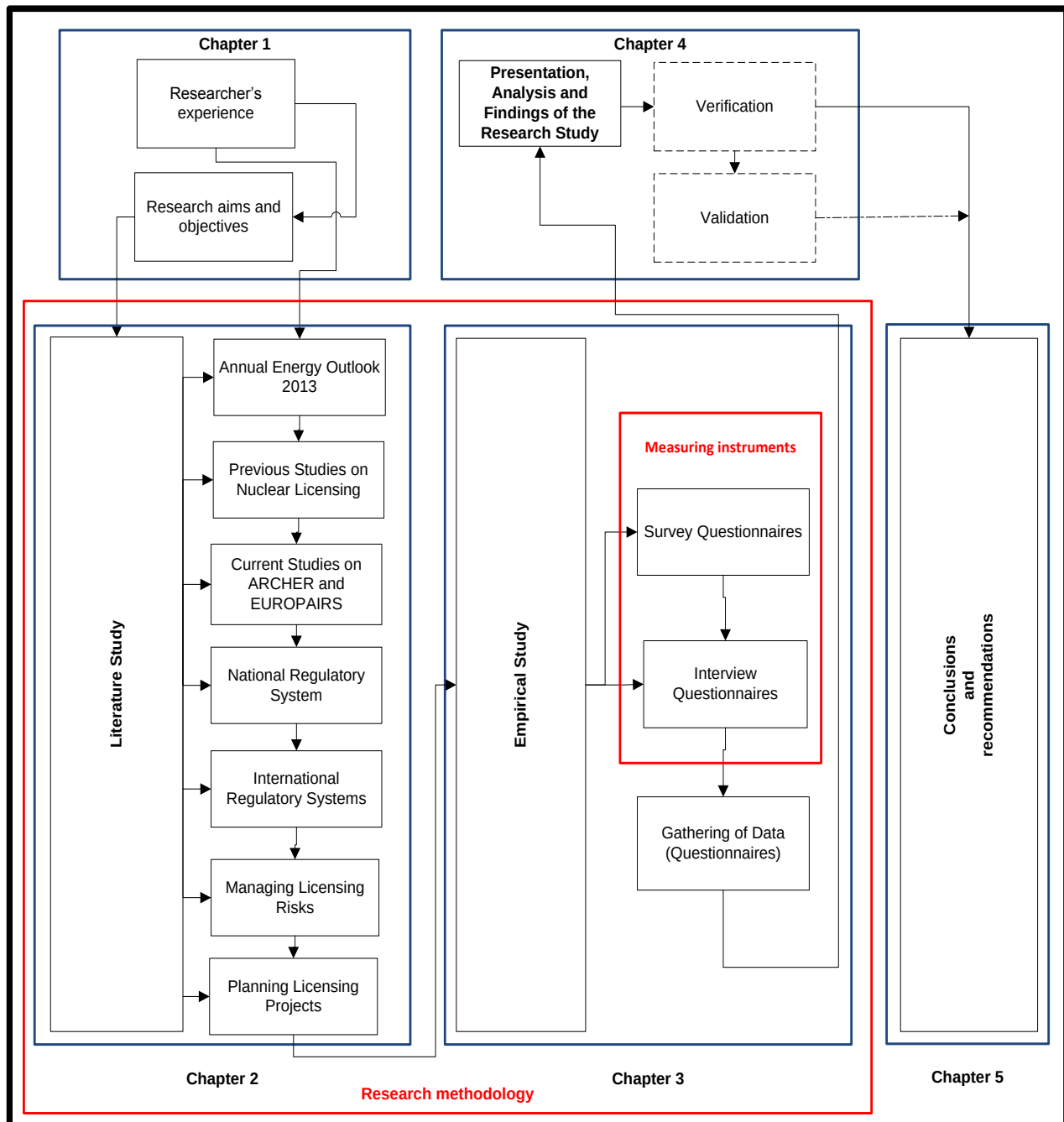
Since the study was broad-based and conceptual, design options and operating conditions of the systems involved are required. The following assumptions were thus made during the development of the licensing plan illustrated in **APPENDIX A**.

Some of these assumptions are fixed durations (i.e. time to review the license) while some were suggesting the sequence of the activities in relation to others. Hence, the following were taken as assumptions and limitations, in particular:

- I. As this research study was concerned with the licensing plan, the layout of the site and physical integration of the systems concerned were not investigated;
- II. In the research project the SA ARCHER team utilise the SASOL scenario “to evaluate the economic viability of Nuclear Coal-To-Liquids (NCTL) production plant” in South Africa (NWU, 2013)
- III. The inclusion of siting and bidding processes will form part of other investigations;
- IV. The nuclear source under investigation was already certified in Europe to supply process heat and power to an adjacent CTL production plant;
- V. The researcher study focuses on the use of steam and helium coupling for the transference of heat to the end-user NCTL production plant.

1.4. Chapter Division

The research study was reported over five (5) Chapters, which are graphically presented in **Figure 1**. The relations between these Chapters and the general research process are illustrated with arrows. Details on the content of each Chapter are given in the subsequent bullets.



Source: Structure of the Dissertation (Author's Own Construction)

Figure 1 – Chapter Division

Chapter 1 presented a summary of the problem statement, aims and objectives, followed by assumptions and limitations and Chapter division.

Chapter 2 will present a summary of the literature study pertinent to the research study under investigation. It will be arranged by starting with an overview of the Annual Energy Outlook (AEO) 2013. The second section will then provide an overview on previous studies on the

research topic. Thereafter, current studies on End-User Requirements for industrial Process heat Applications with Innovative nuclear Reactors for Sustainable energy supply (EUROPAIRS) and ARCHER projects will be covered, followed by the national regulatory system, and International Regulatory systems. The Chapter will also include suggestions on managing licensing risks. The final section will provide an overview on planning licensing projects.

Chapter 3 will focus on the empirical study of the research under investigation. It starts with the research design, the Chapter will also provide an overview of the data gathering method resulting from questionnaires developed by the researcher, this will be followed by a section on ethics and professionalism as the research study unfolded.

Chapter 4 will formally present the results of modeling the licensing plan and discussion on interviews. This will be followed by the results of the self-administered questionnaires. The goal in this Chapter was to provide the reader with a presentation, analysis and findings of the research study.

Chapter 5 will conclude with a summary of the recommendations on the implications of the licensing process when introducing HTR energy to the SASOL CTL process. The Chapter also provided the specific deliverables by revisiting the aim and objectives mentioned in section 1.2.

1.5. Summary

Chapter 1 highlighted the relevant facts of the proposed research study. It provided an understanding of the NCTL production plant and its relationship to the research question. It had also implicitly illustrated the importance and need for the research study. In the next Chapter an overview of the literature study on the licensing of the NCTL production plant for SASOL as the research scenario is discussed. The literature study also provides a deeper understanding of the research problem mentioned in section 1.1.

Chapter 2: Literature Study

2.1. Introduction

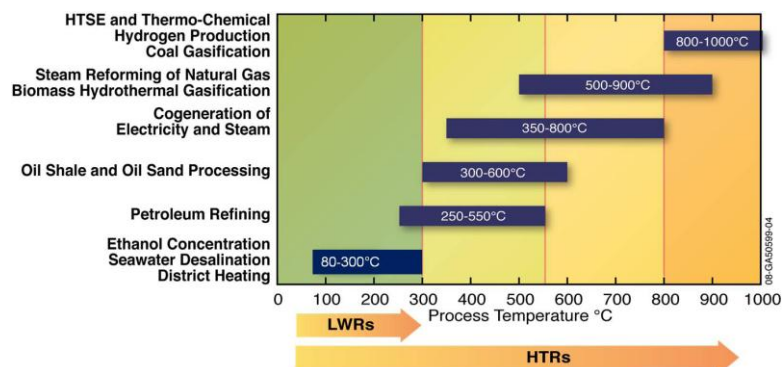
In this Chapter, the researcher has arranged the literature study around the licensing of a NCTL production plant, as it is pertinent to the research study. Significant discoveries and relevant licensing models, concepts and theories of significance were prioritised. The literature study will commence with a discussion on the Annual Energy Outlook (AEO) to show the applicability of the HTR energy to SASOL's CTL process. Later, Chapter 2 will conclude with an overview of planning licensing projects.

2.2. Annual Energy Outlook 2013

In this section, the researcher reviews how applicable the HTR energy is to SASOL's CTL process as it is pertinent to the research study.

2.2.1. Applicability of HTR energy to SASOL's CTL process

High temperature operating conditions make HTR energy applicable to a wide range of energy-intensive industries when compared to light water reactors (LWR(s)) as illustrated in **Figure 2**.



Source: Idaho National Laboratory/NGNP Status and Path Forward (U.S. DoE 2011, p.31)

Figure 2 – Temperature Comparison of LWRs and HTRs

It is noteworthy that small modular reactors (such as HTR(s)) are acknowledged as the expected technology of choice after 2025 as they do not emit CO₂ and may operate at high temperature conditions (AEO, 2013, p. 47). This fact makes the modular HTR(s) applicable to the CTL production plant at SASOL as the research scenario. In this context, “[a] *licensing plan for coupling a nuclear energy source to a chemical process plant*” under investigation will be considered by revisiting the previous and current studies on licensing, in the section hereafter.

2.3. Previous Studies on Nuclear Licensing

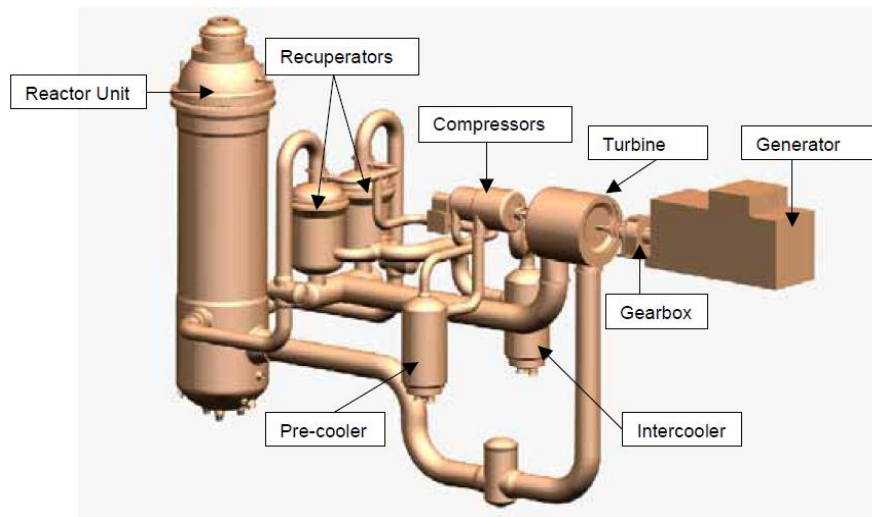
In the previous section, applicability of the HTR modules for coupling the CTL production plant using SASOL as a case study was covered. In the next section, a broad overview of the nuclear technologies and licensing issues are discussed. The Pebble Bed Modular Reactor (PBMR) and Next Generation Nuclear Plant (NGNP) of South Africa and United States (US) are investigated respectively as they are pertinent to the primary aim of the research study mentioned in section 1.2.

2.3.1. PBMR Technology

This section provides an overview of the PBMR technology – including major challenges and lessons learned on licensing in South Africa.

2.3.1.1. PBMR Application

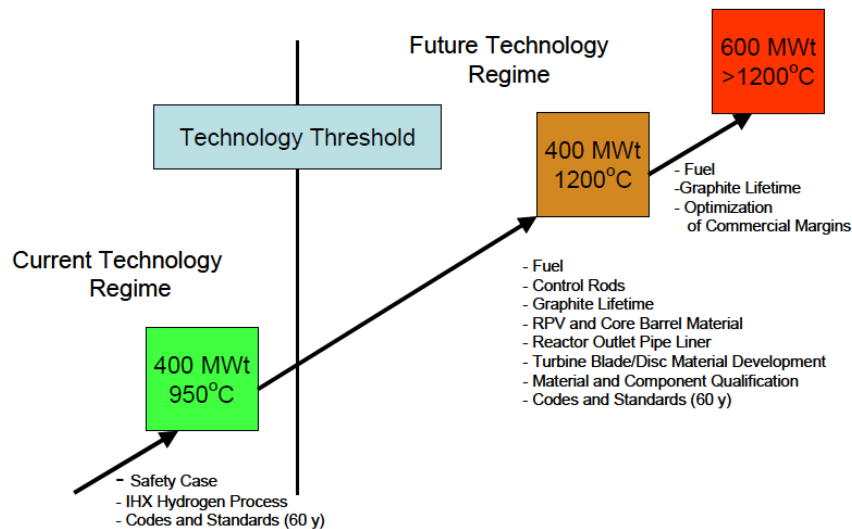
PBMR technology was expected to achieve the goals of safety, environmentally acceptance, efficiency and energy production for high temperature to generate electricity and industrial process heat applications. In September 2003, PBMR Company had formulated the design concept of PBMR’s layout in accordance to the requirements of the US Department of Energy (DoE) (PBMR (Pty) Ltd, 2004) (**Figure 3**). On two separate occasions in August 2003 and February 2004, both the conceptual layout and the design concept (i.e. on the technology) were presented to the DoE’s technical review group. Shortly thereafter, a request for expressions of interest regarding the PBMR project was made to the DoE by Westinghouse Electric Company (PBMR (Pty) Ltd, 2004).



Source: PBMR Project Status and the Way Ahead (PBMR (Pty) Ltd, 2004, p. 10)

Figure 3 – Physical Conceptual Layout of PBMR

Idaho National Laboratory (INL) a science-based, engineering national laboratory dedicated to the US Department of Energy bid was supported by the South African Government. The technology path had substantial potential for early deployment for electrical generation and growth as illustrated in **Figure 4**.



Source: PBMR Project Status and the Way Ahead (PBMR (Pty) Ltd 2004, p.13)

Figure 4 – Growth Path for PBMR

To realise the current technology regime illustrated in **Figure 4**, a nuclear installation license had to be obtained from the safety authority. Thus, a proactive review of PBMR's high

temperature reactor (HTR) technology was performed by the NNR in anticipation of a nuclear installation license application by Eskom (IAEA, 2012, p. 3).

2.3.1.2. PBMR's Nuclear Installation License (NIL) Application

In mid-2000 a nuclear installation license (NIL) application was submitted by Eskom to the NNR for its demonstration HTR plant for electricity generation (IAEA, 2012, p. 3). The basis of the licensing requirements was primarily formulated from the safety standards and regulatory practices and regulations in terms of section 36 and 47 of the National Nuclear Regulatory Act (NNRA).

A multi-staged licensing approach was adopted by Eskom due to the developmental nature and complexity of the PBMR project. The envisaged program to license the PBMR followed five (5) licensing stages, (IAEA, 2012, pp. 4-6):

- I. Site preparation, construction and manufacturing were covered under stages 1 and 2.
- II. Nuclear fuel on site/commissioning and start-up was captured in stage 3;
- III. Commercial operation was covered in stage 4; and
- IV. Decommissioning was dealt with in stage 5.

When the licensing stages unfolded, the NNR was confronted with major challenges when licensing the “new” reactor technology in South Africa (IAEA, 2012, p. 7), in particular:

- I. Acquiring the technical services from international companies to formulate requirements, guidance and reviews;
- II. Developing NNR's staff in-house expertise (i.e. in graphite/gas reactor technology);
- III. Developing a process to license the “first of a kind” reactor in South Africa; and
- IV. Reviewing licensing submissions made by PBMR (Pty) Ltd.

Additionally, experience and lessons were learned on PBMR's licensing project, in particular (IAEA, 2012, p. 16):

- I. During stage 1 (application), the authorisation to design had to entail the assessment of the applicant's management, organisational, design development and control processes;
- II. In stage 2, the design assessment had to contain the assessment of the reference design against supporting information;
- III. Key safety issues had to be agreed upon when identified including its proposed technical resolution;
- IV. The requirements of the NNR's had to be defined and understood prior to engagement by the applicant;
- V. Nuclear safety had to be demonstrated and not assumed;
- VI. All roles had to be understood by the NNR, designer and applicant;
- VII. Safety concept considering safety principles had to be agreed upon (i.e. Defence-in-depth (DiD), safety and quality classification, etc.);
- VIII. The design had to be adequately developed and be stable;
- IX. The design had to survive a postulated transient and accident condition; and
- X. The engagement framework had to be such that the architect/designer engineer can be directly engaged with.

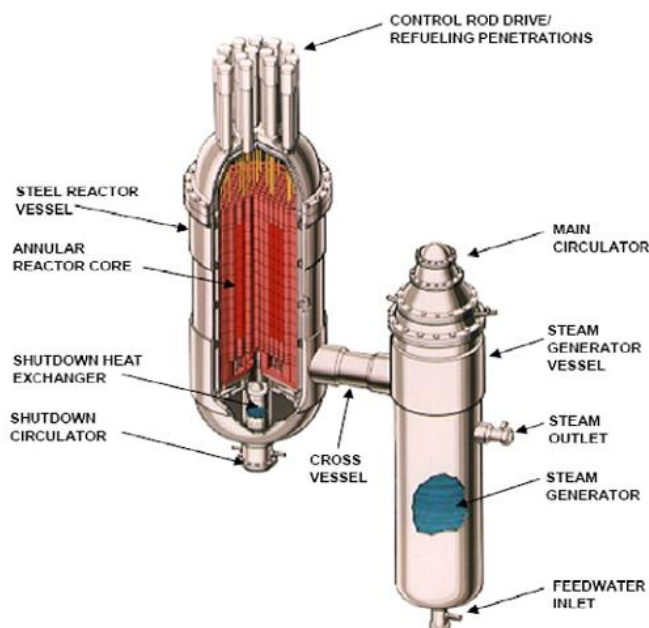
In this section, a general overview on the PBMR technology – including the technology expectations, expression of interest by Westinghouse Electric Company, growth path for the PBMR, Eskom's application for a nuclear installation site license; and lessons learned on licensing the technology by the NNR were provided. The next section provides information on the NGNP technology due to its relevance to the research study.

2.3.2. NGNP Technology

This section builds on the previous studies of the PBMR technology. It also covers pre-licensing application issues on the NGNP technology in the United States.

2.3.2.1. NGNP Application

NGNP is one of several technologies that may be expanded in the US and to other industrial economies not currently served by nuclear energy. Their safety has improved, which allowed the close collocation with industrial processes under the research scenario (U.S. DoE, 2011a, p. 22). The NGNP prototype's heat supply system comprised of three primary components, in particular: a) helium-cooled nuclear reactor, b) heat transport system (steam generator) and c) cross vessel for routing the helium between the reactor and heat transport system (**Figure 5**). The nuclear heat supply system supplied the energy in the form of steam, which is used for the generation of high efficiency electricity and to support energy-intensive industries (U.S. DoE, 2011a, p. 63).



Source: Idaho National Laboratory/NGNP Status and Path Forward (U.S. DoE 2011a, p.45)

Figure 5 – HTR with Heat Supply System for NGNP

In December 2002, the concept of very high-temperature reactors (VHTRs) was pursued by the United States (US) DoE (i.e. from several nuclear energy technologies). In November 2004, they contracted with Idaho National Laboratory (INL) to lead the research and development of the NGNP technologies. In March 2006, the NGNP Project at INL was formally initiated. Since that time the US Government invested \$500 million for undertaking all design, engineering,

licensing, research and development, quality assurance and management activities under one management team (U.S. DoE, 2011a, p. 7).

A joint meeting was held on October 13 and 14, 2010 between representatives of the EUROPAIRS consortium, which included the European Commission. Bredimas (2010, p. 3) indicated that the meeting was aimed at advancing the interest of nuclear energy and heat source to energy-intensive industries, also to improve the public understanding of the HTR technology by the US NGNP. Similarly, it was aimed at identifying the boundary conditions and partnerships for the coupling between a high temperature reactor and energy-intensive industry by EUROPAIRS. The objective of their meeting was to share their experience and to examine the potential for a possible transatlantic co-operation with EUROPAIRS (Bredimas, 2010). Minutes of this meeting revealed that a brief overview was reported on the NGNP technology – including investments made, primary components, constraints, projected cost on the prototype, competing priorities, inability to reach agreement with industry (i.e. on cost share) and a potential for a possible transatlantic co-operation with EUROPAIRS are noteworthy (Bredimas, 2010, p. 5).

On October 17, 2011 the Secretary of Energy forwarded to Congress a report and recommendation on phase 1 of the NGNP Project. It unfortunately stated that the Department would no longer proceed with design activities¹ of phase 2 due to the fact of fiscal constraints, projected cost on the prototype, competing priorities and the inability to reach agreement with industry (i.e. on cost share).

The Secretary's letter also concluded that "[t]he Project will continue to focus on high temperature reactor research and development activities, interactions with the Nuclear Regulatory Commission (NRC) to develop a licensing framework and establishment of a public-private partnership until conditions warrant a change of direction" (U.S. DoE, 2011a, p. 6).

¹ Plant design work beyond pre-conceptual design was not performed from April 2009 to the present by direction of the DoE.

2.3.2.2. NGNP Pre-Licensing Application

NGNP staff members regularly interfaced with industry on licensing issues as they were identified. The interface took place at industry and working group levels, which addressed licensing topics. Pre-licensing application issues were one of the licensing topics for discussion with the National Regulatory Commission (NRC). These issues were selected from various sources including the Exelon PBMR licensing program, the PBMR (Pty) Ltd. U.S. Design Certification program, and NGNP program studies, which are pertinent to objective 2 are summarised in **APPENDIX B** (U.S. DoE, 2011b, p. 32).

2.4. Current Studies on ARCHER and EUROPAIRS

Previous studies on nuclear technologies and their licensing applications were briefly discussed. The next section presents an overview of EUROPAIRS Project and subsequent initiation of the ARCHER Project in support of the primary aim of the research study.

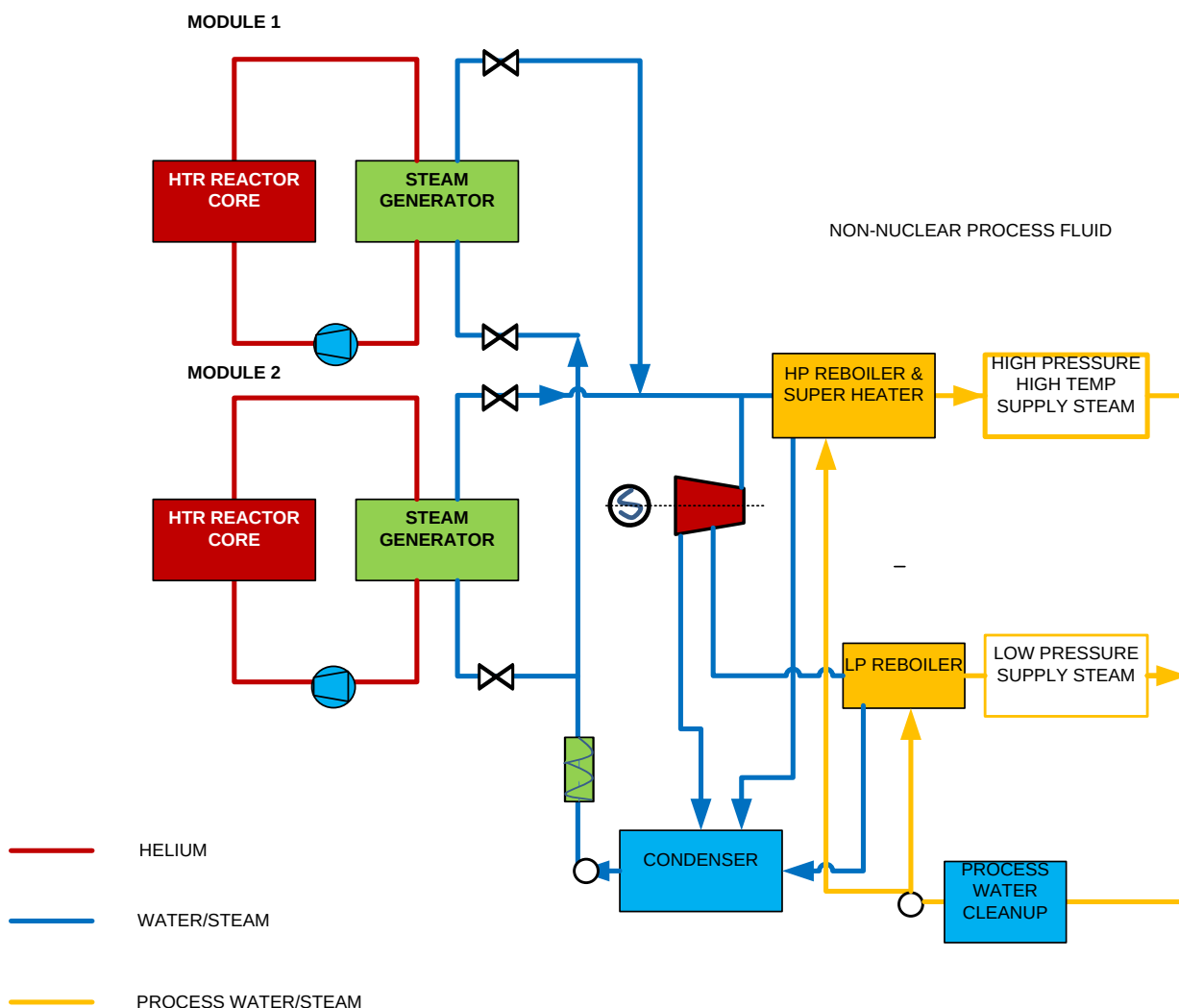
2.4.1. ARCHER and EUROPAIRS Projects

Pieńkowski (2011, p. 25) confirmed that the first meeting of the EUROPAIRS Associated Industry Network took place on January, 27 2011 to extend the dialogue to additional industry sectors (i.e. COGEN Europe). This resulted in the 4 year initiation of ARCHER project on February, 1 2011. The ARCHER project extended the advanced European HTR technology to consortiums consisting of industry, technical support groups, R&D institutes and universities; such as North-West in South Africa. All partners collectively propose efforts to compose the following:

- I. Developments of coupling components;
- II. HTR fuel including fuel back end R&D;
- III. Nuclear cogeneration communication, knowledge management and training.
- IV. Nuclear cogeneration unit coupled to industrial processes system integration assessment;
- V. R&D high temperature material; and

VI. Safety characteristics of critical primary and coupled system.

Figure 6 shows an example of a basic configuration of a commercial process heat cogeneration plant under investigation (Angulo, 2012, p. 33). Lamarsh and Baratta (2001, p. 161) describes a HTR as a helium-cooled, graphite-moderated, thermal reactor. The helium is used as the coolant as illustrated by the red loops as it is far more inert than CO₂. The blue loops presents the water and steam, while the brown loops represents the processed water and steam or non-nuclear process fluid. Several possible coupling schemes exist for introducing the nuclear process heat to SASOL. The most appropriate method is through steam for the end-user processes and heat transfer technology (Angulo, 2012, p. 35).



Source: Adapted by Nuclear Engineering and Design 251 (Angulo et al. 2012, pp.30 – 37)

Figure 6 – Steam Coupling for NCTL Production Plant

The first prototype reactor to be coupled to the process heat application might only be built by 2020. The HTR reactor is known for its inherent safety features (non-melting core and passive safety), which make it a suitable candidate for coupling to an energy-intensive industry (ENEF, 2012, p. 28). Energy-intensive processes in chemical process plants require process heat with sufficiently high temperatures (i.e. greater than 700°C) to support chemical production processes. Both the HTR co-generation plant and the energy-intensive installation requiring process heat to operate together as an integrated complex. According to the European nuclear energy forum (2012), it could be recommended to couple a new HTR cogeneration plant close to an existing energy-intensive user (e.g. such as SASOL) (ENEF, 2012, p. 28).

On the other hand, Pieńkowski (2011, p. 25) states that a breakthrough of the EUROPAIRS project into the market requires a large scale demonstration, which might only be realised within the next 10 to 15 years.

2.4.2. EUROPAIRS Licensing

In October 2010, a joint meeting took place between the Industrial Alliance for NGNP and the EUROPAIRS Project; to discuss licensing challenges, interest of nuclear energy and the heat source to energy-intensive industries. EUROPAIRS-NGNP Alliance meeting took cognisance of various licensing challenges and their solutions, in particular (Bredimas, 2010, p. 16):

- I. Nuclear cogeneration plant will have to be evaluated against existing technologies as well as if it is added to the CTL production plant. Similarly, the possibility of contaminated fluids will have to be discussed with health and safety authorities. Industry acceptance of nuclear cogeneration was also discussed, it requires an adaptation which may be risky and costly from a political, fuel cycle, planning and licensing point of view;
- II. Each part of the coupling system should be approached separately. Whereas the safety case should document the external hazards induced on the coupling process of the NCTL production plant. It also noted that contamination limits (i.e. tritium²) of the steam will be rigorous due to the coupling system; and

² Tritium is a radioactive isotope of hydrogen

- III. Danger studies for the energy-intensive sites could also be integrated in the safety case. It was also noted that France has operating experience in emergency planning involving commonly nuclear and chemical installations.

In this section, an overview was provided on the current studies on the EUROPAIRS and ARCHER projects, extension of the technology to consortiums such as North-West University and licensing challenges were covered.

2.5. National Regulatory System

In this section, a brief overview of South Africa's National Nuclear Regulator system is provided as it is pertinent to objectives 1 and 2. It starts with an overview of the nuclear sector role players and ends with a brief discussion on licensing fees.

2.5.1. Overview of the Legislation, Regulation and Role Players

In this section, a brief overview is presented of the legislation, regulations and nuclear sector role players within South Africa as it supports objective 1 of the research.

South Africa's nuclear sector was primarily controlled by the Nuclear Energy Act (NEA) (No. 131 of 1993), which has been succeeded with the NEA (No 46 of 1999) and the NNRA (No 47 of 1999). Promotional aspects of nuclear endeavours in South Africa are legislated by the NEA (No 46 of 1999), while the promulgation of the NNRA (No 47 of 1999), exclusively deals with regulating the nuclear sector in South Africa.

The NNRA came into force on February, 24 2000, which led to the establishment of the NNR in South Africa (NNR, 2011). Section 5 (b) (as defined in Chapter 2 of the NNRA) mandates the NNR to exercise regulatory control over safety inter alia, for i) siting, designing, manufacturing and constructing stages, including operating and decommissioning and Section 5 (c) "control over other actions" [sic] "through the granting of nuclear authorisations" (NNRA No 47 1999).

The NNR provides safety regulatory oversight on nuclear installations at Vaalputs waste disposal facility (i.e. radioactive), Pelindaba site (The South African Nuclear Energy Corporation Limited (Necsa)), Koeberg nuclear power station (KNPS) and others as illustrated in **Figure 7**.



Source: National Nuclear Regulator Annual Report 2012

Figure 7 – Nuclear Sector Role Players in South Africa

In the next section, details on the NNRA are provided as it is pertinent to objective 1 mentioned in section 1.2.

2.5.2. National Nuclear Regulator (NNR) Act

NNRA (No 47 of 1999) contains seven (7) Chapters and several sections, which is indexed as follows:

- I. Definitions, application and declaration of nuclear installation are captured in Chapter 1 of the NNRA;
- II. Establishment, objects, co-operative governance and functions of the NNR are covered in Chapter 2 of the NNRA. This Chapter also covers, inter alia, its control and management of affairs at the NNR;
- III. Nuclear authorisation and conditions thereof are dealt with in Chapter 3;
- IV. Financial liability and security for nuclear damage cause by vessels are covered in Chapter 4;
- V. Emergency and safety measures as well as the appointment and powers of inspectors are dealt with in Chapter 5;
- VI. Decisions on the appeal process of the chief executive officer (CEO) against inspectors, board against CEO, Minister against boards and High Court against Minister's are provided in terms of Chapter 6; and
- VII. General section deals with regulations, inter alia, delegations and assignment by Minister Exemption from duties and fees and penalties in Chapter 7 of the NNRA.

It is noteworthy that the nuclear authorisations and their conditions are covered in the NNRA. Conditions for nuclear installation or vessel license applications are captured in section 21, while conditions relating to nuclear vessel license, nuclear installation license or certificate of registration are dealt with in section 23.

2.5.3. Regulations on Safety Standards and Practices

In this section, the researcher has arranged relevant regulations around the NCTL production plant under investigation. A brief overview on the content of the three (3) relevant Regulations: R388, R927 and R479 are provided as it supports objective 1.

2.5.4. Regulation (R388)

The NNR established safety standards and regulatory practices (SSRP), which were enforced during the licensing phases of KNPS. In 2006, this initiative led to the publishing of the Regulation (R388) on SSRP. This Safety Standard and Regulation (R388) were developed as a direct result of international best practice on safety. Regulation (R388) is now enforced on all holders and applicants of nuclear installations in South Africa (RSA, 2007).

SSRP (R388) for nuclear facilities contains seven (7) sections, which will have to be adhered to during the licensing of the NCTL production plant is as follows:

- I. Terms and definitions are captured in section 1 of the regulation.
- II. Actions regarding exclusion, exemption, registration, licensing and clearance certificates that are subject to the process of nuclear installation license or nuclear vessel license are dealt with in section 2.
- III. Principle requirements for radiation protection and nuclear safety are covered in section 3. This section also covers, inter alia, accident management and quality management.
- IV. Requirements to regulate actions are captured in section 4. This section also covers, inter alia, maintenance programme and environmental monitoring.
- V. Decommissioning obligations of nuclear installation holders are covered in section 5.
- VI. Information applicable to emergencies, accidents and incidents are dealt with in section 6.
- VII. General section 7 deals with risks and exclusion levels.

2.5.5. Regulation (R927)

The Department of Energy's (RSA DoE, 2011) Regulation (927) on licensing of sites for new nuclear installations was published by the Minister of Energy on 11 November 2011. The aim of this regulation is for requirements to be established for applications of siting new nuclear

installations making it relevant to the research study. Regulation contains seven (7) sections, which is as follows:

- I. Definitions;
- II. Purpose and scope of the regulations;
- III. Lodging of applications;
- IV. Factors to be considered when evaluating sites;
- V. Site Safety Report requirements is dealt with (i.e. a motivation for choosing the site).
- VI. Validity period; and
- VII. Title.

In this addition, The Department of Mineral and Energy's (DME, 2000) Regulations (479) covers the definition, content of the application and address of license applications as well as registration certificates. Regulations (927) and (479) are both relevant to the objective 2, as it establishes the requirements for applications of siting new nuclear installations and content of applications. In the next section, details on the environmental impact assessment (EIA) steps are provided as it is pertinent to the primary aim of the research study.

2.5.6. Environmental Impact Assessment legislation

Environmental authorisation (EA) is required from the competent authority before the construction of any facilities. A thorough scoping and environmental impact assessment (EIA) process is subjected to applicants of NTCL production plant in contrast to the basic environmental impact assessment. Thus, environmental timelines for the thorough scoping and EIA process shown in **Table 1** are objectives of the Department of Environmental Affairs (DEA). These steps are applicable to EIA's in the national electricity response plan (NERP) for South Africa – including independent power producers (IPP) and co-generation facilities. (DEA, 2008, p. 5).

Table 1 – Non-statutory timelines for the steps in the Scoping and Environmental Impact Assessment (EIA) process

Tasks for the Applicant / Environmental Assessment Practitioner (EAP) / Others	Duration
Compile and submit EIA application by applicant	1 day
DEA reviews application; accepts or rejects	10 days
Compile and submit draft scoping report (SR), plan of study (POS) by applicant	45 days
Start public participation by applicant	30 days
DEA requests comments from State Departments	3 days
State Departments comment by applicant	40 days
Public participation by applicant	30 days
DEA sends comments to Applicant's EAP	3 days
Compile and submit Final SR and POS by applicant	30 days
DEA accepts or rejects Final SR and POS	21 days
Compile and submit draft environmental impact report (EIR), environmental management plan (EMP) by applicant	150 days
Start public participation by applicant	20 days
DEA requests comments from State Departments	3 days
State Departments comment by applicant	40 days
Public participation by applicant	40 days
DEA sends comments to Applicant's EAP	3 days
Compile and submit Final EIR and EMP by applicant	45 days
DEA considers completeness of reports	15 days
DEA issues decision	75 days

Source: National Guideline on Environmental Impact Assessments (DEA, 2008, p. 20)

The above bilateral EIA process not only requires timely responses from the DEA but also the applicant. EIA legislation Regulations 56 to 59 also requires participation of the public (Interested and Affected Parties) for both the scoping and subsequent EIA stage (DEA, 2008). In the next section, details on the policy and directives for South Africa are provided.

2.5.7. Policy and Directives

In the previous section, legislation, regulation and role players in the nuclear sector was briefly covered. In this section, a brief overview of the nuclear energy policy and relevant regulatory directives is presented. It will cover the Nuclear Energy Policy and Regulatory Directives (RDs) in order to support the objectives 1 and 2 mentioned in section 1.2.

2.5.7.1. Nuclear Energy Policy

The Nuclear Energy Policy for South Africa (DME, 2000) is pertinent to objective 1, as it covers the promotion of nuclear power as an important option for supplying electricity, inter alia, the reduction of greenhouse gas emissions and to guide the power sector with respect to its actions in developing, promoting, supporting, enhancing and sustaining nuclear energy.

Government aims to achieve the following thirteen (13) objectives through this Policy namely (DME, 2000):

- I. To promote nuclear power as an important option for supplying electricity;
- II. To establish a nuclear programme with the necessary governance structures;
- III. To create an environment that is safe and secure through utilising nuclear power;
- IV. To contribute to South Africa's national programme including development and growth;
- V. To attain long-term leadership in the nuclear power sector globally;
- VI. To exercise control over unprocessed uranium;
- VII. To safeguard the readiness of land for future sites (i.e. nuclear) for energy generation;
- VIII. To involve public in the uranium value chain;

- IX. To promote energy security for South Africa;
- X. To improve the quality of life and advancement of science and technology by humans;
- XI. To reduce greenhouse gas emissions;
- XII. To develop skills relating to nuclear energy; and
- XIII. To guide the power sector with respect to its actions in developing, promoting, supporting, enhancing and sustaining nuclear energy.

Similarly, the present study might contribute to the reduction in the levels of SASOL's greenhouse gas emissions; in support South Africa's commitment of a 34% reduction below 'Business As Usual' by 2020, while promoting energy security.

2.5.7.2. Regulatory Directives

NNR guides the power sector by regulating various facilities through its suite of Regulatory Requirements Documents (RDs). It also regulates actions regarding the Licensing Documents (LDs) (i.e. primary Licensing Documents such as site safety report's and site analysis report's) submitted to the regulator. These NNR's RDs and LDs were established so that the applicant of nuclear authorisations or holders thereof can uphold its specific authorisation.

Three (3) positions papers (i.e. PP-0008, PP-0009 and PP-0012) provides for the oversight of designs, manufacturing of components and guidance on authorisation of nuclear siting and installation activities.

Table 2 shows the minimum requirements of authorisations for nuclear installations, which is relevant to the primary aim of the research study (NNR, c. 2010b, p. 14).

Table 2 – Minimum nuclear authorisation versus activity

Stage	Activity	Minimum Nuclear Authorisation required	Comment
1 (a)	Site establishment:	Authorisation required in the form of a permit.	Mandatory
	Establishment on site of a security infrastructure		Application for site establishment activities can be submitted by an

	Temporary construction support buildings		applicant for a NIL or a NISL
	Site clearance		
1 (b)	Early Site Activities:	Nuclear Installation Site License (NISL) or a NIL to site.	Mandatory
	Initial earthworks and site levelling (terrace)		Application for early site activities can be submitted by an applicant for construction and/or operation of the installation subject to the information required as per the regulations on site licenses being submitted and accepted by the NNR. The design of the nuclear installation to be sited must be at a sufficient level of detail to allow for the relevant assessments to be made as required by the siting regulations. A NIL to site, construct and/or operate as well as applications for a NISL are to comply with the publication and public participation processes as contemplated in Section 21.
	Construction of offices and access control		
	Preparation of construction roads, borrow areas, parking areas, railroad spurs, etc.		
	Utilities such as potable water, electricity, sanitary sewage, systems, data cables, transmission lines, etc.		
	Erection of support buildings		
1 (c)	Early Construction Activities:	Nuclear Installation License (NIL) to site.	Mandatory
	Dewatering		An application for authorisation for early construction activities may be submitted as part of a complete application for a NIL for construction and/or operation. The application must include a safety assessment, as applicable, a description of the activities requested to be performed, and the design and construction information otherwise required, but limited to those activities, and supporting information demonstrating compliance with functional and design requirements of the portions of the nuclear installation. A plan for redress of activities.
	Diaphragm wall		
	Excavation and clearance to bedrock		
2 (a)	Design	Authorisation to Design	Optional
2 (b)	Manufacturing	Authorisation to Manufacture	Optional
			Mandatory for long lead item manufacturing. Conditions of authorisation will include mandatory hold and/or witness points. An application for construction of the nuclear installation has to be in place and being processed.
3	Construction	NIL to construct a nuclear installation	Mandatory
	As per definition		Conditions of authorisation will include mandatory hold and/or witness points
	Component manufacturing		
	Civil works		
	Installation of systems		

	Cold commissioning testing up to and including non-nuclear integrated tests		
	Hot commissioning testing		
4	Operation	NIL for the operation of the installation	Mandatory
5	Decontamination and decommissioning	NIL for the decontamination and decommissioning of the installation	Mandatory

Source: Adapted from Position Paper Authorisation for Nuclear Installations (NNR, c. 2010b, p. 14)

In this section, the Nuclear Energy Policy and the Regulatory directives were briefly presented. In the next section, an overview is provided on the National Energy Regulator of South Africa (NERSA).

2.5.8. Licensing of Electricity

According to NERSA (c. 2011), individuals may not operate any facility (i.e. distribution or transmission or generation) without a license. Electricity generation and distribution licenses should both be applied for separately before an applicant may operate a power plant in South Africa (NERSA, 2012). The fact that electricity generation and distribution licenses should both be applied for separately supports the primary aim of the research and is therefore presented.

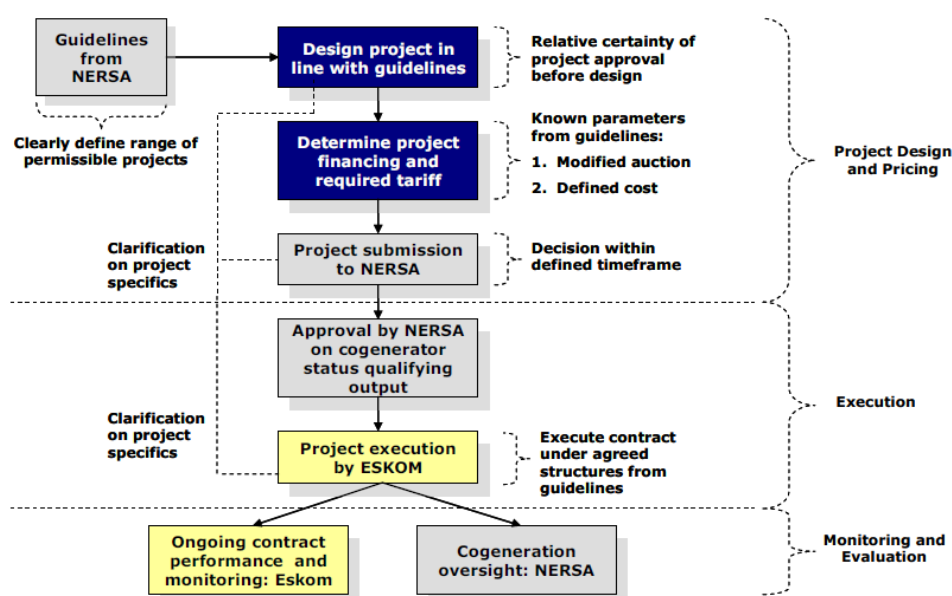
NERSA came into force on October, 1 2005. In terms of its mandate, the National Energy Regulatory Act (NERA) (No. 40 of 2004) is in place to regulate: i) petroleum pipelines, ii) piped-gas industry and iii) electricity industry:

- I. "Petroleum Pipelines Act" (No. 60 of 2003);
- II. "Gas Act"(No. 48 of 2001); and
- III. "Electricity Regulation Act" (No. 4 of 2006).

According to the NERSA, the applicant should also provide preliminary information on the potential electricity supply in the format prescribed by the NERSA (c. 2011, pp. 1-15). In order to document the details of the proposed technology and to inform NERSA of the supply side (i.e. chemical plant) option.

NERSA's license applications will take no longer than 120 days respectively, provided no objections are received after advertising which costs approximately R 42,000.00 (NewspaperDirect , c. 2008). A separate application form is required if an applicant intends operate more than one generation station under the proposed license (NERSA, c. 2011).

Similarly, from a licensing point of view, general co-generators will be managed in the same manner as other IPP. In so doing will require an application for a cogeneration license and other relevant permits (NERSA, 2006, p. 52). **Figure 8** shows the possible implementation of a cogeneration programme in South Africa.



Source: National Electricity Regulator of South Africa (NERSA, 2006, p. 51)

Figure 8 – Process for Project Development under the Guidelines

An overview of the license application for electricity, duration and costs of advertising was provided in this section. In the next section, an overview of nuclear licensing relevant to the NCTL production plant will be discussed.

2.5.9. Nuclear Licensing

In this section, nuclear licensing strategy of the NNR, followed by the licensing stages and authorisation fees are presented as it is pertinent to the primary aim of the research study.

2.5.9.1. Strategy for Nuclear Licensing

According to the National Nuclear Regulator's (NNR, 2008), strategy on licensing is for activities relating to new applications of light water reactors (LWR's). This strategy is utilised as it addressed the challenges by the NNR in the anticipated nuclear build programme in South Africa, in particular:

- I. NNR's licensing concept and optimisation thereof;
- II. The initiation of a nuclear license framework including durations;
- III. NNR's staffing and technical support; and
- IV. Implication on NNR's operational plans, stakeholders and budgets.

In this section, the literature reveals that the strategy is in the process of being revised (NNR, 2008). In the next section, clarity is provided on the licensing stages of the NNR.

2.5.9.2. Licensing Stages

Two (2) license options for applicants who wish to operate a nuclear installation (i.e. design, siting, manufacture, construction, operation and decommission stages) (NNR, c. 2010b, p. 5):

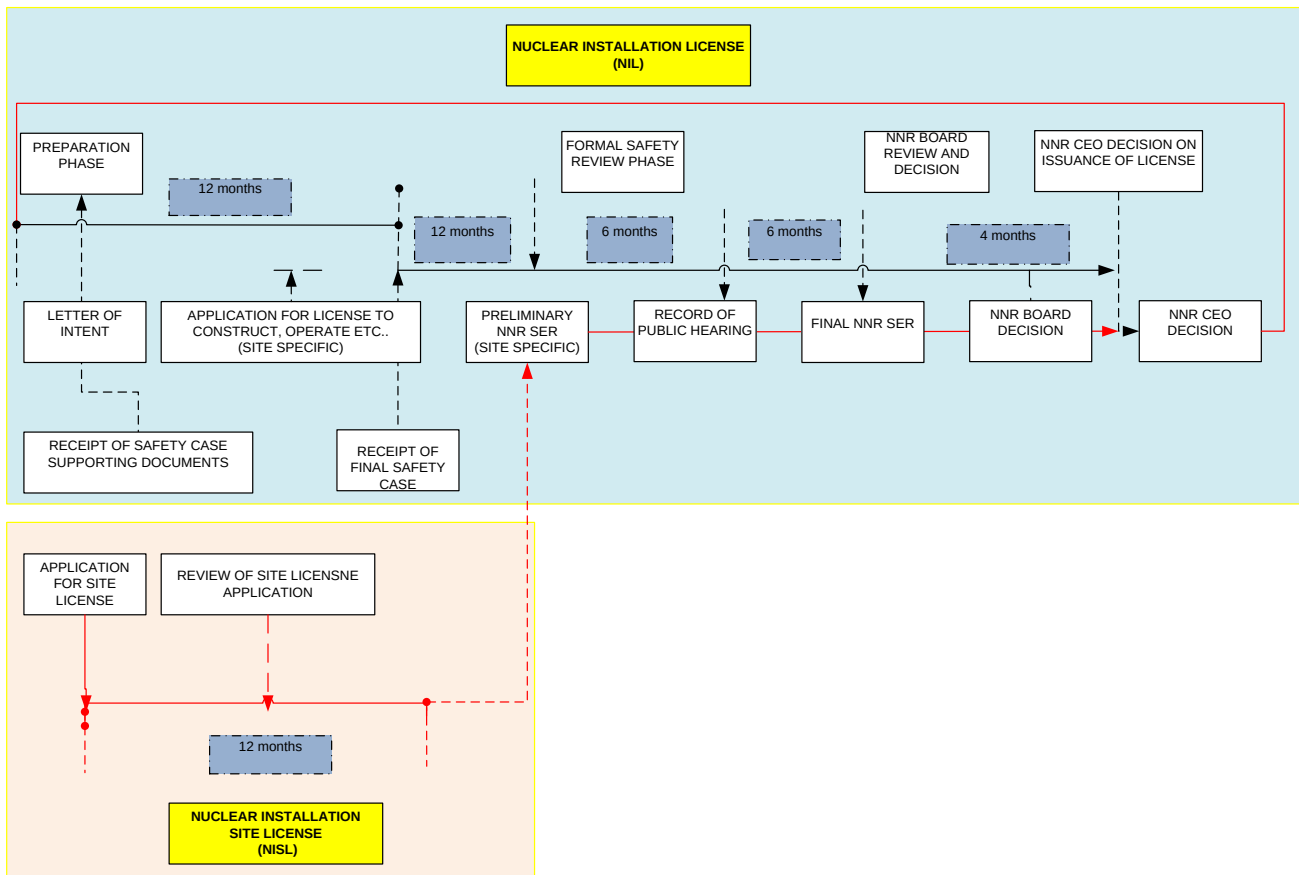
- I. Firstly, applicants wishing to adopt a multi-stage approach towards licensing will require a safety assessment for the anticipated installation holistically. The NNR may grant a license with conditions attached to be addressed in the safety assessment before the commencement of activities. These conditions may later be differed as the safety assessment is entirely developed.

- II. Secondly, applicants have the option to make a combined license application, which covers siting, construction such an applicant should include a safety assessment that addresses all the requirements associated with siting, inter alia, decommission stages.

Section 20 (1), 21 (1) and 23 (2) briefly covered in the preceding Chapter covers the format and content of a nuclear installation license (NIL) application. While the SSRP compels that a prior safety assessment be performed before a safety case is established (i.e. as part of the outcome of the safety assessment). The detailed specification of this safety case should be agreed with the safety authority prior to the submission (NNR, c. 2010b, p. 6).

A nuclear installation site license (NISL) and nuclear installation license (NIL) is initiated separately but are comparable license processes. NISL's may take into consideration multiple nuclear installations. Once these licenses are granted it may not be altered into a NIL.

In contrast, when a NISL for multiple nuclear installations is granted (i.e. after going once through the red dote line process in **Figure 9**), a separate NIL application must still be granted by the NNR (i.e. for construction and operation etc...).



Source: Adapted from NNR's Strategy for Licensing LWRs (NNR, 2008)

Figure 9 – NNR New Build Licensing Strategy

In this section, the licensing stages were discussed. In the next section, license authorisation fees published in the latest Government Gazette are provided as it supports objective 3 of this research study.

2.5.9.3. Licensing Authorisation Fees

The annual authorisation fees published in the Government Gazette were based on the person's-effort³ and the cost recovery principle. Thus, NNR recovers its cost by the number of hours devoted to direct nuclear regulatory activity (RSA DoE, 2012, p. 51). An average increase of 11% was proposed for nuclear installation for the recent fiscal year in terms of the NNRA.

³ This takes into account past operational experience and also expected increases in workload.

As a result, the proposed authorisation fees (VAT exclusive) between 2012 and 2013 for South Africa's three (3) nuclear installations are shown in **Table 3**.

Table 3 – Authorisations Fees for 2012-2013

Authorised Holders	Actual 2011/2012	Proposed 2012/2013	Variation
ESKOM- Koeberg Nuclear Power Station	R 46,131,877	R 51,556,484	12%
Necsa (Pelindaba)	R 21,709,119	R 24,314,213	12%
Necsa (Vaalputs)	R 3,392,050	R 3,731,255	10%

Source: Adapted from Department of Energy for the Republic of South Africa (RSA DoE, 2012, p. 51)

Minister of Energy also stated that the NNR's hourly rate (full cost) was divided by the hours devoted at direct regulatory activity already mentioned. This hourly rate was also captured in the latest Government Gazette published in South Africa. The present hourly rate for new nuclear installation applications to be processed and for site verification visits until application was approved are R1, 130.68 VAT exclusive per hour per person (RSA DoE, 2012, pp. 51-52).

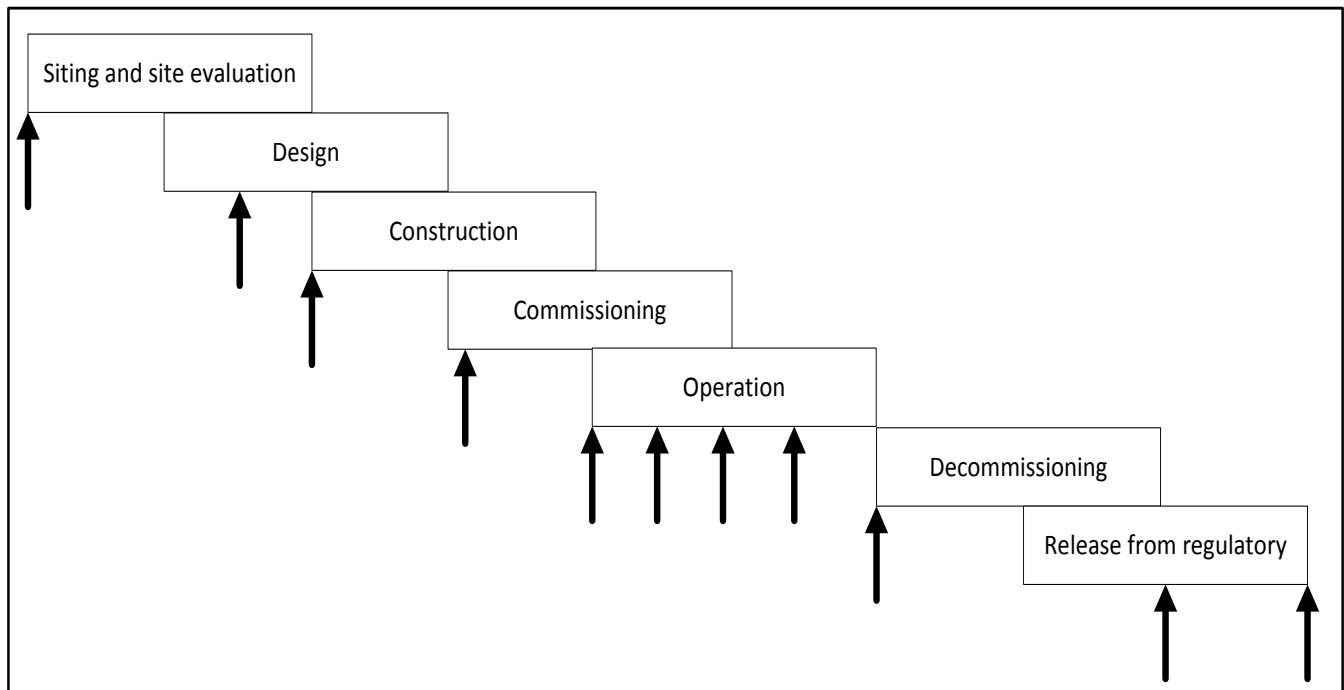
In summary, payment of application fees to the safety authority (i.e. NIL or NISL) before granting a nuclear authorisation was covered. It is also acknowledged that these fees are based on cost recovery principle and then allocated on person-effort, taking past operational experience and envisaged workload into account. In the next section, licensing regulatory systems internationally – including international licensing guide, licensing across economies are discussed.

2.6. International Regulatory Systems

The present section builds on the licensing authorisation study from an international perspective, to enable the researcher to capture international best practice and timelines of nuclear licensing from abroad.

2.6.1. International Licensing Guide

IAEA (2010, p. 4) shows a typical process for licensing during the life-cycle of the nuclear installation (i.e. siting, inter alia, release from the safety authority). Primary stages within the IAEA's licensing process are illustrated in **Figure 10** (IAEA, 2010).



Source: IAEA's licensing process for Nuclear Power Plants (IAEA, 2010, p. 4)

Figure 10 – Steps during the Lifecycle of a Nuclear Installation

“Hold points” are indicated by the upward arrows was set by the safety authority and national legislation, to ensure that the risks to the environment are controlled.

The steps mentioned above may be separated into several sub-steps. Similarly, it may be combined to smooth the process of licensing (IAEA, 2010, p. 22). The licensee may combine the license (i.e. combining construction and operation), which may also provide more certainty in the process when licensing, as in the case of a nuclear installation license (NIL) mentioned in section 2.5.4.2.

2.6.2. International Licensing Across Economies

In this section, the licensing processes derived from abroad are covered. In the countries covered below, there are big differences in the regulatory steps including their timeframes of licensing, which is pertinent to the primary aim of the research study.

2.6.2.1. Licensing Steps across Economies

Seven (7) out of ten (10) countries shown in **Table 4** offer at least two licensing steps (e.g. construction and operating licenses) while others sometimes offer up to four licensing steps. The United Kingdom has a one-step licensing process while the United State and South Africa offer both options (i.e. one-step or multi-step) and are relevant to the primary aim of the research study (WNA, 2013, pp. 12-13).

Table 4 – Licensing Steps in Different Countries

Country	Pre-licensing	Licensing steps
Canada	(License to prepare site) Pre-Licensing Vendor by the CNSC (Canadian Nuclear Safety Commission) when requested by a vendor	1. License for site preparation
		2. License for construction
		3. License for operation
Czech Republic		1. Site license
		2. Construction license
		3. A number of “small” licenses for particular commissioning stages.
		4. Operating license
France	ASN (Autorité de sûreté nucléaire) opinion on safety options (review of safety options)	1. Authorisation decree for the creation of a basic nuclear installation
		2. License for the commissioning of the installation
Germany	“Pre-statement” on project aspects (e.g. design) in the Nuclear Energy Act but never used	1. Construction license in several steps (the first one being a type of design approval)
		2. Operating license in several steps
Japan		1. Site selection phase: environmental review
		2. Preparation phase for construction: reactor installation

		license, safety examination, construction plan
		3. Construction phase: pre-service inspection, operational
		safety program
		4. Operation phase: periodical inspection, safety inspection
Korea	Standard design approval for new design	1. Construction license
		2. Operating license
South Africa		Both options (one-step or multi-step) are available.
		a) NIL for siting, constructing and or operating or decontaminate or decommission
		b) NISL
		c) Nuclear authorisation to design
		d) Nuclear authorisation for manufacture (i.e. components)
Ukraine	Operator can ask authority to do a safety review of a design Feasible sites are on a list to be established by government	1. Construction license (including commissioning) with afterwards a number of regulatory hold points (e.g. first delivery of nuclear fuel, first criticality, commissioning, experimental operation phase)
		2. Operating license
United Kingdom	GDA (Generic Design Assessment)	Nuclear site license. Establishes hold points/consent points, typically:
		• First nuclear concrete
		• First nuclear island construction
		• First fuel brought to site
		• Start of active commissioning
United States	Design certification	10 CFR part 52: COL (combined construction and operating license) 10 CFR part 50:
	Early site permit	1. Construction license
		2. Operating license

Source: Adapted from the World Nuclear Association (WNA, 2013, p. 12)

In this section, the licensing steps were tabulated for countries from abroad. According to the world nuclear association (WNA), there are preferences for one-step or multi-step licensing system (WNA, 2013, p. 14).

2.6.2.2. Licensing Timeframes across Economies

In this section, the timeframe are estimated for a) pre-construction, b) consent for construction and c) commissioning. Some countries specified their timeframes for the entire licensing (shown as P) while others had specified their timeframe for a regulatory review (shown as RR) (NEA, 2012, p. 31).

Licensing timeframe is important to applicants of nuclear installations.

Table 5 shows that the average regulatory reviews take three (3) years from beginning to the start of construction. By the whole, the process may take up to eight (8) years.

Table 5 – Timeframes for Licensing

Countries	Pre-Construction	Consent for construction	Commissioning
	(e.g., environmental assessment/license to prepare site, general design license)	(permit or legal decision before start of construction)*	(commissioning and operating license)*
	Average Time (years)	Average Time (years)	Average Time (years)
Australia	3 (P)	-	-
Brazil	-	-	-
Canada	1.5 (RR)	2 (RR)	1 (RR)
Chile	10 (P)	-	-
China	-	-	-
Czech	3 (RR)	1 (RR)	.5 (RR)
Egypt	-	-	-
France	3 (RR)		1 (RR)
Finland	2 (P), incl. 1(RR)	3 (P), incl. 1,5 (RR)	1.5 (P), incl. 1(RR)
Hungary	.5 (RR)	.5 (RR)	.5 (RR)
Indonesia	-	-	-
Japan	4 (P), 2 (RR)	5 (P)	
Jordan	2 (P)	1 (P)	-

Korea	3.75 (P)		1.67 (P)
Malaysia	-	-	-
Morocco	10 (P)	-	-
Nigeria	5 (P)	-	-
Poland	2 (P)		1.25 (P)
Slovakia	0,4 (RR)	1 (RR)	0,5 (RR)
Slovenia	4 (P)	2 (RR)	3 (P)
Switzerland	4 (P)	4 (P)	4 (P)
Thailand	6 (P)	5 (P)	1 (P)
Tunisia	12 (P)	-	-
UAE	3 (P)		6 (P)
UK	3 (P)		5 (P)
USA	6 (P)		5 (P)
Vietnam	-	-	-
*This estimate does not include the timeframe for construction or commissioning, but some reviews by the regulator may be performed during the construction stage.			

Source: Adapted from the Nuclear Energy Agency (NEA, 2012, p. 31)

Pre-construction, siting and site evaluation were the most prevalent, which required expertise such as project managers, geologists, seismologist, meteorologists, hydrologists, environmental project managers and civil engineers. Similarly, for reviewing the basic design, staff required by the safety authority included electrical, nuclear, structural, civil, mechanical, chemical and material engineers as well as project managers (NEA, 2012, p. 32).

It is noteworthy that the average regulatory reviews will take three (3) years from beginning to the start of construction from an international perspective. By the whole, the regulatory review process will take up to eight (8) years in some cases. It is clear from the above that resources required are substantial when licensing.

In this section, the licensing timeframes were tabulated for countries from abroad. In the next section, an overview of risk and project management is provided due to its relevance to the research.

2.7. Managing Licensing Risks

In this section, information on the management of risks is covered. It starts by describing how risks are identified and assessed. It also explores ways of reducing their consequences to support objective 2.

2.7.1. Defining Risk Management

According to Portny (2007, p. 150), risk management is defined as the method of identifying potential risks while assessing their possibility and planning ways to minimize their negative effects. Risk management offers five (5) basic steps which are used to determine, evaluate and manage risks:

- I. Risk identification; (e.g. possibility of tritium migration)
- II. Assessing their possible effect on the licensing project;
- III. Developing plans for mitigating the risks to protect the project from the effects of risks;
- IV. Monitoring the status of licensing risks constantly to determine new risk and more; and
- V. Inform key stakeholder to share the status and potential effect of all project through to project completion.

As risk identification is pertinent to objective 2 of the research study. It will be briefly expanded on in the next section due to its relevance.

2.7.2. Choosing the Risks to Manage

Risks identified should be addressed proactively. While making this choice, the likelihood of a risk and its potential effect including its potential consequence should be considered.

When the effect of a risk is great and likelihood of occurrence is high, it is best to develop a plan to manage the risks. Similarly, when the effect of the risk is low and the likelihood is high or vice versa.

It is vital to define the expected consequences of the risk via an approach that considers their combined effect (i.e. likelihood (probability) of the event and its possible consequence (impact)). According to Portny (2007, pp. 161-162) the expected risk (i.e. value) equals the quantitative measure by the effect multiply by its probability. So, if the effect is low and the likelihood is low, then the applicant may decide not worry with the risks.

In this section, licensing risks – including defining and choosing the risk to manage were covered. In the next section, information on the process of how to develop a licensing plan is discussed as it is pertinent to the primary aim of the research study.

2.8. Planning Licensing Projects

In this section, information on the process of guiding a typical licensing project from start to finish is presented as part of the research study. It starts off by defining project management, then how to initiate a project schedule and methods of estimating project costs.

2.8.1. Defining Project Management

Portny (2007, p. 11) suggests that project management is a method of directing a project from start to its finish. It consists of three (3) fundamental processes, in particular:

- I. Specifying the desired results, defining the schedules and estimating the resources as in the research study through **planning**;
- II. **Organising** roles and responsibilities of individuals; and
- III. **Controlling** them.

During the planning process a project schedule is developed, which contains specify project activities and detailed project-budget estimates.

2.8.2. Developing a Project Schedule

In this section, Portny (2007, pp. 103-104) suggests that the following steps are chosen to develop the initial project licensing schedule after project activities are specified, in particular:

- I. Identifying predecessors for all relevant licensing activities to define the structure of the network diagram;
- II. Spanning times for all activities to be estimated;
- III. Identifying all intermediate and final dates;
- IV. Identifying all activities outside your project which may affect project's licensing activities;
- V. Drawing a network diagram; and
- VI. Identifying their timelines as well as critical paths.

It is noteworthy that these steps may assist the researcher and ARCHER team with identifying unexpected schedule delays. ARCHER team may often want to finish earlier than the initial schedule allows for, which in turn reduces the project-budget estimates. These estimates may be defined using a combination of methods discussed in the next section.

2.8.3. Estimating Project Costs

In this section, two methods are discussed for developing the detailed budgets, in particular: a) Bottom-up method, which results from developing detailed estimates for each low level activity in the work break down structure (WBS), while b) Top-down method which examines the estimated cost of each work assignment in the WBS (2007, p. 145).

As the bottom-up approach is anticipated and is pertinent for this research study, it is further discussed. It typically consists of the following four (4) steps:

- I. Considering every single low level activity;
- II. Determining labour costs for every single activity, through multiplying the hours per person worked (i.e. by the person's hourly rate);
- III. Estimating the direct costs such as resources for each activity; and
- IV. Determining the indirect costs associated with each activity, not considered for this research study.

2.9. Summary

In this Chapter, we saw that modular HTR(s) are applicable to the CTL production plant. It could be recommended to be coupled to a new HTR cogeneration plant, which is close to an existing energy-intensive user such as SASOL. We saw that a clear regulatory framework for the licensing of nuclear activities exists in South Africa. This framework is similar to approaches in other parts of the world, including the options to adopt either a multi-stage or single-stage licensing approach. Risk identification and management offers a means through which the risks associated with the licensing process could be managed. While the tools of project management should ensure the delivery of products to the scope of work, within cost and time. The bottom-up approach to cost estimation could be used to estimate the costs associated with the proposed NCTL production plant. Bottom-up budget estimates may be developed through four (4) steps to compliment the project schedule for present research study. In the next Chapter, an overview of the research design and data gathering method and ethical considerations will be describe by the researcher.

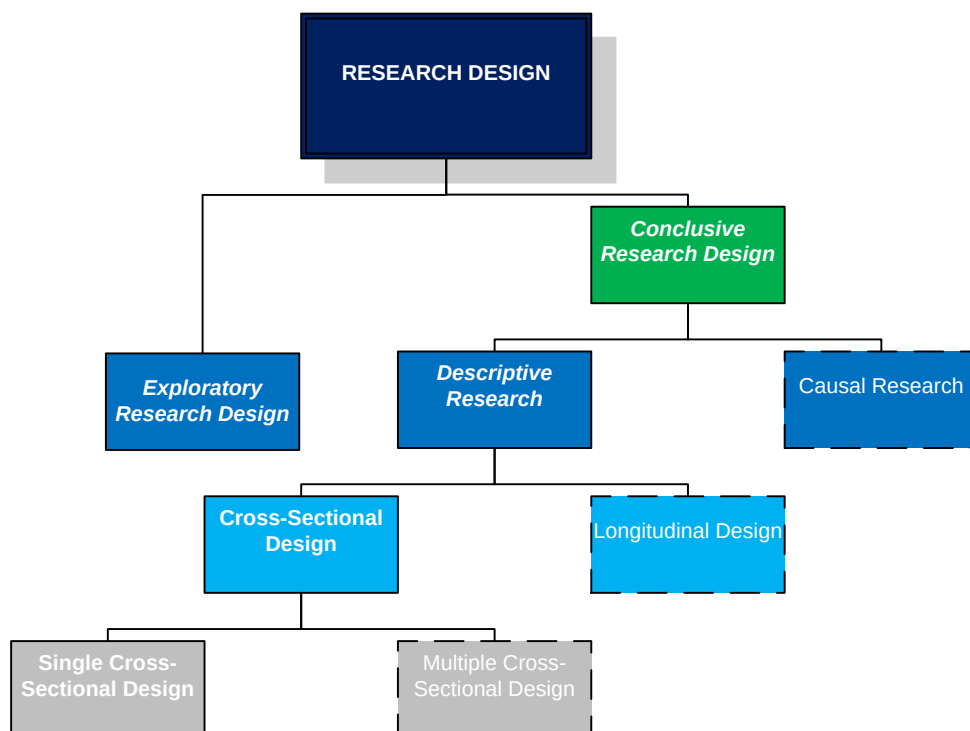
Chapter 3: Empirical Study

3.1. Introduction

In the previous Chapter the focus was on the literature study around the NCTL production plant. The present Chapter focuses on the detailed description of the research design, data gathering method and ethical considerations/professionalism.

3.2. Research Design

According to Rofianto (2013), research design is a blueprint for guiding the research study. The research design detailed the methods necessary for finding the information to structure a research study (Rofianto, 2013). In this context, the present research study is of an exploratory and descriptive research design (**Figure 11**). The researcher also adopted a mixed research approach to address the research problem (refer to section 1.1). Thus, the following phrases are discussed: *exploratory research*, *descriptive research*, and *the mixed research approach*.



Source: Adapted by Exploratory Research Design (Rofianto, 2013)

Figure 11 – Research Design

3.2.1. Phrases

3.2.1.1. Exploratory Research

According to McKenzie (c. 2011), exploratory research may be adopted to acquire a clearer understanding of a particular concept. **Figure 12** shows the most popular exploratory research methods including literature searches, inter alia, case analysis. Exploratory research originated from several types of investigations, in particular: a) a pilot study, b) interview surveys, c) secondary data analysis, d) pilot study case analysis, and e) focus groups (McKenzie, c. 2011).

3.2.1.2. Descriptive Research

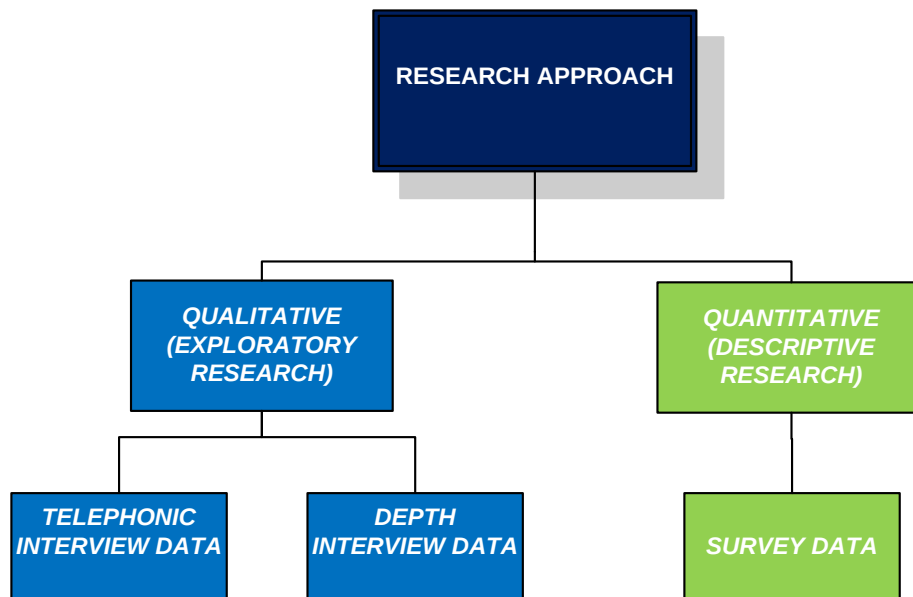
According to Burke (2010), descriptive research follows three (3) steps, in particular: a) selecting a sample from a distinct population, b) determining the sample of individuals and c) gathering the individual's sample of the population. Descriptive research assisted the researcher with measuring frequency (f) distributions and central tendencies, such as percentage (%), for analysing the sample data (Burke, 2010)

3.2.2. Research Approach

The present research study followed a mixture of both quantitative and qualitative approaches (e.g. deductive⁴ and inductive⁵ respectively) (refer to **Figure 12** below).

⁴ Sometimes known as top-down approach, where a researcher works his way down a broad spectrum to a specific conclusion (Crossman, 2013).

⁵ Sometimes known as bottom up approach, where a researcher formulates a tentative plan and end with a general conclusion (Crossman, 2013).



Source: Mixed Research Approach (Author's Own Construction)

Figure 12 – Types of Research Approach

Quantitative approach was followed for the self-administered questionnaire (survey) and was utilised to assess the perceptions of respondents regarding the licensing risks of the NCTL production plant. The quantitative approach guided the researcher with identifying the population⁶, large sample⁷ and data gathering techniques using a top-down approach.

Qualitative approach was also followed for the research. Thus, two (2) types of interviews (i.e. telephonic and in-depth) were used to assess a small sample of the population (refer to **APPENDICES C-2 & D-2 to D5**). This approach assisted the researcher with a deeper understanding of licensing associated with a project of this nature using a bottom-up approach.

In this section, phrases and approach of the research study were briefly discussed. In the next section, the structuring of the measuring research instruments I and II are covered in detail, including the questionnaire division and their design.

⁶ Population = All members selected by the experimenter

⁷ Cluster sampling = Samples by groups (clusters)

3.2.3. Structuring the Measuring Instruments I and II

Eiselen et al. (2005, p. 2) indicated that descriptive related surveys are an integral part of questionnaires. These questionnaires may either take the form of: a) structured interviews or b) self-administered questionnaire. Thus, both these forms of questionnaires were employed, and are now discussed in the following section. Additionally, the researcher adopted the content and face validity approach as this instrument was fully assessed while measuring the point of interest as in the research study of Miller (c. 2011).

3.2.3.1. Research Instruments I: Telephonic and In-depth Interviews

Boyce et al. (2006, p. 3) indicated that interviewing referred to a qualitative research technique that consisted of intensive individual interviews with a small number of participants in order to explore their perspectives on a specific idea, situation, or programme. Hence, both telephonic and in-depth interviews were conducted with various representatives in the nuclear sector to test the implementation of the licensing plan.

3.2.3.1.1. Planning Telephonic and In-depth Interviews

Two (2) interview questionnaires were planned to assess the perceptions of respondents regarding the licensing plan formulated by the researcher. This is so that improvements could be made prior to the submission to the ARCHER team. Firstly, the telephonic interview questionnaire consisted of seven (7) interview questions (refer to **APPENDICE C-1**) while the in-depth interviews questionnaires consisted of eight (8) interview questions (refer to **APPENDICE D-1**). Both interviews that were planned by the researcher and followed the following steps, in particular (Boyce, 2006, p. 4):

- I. Identifying relevant stakeholders who will be involved in the study;
- II. Identifying what information was required and from whom to provide as complete a picture as possible;
- III. Determine a list of stakeholders to be interviewed;

- IV. Determine sample necessary for the research; and
- V. Ensuring ethical research standards were followed (refer to section 3.4).

In this research, validity (i.e. content and face) was ensured by piloting these questionnaires via email to one specialist in the nuclear sector that has several years of knowledge and experienced in the nuclear industry. The participant validated whether the questions were linked to the topic of the research and were not part of the research study (Miller, c. 2011):

- I. *Specialist 1: Saayman, I. (Saaymai@eskom.co.za) has a Master's Degree in Science (11 July 2013).*

The specialist confirmed that the objectives in section 1.2 were linked to the questionnaires shown in **APPENDICES C-1 & D-1**.

3.2.3.2. Research Instrument II: Self-administered Questionnaire

Self-administered questionnaire surveys were designed to assess the perceptions of respondents regarding the licensing risks of the NCTL production plant (refer to **APPENDIX E-1**). Thus, details of the risk questionnaire are provided by starting with the questionnaire division.

3.2.3.2.1. Questionnaire Division

As shown in **APPENDIX E-1**, the risk questionnaire was divided into three (3) primary sections namely:

- I. Section A – captured the demographical information on all participants involved in the survey;
- II. Section B – attained information pertaining to the nuclear organisation of the participant; and
- III. In section C – information pertaining to the risk captured as the research unfolded.

Table 6 shows the total number of questions that was used during the self-administered survey on the research study.

Table 6 – Self-administered Questions per Section

Section	Number of questions
A	5
B	2
C	16
Total survey	23

An original electronic mail was sent to participants who were pre-selected based on their experience in the nuclear sector (refer to **APPENDIX E**) as it was considered convenient by the researcher for the following reasons (Eiselen, 2005, p. 2):

- I. The cost effectiveness of the administration;
- II. Allowed participants the convenience of completing the survey within their own environment and at their leisure;
- III. Less invasive than the telephone;
- IV. Questionnaires are familiar to most people; and
- V. Relatively easy for the interviewee to analyse and administer responses.

3.2.3.2.2. Design Methodology

The researcher designed the questionnaire (survey) by following the below-mentioned steps, in particular (Eiselen, 2005, p. 3):

- I. Formulating the goals of the research by revisiting the objectives;
- II. Defining the target population;

- III. Formulate the questions in order to achieve the objectives of the research. This was done by scrutinising the available knowledge on articles or questionnaires. It was also done through the appropriate statistical technique;
- IV. Questions were then organised in an orderly manner;
- V. A specialist was consulted to ascertain the opinion on formulation of questions. Similarly, a pilot study was performed to test responses and to address problems prior to the survey; and
- VI. Finally, ethical standards were adhered to as the survey unfolded. This provided assurance to participant's that their information was treated with confidentiality at all times. Verbal consent was also obtained from the participants who were involved in the study (refer to section 3.4).

A final printable version of the self-administered questionnaire implemented is shown in **APPENDIX E-1**. Similarly, the specialist confirmed that the objectives in section 1.2 were linked to the self-administered questionnaire (refer to section 3.2.3.2).

3.3. Data Gathering Method

Data gathering for the research study was carried out over three (3) phases. In the first phase, telephonic interview took place with NERSA. In second phase of research, in-depth interviews were carried out with various employee representatives in the nuclear area within South Africa. Thirdly, a survey on the self-administered questionnaire was carried out amongst the nuclear participants from South Africa and abroad. In this section, the focus was on data collection and analysis.

3.3.1. Data Collection

The data collected assisted the researcher with obtaining the empirical evidence to answer the research problem mentioned in Chapter 1. Since participants had to be interviewed, they were contacted telephonically and an appointment was scheduled to discuss the research as part of the planning process. This was followed by an exploratory pilot test to refine the research

questions for the interviews. This allowed the researcher to identify weaknesses within the interview. Only after these weaknesses were identified were revisions made to the interviews prior to the full scale implementation of the interviews.

Thereafter, comprehensive interviews were conducted via telephonic and face-to-face interviewing. The participant that formed the first sample of the research study (i.e. one (1) participant) was interviewed successfully via telephone. Similarly, from the second sample of five (5), only four (4) participants were interviewed successfully via face-to-face in-depth interviews.

For the third sample, responses totalling twenty four (24) were collected from a population of thirty (30) who participated in the survey (i.e. on the self-administered questionnaire). The reasons for the rate of the response could be that the participants were: a) incapable of completing the questionnaire or b) due to other work related priorities.

3.3.2. Data Analysis

The present section builds on the data collection process, it discusses the way the data was analysed as a result of telephonic, in-depth and self-administered questionnaires. It starts off with a discussion on the telephonic and in-depth questionnaires.

3.3.2.1. Questionnaires I: Telephonic and In-depth

In the case of the telephonic and in-depth interviews, the conversation analysis (CA) method was adopted by the researcher when analysing the data. CA's were strongly driven by data and out of the two CA methods considered: a) single case analysis and b) collection study, the researcher adapted the single case analysis for interacting in a single episode with individuals to take a broad view (generalise) in respect to NCTL licensing (Mazeland, 2006). The conversation was carefully analysed after making notes and an audio recording, which were transcribed in accordance with the first specific conventions formulated by Jefferson (2004). Similarly, each transcription convention contained general elements (refer to **Table 7**), which was utilised during the CA resulting from both telephonic and in-depth interviews (Forrester, 2002).

Table 7 – Transcription Conventions

Transcription Elements and Meaning			
Transcription Element	Meaning	Transcription Element	Meaning
↓ or ↑	Marked fall (or rise) in intonation	:::	Sounds that are drawn out (i.e. number of :: will indicate the length)
<u>Underlining</u>	Use for emphasis	[]	Simultaneous speech or interruptions.
UPPER-CASE LETTERS	Indicates an increase in volume	° word °	Speech which is noticeably quieter than the surrounding conversation
.hhh	Inbreath - Row of h's with a dot in front. Outbreath - Without the dot	=	Nearly no gap at all between one utterance and another
(comment)	Analyst comment on the conversation	(.)	Pauses (i.e. small)
> word <	Faster speech.	<word>	Speech which is noticeable slower
?	Rising intonation (i.e. at the end of an word)	(1.4)	Silences (i.e. time in seconds)
,	On-going intonation.	.	Concluding intonation.

Source: How to do Conversation Analysis /A Brief Guide (Forrester, 2002)

3.3.2.2. Questionnaire II: Self-administered

An analysis was performed by the researcher after all the nominal data were received on the questionnaire. In the case of self-administered questionnaire, the researcher made use of an unsophisticated approach for calculating the expected risk value already mentioned in section 2.7.2. (i.e. risk is proportional to probability x impact). The probability and impact of each risk was categorised into a pair of two (2) bands per scale using a risk categorised criteria (**Table 8**) after the frequency (f) distributions⁸ for analysing sample data were measured (Burke, 2010).

⁸ "Arrangement in which each the frequencies of each unique data value are shown" (Burke, 2010, p. 586)

Table 8 – Risk Bands per Scale

Probability				
	H		H	
	L			
		L	H	
Impact				

Source: Risk Bands per Scale (Author's Own Construction)

While the likelihood (probability) of occurrence were assessed, only valid entries were considered by the researcher (i.e. Low or High). Similarly, this was performed for the severity (impact) of the risk.

Similarly, high (H) was considered to have a substantial impact on the cost and schedule whereby substantial action would be required to alleviate the risk. In contrast, low (L) were considered as minimal impact on the cost and schedule whereby normal oversight would be sufficient. In the end only two (2) bands per scale risks (i.e. H as indicated by the red shading in **(Table 8)**) were considered for the NCTL production plant.

3.4. Ethics and Professionalism

Consent was obtained from all participants who were involved in the research study, and recorded as part of the interviews.

Integrity and confidentiality was exercised at all times throughout the execution of the research study. Similarly, integrity related to the publishing of information within the dissertation was adhered to.

3.5. Summary

Chapter 3 dealt with research design, the data gathering methodology – inclusive of the data sample formulation, data collection, data analysis, validity of the research study and ethical considerations. A mixed research approach (i.e. quantitative and qualitative) was adopted, as it utilises both deductive and inductive reasoning. Data collection assisted the researcher with obtaining the empirical evidence to answer the research problem were also outlined. Chapter 4 will provide the results and discussion on the research study. It will also show how the design, data gathering methods and analysis relate to the research objectives in the preceding Chapters.

Chapter 4: Presentation, Analysis and Findings of the Research Study

4.1. Introduction

In the previous Chapter, the research design, data gathering method and ethical considerations/professionalism were discussed. In this Chapter, the formulation of the licensing plan is briefly discussed. It also presents and analyse the results of data collected from a telephonic and in-depth interviews as well as self-administered surveys, as it supports the primary aim and secondary objectives of the research study.

4.2. Research Study

A literature study on licensing including activity-base costs for HTR energy in South Africa, aided the researcher with the formulation of the first draft of the licensing plan, of which the report on electricity generation in South Africa (NERSA, c. 2011); draft integrated energy planning report on the EIA process (RSA DoE, June 2013); NNR's report on authorisations of nuclear installations (NNR, c. 2010b); and fees published in the latest Government Gazette (based on the person's-effort⁹ and the cost recovery principle) (RSA DoE, 2012) were utilised as it contained the key elements for synthesising evidence for the research study.

Similarly, **Table 9** provides an overview of the research aim and objectives, design, data gathering methods and analysis followed for the research study.

⁹ This takes into account past operational experience and also expected increases in workload.

Table 9 – Overview of the Research Objectives, Design, Data Gathering Methods, Analysis and Validity

OBJECTIVES	DESIGN	METHODS	ANALYSIS	VALIDITY
Primary Aim				
• Formulate a licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL Secunda as a case study.	• Explore the Annual Energy Outlook 2013. • Explore and describe previous and current studies on nuclear licensing. • Describe and formulate a licensing plan for coupling a nuclear energy source to a chemical process plant.	• Telephonic and In-depth Interviews (Conversation Analysis) • Integration and synthesis of data resulting from objectives 1 and 3	• Synthesis of evidence • Inductive Reasoning • Deductive Reasoning • Microsoft Project (2003)	• Content validity • Face validity
Secondary Objective 1				
• To define the hierarchy of the NNR act, regulation and authorisation, relevant to the licensing of the NCTL production plant.	• Explore the regulatory systems nationally and internationally.	• Integration of data.	• Inductive Reasoning • Synthesis of evidence	• Content validity
Secondary Objective 2				
• To identify variables influencing licensing and evaluating the relative significance from the perspective of	• Describe the risks of licensing the NCTL production plant. • Describing and choosing the risks to	• Self-administered Surveys	• Deductive Reasoning • Synthesis of evidence • Descriptive statistics – including frequency (f) and percentage (%)	• Content validity

relevant stakeholders.	manage		using Microsoft Excel (2009)	
Secondary Objective 3				
• To evaluate the magnitude of the activity-base costs relating to the licensing plan.	• Explore the WBS of licensing the NCTL production plant. • Explore the appropriate method of estimating the activity-based cost (ABC) estimate when formulating the licensing plan of the NCTL production plant.	• Telephonic and In-depth Interviews (Conversation Analysis)	• Synthesis of evidence • Inductive Reasoning	• Content validity • Face validity

Source: Overview of the Research Objectives, Design, Data Gathering Methods, Analysis and Validity (Author's Own Construction)

4.3. Interviewing

In this section, telephonic and in-depth interviews held with participants for the research study are discussed.

4.3.1. Telephonic Interview

A Deputy Chief Education Specialist from National Energy Regulator of South Africa was interviewed telephonically on 1st July 2013. During the telephonic interview, the researcher raised questions to the participant, which focused specifically on licensing application fees and their timeframe from NERSA's perspective. The researcher assessed the perceptions of the participant on licensing electricity in South Africa (refer to **APPENDIX C-1** for the questionnaire). Seven (7) questions that were posed to the Deputy Chief Education Specialist were reproduced in bold font, while the consequential response were in italics (refer to **APPENDIX C-2**).

4.3.2. In-depth Interviews

Participants that were successfully interviewed consisted of the following four (4) participants:

- I. Nuclear Siting Project Planner (Eskom);
- II. Civil Engineering Specialist (NNR);
- III. Special Nuclear Projects Co-ordinator (NNR); and
- IV. Nuclear Siting Technical Specialist (Eskom)

While in-depth interviews with participants unfolded, the researcher raised questions, which focused on the licensing plan (refer to **APPENDIX A**). The researcher assessed the perceptions of the four (4) respondents by utilising a questionnaire on licensing (**APPENDIX D-1**). Consequently, the eight (8) questions posed to participants were reproduced in bold font, while the consequential response were in italics (refer to **APPENDIX D-2 to D-5**). The goal of the questions of the interviews was to identify the focus areas that may require improvements.

4.3.3. Conversation Analysis of in-depth Interviews with Participants #2 to #4

From the questions posed to the participants in the preceding section, short comings were identified from the interviews conducted with participants on the first draft of the licensing plan, which are discussed next.

4.3.3.1. Short Comings from in-depth Interviews

The analysis of the research data resulted in the identification of short coming to be addressed within the licensing plan. The three (3) main findings are as follows:

- I. Participant #2 indicated that the co-generation of electricity may take longer than expect when going through the schedule as it is modern to South Africa.
- II. Participant #3 indicated that the licensing plan does not include the environmental assessment, siting and bidding process. He also indicated that the NNR stakeholder participation process should last approximately 180 (i.e. 6 months) instead of 130 days and the NNR license application review is at least one year. Similarly, he did not think the NNR has the required human resource capacity to handle 2 applications per year and the applications should be launched in series.
- III. Participant #4 indicated that new hazards need to be identified such as external events and chemical corrosion. Also, ± R400M should be fine for two NISL's and to utilise 30 people instead of 40 people as indicated within the licensing plan.

4.3.3.2. In-depth Interview (Subsequent to Identification of Short Comings) with Participant #5

From the questions posed to the participant #5, the following were the response subsequent to addressing the short comings within the licensing plan, in particular:

- I. Participant 5 indicated that licensing plan is extremely relevant to the legal requirement of nuclear in South Africa.
- II. Also, he indicated that the license plan covers nuclear, EIA and NERSA requirements in South Africa, therefore no further work is needed, however, the plan does not guarantee that the license will be granted as this will depend on the outcome of the safety case.

In this section, no shortcomings were identified for telephonic interviewing. On the other hand, three (3) findings were identified from in-depth interviews in the research study. In the next section, an analysis of the findings on self-administered surveys is presented.

4.4. Self-Administered Surveys

The target audience for self-administered surveys consisted of thirty (N=30) participants. **Table 10** illustrates the sample (N=30) and response (n=24) for this study. The data was captured and analysed using Microsoft Excel (2010) programme for descriptive data – including frequencies (f) and percentages (%) on the sample (N) and response (n) of participants. Items 1 to 5 analysed the demographics data, items 6 to 7 analysed the nuclear arena and items 8 to 23 the perceptions on the implications of time and cost of the licensing risks on the overall coupling of the NCTL production plant.

Table 10 – Target Population and Sample Distribution

Country	Sample (N=30)		Response (n=24)	
	f	%	f	%
United Kingdom	3	10	2	8
Germany	2	7	1	4
Ethiopia	2	7	1	4
South Africa	6	20	6	25
Czech Republic	3	10	1	4
Canada	3	10	2	9
United States	11	36	11	46

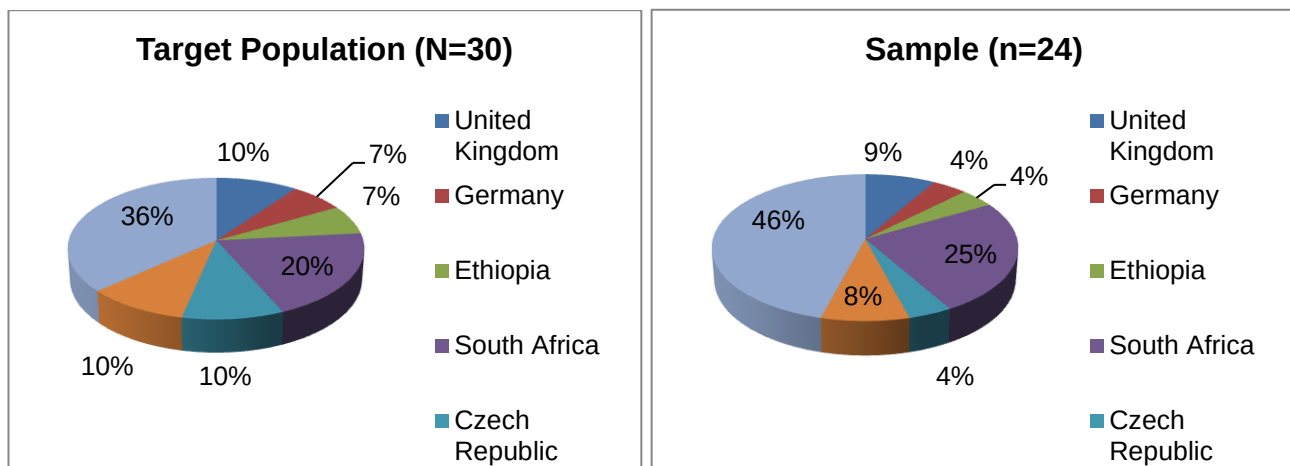


Figure 13 – Target Population and Sample of the study

The next section presents the analysis of the research findings of information on the sample demographics – including the age, occupation, gender, highest qualification attained and years of experience in the nuclear arena.

4.4.1. Age Group

This section of the research presents the target participant's age group. **Table 11** presents the age distribution and this is illustrated in **Figure 14**.

Table 11 – Age Distribution

Age	Participants (n=24)	
	f	%
Less than 30	2	8
31 - 40	3	13
41 - 50	6	25
51 - 60	7	29
61 - more	6	25

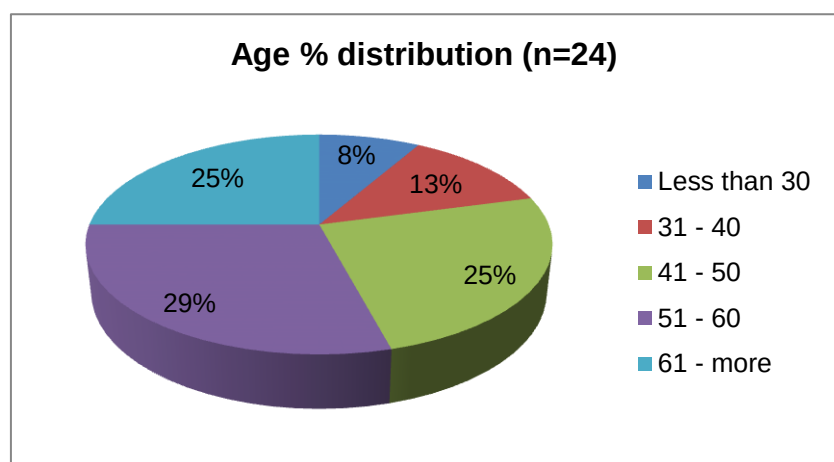


Figure 14 – Age % Distribution

Table 11 shows the least numbers of participants are in the less than 30 (8%) and 31 to 40 (13%) age categories. This is followed by equal distribution in age categories 41 to 50 and 61 and more (25%) while majority of participants range from 51 to 60 years old (29%). This shows that majority of participants with nuclear experience are between from 41 to 50 (25%), 51 to 60 (29%) and 60 plus age (25%).

4.4.2. Occupation

This section of the research presents the participants occupation in the nuclear arena.

Table 12 presents the occupation of participants while **Figure 15** illustrated the percentage.

Table 12 – Occupation Distribution

Occupation	Participants (n=24)	
	f	%
Nuclear Licensing Engineer	7	29
Nuclear Project Manager	4	17
Licensing Project Manager	3	13
Nuclear Engineer	3	12
Licensing and Safety Manager	5	21
Nuclear Safety Analyst	2	8

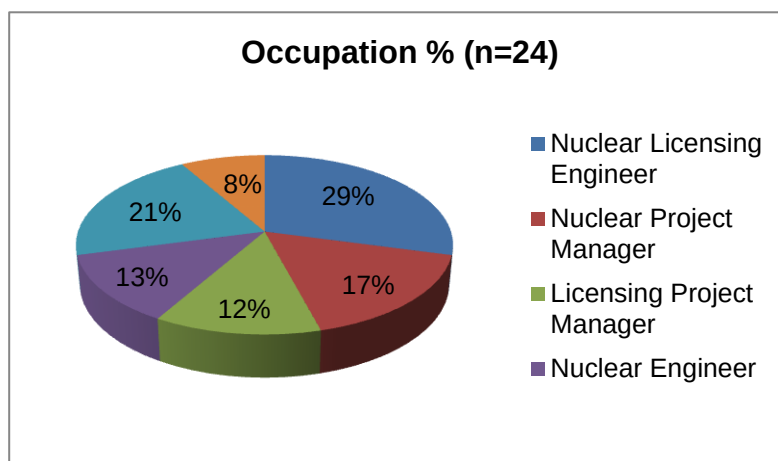


Figure 15 – Occupation Distribution

Table 12 shows an equal distribution of participants for licensing project management and licensing engineering (12%). Nuclear safety analysis has 8% followed by project management (17%) and licensing and safety manager (21%). While majority of participants were nuclear licensing engineers (29%).

4.4.3. Gender

This section of the research presents the participant's gender.

Table 13 presents the gender of participants (n=24).

Table 13 – Gender by Occupation

Occupation	Participants (n=24)			
	Male	%	Female	%
Nuclear Licensing Engineer	7	29	0	0
Nuclear Project Manager	4	17	0	0
Licensing Project Manager	3	13	0	0
Nuclear Engineer	3	12	0	0
Licensing and Safety Manager	5	21	0	0
Nuclear Safety Analyst	2	8	0	0

Table 13 shows that all participants were males. This appears to be common in the nuclear profession (IAEA, 2005) as it was historically a male-dominated arena.

4.4.4. Highest qualification

This section of the research presents the participant's highest qualification attained. **Table 14** presents the participant's qualifications and this is illustrated in **Figure 16**.

Table 14 – Qualification Distribution

Qualification	Participants (n=24)	
	f	%
Matric	0	0
Diploma	1	4
University Degree	13	54
Post Graduate Degree	10	42

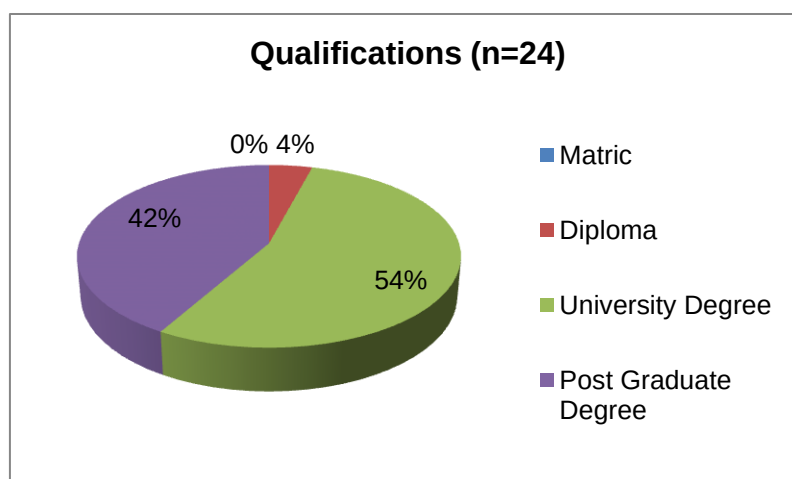


Figure 16 – Qualification Distribution

One participant have a diploma (4%), while majority of participants have university (54%) and post graduate degrees (42%). This shows that all participants have post graduate qualifications.

4.4.5. Nuclear Experience

This section of the research presents participant's experience in nuclear arena. **Table 15** presents participant's years of experience in nuclear and **Figure 17** illustrates the percentage.

Table 15 – Nuclear Experience

Experience (Years)	Participants (n=24)	
	f	%
Less than 5	5	21
6-10	2	8
11-20	1	4
21-30	4	17
31-more	12	50

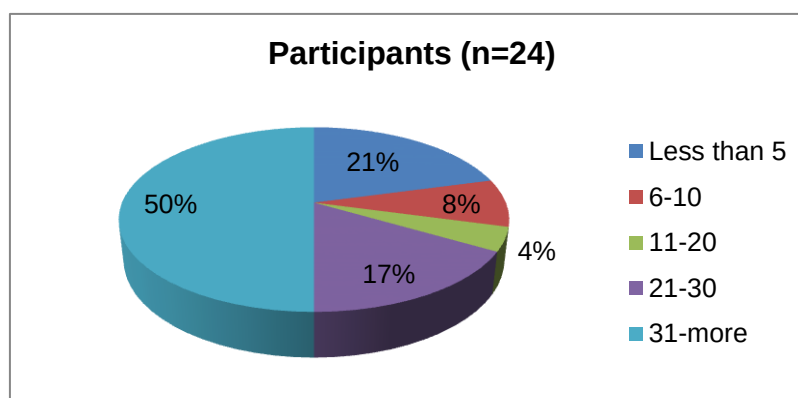


Figure 17 – Nuclear Experience

Figure 17 shows that majority of participants have 31 plus years of experience in nuclear (50%).

4.4.6. Information on Organisations

This section presents the analysis of the research findings of information on the organisations of the participants – including the participation within the nuclear arena and the level of the nuclear organisation in terms of turnover annually. The frequency (f) and percentage (%) of all questions are presented.

4.4.6.1. Participation in Nuclear

This section of the research presents a breakdown of the participants participation in nuclear. **Table 16** presents a breakdown of the participant's arena in nuclear while **Figure 18** illustrates the percentage.

Table 16 – Nuclear Arena

Nuclear Arena	Participants (n=24)	
	f	%
EPC Contractor	7	29
Vendor	2	8
Utility	9	38
Safety Authority	5	21
Government	1	4
Customer	0	0.00

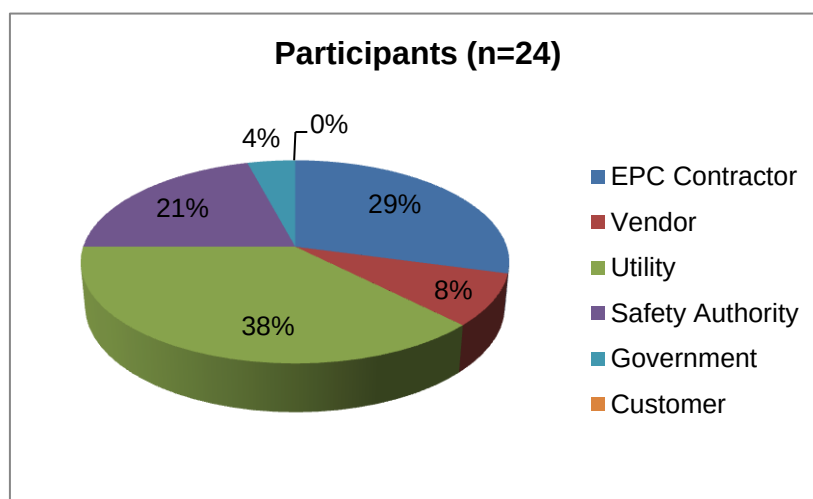


Figure 18 – Nuclear Arena

Table 16 shows majority of participants were from utilities (38%) followed by the EPC Contractor (29%) and safety authority (21%). There is a significant low percentage for the participation from vendors (8%), government (4%) and no response from customers.

4.4.6.2. Nuclear Organisation Level

This section of the research presents organisation level of participants in nuclear. **Table 17** presents the turnover of organisations in nuclear and

Figure 19 illustrates the percentages.

Table 17 – Organisational Level

Turnover	Participants (n=24)	
	f	%
Less than R24M	5	21
R25M – R74M	2	8
R75M – R119M	2	8
R120M – R169M	0	0.00
R170M – R219M	2	8
R220M and more	9	38
Other	4	17

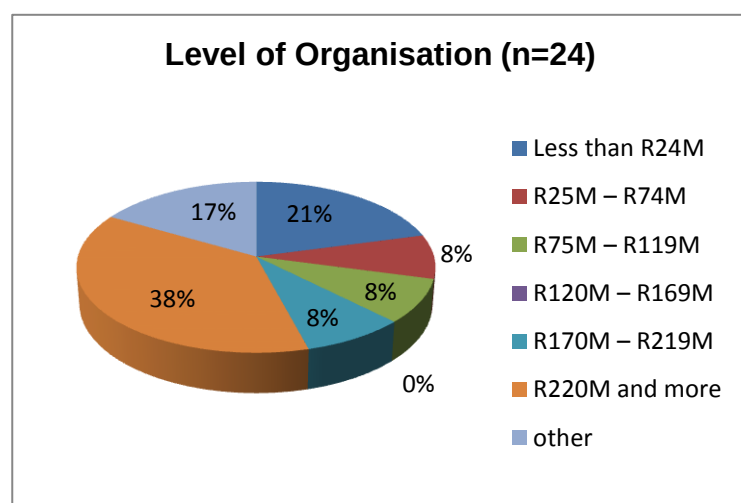


Figure 19 – Organisational Turnover

There is an equal distribution of turnover in the R25M to R74M, R75M to R119M and R170M to R219M turnover category (8%). The majority distribution of turnover is in the R220M plus (38%) category. While 21% is less than R24M and 17% is for other, indicate that participants either don't know their organisations turnover or are seeking the information.

4.4.7. Risk and Opportunity Identification and Assessment

This section presents the analysis and findings regarding the likelihood (probability) and severity (impact) of risks from the perspective of participants. **Table 18** presents the frequency (f) where 8 to 23 are the subscripts of the corresponding item numbers of that frequency (.e.g. f_8 to f_{23}) while percentage (%) bands are indicated by high (H) or low (L) on all questions from items 8 to 23. Where the High (H) band is equal or greater than 50% and the low (L) band is equal or less than 49%.

Table 18 – Perceptions of Respondents on Risk Opportunity and Identification Assessment

Item	Risks	Probability (n=24)				Impact (n=24)			
		f	High (%)	f	Low (%)	f	High (%)	f	Low (%)
8	Tritium migration beyond the nuclear heat system.	11	45.83	13	54.17	14	58.33	10	41.67
9	Uncertainty of licensing a nuclear energy source for coupling to energy-intensive industries.	11	45.83	13	54.17	14	58.33	10	41.67
10	Co-locating multiple HTRs on an existing industrial site.	10	41.67	14	58.33	15	62.50	9	37.50
11	The safety authority independently confirms the HTR project results (e.g. Data needed for safety evaluations).	19	79.17	5	20.83	19	79.17	5	20.83
12	Agreement on scope and schedule between the safety authority and licensee.	13	54.17	11	45.83	17	70.83	7	29.17
13	Early engagement with the safety authority.	18	75.00	6	25.00	18	75.00	6	25.00
14	Revision to existing codes and standards when licensing nuclear energy sources.	12	50.00	12	50.00	17	70.83	7	29.17
15	Safety and health of the public during design basis and beyond design basis accidents.	11	45.83	13	54.17	16	66.67	8	33.33
16	Construction of a nuclear plant on an existing industrial site may raise concerns relating to the adequacy of the site (e.g. seismic qualification, radiological safety and emergency planning).	18	75.00	6	25.00	20	83.33	4	16.67
17	Integrating the security and safety considerations into the HTR design.	16	66.67	8	33.33	17	70.83	7	29.17
18	Licensee managing the HTR's nuclear waste adequately.	18	75.00	6	25.00	18	75.00	6	25.00
19	No decommission fund surety agreement	9	37.50	15	62.50	23	95.83	1	4.17
20	Sharing one control room and other support systems for multiple reactor modules when licensing.	13	54.17	11	45.83	16	66.67	8	33.33
21	Concurrent multi-module plant construction and operations of the energy-intensive plant.	15	62.50	9	37.50	18	75.00	6	25.00
22	Increase of licensing fees for multiple HTR's.	17	70.83	7	29.17	12	50.00	12	50.00
23	Single review and set of hearings by the safety authority.	9	37.50	15	62.50	18	75.00	6	25.00

4.4.7.1. High Risk Items 11 to 14, 16 to 18 and 20 to 22

Majority of participants ($f_{11}=19$, $f_{12}=13$, $f_{13}=18$, $f_{14}=12$, $f_{16}=18$, $f_{17}=16$, $f_{18}=18$, $f_{20}=13$, $f_{21}=15$ and $f_{22}=17$) agree that the probability of these risks are high while the impact ($f_{11}=19$, $f_{12}=17$, $f_{13}=18$, $f_{14}=17$, $f_{16}=20$, $f_{17}=17$, $f_{18}=18$, $f_{20}=16$, $f_{21}=18$ and $f_{22}=12$) is high.

Table 20 19 shows evidence of a high risk of significance (consequence) by participants on items 11, 12, 13, 14, 16, 17, 18, 20, 21 and 22.

Table 19 – High Risk Band for Item 11 to 14, 16 to 18 and 20 to 22

Probability				
	H		x	
	L			
		L	H	
Impact				

Table 19 shows a high (H) probability and high (H) impact for items 11, 12, 13, 14, 16, 17, 18, 20, 21 and 22 whereby substantial action would be required to alleviate the risk.

4.4.7.2. Low to moderate Risk Items 8 to 10, 15, 19 and 23

Majority of participants ($f_8=13$, $f_9=13$, $f_{10}=14$, $f_{15}=13$, $f_{19}=15$ and $f_{23}=15$) agree that the probability of these risks are low while the impact ($f_8=14$, $f_9=14$, $f_{10}=15$, $f_{15}=16$, $f_{19}=23$ and $f_{23}=18$) is high.

Table 20 shows evidence of a moderate significance by participants on items 8 to 10, 15, 19 and 23.

Table 20 – Low to moderate Risk Band for Items 8 to 10, 15, 19 and 23

Probability				
	H			
	L			
Impact				

Table 20 shows a low (L) probability and high (H) impact for items 8 to 10, 15, 19 and 23 whereby moderate action would be required to alleviate the risk.

4.5. Summary

Nuclear professionals were surveyed through telephonic or face-to-face interviews, while others were questioned through an e-mail survey questionnaire. Through the interviews and questionnaires items that should be considered high risk from a nuclear licensing perspective were identified. A breakdown of the sample demographics show that the sample is heavily weighted in terms of age and nuclear experience. Among the biggest risk identified were items 11, 12, 13, 14, 16, 17, 18, 20, 21 and 22 whereby substantial action would be required to alleviate these risks (refer to section 5.4.1). A breakdown of this sample shows that items 11, 13, 16, 18, 20 and 22 are heavily weighted in terms of probability and impact. Sentiments of participants were crucial, owing to the large emphasis that was placed on early engagement with the safety authorities and determination of data requirements for safety evaluations. Participants perceived that there would be concerns relating to the adequacy of the site when constructing a high temperature reactor(s) on an existing industrial site such as SASOL due to seismic qualification, radiological safety and emergency planning concerns. Emphasis was placed on licensees to manage nuclear waste adequately through decommissioning fund agreements. Also, sharing one control room including their support systems for multiple reactors was heavily weighted by these participants as a determination was still to be made by safety

authorities. It was highlighted that the safety authority will need to confirm its position on licensing fee increases for multiple HTR's.

In the next section, these risks will be further unpacked, and recommendations for mitigating these risks proposed.

Chapter 5: Conclusions and Recommendations

5.1. Introduction

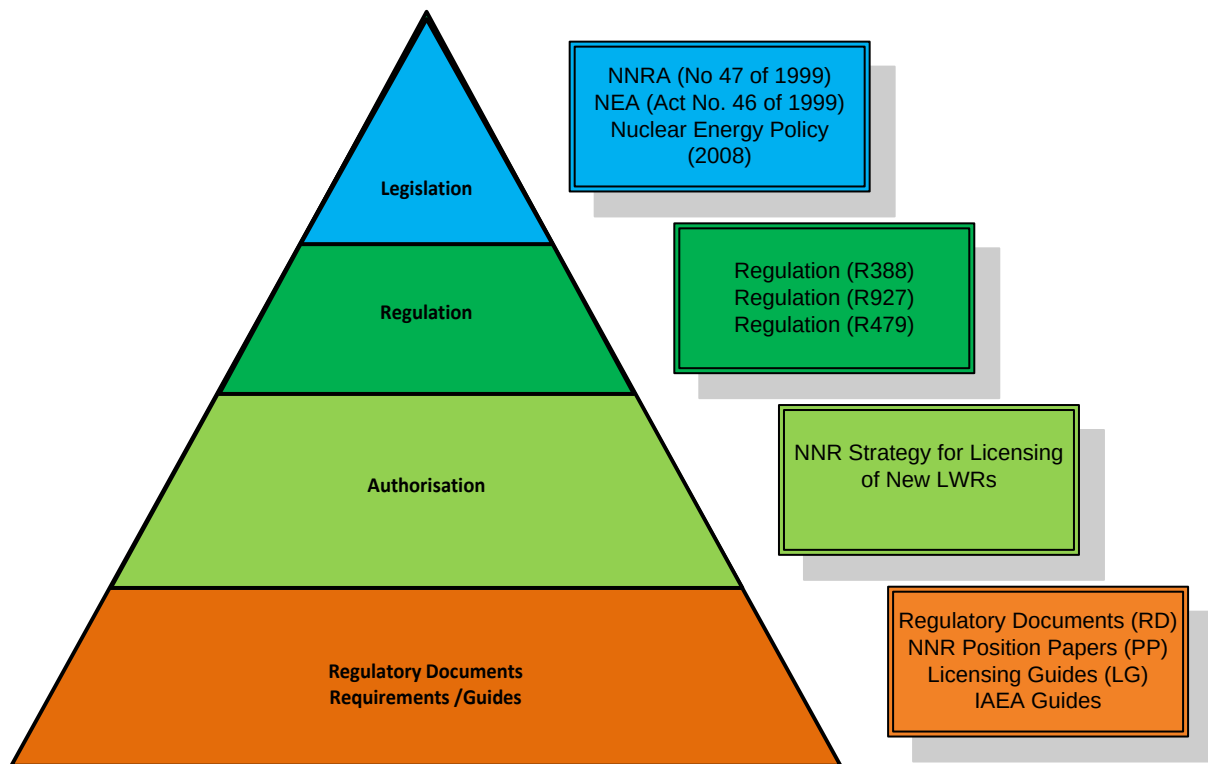
In this Chapter, the outcome of the primary aim and objective of the research study to conclude on the licensing plan of the NCTL production plant using SASOL as the research scenario. It also presents possible solutions for the licensing risks identified, as well as recommendations in respect of licensing and further research.

5.2. Revisiting Primary Aim and Objective 3

The primary aim of the research study was to identify the implications of time and cost of the licensing process on the overall coupling of the NCTL production plant using SASOL as the research scenario by formulating “[a] *licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL Secunda as a case study*”, while objective 3 was “[to] *evaluate the magnitude of the activity-based cost relating to the licensing plan*”, are achieved (refer to **APPENDIX A**: A licensing plan for coupling a nuclear energy source to a chemical process plant, **APPENDIX A-1**: Activity-based cost estimates for a licensing plan for coupling a nuclear energy source to a chemical process plant & **APPENDIX A-2**: Cost estimated for the applicant for a licensing plan for coupling a nuclear energy source to a chemical process plant). The overall timeline indicated conforms to international best practice as stated by Nuclear Energy Agency (NEA, 2012, p. 31).

5.3. Revisiting Objective 1

Objective 1 was to define the hierarchy of the NNR act, regulation and authorisation, relevant to the licensing of the NCTL production plant is achieved (refer to **Figure 20**). The following are the results in respect of this objective.



Source: National Nuclear Regulatory System in the South Africa (<http://www.nnr.co.za/regulatory-framework/>)

Figure 20 – National Nuclear Regulatory System in South Africa

The above-mentioned hierarchical elements of the National Nuclear Regulatory System within South Africa are legally binding by the International Safety Conventions for the NNR to regulate the nuclear industry covered in section 2.5.

5.3.1. Legislation and Regulations

From the top of the hierarchy, promotional aspects of nuclear endeavours are legislated by the NEA (No 46 of 1999) while the promulgation of the NNRA (No 47 of 1999), exclusively deals with regulating the nuclear sector. Thus, the licensing process for nuclear installations is covered in sections 21, 23 and 24 of the NNRA. Also, the Nuclear Energy Policy presents a framework for the utilisation of nuclear energy sources for peaceful intentions.

Legislation is followed by three (3) relevant regulations in the hierarchy: a) R388 developed as a direct result of international best practice on safety, b) R927 set out the requirements for applications of siting new nuclear installations and c) R479 defines the content of the application and postal address of license applications as well as registration certificates. Similarly, follows

the authorisation of nuclear installations (e.g. NISL and NIL) in the hierarchy. Finally, position papers offer guidelines for the oversight of nuclear installation design and authorisation process.

Table 21 lists the safety authorities (NNR) hierarchical documents within the National Nuclear Regulatory System, which are relevant to the NCTL production plant (i.e. from pre-operational to early construction activities).

Table 21 – NNR’s Hierarchical Documents for NIL via NISL

NNR Hierarchical Documents	Pre-operational	<i>NUCLEAR INSTALLATION SITE LICENSE (NISL) APPLICATION</i>	Public Involvement	Mandatory Stage 1 (a) Site establishment	Mandatory Stage 1 (b) Early Site Activities	<i>NUCLEAR INSTALLATION LICENSE (NIL) APPLICATION</i>	Mandatory Stage 1 (c) Early Construction Activities
NNR Act, 1999 (Act No 47 of 1999)	√	√	√		√	√	√
NEA Act, 1999 (Act No. 46 of 1999)	√		√				
Nuclear Energy Policy (2008)	√		√				
Regulation R388 (Safety Standards and Regulatory Practices)	√	√		√	√	√	
Regulation R927 (Licensing of Sites for New Nuclear Installations)	√	√		√	√	√	
Regulation R479 (Format for the application for a nuclear installation license)	√	√				√	

NNR-SD-0001 (NNR Strategy for the Licensing of New LWRs)	√	√	√	√	√	√	√
PP-0009 (Authorisations for Nuclear Installations)	√	√	√	√	√	√	√
RD-0034 (Quality and Safety Management Requirements for Nuclear Installations)	√	√		√	√	√	√
RD-013 (Requirements on Public Safety Information Documents to be produced by applicants for new authorisations)	√	√	√	√	√	√	
LG-1041 (Licensing Guide on Safety Assessments of Nuclear Power Reactor Sites)	√	√			√	√	√

5.4. Revisiting Objective 2

Objective 2 was “[t]o identify variables influencing licensing and evaluating the relative significance from the perspective of relevant stakeholders”, is achieved through Microsoft Excel (2010). The following are the results of the licensing risks identified in respect of this objective and possible solutions are provided.

5.4.1. Possible Solutions for Licensing Risks Identified

From the risk and opportunity identification and assessment process, risk was identified as potential high, in particular: Items 11, 12, 13, 14, 16, 17, 18, 20, 21 and 22 through the survey (refer to **Table 22**).

Table 22 – Potential High Risks Items

Item	Potential High Risks
11	The safety authority independently confirms the HTR project results (e.g. Data needed for safety evaluations).
12	Agreement on scope and schedule between the safety authority and licensee.
13	Early engagement with the safety authority.
14	Revision to existing codes and standards when licensing nuclear energy sources.
16	Construction of a nuclear plant on an existing industrial site may raise concerns relating to the adequacy of the site (e.g. seismic qualification, radiological safety and emergency planning).
17	Integrating the security and safety considerations into the HTR design.
18	Licensee managing the HTR's nuclear waste adequately.
20	Sharing one control room and other support systems for multiple reactor modules when licensing.
21	Concurrent multi-module plant construction and operations of the energy-intensive plant.
22	Increase of licensing fees for multiple HTR's.

Ten (10) solutions are also suggested by the researcher for these problems, which participants identified for nuclear licensing, in particular:

- I. Item 11 to 14 - It is suggested to engage early with the safety authority to determine the data requirements needed for the safety evaluations, agreement on scope and schedule when the license application is made for the NCTL production plant (IAEA, 2012, pp. 4-6).
- II. Item 16 to 17 - it is suggested to formulate a site safety report (SSR) as part of the licensing application to address seismic qualification, radiological safety and emergency planning as it is a regulatory/legal requirement.
- III. Item 18 - The responsibility for nuclear waste disposal have been discharged by Necsa to date (Necsa, 2012). It is suggested that the nuclear waste be managed by the National Radioactive Waste Disposal Institute in South Africa (RSA, 2009)
- IV. Item 20 to 21 - It is suggested that the control room design be a priority research project to define the requirements imposed by multi-unit monitoring and concurrent plant construction including the control of all resources (O'Hara, 2012).
- V. Item 22 - Minister of Energy provides the annual authorisation fees through the Government Gazette, which it suggested to be followed for the NCTL production plant (RSA DoE, 2012, p. 51)

In conclusion, the research objectives are achieved through planning the desired results, defining the schedule and estimating the resources of the applicant, safety and environmental authorities; organising roles and responsibilities; identifying the predecessors for all relevant licensing activities; and cost estimates. Bottom-up approach was chosen for research study and activity-base costs. Thus, NERSA's licensing is expected to continue for approximately 363 days should the licensing plan be initiated early 2014, while the EIA process continues in parallel through to mid-2015. Thereafter, the mandatory stages 1(a) and 1(b) is followed for site establishment and early site activities respectively for approximately 1060 days for a NISL. It is followed by mandatory stage 1(c), optional stages 2(a) and 2(b) – including mandatory long-lead time manufacturing of approximately 965 days. The NCTL production plant license is concluded with mandatory stages 3 and 4 for construction and operation with mandatory hold and witness points for a NIL. The overall timelines of the licensing plan for coupling a nuclear energy source to a chemical process plant is estimated at 8 years as suggested by international best practise. In addition, stage 5 license (e.g. after the life of plant) is initiated for decontamination and decommissioning activities for the NCTL production plant, which is

approximately 705 days. Lastly, the overall funding requirements are summarised in **APPENDICES A-1** and is estimated at ZAR 918,599,904.00 in 2013 value for the overall licensing of the NCTL Production Plant.

5.5. Recommendations

The previous section revisited the three (3) objectives of the research study so that the primary aim is realised (refer to section 1.2). In the next section, recommendations are provided for the research study in respect of the outcomes in the present research study.

5.5.1. Recommendations in Respect of Licensing

On the basis of the outcomes in the present study, the following six (6) recommendations are outlined in respect of the licensee's engagement with the safety authority.

- I. To solicit inputs by the NNR and agree on the overall licensing of the NCTL Production Plant.
- II. In order to gain clarity on the requirements of the content of the site safety report (as required by the Regulations R 927) on the licensing of sites for new nuclear installations for the NISL process.
- III. To agree on how to apply for multiple NILs for construction on a common site after being granted multiple NISLs and completion of the public participation process.
- IV. To agree on communication channels in order to be timeously informed of major changes to Regulations, Regulatory Requirements and Regulatory Position.
- V. To allow the NNR to timeously determine whether it has the required human resource capable of handling 2 license applications per year.
- VI. In order to gain clarity on how to demonstrate safety of the NCTL production plant in South Africa, to support the safety case.

5.5.2. Recommendations for Further Research

The literature study, research results and shortcomings identified, necessitates further research on the development of the NCTL production plant. Thus, further research is recommended on:

- I. The effects of tritium migration beyond the nuclear heat system of the NCTL production plant through system modelling.
- II. Safety of the nuclear energy source due to the effect of the proximity of chemical process plant.
- III. Risks analysis of applying the existing codes and standards applicable to licensing of PWR power plants, to the licensing of NCTL production plants.
- IV. Solution to the management of nuclear waste of the NCTL production plant in the future.
- V. Effect of sharing a control room and other support systems for multiple reactor modules when licensing.
- VI. Vendor bidding and procurement process for integration into the licensing plan.
- VII. Identification of new hazards relating to external events and chemical corrosion emanating from the NCTL production plant.
- VIII. Capability of the NNR to accommodate multiple NIL's applications for the NCTL production plant.
- IX. Development of a project and risk management plan to complement the existing licensing plan for the NCTL production plant.
- X. Define the requirements imposed by multi-model plant monitoring and control on all resources.
- XI. The requirements of a safety plan for constructing a nuclear plant on an existing industrial site.

5.6. Summary

This Chapter addressed the specific problem and their objectives through the formulation of “[a] *licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL*

Secunda as a case study” (refer to Sections 1.1 and 1.2). Similarly, the literature study was also utilised to form the basis of the research study. The Chapter was then concluded by revisiting the aim and objectives; and recommendations in respect of licensing and future research based on the licensing of the NCTL production plant.

Bibliography

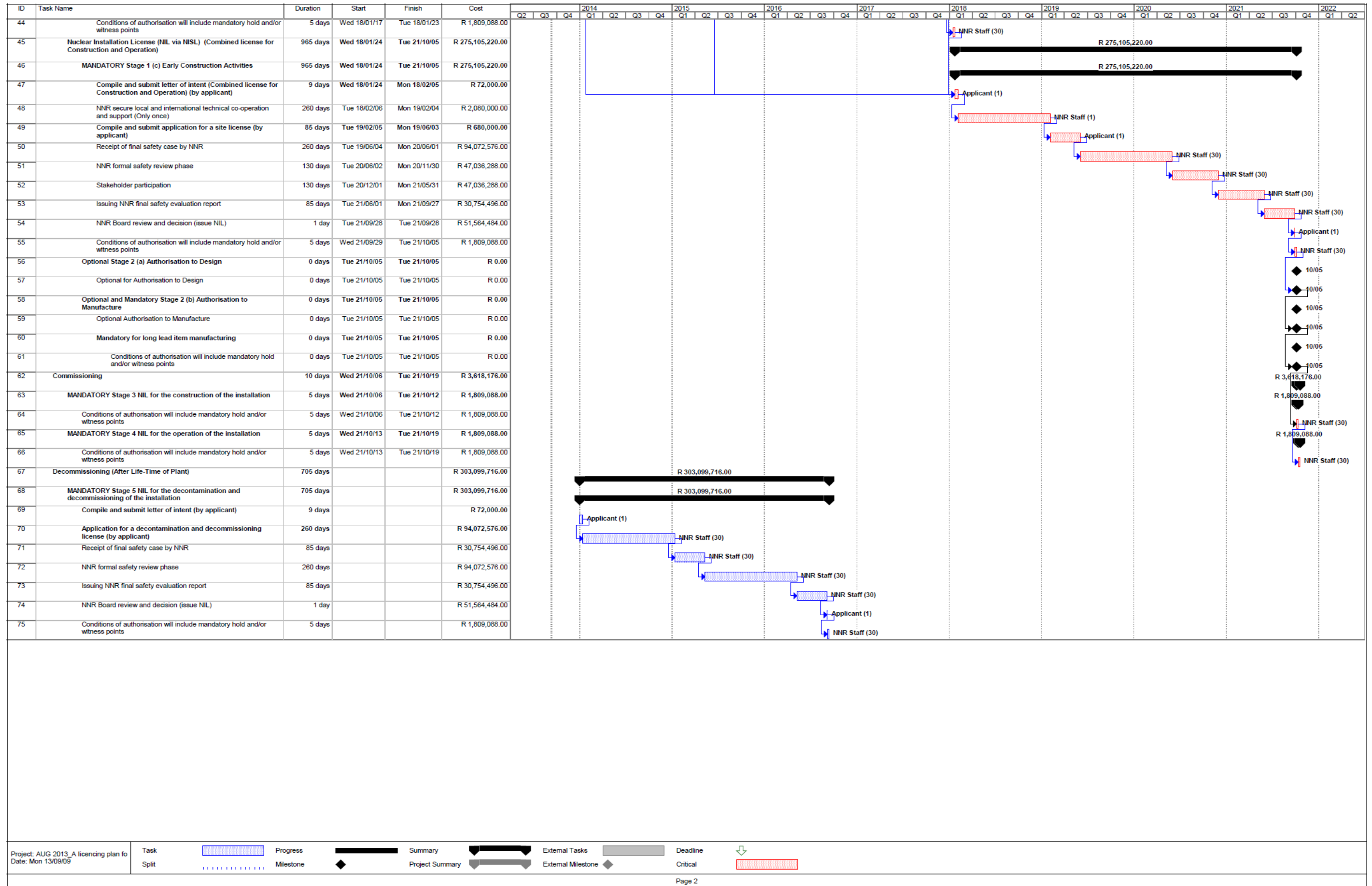
- AEO. (2013). *Annual Energy Outlook 2013 with Projections to 2040*. Washington: DoE USA.
- Angulo, C. B.-G. (2012). The European project on coupling of High Temperature Reactors. *Nuclear Engineering and Design*, 251, pp. 30-37.
- ARCHER. (2013). *Introduction: Advanced High-Temperature Reactors for Cogeneration of Heat and Electricity R&D*. Retrieved June 21, 2013, from ARCHER: <http://archer-project.eu/>
- Boyce, C. &. (2006, May). *Conducting In-depth Interviews: A Guide for Designing and Conducting In-Depth Interviews for Evaluation Input*. Watertown, USA.
- Bredimas, A & Nuttall, W. (c. 2010). *A Comparison of International Regulatory Organisations and Licensing Procedures for New Nuclear Plants*. United Kingdom: Judge Business School, University of Cambridge.
- Bredimas, A. (2010). *Joint meeting between the Industrial Alliance for NGNP and the EUROPAIRS Project*. Paris: EUROPAIRS-NGNP Alliance.
- Burke, J. (2010). Educational Research: Quantitative, Qualitative and Mixed Approaches. In J. Burke, *Educational Research fourth Edition* (p. 366). California: Sage Publishing, Inc.
- Crossman, A. (2013). *Deductive Reasoning Versus Inductive Reasoning*. Retrieved August 2013, 13, from Ask.com: <http://sociology.about.com/od/Research/a/Deductive-Reasoning-Versus-Inductive-Reasoning.htm>
- DEA. (2008). *Guideline on Environmental Impact Assessments for Facilities to be Included in the Electricity Response Plan*. Pretoria: Department of Environmental Affairs & Tourism (Republic of South Africa).
- DME. (2000). *Licensing of sites for new nuclear installations. Regulation 479*. Pretoria: Department of Mineral and Energy (Republic of South Africa).
- DME. (2008, June). *Nuclear Energy Policy for the Republic of South Africa*.
- Eiselen, R. ,. (2005). *Analysing survey data using SPSS13: A workbook*. Johannesburg: JHB University.
- ENEF. (2012). *SWOT Part 2 Report: Competitiveness of Nuclear Power*. Prague: European Nuclear Energy Forum (ENEF).
- Eskom. (2010, May 23). *Load shedding: Frequently asked questions (FAQs)*. Retrieved from Eskom Intranet: http://intranet2010.eskom.co.za/content/FaQ_LoadShed.pdf
- Forrester, M. (2002). *How to do conversation analysis: A brief guide*. Department of Psychology.
- Francesco Sindico. (2010). *The Copenhagen Climate Accord and the future of the international climate change regime*.
- IAEA. (2005, September 16). *IAEA*. Retrieved August 9, 2013, from IAEA Women Honoured for Contribution to Science and Public Education: http://www.iaea.org/newscenter/news/2005/women_honoured.htm
- IAEA. (2010, February 26). *Licensing Process for nuclear installations DS 416: Draft no.3.4*. Vienna.
- IAEA. (2012, October 22-26). *Course on High temperature Gas Cooled Reactor Technology, Regulatory perspectives: PBMR Licensing experience - Lessons learned*.
- Jefferson. (2004). 'Glossary of transcript symbols with an introduction.' In Lerner G (ed.) *Conversation analysis. Studies from the first generation*. Amsterdam Philadelphia: Benjamins. 13–31.
- Lamarsh, J & Baratta, A. (2001). *Introduction to nuclear engineering. 3rd*. New Jersey: Prentice hall.

- Mazeland, H. (2006). *Conversation Analysis*. Netherlands: University of Groningen.
- McKenzie, K. &. (c. 2011). *Problem Definition, Exploratory Research and the Research Process*. Retrieved May 23, 2013, from http://media.wiley.com/product_data/excerpt/86/EHEP0001/EHEP000186-2.pdf
- Miller, J. (c. 2011). *Reliability and Validity*. Western International University.
- Necsa. (2012, August). *Nuclear Power in South Africa*. Retrieved August 20, 2013, from The South African Nuclear Energy Corporation Limited: <http://www.necsa.co.za/Portals/1/Documents/b8171927-6bbe-4a32-a45f-e4176cfa7c5.pdf>
- NERSA. (2006). *Development of Regulatory guidelines and qualifying principles for co-generation projects*. South Africa: National Energy Regulator of South Africa.
- NERSA. (2012). *Electricity distribution license procedure*. South Africa: Nuclear Energy Regulator of South Africa.
- NERSA. (c. 2009). *Frequently asked questions on how to comply with the Petroleum Pipelines Act (Act no. 60 of 2003)*. South Africa: National Energy Regulator of South Africa.
- NERSA. (c. 2011). *Application for an Electricity Generation*. South Africa: National Energy Regulator of South Africa.
- NewspaperDirect . (c. 2008). *Newspaper Direct South Africa: Advertising Rate Card*. Retrieved September 2013, 3, from Newspaper Direct: <http://www.newspaperdirect.co.za/PDF/ratecard.pdf>
- NNR. (2008, October 09). *Strategy for the Licensing of New Light Water Reactors (LWRs): NNR-SD-0001*. Centurion, South Africa: National Nuclear Regulator.
- NNR. (2010). *PP-0008: Design Authorisation Framework*. Pretoria: National Nuclear Regulator.
- NNR. (2011, July 4). *Regulatory Practices of the National Nuclear Regulator*. Retrieved April 16, 2013, from http://gnssn.iaea.org/NNRP/Final%20Documents/Presentations/02-13_SOUTH%20AFRICA.pdf
- NNR. (2012). *NNR Annual Report 2012*. Centurion: National Nuclear Regulator.
- NNR. (c. 2010). *PP-0009: Authorizations of nuclear installations*. Pretoria: National Nuclear Regulator.
- NNR. (c. 2010). *PP-0012: Manufacturing of Components for Nuclear Installations*. Pretoria: National Nuclear Regulator.
- Nuclear Energy Agency. (2012a). *Report of the Survey on the Review of New Reactor Applications*. France: NRC, United States.
- NWU. (2013). *NWU geared to meet South Africa's future energy needs*. Retrieved June 25, 2013, from <http://www.nwu.ac.za/content/nwu-geared-meet-south-africa%E2%80%99s-future-energy-needs-potchefstroom-campus-news-2012>
- O'Hara, P. &. (2012). *Human-Performance Issues Related to the Design and Operation of Small Modular Reactors*. New York: Brookhaven National Laboratory.
- PBMR (Pty) Ltd. (2004). *PBMR Project status and the way ahead*. Centurion: Pebble Bed Modular Reactor (Pty) Ltd.
- Pieńkowski, L. (2011). *HTR Reactors for Industry Perspectives of Nuclear Cogeneration*. Warsaw: University of Warsaw.
- Portny, S. (2007). *Project Management For Dummies®, 2nd Edition*. Indianapolis, Indiana: Wiley Publishing, Inc.
- Rofianto, W. (2013). *Exploratory research design*. Retrieved 07 14, 2013, from http://rofianto.files.wordpress.com/2011/04/mr_02.pdf

- RSA. (1999, December 23). *NNR Act No. 47 of 1999 for the Republic of South Africa*. Retrieved October 08, 2013, from South African Government Online:
<http://www.info.gov.za/view/DownloadFileAction?id=70614>
- RSA. (2002, February 21). *Gas Act (Act No. 48) 2001 for the Republic of South Africa*. Retrieved October 07, 2013, from National Energy Regulator of South Africa:
<http://www.nersa.org.za/Admin/Document/Editor/file/Legislation/Piped%20Gas/Acts/Gas%20Act.pdf>
- RSA. (2004, June 7). *Petroleum Pipelines Act (Act No. 60) 2003 for the Republic of South Africa*. Retrieved October 07, 2013, from South African Government Online:
<http://www.info.gov.za/view/DownloadFileAction?id=68038>
- RSA. (2005, April 06). *Energy Regulator Act (Act No. 40) 2004 for the Republic of South Africa*. Retrieved October 07, 2013, from South African Government Online:
<http://www.info.gov.za/view/DownloadFileAction?id=67980>
- RSA. (2006, July 05). *Electricity Regulation Act (Act No. 4) 2006 for the Republic of South Africa*. Retrieved October 07, 2013, from South African Government Online:
<http://www.info.gov.za/view/DownloadFileAction?id=67980>
- RSA. (2007, November 02). *Regulations on Safety Standards and Regulatory Practices No. R388, 2006 for the Republic of South Africa*. Retrieved October 08, 2013, from South African Government Online: <http://www.info.gov.za/view/DownloadFileAction?id=73716>
- RSA. (2009, January 09). *National Radioactive Waste Disposal Institute Act No. 53, 2008 for the Republic of South Africa*. Retrieved October 07, 2013, from South African Government Online: <http://www.info.gov.za/view/DownloadFileAction?id=94446>
- RSA DoE. (2011). *The Regulation on Licensing of Sites for New Nuclear Installations*. Pretoria: Department of Energy (Republic of South Africa).
- RSA DoE. (2012, September 7). *Fees for Nuclear Authorisations 2012-2013*. Cape Town, Western Cape, Republic of South Africa.
- RSA DoE. (June 2013). *Draft 2012 Integrated Energy Planning Report (For Public Consultation)*. Pretoria: Department of Energy South Africa.
- U.S. DoE. (2011a). *Idaho National Laboratory: NGNP 2011 Project Status and Path Forward*. Idaho: U.S. Department of Energy.
- U.S. DoE. (2011b). *Idaho National Laboratory: Next Generation Nuclear Plant Licensing Plan*. Idaho: U.S. Department of Energy.
- WNA. (2011, August). Retrieved April 25, 2013, from World Nuclear Association:
<http://www.world-nuclear.org/info/Current-and-Future-Generation/The-Nuclear-Renaissance/#.UXjxUORBPwY>
- WNA. (2013). *Licensing and Project Development of New Nuclear Plants*. London: Licensing & Permitting Task Force of the World Nuclear Association.

Appendix A: A licensing plan for coupling a nuclear energy source to a chemical process plant – SASOL Secunda as a case study





Appendix A-1: Activity-based cost estimates for a licensing plan for coupling a nuclear energy source to a chemical process plant – SASOL Secunda as a case study

TASK NAME	ACTIVITY-BASED COST ESTIMATE
PRE-OPERATIONAL	
NERSA Licensing	ZAR 3,586,000.00
Application for a Construction license by the applicant for Electricity Generation (by applicant)	ZAR 8,000.00
NERSA formal review and decision	ZAR 960,000.00
Application for an Operation license by the applicant for Electricity Generation (by applicant)	ZAR 8,000.00
NERSA formal review and decision	ZAR 960,000.00
Application for a Distribution license by the applicant for the Electricity (Co-generation) (by applicant)	ZAR 8,000.00
Application advertisement by applicant and return to NERSA (by applicant)	ZAR 282,000.00
Completion and return of the Inspection in the loco questionnaire (by applicant)	ZAR 80,000.00

NERSA formal review and decision	ZAR 1,280,000.00
EIA Process	ZAR 7,144,000.00
Compile and submit EIA application (by applicant)	ZAR 600,000.00
DEA reviews application; accepts or rejects	ZAR 160,000.00
Compile and submit Draft SR, POS (by applicant)	ZAR 480,000.00
Start public participation (by applicant)	ZAR 480,000.00
DEA requests comments from State Departments	ZAR 24,000.00
State Departments comment (by applicant)	ZAR 480,000.00
Public participation (by applicant)	ZAR 480,000.00
DEA sends comments to Applicant's EAP	ZAR 24,000.00
Compile and submit Final SR and POS (by applicant)	ZAR 480,000.00
DEA accepts or rejects Final SR and POS	ZAR 168,000.00
Compile and submit Draft EIR, EMP (by applicant)	ZAR 320,000.00
Start public participation (by applicant)	ZAR 320,000.00
DEA requests comments from State Departments	ZAR 24,000.00

State Departments comment (by applicant)	ZAR 640,000.00
Public participation (by applicant)	ZAR 640,000.00
DEA sends comments to Applicant's EAP	ZAR 24,000.00
Compile and submit Final EIR and EMP (by applicant)	ZAR 360,000.00
DEA considers completeness of reports	ZAR 240,000.00
DEA issues decision (Environmental Authorisation)	ZAR 1,200,000.00
Nuclear Installation Site License (NISL x 2)	ZAR 326,046,792.00
Compile and submit letter of intent (by applicant)	ZAR 72,000.00
MANDATORY Stage 1 (a) Site establishment: Compile and submit permit application for site establishment (by applicant)	ZAR 8,000.00
MANDATORY Stage 1 (b) Early Site Activities: Conditions of authorisation will include mandatory hold and/or witness points	ZAR 1,809,088.00
Compile and submit application for a site license (by applicant)	ZAR 320,000.00
Receipt of final safety case by NNR	ZAR 94,072,576.00
NNR formal safety review phase	ZAR 47,036,288.00
Stakeholder participation	ZAR 47,036,288.00

Issuing NNR final safety evaluation report	ZAR 30,754,496.00
NNR Board review and decision (issue NISL x 2)	ZAR 103,128,968.00
Conditions of authorisation will include mandatory hold and/or witness points	ZAR 1,809,088.00
Nuclear Installation License (NIL via NISL) (Combined license for Construction and Operation) MANDATORY Stage 1 (c) Early Construction Activities	ZAR 275,105,220.00
Compile and submit letter of intent (Combined license for Construction and Operation) (by applicant)	ZAR 72,000.00
NNR secure local and international technical co-operation and support (Only once)	ZAR 2,080,000.00
Compile and submit application for a site license (by applicant)	ZAR 680,000.00
Receipt of final safety case by NNR	ZAR 94,072,576.00
NNR formal safety review phase	ZAR 47,036,288.00
Stakeholder participation	ZAR 47,036,288.00
Issuing NNR final safety evaluation report	ZAR 30,754,496.00
NNR Board review and decision (issue NIL)	ZAR 51,564,484.00
Conditions of authorisation will include mandatory hold and/or witness points	ZAR 1,809,088.00

Optional Stage 2 (a) Authorisation to Design	ZAR 0.00
Optional for Authorisation to Design	ZAR 0.00
Optional and Mandatory Stage 2 (b) Authorisation to Manufacture	ZAR 0.00
Optional Authorisation to Manufacture	ZAR 0.00
Mandatory for long lead item manufacturing	ZAR 0.00
Conditions of authorisation will include mandatory hold and/or witness points	ZAR 0.00
COMMISSIONING	ZAR 3,618,176.00
MANDATORY Stage 3 NIL for the construction of the installation: Conditions of authorisation will include mandatory hold and/or witness points	ZAR 1,809,088.00
MANDATORY Stage 4 NIL for the operation of the installation: Conditions of authorisation will include mandatory hold and/or witness points	ZAR 1,809,088.00
DECOMMISSIONING (AFTER LIFE-TIME OF PLANT)	ZAR 303,099,716.00
MANDATORY Stage 5 NIL for the decontamination and decommissioning of the installation	
Compile and submit letter of intent (by applicant)	ZAR 72,000.00
Application for a decontamination and decommissioning license (by applicant)	ZAR 94,072,576.00

Receipt of final safety case by NNR	ZAR 30,754,496.00
NNR formal safety review phase	ZAR 94,072,576.00
Issuing NNR final safety evaluation report	ZAR 30,754,496.00
NNR Board review and decision (issue NIL)	ZAR 51,564,484.00
Conditions of authorisation will include mandatory hold and/or witness points	ZAR 1,809,088.00
TOTAL	ZAR 918,599,904.00

Appendix A-2: Cost estimated for the applicant for a licensing plan for coupling a nuclear energy source to a chemical process plant – SASOL Secunda as a case study

TASK NAME	APPLICANT ESTIMATED COST
NERSA Licensing	ZAR 386,000.00
Application for a Construction license by the applicant for Electricity Generation (by applicant)	ZAR 8,000.00
Application for an Operation license by the applicant for Electricity Generation (by applicant)	ZAR 8,000.00
Application for a Distribution license by the applicant for the Electricity (Co-generation) (by applicant)	ZAR 8,000.00
Application advertisement by applicant and return to NERSA (by applicant)	ZAR 282,000.00
Completion and return of the Inspection in the loco questionnaire (by applicant)	ZAR 80,000.00
EIA Process	ZAR 5,280,000.00
Compile and submit EIA application (by applicant)	ZAR 600,000.00

Compile and submit Draft SR, POS (by applicant)	ZAR 480,000.00
Start public participation (by applicant)	ZAR 480,000.00
State Departments comment (by applicant)	ZAR 480,000.00
Public participation (by applicant)	ZAR 480,000.00
Compile and submit Final SR and POS (by applicant)	ZAR 480,000.00
Compile and submit Draft EIR, EMP (by applicant)	ZAR 320,000.00
Start public participation (by applicant)	ZAR 320,000.00
State Departments comment (by applicant)	ZAR 640,000.00
Public participation (by applicant)	ZAR 640,000.00
Compile and submit Final EIR and EMP (by applicant)	ZAR 360,000.00
Nuclear Installation Site License (NISLx2)	ZAR 103,528,968.00
Compile and submit letter of intent (by applicant)	ZAR 72,000.00
MANDATORY Stage 1 (a) Site establishment: Compile and submit permit application for site establishment (by applicant)	ZAR 8,000.00

Compile and submit application for a site license (by applicant)	ZAR 320,000.00
NNR Board review and decision (issue NISL)	ZAR 103,128,968.00
Nuclear Installation License (NIL via NISL) (Combined license for Construction and Operation) MANDATORY Stage 1 (c) Early Construction Activities	ZAR 52,316,484.00
Compile and submit letter of intent (Combined license for Construction and Operation) (by applicant)	ZAR 72,000.00
Compile and submit application for a site license (by applicant)	ZAR 680,000.00
NNR Board review and decision (issue NIL)	ZAR 51,564,484.00
DECOMMISSIONING (AFTER LIFE-TIME OF PLANT) MANDATORY Stage 5 NIL for the decontamination and decommissioning of the installation	ZAR 145,709,060.00
Compile and submit letter of intent (by applicant)	ZAR 72,000.00
Application for a decontamination and decommissioning license (by applicant)	ZAR 94,072,576.00
NNR Board review and decision (issue NIL)	ZAR 51,564,484.00
TOTAL	ZAR 307,220,512.00

Appendix B: NGNP Pre-application issues high level summary

1. Tritium Migration:
The design of the NGNP must ensure that the migration of tritium beyond the nuclear heat system is limited such that the maximum amount of tritium released from the integrated NGNP facilities or found in drinking water does not exceed established standards.
2. Nuclear-Industrial Island Boundary:
In regards to licensing and regulatory oversight, the NGNP Project presents the issue of defining an interface (i.e., “boundary”) between the Nuclear Island and the remainder of the plant. This issue is important not only for the NGNP, but also for the follow-on commercial plants for which NGNP is the demonstration project.
3. Regulatory Guidance for Co-location of HTGR at Existing Industry Sites:
NGNP will evaluate applicable regulatory guidance and restrictions related to co-locating HTGRs at existing industrial sites. This item will then be addressed as a pre-application issue if it is determined that changes or updates to the regulatory guidance are needed.
4. Regulatory Technology Development Plan:
For an efficient and comprehensive review of the NGNP Project, the NGNP team and the NRC staff need to ensure that the NGNP technology development program provides the data needed for safety evaluations. In addition, the NRC staff may determine that it needs to conduct its own selected R&D that will independently confirm the NGNP project results or they may propose collaborative research programs.
5. Site Evaluation:
Erection of a NP at an existing industrial site will likely raise issues related to the adequacy of that site (e.g., seismic qualification, emergency planning, and radiological safety) that should be addressed during pre-application to avoid unnecessary delays during review of the license application.
6. Waste Confidence Rule:
NRC confidence in that the government (DoE) will be able to manage nuclear waste in the future when the spent fuel is removed.
7. License Application Review Fees:
10 CFR Part 170 addresses NRC review fees for license application reviews. Agreement is needed with the NRC on the extent of fees for review of the NGNP applications, considering the possibility of an exemption for work that supports NRC long-range development of their HTGR experience and R&D.
8. Decommissioning Cost and Funding Method:
The NRC has recently revisited the topic of decommissioning funding surety agreements (SECYs 2006-0065 and 2007-0197).

9. Modular HTGR Design Certification:
While the NGNP includes only a single reactor module, one of the project goals is that this first plant be a demonstration project for follow-on commercial plants some of which may include more than one reactor module. Therefore, it may be advantageous to begin discussions with NRC staff so that any related design matters such as sharing of the control room and support systems can be factored into both the NGNP design and that for Design Certification of the follow-on commercial plants.
10. Modular HTGR Operator Staffing:
The NGNP Project needs a determination as to whether a NCTL production plant is allowed to control several reactors from one control room.
11. Modular HTGR Operation and Construction:
Concurrent construction and operations at a multi-module plant would need to be addressed in regards to design, safety, and plant security. NRC input on the resolution of this issue is needed.
12. Modular HTGR Annual Fees:
The NRC staff needs to confirm its position that, as a result of the Omnibus Budget Reconciliation Act of 1990, no further change is needed to the 10 CFR 171 fee rule.
13. Modular HTGR Licensing:
The NRC and the NGNP Project need to determine whether a multi-modular plant can be licensed with a single review and set of hearings.

Source: Idaho National Laboratory: NGNP Plan (U.S. DoE, 2011b, p. 32)

Appendix C: Original electronic mail sent to participant requesting a telephonic interview for a licensing plan for coupling a nuclear energy source to a chemical process plant - Sasol Secunda as a case study

Dear Sir/Madam

I, Randall. Lavelot is currently undertaking a research project to formulate a licensing plan for coupling a nuclear energy source to a chemical process plant which is the currently subject of an MENG dissertation.

To this end I kindly request a telephonic interview with you taking no longer than 10 minutes. If in agreement, please could you reply to me via e-mail: rlavelot@gmail.com to arrange the best time for me to call?

Reply at your earliest convenience is appreciated.

Yours sincerely

Randall. Lavelot

DATE: 1 JULY 2013

Appendix C-1: Telephonic interview questionnaire

 NORTH-WEST UNIVERSITY YUNIBESITHI YA BOKONE-BOPHIRIMA NOORDWES-UNIVERSITEIT	INTERVIEWEE: DATE: TIME: TELEPHONE: EMAIL:
TELEPHONIC INTERVIEW QUESTIONNAIRE	
Nuclear licensing is known to be a complex endeavour. Specific licensing requirements for coupling nuclear energy sources to a chemical process plant are yet to be assessed and experienced. Thus, research is required into the feasibility of the research topic. The intention of this interview is to provide the participant who is involved in the nuclear arena, with an opportunity to comment on the researchers licensing plan. Furthermore, so that the researcher might acquire adequate knowledge on the research topic in an attempt to realize the risk of time and cost of licensing to support the development of “[a] licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL Secunda as a case study”. Information provided by the participant will be handled as confidential. While the participant is interviewed, the researcher will be taking down notes. Participant is welcome to ask the researcher to rephrase or repeat question if he don’t understand them. Participant is expected to complete the seven (7) interview questions, lasting no longer than 10 minutes: Question 1: Do you agree to the short telephonic interview? Question 2: What is your name and current position? Question 3: What does NERSA do? Question 4: What would be the applicable license applications fees for the electricity industries in the South Africa? 	

.....
Question 5: For interest sake, how are NERSA' costs recovered?
.....
.....

Question 6: What are the typical durations of new license applications for electricity industries in South Africa?
.....
.....

Question 7: To conclude, do you agree that opinions expressed during the telephonic interview may be applied freely by the researcher. Similarly, that permission for your name to be published in the research?
.....
.....

(END OF TELEPHONIC INTERVIEW)

Appendix C-2: Telephonic interview convention i



NORTH-WEST UNIVERSITY
YUNIBESITHI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

INTERVIEWEE: MR. TSHEPO RAMOKOKA

DATE: 1 JULY 2013

TIME: 15H25 – 15H35

TELEPHONE: +2712 401 4774

EMAIL: tshepo.ramokoka@nersa.org.za

(CONTEXT: TELEPHONIC CONVERSATION CONDUCTED FROM RANDALL'S OFFICE IN CAPE TOWN WHILE THE INTERVIEWEE IS AT WORK IN PRETORIA)

Randall: *Good day:: :[::] my name is Randall (1.0) I am currently conducting research on the topic of Nuclear licensing. This research is part of a feasibility study on coupling nuclear energy sources to a chemical process plant.*

Tshepo: *[↑OK] (1.4)*

Randall: *>The intention of this telephone call is to provide you with an opportunity to comment on the licensing plan from NERSA's perspective. Also, that the researcher might acquire adequate knowledge on the research topic in an attempt to document the risk of time and cost of licensing to support the development of "[a] licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL Secunda as a case study" <(1.4)*

Tshepo: *↑ understand (1.0)*

Randall: *>Information provided by you will be handled as confidential (.) while the participant is interviewed, the researcher will be taking down notes as well as an audio recording. The participant is welcome to ask the researcher to REPHRASE OR REPEAT QUESTIONS if he don't understand them. The participant is expected to complete seven (7) interview questions, lasting no longer than 10 minutes<.*

Randall: *[Question 1] (.) do you agree to the short telephonic interview?*

Tshepo: *↑Yes, I agree >to be interviewed<.*

Randall: *[Question 2] (1.0) what is your name and current position?*

Tshepo: *>My name is Mr. Tshepo Ramokoka (.) I am the current Deputy Chief Education Specialist at NERSA<.*

Randall: *[Question 3]. What does NERSA do?*

Tshepo: *°In terms of its mandate° (1.0) NERSA is in place to regulate petroleum pipelines, piped-gas industries and the electricity industries in South Africa.*

Randall: [Question 4]. What would be the applicable license applications fees for the electricity industries in South Africa?

Tshepo: *>↑NO FEES ARE APPLICABLE FOR ELECTRICITY GENERATION<, gas or petroleum applications (.) However, the applicant has to bear < the cost of advertising > that is performed on the behalf of the applicant by NERSA.*

Randall: [Question 5]. For interest sake, how are NERSA' costs recovered?

Tshepo: *Well ↑ NERSA's costs are recovered via Government (through levies). Please also see our latest Electricity Regulation (No. 4 of 2006). ° This Regulation will explain this in more detail °.*

Randall: [Question 6]. What are the typical durations of new license applications for electricity industries in South Africa?

Tshepo: *Similarly (1.4) this will be freely available on NERSA's website (<http://www.nersa.org.za>). >The latest sources may be downloaded from this ↓ URL link already provided<.*

Randall: [Question 7]. To conclude, do you agree that opinions expressed during the telephonic interview may be applied feely by the researcher. Similarly, that permission for your name to be published in the research?

Tshepo: *Yes (.) you may publish the interview that we just had (1.4) It is also a pleasure to be of assistance = Last:::ly, all the best with your research.*

(TRANSCRIPTION CONVENTION ENDS)

Appendix D: Original electronic mail sent to participants requesting an interview for a licensing plan for coupling a nuclear energy source to a chemical process plant - Sasol Secunda as a case study

Dear Sir/Madam

I, Randall. Lavelot is currently undertaking a research project to formulate a licensing plan for coupling a nuclear energy source to a chemical process plant which is the currently subject of an MENG dissertation.

To this end I kindly request an interview with you taking no longer than 20 minutes. If in agreement, please could you reply to me via e-mail: rlavelot@gmail.com.

Reply at your earliest convenience is appreciated.

Yours sincerely

Randall. Lavelot

DATE: 1 JULY 2013

Appendix D-1: In-depth interview questionnaire

INTERVIEWEE:

TELEPHONE: **EMAIL:**

VENUE:

DATE:

TIME:



NORTH-WEST UNIVERSITY[®]
YUNIBESITHI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

IN-DEPTH INTERVIEW QUESTIONNAIRE

Nuclear licensing is known to be a complex endeavour. Specific licensing requirements for coupling nuclear energy sources to a chemical process plant are yet to be assessed and experienced. Thus, research is required into the feasibility of the research topic.

The intention of this interview is to provide the participant who is involved in the nuclear arena, with an opportunity to comment on the researchers licensing plan. Furthermore, so that the researcher might acquire adequate knowledge on the research topic in an attempt to realize the risk of time and cost of licensing to support the development of “[a] licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL Secunda as a case study”.

Information provided by the participant will be handled as confidential. While the participant is interviewed, the researcher will be taking down notes as well as an audio recording. Participant is welcome to ask the researcher to rephrase or repeat question if he don't understand them. Participant is expected to complete the eight (8) interview questions, lasting no longer than 20 minutes:

Question 1: Do you agree to the brief interview?

.....
.....

Question 2: What is your current position?

.....
.....

Question 3: What initiatives are your organization currently participating with in relation to nuclear?

.....

.....

Question 4: What issues would you say the (attached) licensing plan provides?

.....

.....

Probe: Are there gaps in the compilation of the licensing plan? (Typical hold and witness points, durations, etc.)

Question 5: What would you consider to be the challenges in applying the licensing plan from this research initiative?

.....

.....

Probe: What makes licensing nuclear energy source with a chemical process plant so unique? What is the maximum amount or standard of tritium that may be released from the integrated NCTL production plant in South Africa?

Question 6: Overall, how relevant would you say that the research findings (i.e. licensing plan) are from other licensing plans submitted to the safety authority? (i.e. 0 = not at all, 1 = somewhat, 2 = quite relevant, 3 = very relevant or 4 = extremely relevant)

.....

.....

Question 7: Two part question. a) In your opinion, what needs to be done to increase the acceptance of the licensing plan? b) Additionally, what would you identify as the obstacles to achieving those objectives?

.....

.....

Question 8: Do you agree that opinions expressed during the interview may be applied freely by the researcher. Similarly, that permission for your name to be published in the research?

.....

.....

(END OF IN-DEPTH INTERVIEW)

Appendix D-2: In-depth interview convention ii

INTERVIEWEE 2: MR. MARK OOSTHUIZEN

TELEPHONE: +2721 553 2447 **EMAIL:** OosthuM@eskom.co.za

VENUE: Koeberg Nuclear Power Station-Environmental Boardroom

DATE: 5 JULY 2013

TIME: 08H00 – 08H20



IN-DEPTH INTERVIEW CONVENTION

Randall: *Good day [::] my name is Randall (.) >I am currently conducting research on the topic of Nuclear licensing. This research is part of a feasibility study on coupling nuclear energy sources to a chemical process plant<.*

Mark: [*↑YES*] (1.0)

Randall: *>The intention of this interview is to provide you with an opportunity to comment on the licensing plan. Also, that the researcher might acquire adequate knowledge on the research topic in an attempt to document the risk of time and cost of licensing to support the development of “[a] licensing plan for coupling a nuclear energy source to a chemical process plant - SASOL Secunda as a case study” <*

Mark: [*↑OK*] (1.2)

Randall: *>Information provided by you will be handled as confidential (.) while the participant is interviewed, the researcher will be taking down notes as well as an audio recording. The participant is welcome to ask the researcher to REPHRASE OR REPEAT QUESTIONS if he don’t understand them. The participant is expected to complete EIGHT (8) interview questions, lasting no longer than 20 MINUTES<.*

Mark: *>OK<*

Randall: [Question 1]. Do you agree to the brief interview?

Mark: [*↑Yes [I agree]*].

Randall: [Question 2]. What is your name and current position?

Mark: MARK OOSTHUIZEN (.) ESKOM NUCLEAR SITING PROJECT PLANNER.

Randall: [Question 3] (.) what initiatives are your organization currently participating with in

relation to nuclear?

Mark: ↑Numerous=

- Post-Fukushima lessons learnt to ensure South Africa's current nuclear installations don't suffer the same fate◦.
- Updating of the Koeberg Site Safety Report (SSR)◦.
- Additional Probabilistic studies to determine Seismic hazards, not only at Koeberg, but also at possible newly selected sites◦.
- Safety Culture enhancement programme (SCEP)◦.

Randall: [Question 4]. What issues would you say the (attached) licensing plan provides?

Mark: .hhh keeping in mind Eskom's current licensing difficulties with the NNR and with cogeneration using nuclear being new in South Africa, >it may take a lot longer than expected as it is modern to South Africa<.

Randall: (Probe) Are there gaps in the compilation of the licensing plan? (Typical hold and witness points, durations, etc.)

Randall: [Question 5]. What would you consider to be the challenges in applying the licensing plan from this research initiative?

Mark: ↓◦I feel I am not learned enough◦ in this regard to answer this question (1.4) sufficiently.

Randall: (Probe) What makes licensing nuclear energy source with a chemical process plant so unique? What is the maximum amount or standard of tritium that may be released from the integrated NCTL production plant in South Africa?

Mark: ↓◦As mentioned before, I feel I am not learned enough◦ in this regard to answer this question (1.4) sufficiently.

Randall: [Question 6]. Overall, how relevant would you say that the research findings (i.e. licensing plan) are from other licensing plans submitted to the safety authority? (i.e. 0 = not at all, 1 = somewhat, 2 = quite relevant, 3 = very relevant or 4 = extremely relevant)

Mark: Current::ly Eskom does not have an approved licensing plan, so I would say that this licensing plan (for NCTL production plant) is very relevant >as it has at least been drafted<=Therefore, 3 (very relevant).

Randall: [Question 7] (.) Two part question. a) In your opinion, what needs to be done to increase the acceptance of the licensing plan? b) Additionally, what would you identify as the obstacles to achieving those objectives?

Mark: >I feel that with good proactive public relations and educating the public about the safety and the advantages of Nuclear should quell most of the obstacles that could be faced<.

>I feel that the public as a whole fears nuclear because they do not understand it<. ↓The current

reactive approach to public relations is not boding well as it gives the impression that there are things to hide, that only if the public asks, will they be told. This has to change.

Randall: [Question 8]. Do you agree that opinions expressed during the interview may be applied freely by the researcher. Similarly, that permission for your name to be published in the research?

Mark: Yes (.) *you may publish my details in your dissertation?*

(TRANSCRIPTION CONVENTION ENDS)

Appendix D-3: In-depth interview convention iii

INTERVIEWEE 3: DR. SIFISO NHLEKO

TELEPHONE: +27 71 360 9652 **EMAIL:** snhleko@nnr.co.za

VENUE: Necsa Science Centre (Boardroom)

DATE: 18 JULY 2013

TIME: 12H30 – 13H00



IN-DEPTH INTERVIEW CONVENTION

Randall: *Good day (.) my name is Randall Lavelot (.) >I am currently conducting research on the topic of Nuclear licensing<.*

Sifiso: .hhh

Randall: *>I would like to interview you and provide you with opportunity to comment on the licensing plan I have formulated.*

Sifiso: *↑OK (1.0)*

Randall: *>Information provided by you will be handled as confidential ↑ while the participant is interviewed, the researcher will be taking down notes as well as an audio recording. The participant is welcome to ask the researcher to REPHRASE OR REPEAT QUESTIONS if he don't understand them. The participant is expected to complete EIGHT (8) interview questions, lasting no longer than 20 MINUTES<.*

Sifiso: *>I UNDERSTAND<*

Randall: [Question 1]. Do you agree to the brief interview?

Sifiso: *↑Yes [:::] I agree to the interview.*

Randall: [Question 2]. What is your name and current position?

Sifiso: SIFISO NHLEKO (.) CIVIL ENGINEERING SPECIALIST, DESIGN SAFETY, at the NATIONAL NUCLEAR REGULATOR.

Randall: [Question 3] (.) what initiatives are your organization currently participating with in relation to nuclear?

Sifiso: *↑Updating the regulatory framework in preparation for the NEW BUILD.*

Randall: [Question 4]. What issues would you say the (attached) licensing plan provides?

Sifiso: *The ENVIRONMENTAL ASSESSMENT PROCESS is not reflected (only the NNR process is shown) (.) >It is not clear whether this licensing plan assumes that SITING which can be quite lengthy has been done already or it is part of this plan<.*

Randall: (Probe) Are there gaps in the compilation of the licensing plan? (Typical hold and witness points, durations, etc.)

Sifiso:

The NNR stakeholder participation process should last approximately 180 (i.e. 6 months) instead of 130 days. NNR license application review is at least one year.

>The vendor bidding process is not reflected in the plan<

Randall: >Stakeholder participation excludes week-ends (.) therefore 6 months is approximately 130 days instead of 180 days<.

Randall: [Question 5]. What would you consider to be the challenges in applying the licensing plan from this research initiative?

Sifiso: *I do not think the NNR has the required human resource capacity to handle 2 applications per year ° (with all the site familiarization required) <in which case the applications will have to be launched in series>.*

Randall: (Probe) What makes licensing nuclear energy source with a chemical process plant so unique? What is the maximum amount or standard of tritium that may be released from the integrated NCTL production plant in South Africa?

Sifiso: *The NNR REGULATIONS AND REQUIREMENTS were developed either for research reactor type facilities or nuclear power plants. >Anything that falls in between needs a slight adaptation of the requirements (for example by applying of the graded approach)< (.) Thus the absence of explicit requirements brings an UNPREDICTABILITY element in the licensing process.*

Sifiso: *.hhh It is that quantity that will result in the violation of the regulatory exposure limits ↑stated in RD 24.*

Randall: [Question 6]. Overall, how relevant would you say that the research findings (i.e. licensing plan) are from other licensing plans submitted to the safety authority? (i.e. 0 = not at

all, 1 = somewhat, 2 = quite relevant, 3 = very relevant or 4 = extremely relevant)

Sifiso: ∴ 3 (very relevant).

Randall: [Question 7] (.) Two part question. a) In your opinion, what needs to be done to increase the acceptance of the licensing plan? b) Additionally, what would you identify as the obstacles to achieving those objectives?

Sifiso: ↓ >Include activities that have been omitted in the plan such as siting, the EIA process, vendor bidding process< (1.0)

Optimising the EIA and NNR processes.

Randall: [Question 8]. Do you agree that opinions expressed during the interview may be applied freely by the researcher. Similarly, that permission for your name to be published in the research?

Sifiso: Yes

(TRANSCRIPTION CONVENTION ENDS)

Appendix D-4: In-depth interview convention iv

INTERVIEWEE 4: MR. PETER BESTER

TELEPHONE: +27 82 882 5630 **EMAIL:** PBester@nnr.co.za

VENUE: National Nuclear Regulator (Centurion office)

DATE: 1 AUGUST 2013

TIME: 14H30 – 15H00



IN-DEPTH INTERVIEW CONVENTION

Randall: *Good day. My name is Randall as your already know (.) >I am currently conducting research on the topic of Nuclear licensing<.*

Randall: *>Already discussed in my email, I would like to interview you and provide you with opportunity to comment on the licensing plan I have formulated<.*

Peter: *↑OK (1.0)*

Randall: *>Information provided by you will be handled as confidential ↑ while the participant is interviewed, the researcher will be taking down notes as well as an audio recording. The participant is welcome to ask the researcher to REPHRASE OR REPEAT QUESTIONS if he don't understand them. The participant is expected to complete EIGHT (8) interview questions, lasting no longer than 20 MINUTES<.*

Peter: *>I UNDERSTAND<*

Randall: [Question 1]. Do you agree to the brief interview?

Peter: *YE::S.*

Randall: [Question 2]. What is your name and current position?

Peter: *PETER BESTER (.) SPECIAL NUCLEAR PROJECTS CO-ORDINATOR (.), at the NATIONAL NUCLEAR REGULATOR.*

Randall: [Question 3] (.) what initiatives are your organization currently participating with in relation to nuclear?

Peter: *↑Relating to what (.)*

Randall: *>Relating to nuclear or what you doing at the moment<*

Peter: *Busy Preparing Regulations (.) revising suite of REGULATIONS (1.4) and <REQUIREMENTS DOCUMENTS>.*

Randall: [Question 4]. What issues would you say the (attached) licensing plan provides?

Peter: *<I can say what issue a typical licensing plan needs to highlight. YOU NEED TO CONSIDER THAT STRATEGY PAPER TIMELINES INDICATED is based on the assumption that <the technology :: has a proven track record and has been licensed elsewhere, OK [::] so for novel technologies those timelines may not be appropriate, OK, So you cannot assume that it will be applicable to your case>. (2.0)*

So for novel design you need to consider issues that could impact on safety (hazards) which should be addressed in the SAFETY CASE. >It MUST be supported by a comprehensive test and qualification programme (SAFETY MUST BE DEMONSTRATED) <. In summary, NOVEL ISSUE AND NEW ISSUES NEEDS TO BE IDENTIFIED TO THE SATISFACTION OF THE REGULATOR. THE SAFETY CASE MUST BE SUPPORTED BY DEMONSTRATING TEST AND QUALIFICATION PROGRAMME (.)

Randall: (Probe) Are there gaps in the compilation of the licensing plan? (Typical hold and witness points, durations, etc.)

Peter: *IT DEPENDS ON THE APPROACH TO LICENSING (1.4) the applicant has the privilege to decide to go with combined licensing or stage license approach. In the case of siting :: the °hold and witness points will only be for siting° (1.4) if it is for construction (.) the HOLD AND WITNESS POINTS will be <from a construction point of view> [:::]] Depending on the completeness of the safety case (.) THE NNR WILL DETERMINE THE HOLD AND WITNESS POINTS ::::*

Example (.) If you don't have enough information to demonstrate that certain mechanical components (vessel) are appropriate (.) <then we might only allow you to do civil construction (.) subject to more information being available> therefore we won't allow you to bring in the vessel onto site. Once we issue a license to construct we will do civil construction (.) so typical hold and witness points would be for civil construction, commissioning (installation of equipment) :::: cold-commissioning (with no fuel on site and produce heat via heaters ONLY) then if we satisfied that the equipment performs as it should (.) we will allow you to bring fuel on site (.) when fuel is loaded it will also be a hold and witness point by the NNR (in the case of hot commissioning). WE WON'T ALLOW YOU TO GO CRITICAL UNTIL YOU DEMONSTRATE THAT YOUR SAFETY FEATURES WORK (WE MAY WANT TO WITNESS YOU WELDING TECHNIQUE) (.) SEE GENERIC ONES (HOLD AND WITNESS POINTS) IN PP-009 of the NNR.

Randall: [Question 5]. What would you consider to be the challenges in applying the licensing plan from this research initiative?

Peter: °YOU NEED TO IDENTIFY THE NEW HAZARDS (.) ISSUE RELATING TO EXTERNAL EVENTS AND CHEMICAL (CORROSION)°(.) that will be you challenges from my perspective regarding licensing (10.0)

Randall: (Probe) What makes licensing nuclear energy source with a chemical process plant so unique? What is the maximum amount or standard of tritium that may be released from the integrated NCTL production plant in South Africa?

Peter: hhh don't know the detail.

Randall: [Question 6]. Overall, how relevant would you say that the research findings (i.e. licensing plan) are from other licensing plans submitted to the safety authority? (i.e. 0 = not at all, 1 = somewhat, 2 = quite relevant, 3 = very relevant or 4 = extremely relevant)

Peter: Your plan is in between (.) 3 (very relevant).

Randall: [Question 7] (.) Two part question. a) In your opinion, what needs to be done to increase the acceptance of the licensing plan? b) Additionally, what would you identify as the obstacles to achieving those objectives?

Peter: ↓ >Licensing fees seem alot< (10.0)

Randall: I worked on two NISL's.

Peter: OK (.) ± R400M should be fine for two NISL's then. You should work on 30 people not 40 people (referring to your plan) per year. Use 30 people (.) this is in accordance with our latest estimations (.) R40M per year (.) therefore R1M+ per person (.) rough estimates(.)

Randall: O::h.

Peter: What I don't see in the plan it appreciation for the issues. Once you submit a safety case (.) what you need to attach is a risk plan when licensing as a solution to the issues. Also your project plan (.) is needed with regards to test and qualification. Therefore, it will be difficult to accept a licensing plan without a project plan. PP-008 will help you (4.0)

Randall: I have IDENTIFIED RISKS as part of my secondary objective.

Randall: b) Additionally, what would you identify as the obstacles to achieving those objectives?

Peter: >Its really (.) the novelty of the design is the obstacle in my view. Licensing requirement are the same if it's a research reactor or new power plant< (.) to me it the type of technology and the experience of people that will be the issue.

Randall: [Question 8]. Do you agree that opinions expressed during the interview may be applied feely by the researcher. Similarly, that permission for your name to be published in the research?

Peter: Yes (.) I am doing the interview as an individual (.) NOT AS THE NNR >So Peter Bester

responded not the NNR<.

(TRANSCRIPTION CONVENTION ENDS)

Appendix D-5: In-depth interview convention v subsequent to short comings

INTERVIEWEE: MR. ISRAEL SEKOKO

TELEPHONE: +27 82 886 1606 **EMAIL:** Sekokol@eskom.co.za

VENUE: Nelson Mandela Metropolitan University

DATE: 3 SEPTEMBER 2013

TIME: 18H00-18H20



IN-DEPTH INTERVIEW CONVERSATION

Randall: *Good day. My name is Randall (.) >I am currently conducting research on the topic of Nuclear licensing<.*

Randall: *> I would like to interview you and provide you with opportunity to comment on the licensing plan I have formulated<.*

Israel: *↑OK (1.0)*

Randall: *>Information provided by you will be handled as confidential ↑ while the participant is interviewed, the researcher will be taking down notes as well as an audio recording. The participant is welcome to ask the researcher to REPHRASE OR REPEAT QUESTIONS if he don't understand them. The participant is expected to complete EIGHT (8) interview questions, lasting no longer than 20 MINUTES<.*

Israel: *>OK<*

Randall: [Question 1]. Do you agree to the brief interview?

Israel: *↑Yes [I agree].*

Randall: [Question 2]. What is your name and current position?

Israel: *NUCLEAR SITING TECHNICAL SPECIALIST (.) AT ESKOM.*

Randall: [Question 3] (.) what initiatives are your organization currently participating with in relation to nuclear?

Israel: *>NUCLEAR SITING<*

Randall: [Question 4]. What issues would you say the (attached) licensing plan provides?

Israel: .hh the plan seems to make provision for the license application to generate electricity, however, >it is not clear what the purpose of the chemical plant will be<.

Randall: Probe: Are there gaps in the compilation of the licensing plan? (Typical hold and witness points, durations, etc.)

Israel: IS NOT EASY TO TELL WITHOUT INFORMATION ON THE ACTUAL PURPOSE OF THE CHEMICAL PLANT, <note that you may need additional permits over and above the EIA and the NNR> (.) The location of the both plants is also important and thus it is important to give more details of the location.

Randall: [Question 5]. What would you consider to be the challenges in applying the licensing plan from this research initiative?

Israel: DEPENDING ON THE INTENDED USE OF THE CHEMICAL PLANT, both the nuclear application and the EIA application will pose a problem in terms of a schedule (.) NUCLEAR EIA ARE NOTORIOUSLY KNOWN FOR PROLONGED COURT CASES AND STRONG OPPOSITION (.) The siting of the nuclear installation is also important as one need to adequately account for potential hazards that could affect the design and safe operation of the plant. <The proposed chemical plant might be an ↑ external hazard to the nuclear plant>.

Randall: Probe: What makes licensing nuclear energy source with a chemical process plant so unique? What is the maximum amount or standard of tritium that may be released from the integrated NCTL complex in South Africa?

Israel: (2.0)

Randall: [Question 6]. Overall, how relevant would you say that the research findings (i.e. licensing plan) are from other licensing plans submitted to the safety authority? (i.e. 0 = not at all, 1 = somewhat, 2 = quite relevant, 3 = very relevant or 4 = extremely relevant)

Israel: ∴ 4 (.) > LICENSING PLAN IS EXTREMELY RELEVANT TO THE LEGAL REQUIREMENT OF NUCLEAR IN SOUTH AFRICA<

Randall: [Question 7] (.) Two part question. a) In your opinion, what needs to be done to increase the acceptance of the licensing plan? b) Additionally, what would you identify as the obstacles to achieving those objectives?

Israel: >The license plan covers nuclear, EIA and NERSA requirements in South Africa, therefore no further work is needed< HOWEVER (1.0) THE PLAN DOES NOT GUARANTEE THAT THE LICENSE WILL BE GRANTED AS THIS WILL DEPEND ON THE SAFETY CASE.

Randall: [Question 8]. Do you agree that opinions expressed during the interview may be

applied feely by the researcher. Similarly, that permission for your name to be published in the research?

Israel: YES

(TRANSCRIPTION CONVENTION ENDS)

Appendix E: Original electronic mail sent to participants on the survey questionnaire for a licensing plan for coupling a nuclear energy source to a chemical process plant - Sasol Secunda as a case study

Dear Sir/Madam

I, Randall. Lavelot is currently undertaking a research project to formulate a licensing plan for coupling a nuclear energy source to a chemical process plant which is the currently subject of an MENG dissertation. To this end I kindly request that you complete the following short questionnaire, which should take no longer than 10 minutes of your time. Since your participation in this survey is entirely voluntary, your response is of the utmost importance to me.

Please do not enter your contact details on the questionnaire as it will remain anonymous. Kindly return the completed the questionnaire on or before 30 August 2013. The results of this research will be summarised and be published in my dissertation.

Should you have any comments or questions relating to the attached **self- administered survey**, you are welcome to contact me on my cellular phone number: 074 375 3067 or via e-mail: rlavelot@gmail.com.

Yours sincerely

Randall. Lavelot

DATE: 1 JULY 2013

Appendix E-1: Survey Questionnaire for a licensing plan for coupling a nuclear energy source to a chemical process plant - Sasol Secunda as a case study



SELF- ADMINSTERED SURVEY

The survey has three possibilities for you to make a response, which are illustrated with the following three examples:

Q.1 Select your age group please (i.e. years).

Less than 30 ☐ 31-40 ☐ 41-50 ☒ 51-60 ☐ 61-more ☐

Q.2 Select your occupation please.

Nuclear Licensing Engineer	☐
Nuclear Project Manager	☒
Licensing Project Manager	☐
Nuclear Engineer	☐
Licensing and Safety Manager	☐
Nuclear Safety Analyst	☐
Other	☐
If other, please specify	

Note: If “Other”, then write your answer on the line provided as in the example above. Similarly, in the case of “If other, please specify”.

Q.7 Tritium migration beyond the nuclear heat system (i.e. from nuclear energy source coupled to energy-intensive industry)

Low =(L) or High=H

Low =(L) or High=H

Option 1: Probability (1) Impact (2) or

Option 2: Probability (1) Impact (2) or

Option 3: Probability (1) Impact (2) or

Option 4: Probability (1) Impact (2)

PLEASE COMPLETE THE NEXT 23 QUESTIONS ON THE FOLLOWING 4 PAGES

SECTION A: INFORMATION ON DEMOGRAPHICS

Q.1 Select your age group please (i.e. years).

Less than 30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 61-more ☐

Q.2 Select your occupation please.

Nuclear Licensing Engineer

☐

Nuclear Project Manager

☐

Licensing Project Manager

☐

Nuclear Engineer

☐

Licensing and Safety Manager

☐

Nuclear Safety Analyst

☐

Other

☐

If other, please specify

☐

Q.3 Select your gender please.

Male ☐ Female ☐

Q.4 Your highest qualification attained.

Matric ☐ Diploma ☐ University Degree ☐ Post Graduate Degree ☐

Q.5 Select how many years have you been working in the nuclear arena.

Less than 5 ☐ 6-10 ☐ 11-20 ☐ 21-30 ☐ 31-more ☐

SECTION B: INFORMATION ON THE NUCLEAR ORGANISATION OF THE PARTICIPANT

Q.6 Select your participation in the nuclear project arena.

EPC Contractor

☐

Vendor

☐

The Utility

☐

Safety Authority

☐

Government (for policy making)

☐

Customer (in the Market wanting electricity)

☐

Other

☐

If other, please specify

Q.7 Level of your nuclear organisation in terms of turnover annually (i.e. Million Rand)

Less than R24M

☐

R25M – R74M

☐

R75M – R119M

☐

R120M – R169M

☐

R170M – R219M

☐

R220M and more

☐

Other

☐

If other, please specify

☐

SECTION C: RISK AND OPPORTUNITY IDENTIFICATION AND ASSESSMENT

Q.8 Tritium migration beyond the nuclear heat system.

Probability (1) ☐ X Impact (2) ☐

Q.9 Uncertainty of licensing a nuclear energy source for coupling to energy-intensive industries.

Probability (1) ☐ X Impact (2) ☐

Q.10 Co-locating multiple HTRs on an existing industrial site.

Probability (1) ☐ X Impact (2) ☐

Q.11 The safety authority independently confirms the HTR project results (e.g. Data needed for safety evaluations).

Probability (1) ☐ X Impact (2) ☐

Q.12 Agreement on scope and schedule between the safety authority and licensee.

Probability (1) ☐ X Impact (2) ☐

Q.13 Early engagement with the safety authority.

Probability (1) ☐ X Impact (2) ☐

Q.14 Revision to existing codes and standards when licensing nuclear energy sources.

Probability (1) ☐ X Impact (2) ☐

Q.15 Safety and health of the public during design basis and beyond design basis accidents.

Probability (1) ☐ X Impact (2) ☐

Q.16 Construction of a nuclear plant on an existing industrial site may raise concerns relating to the adequacy of the site (e.g. seismic qualification, radiological safety and emergency planning).

Probability (1) ☐ X Impact (2) ☐

Q.17 Integrating the security and safety considerations into the HTR design.

Probability (1) ☐ X Impact (2) ☐

Q.18 Licensee managing the HTR's nuclear waste adequately.

Probability (1) ☐ X Impact (2) ☐

Q.19 No decommission fund surety agreement.

Probability (1) ☐ X Impact (2) ☐

Q.20 Sharing one control room and other support systems for multiple reactor modules when licensing.

Probability (1) ☐ X Impact (2) ☐

Q.21 Concurrent multi-module plant construction and operations of the energy-intensive plant.

Probability (1) ☐ X Impact (2) ☐

Q.22 Increase of licensing fees for multiple HTR's.

Probability (1) ☐ X Impact (2) ☐

Q.23 Single review and set of hearings by the safety authority.

Probability (1) ☐ X Impact (2) ☐

Please add any further comments that you may wish to make about the research survey below:

Thank you once again for completing the questionnaire. Your input is important and your comments or contributions are valued.