INTEGRATED SUSTAINABILITY TRANSITIONS FRAMEWORK TO GUIDE GOVERNANCE OF STRATEGIC ELECTRICTY PLANNING

LWANDLE JACKIE MQADI

A dissertation

presented for the degree of **Doctor of Philosophy in Public and Development Management** under the School of Public Leadership of the Faculty of Economic and Management Sciences at Stellenbosch University

Promoter: Prof. Josephine Kaviti Musango

Co-promoter: Prof. Alan C. Brent

April 2019

Declaration

By submitting this dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third-party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

This dissertation includes two original papers published in peer-reviewed journals and one original unpublished publication (submitted for publication). The development and writing of the papers (published and unpublished) were the principal responsibility of myself.

Date: March 2019

Abstract

South Africa's electricity sector is characterised by the unique social, political and economic legacy of apartheid, which still profoundly impacts decision making and the contemporary politics of sustainability transition. A series of processes is converging to force the issue of sustainability and to drive South Africa's low-carbon energy transition. The overall research question of this study was: Can a sustainability transition framework be conceptualised to address the challenge of low-carbon electricity transition in South Africa? This was achieved through a critical literature analysis, qualitative system dynamics using causal loop diagrams and stakeholder and expert interviews. From the literature, it was observed that the challenges facing South Africa's strategic electricity planning result from the related politics, differing views owing to different stakeholder preferences, lack of transparency in electricity planning and misalignment between development policies and objectives. On this basis, the study developed a conceptual integrated electricity sustainability transition framework. From qualitative system dynamics, it was observed that resistance to Integrated Resource Plan development, adoption and overall implementation has contributed negatively to the electricity sustainability transition agenda. Further, ongoing interventions merely deal with symptoms rather than the root cause of the Integrated Resources Plan challenges. It is in this context that this study engaged with the stakeholder and various experts and reviewed the strategic electricity planning process in South Africa, taking into consideration the socio-political economy complexity challenges within an established theoretical sustainability transition framework. The study finally recommends for the need to entrench the integrated electricity sustainability transition framework into the existing Integrated Resources Plan approach in South Africa. This would ensure that the complex sustainability policy objectives are aligned within the electricity planning process. An examination of implementation feasibility and relevance of the proposed conceptual framework affirmed the persistent resistance towards Integrated Resources Plan development and its adoption as well as how its implementation has negatively impacted the electricity sustainability transition agenda. Further, the study established that a policy governance-driven framework, embedded in South Africa's Integrated Resources Plan approach, is vital to tackle issues of policy and governance, transparency, vested interests and associated politics, alignment, stakeholder engagement and monitoring and evaluation.

Opsomming

Suid-Afrika se elektrisiteitsektor word gekenmerk deur die unieke maatskaplike, politieke en ekonomiese erfenis van apartheid, wat stil 'n diepgaande impak op besluitneming en die hedendaagse politiek van volhoubare oordrag het. 'n Reeks prosesse loop ineen om die kwessie van volhoubaarheid af te dwing en om Suid-Afrika se oorgang na laekoolstof-energie aan te dryf. Die oorhoofse navorsingsvraag van hierdie studie was: Kan 'n volhoubaarheidsoorgangsraamwerk gekonseptualiseer word om die uitdaging van oorgang na laekoolstof-elektrisiteit in Suid-Afrika aan te pak? Dit is bereik deur 'n kritiese literatuurontleding, kwalitatiewe stelseldinamika met die gebruik van kousale lusdiagramme en onderhoude met belanghebbendes en kundiges. Uit die literatuur is waarneem dat die uitdagings vir Suid-Afrika se strategiese elektrisiteitsbeplanning uit die verbonde politiek, uiteenlopende sieninge weens wisselende voorkeure van belanghebbendes, 'n gebrek aan deursigtigheid in elektrisiteitsbeplanning en wanooreenstemming tussen ontwikkelingsbeleide en -doelstellings spruit. Op hierdie grondslag is 'n konseptuele volhoubaarheidsoorgangsraamwerk ontwikkel. Uit kwalitatiewe stelseldinamika is waargeneem dat weerstand teen die ontwikkeling, aanvaarding en algehele implementering van die Geïntegreerde Hulpbronplan (GHP) negatief tot die agenda van elektrisiteitsvolhoubaarheidsoorgang bygedra het. Voorts hanteer voortgesette intervensies bloot simptome eerder as die grondoorsaak van die GHP-uitdagings. In hierdie konteks is belanghebbende spesialiste betrek en is die strategiese elektrisiteitsbeplanningsproses in Suid-Afrika geëvalueer, met inagname van die uitdagings van die kompleksiteit van die sosiopolitieke ekonomie in 'n gevestigde teoretiese volhoubaarheidsoorgangsraamwerk. 'n Argument word gevoer vir die noodsaaklikheid om die volhoubaarheidsoorgangsraamwerk in die bestaande GHP-beleidsbeplanningsontwikkelingsbenadering in Suid-Afrika te veranker. Dit sal verseker dat die komplekse volhoubaarheidsbeleidsdoelstellings in ooreenstemming met die elektrisiteitsbeplanningsproses is. 'n Ondersoek van die volhoubaarheid van implementering en die toepaslikheid van die voorgenome konseptuele raamwerk het die volhardende weerstand teen GHP-ontwikkeling en -aanvaarding bevestig, asook dat die implementering daarvan 'n negatiewe impak op die agenda vir elektrisiteitsvolhoubaarheidsoorgang gehad het. Die studie het ook bepaal dat 'n beleids- en bestuursgedrewe raamwerk, veranker in Suid-Afrika se GHP-beleidsbeplanningsontwikkeling, noodsaaklik is om kwessies van beleid en bestuur, deursigtigheid, gevestigde belange en verbonde politiek, inlynstelling, betrokkenheid van belanghebbendes en monitering en evaluering aan te pak.

Acknowledgements

Sincere gratitude to my supervisors, Prof Josephine Musango and Prof Alan Brent. I am forever grateful and appreciative of your understanding, guidance, patience and support during my studies. To my UMaMa research group colleagues at Stellenbosch University, thank you for always availing yourself whenever I called on you and for your assistance during my studies, especially Paul Currie and Benjamin Batinge. Paul, thank you for your kindness and for welcoming me to your home. Benjamin, thank you for always answering my desperate calls for guidance during the course of my studies.

Eskom SOC is acknowledged for granting me a bursary and time to pursue my PhD studies. Thank you to my managers for all the support. I would also like to thank all the sector specialists who took time to respond to my questionnaire and those who made themselves available for detailed one-on-one interviews. I am also grateful to the team at the CSIR Energy Centre, especially Dr Clinton Carter Brown and colleagues, for their critique, views and guidance.

A big thank you to Dr Steve Lennon for planting a seed with me to pursue my PhD studies by involving me as his representative to focus on sustainability issues within the Integrated Strategic Electricity Plan process at Eskom in 2014. I am forever grateful to Dr Senzo Myeni for assisting me in formulating and constructing my initial thoughts for PhD studies and for suggesting that I pursue my studies at Stellenbosch University. Sincere appreciation to Mr Corné du Plessis, my system dynamics guru, for his kindness and for being a great teacher. Thank you to Dr Liz Aswegen for all the editing when I undertook various courses, conference papers and journal submissions.

I am grateful to all my dear friends especially, Mapula, Ntate Balisi,Yaw, Ntate Andrew, Ntate Maesela, Ntate Kali,Khaya,Thabi, Sandra, James, Nicole, Deborah, Nonjabulo, Sthombe, Maria, Kgaugelo, Siya, Vhali,Siphokazi and Nwabisa, for encouraging me at all times.

To my beautiful miracle Nzinga born on 5 January 2018 at 19:42, thank you for being a tactical and an understanding co-pilot during the critical times of this PhD journey. Your father and I are forever grateful for choosing us to be your parents, especially in the midst of your mother's PhD journey.

To my parents, thank you for inspiring me and for instilling a love of books, reading and knowledge from a very young age. You trusted and reminded me at all times that I can still finish my PhD studies as planned, despite everything. Indeed it does take a village to raise a child and complete a PhD! I love you and thank you. This has indeed been my Comrades Marathon, with you on the side of the road cheering me on!

To my partner, Phakade, and my siblings, Nkanyezi, Lwazi, Nyanga, Fumani, Phakade, Lehlohonolo and Phesheya, we are indeed our ancestors' wildest dreams! I love you and thank you.

Table of contents

List of figures

List of tables

List of abbreviations and acronyms

AFOLU	Agriculture, Forestry and Other Land Use
ANC	African National Congress
CAS	Complex adaptive system
CLDs	Causal loop diagrams
DOE	Department of Energy
DSM	Demand-side management
ETP	Electricity Transition Platform
GHGs	Greenhouse Gases
GEF	Grid Emission Factor
IEP	Integrated Energy Plan
IPP	Independent Power Producer
IPAP	Industrial Policy and Action Plan
IRP	Integrated Resource Plan
LTMS	Long Term Mitigation Scenarios
MEC	Minerals-energy complex
MLP	Multilevel perspective
MPA	Mitigation Potential Analysis
MTSF	Medium Term Strategic Framework
NDC	Nationally Determined Contributions
NDP	National Development Plan
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SNM	Strategic niche management
TIS	Technological innovation system
TM	Transition management
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER 1: INTRODUCTION

1.1 Introduction

The problems of development and planning form a central theme of economic thought (Katz-Suchy, 2014; Montmasson-Clair & Ryan, 2014). Therefore, by expanding strategic planning considerations, governments have an opportunity to substantially influence economic development through increased resilience, positive impact on household income, reduced poverty levels and increased access to basic services, among other things (Schweikert, Chinowsky, Kwiatkowski & Espinet, 2014). Strategic planning for electricity generation includes the choice and cost of different technological solutions, expected long-term demand and capacity requirements (Katz-Suchy, 2014; Montmasson-Clair & Ryan, 2014). Such planning is a complex process that entails the involvement of contradicting sustainability factors (Kaldellis, Anestis & Koronaki, 2013). For instance, the choice of an appropriate electricity technological mix to achieve the goals of access to all at affordable cost and the diversification of generation to reduce carbon emissions are challenging issues, especially for power sectors in developing countries (D'Sa, 2005).

Traditional approaches to electricity sector planning have focused mainly on projections of future electricity demand and the expansions required in terms of electricity supply to meet the anticipated demand. This has often resulted in excess capacity and higher-than-necessary energy costs, while far less attention has been paid to social and environmental welfare or what may be termed 'public benefits'. Furthermore, how policy is developed affects how approaches are eventually implemented, sometimes leading to minimal integration of the plans into appropriate governance frameworks (Dixit, Chitnis, Jairaj, Martin, Wood & Kundi, 2014; Nichols & Von Hippel, 2012). However, with some form of power sector reform that has been taking place, there appears to be scope for new institutions and remedies, including planning processes (D'Sa, 2005). One of the key strategic planning approaches advocated is the Integrated Resource Plan (IRP). This strategic planning approach is aimed at integrating equitable access and judicious use of resources. There has also been increasing interest in the governance of the electricity sector as one of the highly regulated sectors, including how existing governance regimes affect the policy development process, for instance the implementation of initiatives aimed at transition (De Gooyert, Rouwette, Van Kranenburg, Freemand & Van Breen, 2016; Doukas, Patlitzianas, Kagiannas & Psarras, 2008; D'Sa, 2005; Edomah, Foulds & Jones, 2017; Schweikert et al., 2014).

This dissertation focused on examining how strategic energy planning can be an integral part of energy policy development with a specific focus on electricity sector planning and its related challenges.

1.2 Energy planning and energy policy

Energy planning involves major infrastructure development over a long term. It is viewed as large-scale systems management based on both 'hard' and 'soft' systemic structures that allow for systematic learning and implementation for large-scale systems, referred to as 'unifying the systems perspectives' (Yeo, 1995). The World Energy Council (1992) defines energy planning as a process of building and verifying strategies in an energy economy while taking into account the analysis of energy supply and demand as well as the implementation of means to ensure coverage of energy needs in a national or international context. It is also widely acknowledged that energy consumption is one of the most reliable indicators of development and quality of life reached by a country, while satisfying a forecasted energy demand over a certain period is the basis for energy planning (Cormio, Dicorato, Minola & Trovato, 2003).

The energy planning discipline takes into account policy development dynamics within the electricity sector's political economy aspects as well as social and environmental considerations. This can be achieved by considering the historical data collected from previous energy plans of the country under examination (Hirst, Tonn & Bauer, 1995; Montmasson-Clair & Ryan, 2014; Wang & Min, 1998). Energy planning methods are generally classified into three categories, namely planning by models, planning by analogy and planning by inquiry (Bakken & Lucas, 1996; Cormio et al., 2003; Reddy & Sumithra, 1997). However, with increasing public awareness of sustainability issues in relation to energy demand and supply, planning frameworks have evolved (Hu, Wen, Wang, Tan, Nezhad, Shan & Han, 2010).

Concepts on energy planning initially emerged in the 1970s during the oil crisis, with an increase in land-use costs and heightened environmental pressures. According to Doukas et al. (2008), energy planning constitutes the most important scientific process of decision making in the energy market. Initially, the general objective of energy planning was to estimate the energy demand of the future, with the optimal scenario results based on various economic and social challenges. As a result, the basic trends of energy planning were constituted of several stages of development that included the traditional definition of energy planning with a progression to integrated resource planning (for the power/electricity sector specifically), whereby the optimal scenario that covered demand arose from a combination of choices of supply and the possibilities of demand management. This later led to energy planning constituting a systematic process of analysis of energy supply and demand and the presentation of results to decision makers for the formulation of plans of action (Doukas et al., 2008).

In addition to the progression in terms of energy planning, there was also an intense interest in how the policy development dynamics within the sector's political economy aspects and decision making influenced the energy planning process or even to what extent the scenarios and forecasts would finally correspond with reality, especially taking into consideration all the related parameters (Doukas et al., 2008). In this context, Edomah et al. (2017) similarly highlight the increasing role of governments in energy decisions that are enacted through regulations and other forms of control that have always existed within energy markets. All the above highlight the strong relationship between and importance of energy planning and energy policy, including the requirement for endogenisation of energy planning into energy policy frameworks (see Figure 1.1).

Figure 1.1 depicts the relationship between energy policy and energy planning. It illustrates how energy policy has always been necessary to provide the objectives and the priorities on which energy planning should be based as well as the basic parameters of analysis. In addition, it showcases how the results of energy planning are targeted at informing the institutions of policy making about possible developments in the energy sector and present possible solutions and scenarios regarding the expected impacts (Doukas & Ballesteros, 2015; Doukas et al., 2008).

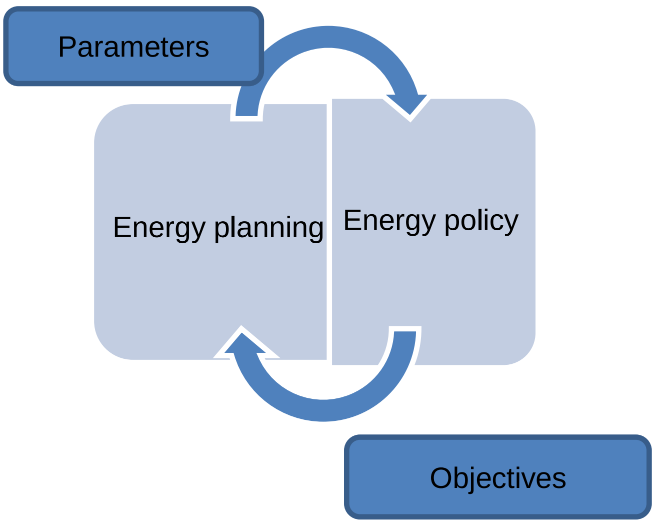


Figure 1.1: Energy policy and energy planning interactions

Source: Doukas et al. (2008)

According to Pasimeni, Petrosillo, Aretano, Semeraro, De Marco, Zaccarelli and Zurlini (2014), the challenges faced by energy planning are crucial due to its complexity and multiple interactions with other key issues, such as the role of various stakeholders, public participation, low carbon growth targets and the overall governance process for its implementation. It is in this context that participatory approaches have been introduced into energy planning due to the essential role played by various stakeholders. In addition, new governance practices and policy development practices that require transformation into more decentralised, reticular and interactive forms have become important. In this instance, communication processes such as bargaining, negotiations and arguing are becoming essential elements of policy making, while from a technological perspective, innovation is needed to accelerate the use of economically viable clean energy. These developments furthermore introduce a new type of uncertainty and complexity for energy planners (Doukas & Ballesteros, 2015; Pasimeni et al., 2014; Sovacool, 2011).

Despite the progress and relationship between energy planning and energy policy, a range of challenges has emerged over the years and this has led to the subsequent introduction of planning concepts such as the IRP and demand-side management (DSM) to tackle some of the energy planning issues (Hu, Tan, Yang, Wen, Shan & Han, 2010; Hu, Zhaoguang et al., 2010; Sampaio, Dias & Balestieri, 2013). These challenges further require an understanding of the impact of the policy-making process on energy infrastructure provision over time (Edomah et al., 2017).

Furthermore, due to limited research that links energy policy development, policy process decision dynamics specifically its governance and their influences on energy infrastructure planning provision and implementation from a developing country perspective, the need to explore such influences, dynamics and relationships is therefore justified (Bale, Varga & Foxon, 2015; Edomah et al., 2017). It was in this context that this dissertation focused on energy policy development in the context of energy planning, specifically the IRP, the related policy dynamics and the governance thereof in South Africa.

1.3 The Integrated Resources Plan (IRP)

In the early 1970s, power utilities in the USA began to rethink how to minimise the cost of power supply. Over the years, the objective of traditional electricity planning frameworks had been to provide and secure cheap electricity supply to meet electricity demands (Hu, Tan et al., 2010; Vollans, 1994). However, with increasing public awareness of sustainability issues in relation to electricity demand and supply and the overall energy planning complexities, including the role of various stakeholders and required processes, electricity sector planning frameworks evolved. Some of the sustainability indicators for electricity planning include the environmental and social aspects of electricity production as well as the potential for reducing or shaping electricity demand (i.e. DSM) (D'Sa, 2005).

The IRP was promoted as a policy development process for government's macro-strategic planning process aimed at developing energy resource strategies and maximising related national benefits. It provided an integrated plan for the power system (Hu, Tan et al., 2010). The IRP was an approach intended to meet the estimated long-term requirements for electricity services during a specified period with a least-cost combination of supply and end-use efficiency measures while incorporating equity, environmental protection, reliability and other country-specific goals (D'Sa, 2005). Figure 1.2 provides an overview of the IRP as electricity sector policy planning process (Dixit et al., 2014; D'Sa, 2005).

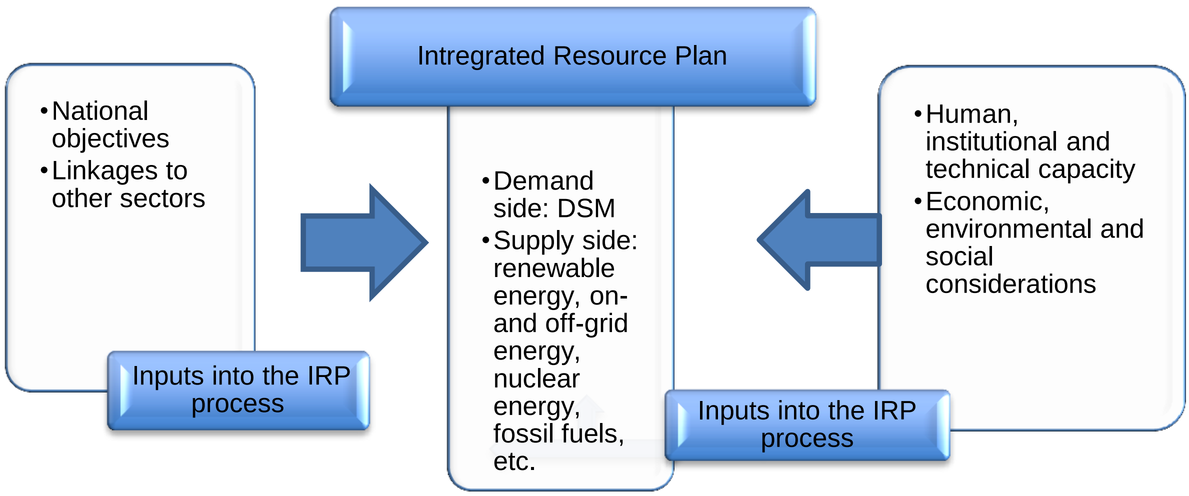


Figure 1.2: The IRP as electricity sector planning process

Source: D'Sa (2005) and Dixit et al. (2014)

The concept of the IRP had been introduced in most developing countries by the late 1990s. However, only a few utilities in these countries developed comprehensive electricity plans based on an IRP (Malik & Sumaoy, 2003). China, Brazil, South Africa, India and Thailand each initiated a unique approach to developing an IRP (Dixit et al., 2014; Hu, Tan et al., 2010; Hu, Wen et al., 2010). Coincidentally, in these countries, electricity sector challenges, privatisation and deregulation influenced IRP development. This prompted a modification of the respective IRPs to fit the new power utility business environment driven by various stakeholders with sometimes varying and competing sustainability objectives (Cormio et al., 2003; D'Sa, 2005; Malik & Sumaoy, 2003). Some of the challenges and barriers facing the IRPs in these countries included the following:

- Supply bias: This stemmed from the belief held by most countries and utilities that augmenting generation capacity was the only effective way of meeting the projected (increased) demand for electricity. Forecasting tools utilised as part of the IRP approach assumed future capacity without considering demand reduction through increased efficiency (D'Sa, 2005).
- Institutional arrangements: In this case, related subjects were treated as different sectors and the controlling departments were separate entities with related programmes planned and implemented, to whatever extent, independently of one another, for example water conservation and environment. Furthermore, limited coordination between the energy demand and supply programmes contributed to the challenges faced by the IRP implementation process (Dixit et al., 2014; Montmasson-Clair & Ryan, 2014).
- Financial difficulties: Troubled and debt-ridden electricity utilities resorted to stop-gap measures rather than long-term planning (Davidson & Mwakasonda, 2004; Rudd, Greenley, Beatson & Lings, 2008).
- Preoccupation with other problems: In cases in which restructuring of the electricity system was in progress and changes were expected in the position and jurisdiction of utilities, the long-term forecasts traditionally used for the IRP did not seem practical. Moreover, restructuring tended to preoccupy those in authority to the exclusion of longer-term issues (Hu Tan et al., 2010; Prasad, Bansal & Raturi, 2014).
- External costs of electricity generation (externalities): The IRPs were biased towards inclusion of the quantitative and qualitative costs of damages (and benefits) caused by air pollution, water quality impacts, water consumption and pricing, greenhouse gas emissions, health costs and socio-economic benefits of electrification (Bakken & Lucas, 1996; Løken, 2007; Spalding-Fecher & Matibe, 2003; Vollans, 1994). These sustainability issues posed a challenge to the IRP approach. An ability to integrate these sustainability indicators was important. For South Africa, the institutionalisation of the IRP process was expected to maximise the positive interplay among planning, security of supply and affordable and stable electricity prices.

South Africa adopted the IRP approach as the main policy planning process to drive the country's electricity sustainability transition, while the Department of Energy sets policy guidelines for the overall energy sector (Department of Energy, 2009; Montmasson-Clair & Ryan, 2014).

1.4 South Africa’s electricity sustainability transition and strategic integrated long-term planning

Geels, Berkhout and van Vuuren, (2016) define low-carbon transitions as major changes in buildings, energy, and transport systems that substantially enhance energy efficiency, reduce demand, or entail a shift from fossil fuels to renewable inputs. These system transitions entail not only technical changes, but also changes in consumer behaviour, markets, institutions, infrastructure, business models and cultural discourses. In low carbon transitions and system innovation are enacted by a wide range of actors such as firms, consumers, national policymakers, local authorities, researchers, social movements and wider publics. Additionally, the actors often have different interests, resources, capabilities and different beliefs about preferred low-carbon solutions. Transitions therefore commonly involve struggles including business struggles between incumbents and new entrants (which involve industry structures, market power, alliances and strategies), discursive struggles in public debates (which involve claims and counterclaims, framing contests, and arguments over credibility and legitimacy) and political struggles over goals, policy frameworks and the setting of specific instruments (Geels et al., 2016)

South Africa is recognised as energy-intensive, which means that the country uses a large amount of energy for every rand of economic output and is rated among the world’s top 20 most carbon-intensive economies (Alton, Arndt, Davies, Hartley, Makrelov, Thurlow & Ubogu, 2012). An abundance of coal resources and subsidised coal-fired electricity has led to reliance on energy-intensive mining and heavy industry as the historical drivers of economic development (Alton et al., 2012). There has been increasing pressure from various stakeholders to ensure that South Africa’s economic development is sustainable and that particular attention is paid to the way in which economic, social and environmental assets are used. This is termed ‘low-carbon growth’, ‘sustainability transition’, ‘transition to a low-carbon economy’ or ‘transition to a green economy’ (Musango & Brent, 2011; Musango, Brent & Tshangela, 2014; Winkler & Marquard, 2009).

South Africa has been in the process of employing various instruments as part of a suite of policy interventions guided by various strategic plans to support its sustainability transition. South Africa’s sustainability transition agenda mainly includes policies on how each economic sector responds to climate change from both adaptation and mitigation perspectives, in the context of sustainable development and poverty alleviation (Musango & Brent, 2011; Musango et al., 2014; Winkler & Marquard, 2009). Each of the sectors within the South African economy has made attempts through policy development and strategic plans to initiate and contribute to the country’s sustainability transition path. Some of these attempts include an industrial policy action plan focused on low-carbon industrial development; water, agricultural, human settlement and health sector strategies on climate change; and a carbon-constrained integrated resources long-term plan for the electricity sector. These strategies are aimed at supporting the transition of the electricity sector, termed 'electricity sustainability transition' (Department of Environmental Affairs, 2010; 2011; Alton et al., 2012; Musango et al., 2014; Winkler & Marquard, 2009).

According to Kuzemko, Lockwood, Mitchell and Hoggett (2016), electricity sustainability transition is a large-scale transformation within society during which the structure of the socio-technical system fundamentally changes. It is in this context that, owing to its role in the South African economy combined with its contribution to the sustainability transition agenda, the electricity sector is tasked with supporting the key policy imperatives articulated by South Africa's first extensive National Development Plan (NDP) 2030. The NDP 2030 defines South Africa's development pathway which is closely aligned to the Sustainable Development Goals. It provides strategic context for policies and planning instruments in South Africa therefore it is implemented by integrating its objectives into a range of policy planning documents with short and medium term horizons (National Planning Commission, 2012). Some of the main strategic frameworks, plans and policy informing studies aimed at South Africa's electricity transition are shown in Table 1.1.

Table 1.1: Main strategic frameworks, plans and policy informing studies relevant to the electricity sector's sustainability transition

Strategic plan	Description
Integrated Energy Plan (IEP)	The purpose of the IEP is to provide a roadmap of the future energy landscape for South Africa which guides future energy infrastructure investments and policy development. It analyses current energy consumption trends within the different sectors of the economy and utilises this to project future energy requirements based on different scenarios Department of Minerals and Energy (2003a); Department of Energy (2013).
IRP 2010–2030	This is a twenty-year long-term plan for the South African electricity sector. It is a sub-set of the Integrated Energy Plan (Department of Energy, 2011).
New Growth Path	It identifies strategies that will enable South Africa to grow in a more equitable and inclusive manner while attaining South Africa's developmental agenda. The bulk of green economy jobs will be in natural resources management in the short term, with renewable energy focus in the medium to long term (Economic

	Development Department, 2010).
Medium Term Strategic Framework (MTSF)	This Medium Term Strategic Framework (MTSF) is Government's strategic as it reflects the commitments made in the election manifesto of the governing party, including the commitment to implement the NDP. The MTSF sets out the actions Government will take and targets to be achieved. It also provides a framework for the other plans of national, provincial and local government (The Presidency, 2014)
The Industrial Policy and Action Plan (IPAP)	It is aligned to the NDP 2030 and drives industrial economic development in the context of climate change and sustainable development (Department of Trade and Industry, 2015).
National Gas Infrastructure Development Plan	It provides the government with a blueprint for the development of an infrastructure for future gas market developments. It is intended to coordinate development on the east and west coast of South Africa (Department of Energy,2016)
Energy Security Master Plan for Electricity	This master plan addresses energy requirements of the poor; enhances the competitiveness of the economy by provision of low cost, high quality energy inputs to industrial, mining and other sectors; and · Achieve environmental sustainability of natural resources (Department of Minerals and Energy, 2007)
National Strategy for Sustainable Development and Action Plan	The IRP is one of the interventions that South Africa needs to implement to meet green economy objectives (Department of Environmental Affairs, 2010; Department of Environmental Affairs and Tourism, 2008).
National Water Resource Strategy	Power generation remains a strategically important aspect of water use. Energy production capacity is expected to increase, as the Department of Energy is planning significant investment in new power generation capacity. Current plans include building more water-efficient, dry-cooled, coal-fired power stations. However, the power stations are located in water-scarce areas and will strain available water resources. The return to service of older wet-cooled power stations has further burdened available water resources. The NDP 2030 proposes the use of renewable energy sources to mitigate carbon emissions (Department of Water Affairs, 2013).
Long-Term Mitigation Scenarios (LTMS)	This policy informing study (2005-2008) explores a wide range of detailed mitigation actions and proposals for four strategic options (i.e. Start now, Scale up, Use the market and Reaching for the

	goal) that South Africa could pursue. It is a basis of the Peak, Plateau and Decline (PDD) trajectory range that in turn formed basis of South Africa's pledge in Copenhagen (Department of Environmental Affairs, 2009)
Mitigation Potential Analysis (MPA)	This policy informing study presents a set of viable options for reducing greenhouse gas emissions in key economic sectors i.e. energy, industry, transport, waste and Agriculture, Forestry and Other Land Use (AFOLU) (Department of Environmental Affairs, 2014).
Grid Emission Factor (GEF)Review	This policy informing study (2017) was aimed at updating the grid emission factor of the electricity system of the Southern African Power Pool (SAPP) (National Business Initiative, 2013).
GHG Emission Pathways Study	This policy informing study has been aimed at conducting an analysis of projected national GHG emission pathways for South Africa to 2050 ranging from those under which no mitigation is taken to those in which mitigation action is taken in an economy with a structure largely similar to that of today to those under which there is greater transformation of the economy (Department of Environmental Affairs, 2018).
National Employment Vulnerability Assessment Policy Study	This policy study focused on the impacts of climate change on employment, with the intention of addressing potential job losses that may result from measures to address climate change. Economic Development Department, 2017; Department of Environmental Affairs, 2017)
Low-Carbon Technology Stocktake Study	This policy informing study focuses on the assessment of current uptake of low-carbon technology in South Africa (Department of Science and Technology, 2018).

Additional electricity-related legislation, regulation and policies that support the specific policy objectives of the NDP 2030 and overall sustainability transitions in South Africa are presented in Table 1.2.

Table 1.2: Electricity related legislation, regulation and policies that support specific policy objectives of the NDP 2030 and overall sustainability transitions in South Africa

Legislation, regulation and policies that support specific policy objectives of the NDP 2030 and overall sustainability transitions in South Africa	**Reference**
Constitution for South Africa	Republic of South Africa (1996)

White Paper on the Energy Policy	Department of Minerals and Energy (1998a)
Act 34 of 2008 National Energy Act	Republic of South Africa (1999)
Act No. 46 of 1999 Nuclear Energy	Republic of South Africa (1999)
Act No. 48 of 2001 Gas Act	Republic of South Africa (2002)
White Paper on the Renewable Energy Policy	Department of Minerals and Energy (2003b)
The Draft Gas Amendment Bill, 2013	Department of Energy (2013)
Act No. 4 of 2006, Electricity Regulation	Republic of South Africa (2006)
Act No.40 of 2004 National Energy Regulator	Republic of South Africa (2005)
Act No. 57 of 2002 The Disaster Management Act	Republic of South Africa (2003)
Energy Efficiency and Demand Side Management Policy	Department of Energy (2010)
National Climate Change Response Policy	Department of Environmental Affairs (2011)
Energy Efficiency Building Regulations	Department of Energy (2011)
Act 39 of 2004 National Environmental Management : Air Quality (as amended)	Department of Environmental Affairs (2014)
South Africa's Nationally Determined Contribution (NDC) submission to the United Nations Framework Convention on Climate Change (UNFCCC)	Department of Environmental Affairs (2016)
National Energy Efficiency Strategy (Post 2015) Draft Policy	Department of Energy (2016)
Desired Emission Reduction Outcomes (Sectoral Emission Targets) 2016-2020 for South African government departments	Department of Environmental Affairs (2016)
Carbon budgets 2016-2020 for South African organisations	Department of Environmental Affairs (2016)
National Adaptation Strategy Draft Policy	Department of Environmental Affairs (2017)
Climate Change Legal Framework Draft Policy	Department of Environmental Affairs (2017)
Draft Revised White Paper on National Transport Policy	Department of Transport (2017)
Greenhouse gas (GHG) Reporting and Pollution	Department of Environmental Affairs (2017)

Prevention Plans	
Carbon Tax Draft Legislation	National Treasury (2018)

While the abovementioned strategic plans, policy informing studies, legislation, regulation and policies (Table 1.1 and Table 1.2) are aimed at supporting South Africa’s electricity sustainability transition, these policies and plans were drafted by different national departments and ministries with diverse and varied constituencies and driven by different coalitions of interest groups. This in turn resulted in policy misalignment and minimal endogenisation of these policies into the electricity sector’s sustainability frameworks and pathways. In addition, South Africa’s electricity sector is a heavily regulated sector with minimal focus on the governance of its policy development and review processes. This has also contributed to the IRP development, adoption and overall implementation including its subsequent updates facing governance challenges (Electricity Governance Initiative of South Africa, 2013; Energy Research Centre, 2012).

1.5 Governance challenges and sustainability transitions

Turnheim, Berkhout, Geels, Hof, McMeekin, Nykvist, and van Vuuren, D (2015), define policy and governance as one of the key interacting dimensions of a sustainability transition process. They further stress that even though many countries have made policy commitments for decarbonisation and sustainability transitions, however, the scale, scope and urgency of the transitions required are considerable, while deliberately managing such processes is a huge challenge, even for large and powerful actors like governments and global businesses. As a result, effective governance of transitions is required for their management. This effective governance would need to be appreciative of complexity, diversity of opinion that exists about governing and steering technology and structural changes in society, uncertainty, emergence and asymmetries of power. Additionally, it would require a need to mobilise deep analysis and timely data, and involve a broad variety of actors in processes of learning, experimentation and adaptive adjustment as new facts and perspectives become available (Geels et al.,2016). Turnheim et al. (2015) further confirm that there remains a great variety of perspectives on governing transitions (e.g. command and control form of governance, public-private governance and adaptive governance) and accepting this variety should include integrated appraisal approaches and frameworks. Also, central to the analysis of transitions and governance of transitions pathways is the appreciation of a process of change in interacting social, technical, institutional and ecological systems (Turnheim et al., 2015).

Geels et al. (2016) confirm that current policies and strategies aimed at transitions are often not sufficient to meet the required transitions or even targets on their own due to lack of effective governance. Therefore, while there is a need to improve understanding of transitions processes in order to better inform policy, it should be noted that such transformations involving technological, economic, social and ecological change are complex and they require effective governance. Taking into consideration the complexity challenges of policy misalignment and minimal endogenisation of South Africa's strategic integrated electricity planning (i.e. the IRP approach) into overall electricity transitions, effective governance is deemed necessary to further appreciate the complexity of the IRP approach and South Africa's low carbon transitions journey, whilst still managing diversity of opinion that exists about governing and steering technology and overall required structural changes.

1.6 Rationale for the study

According to Inglesi and Pouris (2010) and De Vos (2014), from 2007, South Africa has experienced a lack of capacity in the generation and reticulation of electricity. In the first quarter of 2008, blackouts known as 'load shedding' became the norm, with damaging effects on the South African economy (Inglesi & Pouris, 2010; De Vos, 2014). The main reason given for the energy crisis of 2008 was the imbalance between electricity supply and demand. The IRP 2010–2030 was promulgated in May 2011. For the first time, South Africa put a framework in place that set out the scale and mix of new electricity capacity required for the upcoming two decades.

The IRP 2010–2030 was intended to double the capacity of South Africa's electricity system, to change the energy mix and to mix the players dramatically, resulting in coal dominance being expected to decrease from 90% to 65% by 2030, while increasing the share of renewables in the electricity generation mix from 0% to 9% and increasing the share of nuclear energy from 5% to 23% (Department of Energy, 2011). In addition, the IRP saw the private sector coming in to build 30% of new capacity through government's Renewable Energy Independent Power Producer Procurement Programme (REIPPPP). The IRP also attempted to balance South Africa's security of electricity supply and economic growth while reducing the country's carbon footprint. Furthermore, the IRP provided some level of certainty about what choices would be made and what the path would be for the electricity industry in the future in terms of who would build and what would be built, the electricity price path and what the electricity price should be to cover the cost of the investment in new capacity. This transformation presented by and through the IRP was then termed 'electricity sustainability transition'.

However, in 2008 and 2014 respectively, blackouts hit South Africa again. These were attributed to the maintenance backlog, delays in the building of power plants and a barrage of technical problems facing the ageing power stations of Eskom, the single national electric utility. However, even though the 2014 load shedding incidents could be attributed to technical problems faced by Eskom at the time, these challenges could also be attributed to the slow pace of IRP allocations and even policy resistance towards the IRP development, adoption and implementation by various strategic stakeholders. In addition to this policy resistance, Davies, Swilling and Wlokas (2018) further highlight that the three challenges within the REIPPPP namely; governance and coordination, implementation and reporting, monitoring and evaluation. These challenges could directly be attributed to their lack within the overarching IRP development, adoption and implementation process approach.

Both the 2008 and the 2014 blackouts could also be attributed to the delays and complex governance challenges facing the IRP approach. These include public policy development dynamics referred to in this study, namely the minerals-energy complex (MEC) that define the socio-political economy in which the IRP was developed. The 2016 updates of the IRP saw the same public policy dynamics, that is, issues of vested interests and political economy, playing out. These dynamics include power dynamics, vested interests and beneficiaries of South Africa’s energy sector, who have also played a large role in shaping South Africa’s electricity sector (Baker, 2015, 2016b; Morris & Martin, 2015; Yelland, 2016). It is in this context that Morris and Martin (2015) suggest that for South Africa, a political economy approach is useful in analysing the outcomes of energy policy due to its explicit focus on the power dynamics among various stakeholders and because this approach is very necessary in formulating an understanding of the sector’s future (Baker, 2015, 2016b; Morris & Martin, 2015).

1.7 Problem statement

National electricity plans potentially provide an opportunity for an integrated goal-oriented management plan encouraged by electricity sustainability transition management (TM) literature (Baker, Newell & Phillips, 2014). According to Montmasson-Clair and Ryan (2014), a systems perspective on energy planning, specifically electricity planning, is crucial due to the associated provisions in terms of major infrastructure for electricity systems. The public policy development dynamics in South Africa, namely the MEC, is the socio-political economy in which the IRP was developed. In this dissertation, the preliminary investigation suggested the following:

- There is a strong relationship between energy policy and energy planning, however there remains limited research in governance frameworks aimed at facilitating policy process decision making. South Africa's IRP approach, the main policy planning tool for long-term strategic electricity planning, encountered several challenges creating policy resistance towards the IRP development, adoption and its implementation among stakeholders. This policy resistance has resulted in misalignment of the IRP approach with other national strategic plans, leading to its minimal endogenisation within the overall South African electricity transition policy process.

- There is evident misalignment and minimal endogenisation of current electricity policies, frameworks and plans into the electricity sector's sustainability frameworks and pathways as some of these policies and plans were drafted by different national departments and ministries with diverse and varied constituencies and driven by different coalitions of interest groups.
- The misalignment and lack of overall sustainability vision for the country in terms of electricity sustainability transitions can also be attributed to the fact that South Africa's electricity sector is a heavily regulated sector with minimal focus on the governance of its policy development and review processes. This has also contributed to the governance challenges facing the IRP development process and its subsequent updates.
- Effective governance of sustainability transitions remains a global phenomenon and it needs to be appreciative of complexity, diversity of opinion that exists about governing and steering technology and structural changes in society, uncertainty, emergence and asymmetries of power. For effective governance of South Africa's IRP development process, adoption and implementation within an energy policy development context, complexity of governance challenges will need to be defined and assessed whilst an effective governance approach for the overall management of the IRP approach to drive and manage electricity transitions would be advocated for.

It is in this context that this dissertation has focused on energy planning, specifically electricity planning as part of energy policy development thus examining governance challenges facing strategic integrated electricity planning and as a response develop a governance based integrated electricity sustainability transition framework with an aim to tackle some of the complexity challenges and reduce policy resistance faced by the IRP approach. This framework is aimed at complementing and guiding the existing IRP approach and its future updates with an aim to improve the misalignment with other national strategic plans, while promoting the overall endogenisation of the IRP approach into South Africa's energy governance framework to drive electricity sustainability transitions.

1.8 Objectives of the dissertation

The overall objective of this dissertation was to examine how a sustainability transition framework can be conceptualised to address the challenges facing strategic integrated electricity planning aimed at low carbon electricity transitions in South Africa. This was achieved through the following sub-objectives:

i. To examine governance challenges facing the strategic IRP approach
ii. To develop an integrated electricity sustainability transition framework to facilitate alignment and endogenisation of the IRP approach
iii. To evaluate the implementation feasibility and relevance of the developed framework within the IRP approach

1.9 Research Methodology

The purpose of this section is to provide an overview of the research methodology implemented in this dissertation. A research approach is then followed by a research design and as part of that a research paradigm. An overview of research methods and research techniques utilised are also presented. A research strategy followed is then outlined.

1.9.1 Research Approach, description and classification

There are two research approaches, namely, quantitative and qualitative research processes. Bengtsson (2016) and Bryman, Bell, Hirschsohn, Dos Santos, Du Toit& Masenge (2014) describe qualitative research as a structured approach to the collection and analysis of primarily non-numerical data which may include words, pictures and actions. As a result, qualitative research can be employed to investigate specific and defined research questions of the kind normally associated with quantitative research processes. On the other hand, quantitative research tends to emphasise quantification in the collection and analysis of data; emphasis is placed on testing theories and it embodies a view of social reality as an external, objective reality (Bryman et al., 2014). However, since the mid-1980s, qualitative research has become more influential. A typical qualitative structured approach normally includes choice of topic and research questions, literature review, choice in terms of qualitative research design, selection of site and subjects, selection of methods for data collection, analysis and interpretation of data, inputs into conceptual and theoretical work, and final write up (Bryman et al., 2014).

Bryman et al. (2014) further highlight that in qualitative research, theories and concepts are viewed as outcomes of the research process (i.e. inductive generation of theory from data); however, owing to the growing maturity of qualitative research approaches, qualitative data can and should also play an important role in testing theories that are specified in advance of data collection or during the research process (i.e. abductive and deductive, empirical testing). In this study, an abductive qualitative research approach was utilised. In terms of theoretical contributions, Eisenhardt and Graebner (2007) confirm that there are two ways that empirical research can make theoretical contributions: one is to test theory; this is done by utilising theory to formulate a hypothesis before testing the hypothesis with observations. The second one is by building theory; this is done by using empirical evidence from one or more cases to create theoretical constructs and propositions. As such, theory testing and theory building are key components in theoretical contribution that can coexist in empirical research with the aim to share and build knowledge (Eisenhardt & Graebner, 2007). For theoretical contribution, this dissertation underwent theory testing and theory building by initially examining governance challenges facing the IRP approach utilising qualitative system dynamics research method (Section 2.5). This was followed by a qualitative content analysis and literature review whereby an integrated electricity sustainability transition conceptual framework guided by and emanating from complexity and sustainability transitions theories and specifically governance based transitions management theory was conceptualised (Section 3.4). Additionally this dissertation was aimed at building theory using empirical evidence to evaluate the implementation feasibility and relevance of the proposed conceptual integrated sustainable electricity transitions framework within South Africa's IRP approach resulting in a recommended integrated sustainable electricity transitions framework (Section 4.4.).

1.9.2 Research Design

Priest et al. (2002) confirm that using an appropriate research design and method for inquiry are critical to successful research. However, one of the main difficulties of conducting interpretive research is to identify an appropriate starting point for the research, and the basic framework within which the data will be collected and analysed (Priest et al., 2002). Crotty (1998) highlights that three questions are central to the design of research namely; what knowledge claims are being made by the researcher, including a theoretical perspective? What strategies of inquiry will inform procedures? What methods of data collection and analysis will be used? Bryman et al. (2014) also state that each research design chosen should be able to answer research questions or hypotheses, as it provides the structure that guides the use of a specific research method and the analysis of the subsequent data. Research designs are basically frameworks used to collect and analyse data (Crotty, 1998; Bryman et al., 2014). Types of research designs include;

- Experimental design, such as laboratory experiment and field experiment;
- Cross-sectional design which involves a nomothetic approach which involves the collection of data on more than one case at a period;
- Longitudinal design that includes panel studies and cohort studies;

- Case study design which is a research design that entails the detailed and intensive analysis of a single case but is sometimes extended to include the study of two or three cases for comparative reasons; and
- Comparative design refers to a research design that entails the comparison of two or more cases in order to illuminate existing theory or generate theoretical insights as a result of contradictory findings uncovered through the comparison (Crotty, 1998; Creswell, 2003; Bryman et al., 2014).

Bryman et al. (2014) further emphasise that research design comprises the following criteria that are utilised to evaluate research, namely; reliability, replication, validity, trustworthiness and authenticity, including the research question itself. According to Mills, Bonner & Francis, (2006) to be able to ensure a strong research design, researchers must choose a research paradigm that is consistent with their beliefs about the nature of reality. Therefore, consciously subjecting such beliefs to an ontological[1] interrogation in the first instance illuminates the epistemological[2] and methodological possibilities that are available. For the purposes of this study, a case study research design was followed. A case study was on the strategic integrated energy planning and specifically the IRP approach. The next section focuses on the research paradigm utilised in this dissertation.

1.9.2.1 Research Paradigm

In research paradigms, positivism is quantitative and is an epistemological approach that advocates the application of natural science methods to understand social reality. It focuses on the discovery on the laws that govern behaviour (Ogano, 2017). Bryman et al. (2014) defines interpretivism as an approach which is implemented by the researcher in order to synthesize facts which are derived mainly from secondary sources, and which are qualitative in nature and it focuses on understanding from an insider perspective guided by research questions. In addition, Creswell (2003), confirms constructivism involves understanding of multiple participant meanings and theory generation. This dissertation is then structured as a qualitative research of interpretivist/ constructivist paradigm focused on subjective knowledge and a theory building approach. It relies on literature review and respondent’s knowledge, perspectives and their participation within South Africa’s sustainability transitions and specifically strategic integrated electricity planning.

[1] Ontology is a theory on the nature of social phenomena/entities, whether they are objective and independent of social external factors (objectivism) or social phenomena constructed from the perceptions and actions of social actors (constructionism) (Bryman et al., 2014).
[2] Epistemology is a theory of knowledge concerned with the question of what is (or should be) regarded as acceptable knowledge in a discipline (Bryman et al., 2014).

1.9.3 Research methods

Elliot and Higgins (2012), Bryman et al. (2014) and Bengtsson (2016) outline several research methods that are utilised in qualitative research. These include:

- Phenomenological designs which involves research through the eyes of those with direct lived experience with an aim to discover how they interpret their experiences and make sense of their world. As reality is constructed collaboratively, the interviewer is part of the process, but seeks to limit his or her preconceptions to grasp the subjective experiences of others;
- Hermeneutics which involves the interpretation of documents qualitatively by examining text from the perspective of its author in terms of moments, i.e. social-historic moment, formal moment and interpretation-reinterpretation moment;
- Grounded theory which includes developing theory based on data and information collected. It involves concept labelling, categorising, identifying core categories, finding relations among categories, and generating a theory from such relationship;
- Phenomenography which is a philosophical approach concerned with questions of how individuals make sense of the world around them, including perceptions, in a graphical manner;
- Ethnography which refers to a study of human interaction and communities through immersion, direct participation and observation within the community you wish to study;
- Qualitative content analysis which focuses on a systematic and objective means to make valid inferences from verbal, visual, or written data in order to describe and quantify specific phenomena; and
- Case study research which refers to an in-depth study of one or more individuals or phenomena in an existing similar context (Elliot & Higgins, 2012; Bryman et al., 2014; Bengtsson, 2016).

This dissertation utilised various research methods which include system dynamics, qualitative content analysis, literature review and the informed constructivist grounded theory (See sections 2.5, 3.3 and 4.2) research methods. Thus, the research techniques utilised in this dissertation emanated from these research methods.

1.9.4 Research Techniques

1.9.4.1 Data collection and analysis

Ogano (2017) outlines three types of data needed to develop the structure and for decision making; numerical, written and mental data. Numerical data are said to be the familiar time series and cross-sectional records in various databases whilst written data includes records such as operating procedures, reports, plans, submissions, emails and any other archival materials rules which should be considered. Mental data cannot be accessed directly but must be solicited through interviews, surveys, observations, focus groups and other methods (Ogano, 2017; Sterman 2000).

Bryman et al. (2014) outline the following research techniques to collect qualitative data; these include direct observation, participative observation, qualitative interviews, open-ended surveys, focus groups, language-based methods that may include discourse conversation analysis, and content analysis.

For sampling purposes, Carmichael and Cunningham (2017) reiterate that in qualitative research, sampling is generally done non-randomly and often purposively; thus, individuals are selected because they are experts. Therefore, the focus of these studies is on the quality of the interviews and the subsequent in-depth analysis. The sampling is thus undertaken in the same manner with the aim of gaining insights from the experts, thus ensuring that theory (or theoretical propositions) is conveyed to the rightful audience (Carmichael & Cunningham, 2017). Additionally, according to Creswell (2003) and Carmichael and Cunningham (2017), the researcher may collect data initially with a purposively selected sample; therefore, the data from these initial encounters are iteratively compared and coded before more data are collected or generated. Consequently, the emerging theoretical ideas from the early analysis then guide the selection of the next respondents, and the cycle of data collection and analysis is repeated. This cycle of data collection involves concept labelling, categorising, identifying core categories, finding relationships among categories, and generating a theory from such relationships (Cho & Lee, 2014). Data collection and analysis occur simultaneously and iteratively in the informed constructivist grounded theory; thus, there is constant comparison of new data with the previously collected data (Charmaz, 2000, 2008). In terms of research participant numbers, they may vary from 6 participants to 20–35 participants; even though this sample may be regarded as small, it can, however produce study results of lasting significance.

In this dissertation, written and mental data were utilised. In terms of written data, Chapter 2 and Chapter 3 relied only on written data whilst Chapter 4 was mainly based on mental data as respondents were approached. Furthermore, in terms of mental data collated in this dissertation, specifically, section 4.2.2 of this dissertation, provides details on how empirical evidence was collected in addition to qualitative content which was collated for the examination of the governance challenges facing the IRP approach and the development of the conceptual integrated sustainable electricity transitions framework i.e. sub-objectives 1&

2 of this dissertation. Purposeful sampling was utilised with a focus on specialists and stakeholders involved with sustainability transitions, electricity sector and specifically electricity planning in South Africa. Furthermore, several research techniques were utilised to analyse data collected. These ranged from qualitative system dynamics to descriptive statistics, coding and content analysis (Sections 2.8, 3.3 and 4.3) of this dissertation.

1.9.5 Research strategy

The research strategy sets out the logic or procedure that helps to answer research objectives of this research study. In this instance Sub-Objective 1: “To examine governance challenges facing the strategic IRP approach”. Chapter 2 of this dissertation examined the governance challenges facing the strategic IRP process approach. This was achieved through undertaking a qualitative content analysis and critical literature review of governance of the energy sector and exploring how governance challenges can be overcome to improve the implementation of energy policy planning processes, such as the IRP. Other aspects considered were energy policies contributing to the electricity sustainability agenda, the issues of a public policy development process and associated politics in the context of electricity sustainability transition. A qualitative system dynamics using causal loop diagrams (CLDs) research method was further utilised to understand how the identified challenges are endogenously influencing the IRP approach in South Africa. To respond to sub-objective 1: It was observed that the IRP governance challenges exhibit fixes that fail and shifting the burden system archetypes. The dynamic relationships identified informed and were the motivation for the development of a governance-based electricity transition framework, which was the Sub-objective 2 of this study. A peer reviewed journal paper was published in the Journal *Administratio Publica* on this Chapter.

For Sub-objective 2: “To develop an integrated electricity sustainability transition framework to facilitate alignment and endogenisation of the IRP approach”. Chapter 3 of this dissertation developed an integrated electricity sustainability transition framework to facilitate alignment and endogenisation of the IRP approach. This was achieved through critical literature analysis of the planning and complexity theory and practice approaches and Transition Management framework, as basis for managing the transitioning of the persistent governance challenges facing the IRP, grounded in South Africa’s “mineral energy complex” system. To respond to sub-objective 2: A conceptual integrated electricity sustainability transition framework, embedded in the existing key IRP approach, was therefore developed to tackle challenges and policy resistance facing the IRP approach. Further, the framework was aimed at facilitating alignment of the IRP approach with other national strategic plans, endogenising the IRP approach into the overall South African electricity transition path. This framework was also aimed at complementing the existing strategic IRP approach by providing a platform that could be utilised to build capacity for addressing the complex public policy challenges, both historical and current, including the impacts and gaps currently faced by the electricity planning process in South Africa. The framework formed the basis for engaging with stakeholders and experts to address Sub-objective 3 of this study and is one of the theoretical contributions to this study. A peer reviewed journal paper was published in the *South African Journal of Industrial Engineering* on this Chapter.

For Sub-objective 3: “To evaluate the implementation feasibility and relevance of the developed framework within the IRP approach”. Chapter 4 of this dissertation evaluated the implementation feasibility and relevance of the developed framework within the IRP approach governance process. This was achieved through empirical evidence through online surveys, detailed one on one interviews, a focus group with key electricity stakeholders and experts and submissions made to the Department of Energy (See Annexure A). Respondents within the strategic planning, sustainability and electricity planning expertise arenas were targeted and identified to participate in this study. Data and information from an online survey, one-on-one detailed questionnaires with selected specialists and submissions made to the Department of Energy on the IRP 2016 process provided input for demonstrating the building blocks, relationships and alignment required for an integrated strategic electricity transition framework for South Africa. The building blocks, relationships and alignment requirements were made explicit through the coding process as prescribed by an informed constructivist grounded theory research method utilised in this study. To respond to sub-objective 3: As a result, views on sustainability transition challenges, IRP challenges, sustainability transition and the IRP and proposed interventions were solicited from the respondents involved with sustainability transition and electricity planning in South Africa. The respondents highlighted an overall challenge of policy and governance in addition to the specific IRP technical development and transparency challenges. These challenges triggered the need for interventions geared towards them, hence the recommended integrated electricity sustainability transition framework which is also a theoretical contribution to this study.

Figure 1.3 presents the above mentioned research strategy followed to address the overall research objective and the associated sub-objectives. This dissertation was structured in a format of three journal papers, each examining the specific research sub-objective of this study, briefly described below whilst Chapter 1 provides the basis for the study, Chapter 5 focus.

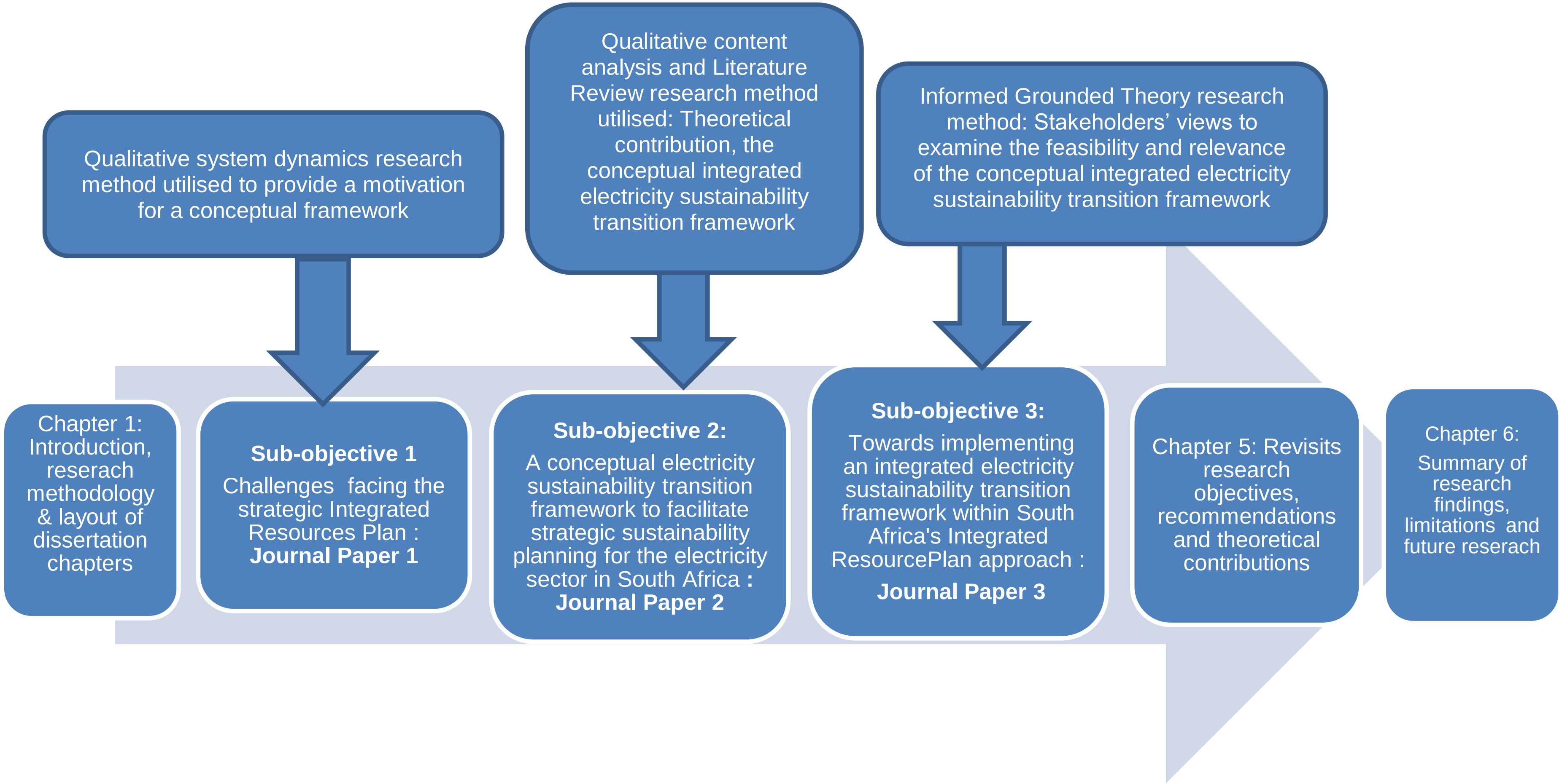


Figure 1.3: Research strategy

Source: Researcher's conceptualisation

1.10 Layout of the dissertation chapters

Chapter 1: This chapter presents the background of the study, the research problem, the research objectives, the rationale for the study, the research strategy and the scope and outline of the chapters.

Chapter 2: This chapter focuses on the governance challenges facing the IRP approach. A qualitative system dynamics approach is used to define the complex governance challenges facing the IRP. The study found that the IRP public policy development dynamics and the associated politics had resulted in resistance towards the IRP development process and its update by various stakeholders, leading to misalignment of the electricity long-term plan, the IRP, with other national strategic plans and to minimal endogenisation of this long-term plan into existing governance frameworks, including institutional processes aimed towards South Africa's electricity transition. A qualitative system dynamics approach utilising CLDs and associated system archetypes was the method utilised to assess and explain the complexity faced by South Africa's IRP approach. By utilising CLDs, the resistance towards the IRP and the related IRP challenges, represented by a reinforcing loop, emphasises the system's inability to achieve its objectives with the quick-fix solution, hence the need to focus on a long-term fundamental solution.

Chapter 3: The chapter developed a governance-based electricity transition framework to facilitate alignment and endogenisation of the IRP as part of Sub-objective 2 of this study. To meet this objective, theoretical gaps in the current strategic integrated electricity planning process illustrated the need to rethink the current electricity planning approach theory and practice, with South Africa's IRP as case study. A combination of the strategic planning theory and theories on complexity and sustainability transition was reviewed, together with a focus on the Transition Management framework approach as basis for managing the transitioning of current persistent societal governance problems facing the IRP, grounded in South Africa's MEC system. This conceptual transition framework defined South Africa's IRP as a CAS and proposed a complexity-based governance process approach to ensure alignment of different, competing, complex sustainability policy objectives within the electricity planning process, thereby leading to the endogenisation of the IRP approach into existing energy governance frameworks in South Africa, for example the IEP, which is also aimed at driving South Africa's transition path.

Chapter 4: This chapter focuses on examining the potential application of the proposed conceptual framework. Participative action research and an informed grounded theory research method were utilised to analyse and collect data to verify and validate the electricity sustainability transition framework for South Africa. The chapter considered the IRP approach to guide South Africa's electricity sustainability transition. An informed constructivist grounded theory research method provided a basis for qualitative data collection and analysis. Various research techniques were utilised to collate and analyse the empirical evidence from specialist respondents. As a result, views on sustainability transition challenges, IRP challenges, sustainability transition and the IRP and proposed interventions were solicited from the respondents involved with sustainability transition and electricity planning in South Africa. The respondents highlighted an overall challenge of policy and governance in addition to the specific IRP technical development and transparency challenges. These challenges triggered the need for interventions geared towards them, hence the recommended integrated electricity sustainability transition framework. The next chapter focuses on the synthesis and theoretical contribution of the study, key insights from the results, the limitations of the study and recommendations for future research.This chapter focuses on examining the potential application of the proposed conceptual framework. Participative action research and an informed grounded theory research method were utilised to analyse and collect data to verify and validate the electricity sustainability transition framework for South Africa.

Chapter 5: This Chapter examines if research objectives have been achieved through research efforts and the specific contributions made by this study.

Chapter 6: This Chapter focuses on the summary of research findings, implications of the study, limitations and future research opportunities.

CHAPTER 2: CHALLENGES FACING THE STRATEGIC INTEGRATED RESOURCE PLAN: A QUALITATIVE SYSTEM DYNAMICS APPROACH[3]

2.1 Introduction

Kern and Smith (2008) define electricity systems in the context of sustainability transition as characterised by socio-technical systems that provide energy services such as heat, light and power necessary to perform societal functions. According to Markard, Raven and Truffer (2012), a socio-technical system consists of networks of actors, who could be individuals, firms and other organisations; collective actors, such as institutions, which determine societal and technical norms, regulations and standards of good practice; and material artefacts and knowledge. The different elements of each system interact, and together they provide specific services to society (Markard et al., 2012). In addition, Safarzyńska, Frenken and Van den Bergh (2012) stress that the need for sustainability in transition can be attributed to persistent structural complex challenges faced by the sectors in which these systems exist. In this instance, sustainability transition is defined as long-term, multidimensional and fundamental transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption (Markard et al., 2012). For the electricity sector, sustainability transition concepts define electricity systems as multiple, interconnected areas with a crucial role in promoting innovation for long-term sustainable change, while governance is at their core in enabling sustainable innovations and overall transition (Rogge & Reichardt, 2016).

In defining the challenges facing the sustainability transition agenda within the energy sector, Kuzemko et al. (2016) highlight that countries make different governance choices as part of the highly complex and unprecedented process of enabling profound energy system changes or transitions with the aim of ensuring affordable and secure energy services. Kuzemko et al. (2016) further stress that governing for sustainability transition is contingent upon both broader policy processes and related domestic policy institutions as well as on indigenous energy resources. Therefore, different configurations of policy processes, institutions and indigenous energy resources tend to influence the types of governance choices made and the nature of changes, including the related complex and unprecedented challenges encountered in electricity systems (Kuzemko et al., 2016). It is therefore in this context that this chapter focuses on an analysis of the challenges facing the IRP, aimed at contributing to

[3] Mqadi, L.J., Musango, J.K. and Brent, A.C., 2018. Challenges Facing South Africa's Electricity Sector 'Integrated Resource Plan: A Qualitative System Dynamics Approach. Administratio Publica, 26(2):118-137

South Africa's electricity sustainability transition and specifically the governance thereof, which was Sub-objective 1 of this study.

2.2 Governance and the electricity sector

Sovacool (2011) and Edomah et al. (2017) define governance as a process of defining who can do what and who would monitor it, including how rules are modified and changed over time. Governance includes any of the myriad processes through which a group of people enforces the rules needed to enable that group to achieve desired outcomes. In the energy sector, governance processes are used to ensure the provision of energy as a public good and to address the associated market failures (e.g. externalities), while specifically policy governance structures play a vital role in the security of energy supply. This in turn affects other sectors that rely on energy, such as the residential, transport and industry sectors (Edomah et al., 2017; Markard et al., 2012). For the electricity sector, governance comprises of rules, incentives and institutions that drive its successful implementation, while technological innovations and market actors remain the main drivers of change (Markard et al., 2012).

Doukas et al. (2008) describe the evolution in the governance process and the foci of energy (electricity) policy during the 20th century as characterised by the following distinct phases or periods:

i. The energy abundance period (until the first oil crisis in 1974): This period was characterised by increased energy demand, increased energy consumption and increased economic growth. No significant energy policies existed until the oil crisis, when governments were forced to develop clear policy frameworks to protect and strengthen the energy market in both the short and the long term. Government intervention in the energy market was also strengthened in both the short term (e.g. political economy measures) and the long term (e.g. high investments for exploitation of domestic energy sources).

ii. The energy insufficiency period (until 1985), demonstrating the need for reduced energy dependence: This period was characterised by increased policy focus on energy efficiency, energy conservation, energy savings and energy management, with emphasis on the rational use of energy. This further gave rise to long-term energy planning frameworks to support governance frameworks for the sector.

iii. The energy balance period (up to 2000): This period was characterised by increased focus on energy environmental policies to counteract the severe impact of excessive production and consumption activities on the environment. These policy constraints have also further been integrated into long-term energy planning frameworks to support governance frameworks for the sector.

iv. The present period: In the present period, energy policy is directed by security of supply, competitiveness of the energy industry and environmental protection, based on international and national energy objectives. The long-term energy planning frameworks have taken these energy objectives into consideration (Doukas et al., 2008).

In further defining the practice and process of governance for the abovementioned energy periods, Edomah et al. (2017) argue that energy policy should have desirable objectives and should encourage close collaboration among stakeholders who are also key energy players (e.g. energy users, energy companies and government), with the aim to confront and tackle the various challenges facing the energy policy development process. In addition, Doukas et al. (2008) stress that in particular, energy policy constitutes a field that, even if supported by scientific practices, for example energy planning processes, tools and approaches, will remain intensely influenced by traditional forms of governance. In recent times, energy legislation and related policies have been increasingly influenced by a 'new wave of issues' or 'sustainability' issues relating to security of supply, environmental protection, the role and influence of different stakeholders, especially with energy supply and demand dynamics, and energy market competitiveness. As a result, while energy legislation has continuously focused mainly on setting out regulatory frameworks, there have been struggles and policy resistance towards the governance and implementation of the sustainability issues (Doukas et al., 2008; Edomah et al., 2017; Ostrom, 2011).

However, the energy regulatory frameworks only form part of the institutionalised and unwritten rules for tackling the governance of the energy sector, which is constituted of national electricity laws, national electricity markets, national energy retail laws and national gas laws. This further confirms the lack of detailed governance approaches in highly regulated sectors such as the energy sector (Doukas et al., 2008; Sovacool, 2011). As such, for the energy sector, governance is affected by factors such as changes in stakeholder composition (including the power of vested interests through opportunistic rent seeking), inflexible and homogenous rules, rapid changes in technology, information failures among groups or generations, and dependence on external sources for resources or aid, defined as the 'complexity of energy governance' (Edomah et al., 2017; Markard et al., 2012; Sovacool, 2011).

Doukas et al. (2008) and Edomah et al. (2017) further confirm that the decision-making processes and dynamics currently employed in the governance of energy infrastructure provision could either foster the provision of the needed infrastructure, following the right energy mix, or increase the energy vulnerability of the given geography or society through energy planning processes. In this uncertainty of traditional governance, the energy planning processes required might fall short and some form of collaboration with other stakeholders might be required. Furthermore, new transition literature allows for the consideration of issues of equity, inclusivity through multi-stakeholder involvement, organisational multiplicity and adaptability (Loorbach, 2010; Sovacool, 2011). It is in this context that this study further contributes to the assessment of the complexity challenges facing the IRP process and its update, as mainly driven by South Africa's Department of Energy, and the governance thereof.

2.3 Public policy development dynamics in sustainability transition

De Gooyert et al. (2016) stress that sustainability TM policies are not meant to replace regular policies, but to complement policies with a strategic, long-term procedural, governance and transformational approach aimed at structural change. Therefore, sustainability transition policy studies create space for short-term innovation while developing long-term sustainability visions linked to desired societal transition (Kern & Smith, 2008; Markard et al., 2012). Specifically, in terms of long-term sustainability, sustainability transition policy studies are aimed at understanding how transitions evolve over time while providing policy recommendations that are normally intended to support the progression of each particular transition (De Gooyert et al., 2016).

Loorbach (2010) contends that sustainability transition is characterised by fundamental uncertainties and complexities, which means that even the formulation of a policy problem is ambiguous and contested, let alone policy goals, strategies and expected outcomes. Grossman (2015) further highlights that policy process theories stress the importance of cognition and framing, and as such seem to be particularly fruitful for sustainability transition studies. Furthermore, one of the main challenges in the emerging field of sustainability transition is the improvement and understanding of public policy process dynamics. An example is the move towards a decarbonised energy system and the public policy development that surrounds it or is embedded in the process (Markard et al., 2012). According to Markard, Suter and Ingold (2016), despite the crucial role of policy development and political economy dynamics in sustainability transition, circumstances that make the adoption and endogenisation of such policies possible are rarely considered. To illustrate this, Markard et al. (2016) highlight how energy transition in Germany was closely linked to a variety of policies that included the deployment of subsidies for renewable energies and policy regulations targeting nuclear out-phasing; however, Germany still faced challenges in terms of its overall policy adoption and the required transformation processes (i.e. endogenous system processes). Meadowcroft (2011) further contends that politics are the constant companion of sustainability transition, serving alternatively, and often at the same time, as context, arena, hindrance, enabler, intermediary and manager of repercussions. Meadowcroft (2011) also suggests that political economy dynamics are driven by the three interrelated domains of ‘interests’, ‘institutions’ and ‘ideas’. Even though studies (e.g. that of Baker et al., 2014; Kemp, Rotmans & Loorbach, 2007; Kern & Howlett, 2009; Kern & Smith, 2008; Laes, Gorissen & Nevens, 2014; Markard et al., 2016) have attempted to incorporate political dynamics of Dutch, British, German, South African and Swiss energy transition respectively, the focus on policy has been limited; that is, less attention has been devoted to the politics or related policy dynamics that make the adoption and endogenisation of such policies likely (Meadowcroft, 2011). This indicates that an understanding of policy development dynamics and political economy dynamics in terms of policy adoption, policy endogenisation and its associated transformation is crucial for sustainability transition (Markard et al., 2016).

Meadowcroft (2011) further outlines that the public policy development dynamics of sustainability transition require a redefinition of societal interests. This implies the need for political economy engagements to build reform coalitions, creating new centres of power, buying off powerful lobbies, isolating diehards and compensating losers. These struggles involve not only established stakeholders such as influential stakeholders and major economic groups, but also emergent forces associated with new technologies, experimental practices and social movements (Hess, 2014; Kuzemko et al., 2016; Meadowcroft, 2011). Kern and Smith (2008) provide an example in this regard of the Netherlands, where sustainability transition thinking has been the foundation for energy policy development and adoption for nearly a decade; however, results have not been able to meet expectations owing to public policy development dynamics and associated politics. The continued policy resistance has therefore been the main characteristic of sustainability transition (Ghaffarzadegan, Lyneis & Richardson, 2011).

The next section focuses on system dynamics as a tool that can be utilised to assess and understand the public policy dynamics facing sustainability transition.

2.4 Application of system dynamics in public policy development

According to Ghaffarzadegan et al. (2011), there is a long tradition of using system dynamics to study public policy management questions. Powell and Coyle (2005) have also noted that system dynamics has always taken a pragmatic policy orientation to whatever type of problem a practitioner happens to address. However, despite the high applicability to public policy problems, system dynamics has not been utilised to its full potential in government policy making. It has mainly been mechanistic, thereby excluding equally important system attributes such as power, leverage, influence and control, which have also been inappropriate for a large class of problems involving agents and groups of agents in the system definition (Powell & Coyle, 2005).

Sterman (2001) stresses that much of the art of system dynamics lies with discovering and representing the feedback processes and other elements of complexity that determine the dynamics of a system. All dynamics arise from an interaction of just two types of feedback loops: positive (referred to as self-reinforcing) and negative (referred to as self-correcting). Positive loops tend to reinforce or amplify whatever is happening in a system, while they are self-stimulating processes that generate their own growth. Negative loops counteract and oppose change and are self-limiting processes that create balance and equilibrium (Sterman, 2001). In addition, Sterman (2001) contends that the lack of taking an endogenous perspective in making decisions is common and is sometimes a major reason for suboptimal performance in system dynamics. He refers to it as the ‘misperception of feedback’ within the system dynamics tradition.

De Gooyert et al. (2016) highlight that sustainability transition can be understood as transformation in a complex system consisting of several feedback loops. There is also confirmation that system dynamics complements sustainability transition, as it provides a holistic view and enables the mapping out of the structure of the system responsible for all challenges or symptoms, thereby permitting policy makers to identify high leverage points that support sustainability transition (De Gooyert et al., 2016). In this context, system dynamics supports a better understanding of complex systems by identifying the causal relations between physical and behavioural components that provide an explanation for the behaviour of each system (Sterman, 2001). With this understanding, successfully managing a sustainability transition path, especially in a public policy setting, becomes a matter of identifying high-leverage points in those feedback loops that can support the progression of the transition itself utilising system dynamics (De Gooyert et al., 2016).

A fundamental principle of system dynamics is that the structure of a system gives rise to its behaviour (Sterman, 2001). In complex systems, different people placed in the same structure perceive and interpret system structures differently (Probst & Bassi, 2014). Meadowcroft (2011), Hess (2014) and De Gooyert et al. (2016) argue that even with different interpretations and perceptions, successfully managing a sustainability transition approach requires identifying high-leverage points in the feedback loops that can support the progression of the transition, thereby overcoming policy challenges and related root causes. In addition to overcoming complex public policy challenges, particularly policy resistance, and understanding their related root causes, a significant inference is that good governance influences the success of sustainable energy transition (Kuzemko et al., 2016). Ghaffarzadegan et al. (2011) emphasise the importance of system dynamics in public policy problems, as this can offer insights into appropriate policy responses. Furthermore, Ghaffarzadegan et al. (2011) identified five features that characterise public policy problems:

- Policy resistance from the environment, where a policy action generates feedback from its environment that mostly aggravates the initial problem situation
- The need for experimenting and cost of experimenting, which is fundamental in public policy learning and which is faced with policy resistance and long delays between action and consequences
- The need to persuade different stakeholders, because diverse stakeholders have a role in developing and influencing the effectiveness of policies
- Overconfident policy makers, who often underestimate the limits of their knowledge when proposing reforms
- The need to have an endogenous perspective, because policy makers tend to attribute undesirable outcomes to exogenous sources rather than to endogenous consequences of their earlier actions.

From the above discussion, one can underscore the need for an endogenous perspective to advance visions or insights into the political economy dynamics of policy development and action that can heavily influence sustainability transition. This study therefore used system dynamics to examine the root cause for lack of engagement, transparency and overall policy resistance while attempting to understand all the related policy resistance characteristics.

2.5 Method

2.5.1 System dynamics

The emergence of the system dynamics field can be dated to the 1950s and can be considered as “the study of the information feedback characteristics of industrial activity to show how organizational structure, amplification (in policies), and time delays (in decisions and actions) interact to influence the success of the enterprise" (Forrester, 1958:40). The system dynamics approach can simplify the endogenous structure of each particular system under assessment, identify the interrelationships of different elements of the system and account for different alternatives for simulation (Musango & Brent, 2011; Sterman 2001).

System dynamics models further allow for the understanding of the system structure, analyses of policies and strategies, testing of theories, and system modelling and simulation to support public policy analysis and evaluation (Winz, Brierley & Trowsdale, 2009). Several studies have developed guidelines and strategies for the system dynamics modelling process, thereby providing a range of steps; however, they all include similar iterative activities that involve both qualitative and quantitative modelling (Davies, Musango & Brent, 2016; Probst & Bassi, 2014; Winz et al., 2009). In this context, Probst and Bassi (2014) have proposed the following phases for system dynamics modelling:

- Problem identification: In this phase, the problem or challenge is defined by identifying the causes and effects through the definition of boundaries, which include political, environmental, economic and social dimensions. This is followed by the identification and analysis of causes and effects of key variables and actors directly linked to the problem. Once the root causes of the problem and their effects on the system have been identified and delimited, an analysis of future behavioural paths and impacts is also undertaken. In this instance, indicators and influence tables can be utilised as tools.
- System characterisation: In this phase, the mapping of complexity, including the assessment of the dynamic properties of the system, is undertaken. This phase includes the building or development of CLDs, a review of the system boundaries, overall understanding of the system and the identification of key feedback loops and entry points for intervention, i.e. strategy or policy identification. In this phase, indicators, influence tables, CLDs and scenarios are suggested tools.
- Strategy/policy assessment: This phase focuses on the design potential of interventions, assessment of the interventions and selection of viable options and indicators. Suggested tools for this phase include indicators, CLDs and scenarios.
- Decision making and implementation: In this phase, a multi-stakeholder approach is promoted to assess roles and responsibilities, followed by an analysis (which may include both qualitative and quantitative modelling) of the expected impacts across sectors and actors, and the overall definition of the strategy or policy. Again, the suggested tools for this phase include indicators, CLDs and scenarios.

- Monitoring and evaluation: In this phase, the strategy is implemented and the development of the system is monitored, while an analysis of the sectors and stakeholders is also undertaken. In addition, lessons learned for the next decision-making process are utilised. Tools suggested in this instance also include indicators, CLDs and simulations.

The abovementioned process consists of both qualitative and quantitative modelling. Quantitative modelling enables visualisation of the effects of different intervention strategies through simulations (Sterman, 2000). It requires explicit statements regarding assumptions about the underlying model and identification of uncertainties associated with system structure, including the identification of gaps in data availability, with the aim to promote transparency. Furthermore, quantitative modelling has been advocated because it uses mental models and structural elements of problems, identifies and integrates both soft and hard variables, simulates dynamic behaviour of the problem under assessment and assists in greater problem understanding as well as an improved ability to further clarify, define and manage dynamic real-world issues (Sterman, 2000).

Despite the advocacy of quantitative modelling, it has faced considerable challenges in the devising and quantification of soft and uncertain variables, as tackled by qualitative modelling (Davies et al., 2016). While mainstream system dynamics scholars such as Wolstenholme (1999) agree that modelling is an essential aspect of system dynamics modelling, other scholars have emphasised the critical role of quantitative modelling as well in the pursuit of dynamic knowledge (Coyle, 2000; Wolstenholme, 1999). Coyle (2001) stresses that the early 1980s witnessed the development of purely qualitative modelling, which only consists of CLDs. CLDs provide the conceptualisation and feedback structure at an aggregate level. CLDs can then be transformed into stock flow diagrams for simulation modelling. However, there is still an argument that a quantified simulation model is always superior to a qualitative model because it provides more insights (Pruyt, 2013). However, in situations where the issue investigated mainly entails soft and uncertain variables, qualitative system dynamics using CLDs becomes more relevant (Wolstenholme & Coyle, 1983).

According to Probst and Bassi (2014), the creation of a CLD has several purposes and benefits: It combines ideas, knowledge and opinions; it highlights the boundaries of the analysis; and it allows stakeholders to achieve basic to advanced knowledge of the systemic properties of the analysed issue. In this context, causal interrelationships are plotted for generating greater understanding of the nature of a problem with a view to gaining greater insight into potential interventions or problem solutions. In addition, CLDs have the ability to represent a complex real-world problem that requires a long narrative explanation on a single diagram, to stimulate discussion and understanding of the different relationships of a complex real-world problem being investigated, to enable the identification of feedback loops that may assist in explaining behaviour or generating insights and to identify wider contexts of a modelling task. Despite these strengths, the effectiveness of the CLD is directly linked to the quality of the process, which in turn influences the conceptualisation of the CLD. The building blocks of CLDs include the following (Davies et al., 2016; Probst & Bassi, 2014):

- Variables represent a condition, situation, action or decision that can influence and be influenced by other variables. A variable can also be quantitative or qualitative, since CLDs can incorporate both variables.
- Links/arrows illustrate the relationship and the direction of influence or causation among variables.
- Direction of influence is denoted by the symbol S / (+), meaning 'same direction', or O / (-), meaning 'opposite direction'. Also, the arrows indicate the way in which one variable moves or changes in relation to another.
- There are two types of feedback loops: balancing feedback loops that pursue equilibrium and are represented by 'B' and reinforcing feedback loops that amplify changes and are represented by 'R'.

CLDs can be utilised to support all the decision-making phases. In the problem identification phase, they help identify the causal chain that determines the problem to be solved, from an endogenous perspective. During the strategy/policy assessment phase, they facilitate the identification of the key entry points for interventions, where they also support the evaluation of selected interventions: short-term vs. long-term, and direct and indirect impacts, including responses. During the decision-making and implementation phase, and the monitoring and evaluation phase, CLDs can be utilised to bring together diverse stakeholders to promote synergies, coordination and integrated strategies and action plans, and to identify unintended consequences of implemented interventions (Probst & Bassi, 2014).

Because this study was aimed at utilising qualitative system dynamics, and specifically CLDs, due to its focus on public policy dynamics (i.e. challenges facing the IRP approach) and associated causal relationships, the next section further focuses on generic CLDs, namely system archetypes, which are cornerstones of qualitative system dynamics.

2.5.2 System archetypes

System archetypes are defined as highly effective tools (i.e. CLDs) for gaining insight into patterns of behaviour and underlying system structures from which the archetypal behaviour emerges (Braun, 2002). System archetypes are effective tools for understanding why certain problems persist over time (Meadows, 2008). In addition, system archetypes are also useful for planning, as the archetypes can be applied to test whether the policies and structures under consideration can alter the organisational structure in such a manner as to produce the archetypal behaviour (Braun, 2002; Meadows, 2008; Pruyt, 2013; Senge, 2006).

As such, the following 10 system archetypes are generally acknowledged as forming the set of tools that reveal patterns of system behaviour (Braun, 2002; Maani & Cavana, 2007; Meadows, 2008; Pruyt, 2013; Senge, 2006):

- Limits to growth (limits to success): This archetype states that a reinforcing process of accelerating growth or expansion will encounter a balancing process as the limit of a system is approached. Therefore, by mapping out the growth engines or potential danger points in advance, we can anticipate future problems and eliminate them before they become a threat.

- Shifting the burden: This archetype states that a problem can be resolved either by using a symptomatic solution or by applying a fundamental solution. It hypothesises that once a symptomatic solution is used, it alleviates the problem symptom and reduces the pressure to implement a fundamental solution, a side effect that undermines fundamental solutions. In this archetype, a short-term solution is used to correct a problem with seemingly positive immediate results. As this correction is used more and more, fundamental long-term corrective measures are used less. Over time, the mechanisms of the fundamental solution become disabled, leading to even greater reliance on the symptomatic solution.

- Eroding goals: In this archetype, when all else fails, standards are lowered. This archetype examines dynamic behaviour in the present that is the result of forecasts of the future made in the past. It states that a gap between a goal and an actual condition can be resolved in two ways: by taking corrective action to achieve the goal or by lowering the goal.

- Escalation: This archetype presents an ‘irony of the management process’, whereby in the name of protecting and/or furthering the best interests of their organisation, managers engage in escalating behaviour to the point where they harm their organisations, thereby reducing value to customers, stakeholders and shareholders, for example with price wars.

- Success to the successful: This archetype describes the common practice of rewarding good performance with more resources in the expectation that performance will continue to improve.
- Tragedy of the commons: In this archetype, individuals keep intensifying their use of a commonly available but limited resource until all individuals start to experience severely diminishing returns.
- Fixes that fail: In this archetype, initial problem symptoms are worsened by the fix that is applied to them, thereby contributing to exacerbation of the problem symptom.
- Accidental adversaries: This archetype is similar to the escalation archetype in terms of pattern behaviour that develops over time. In this archetype, accidental adversaries start with win-win goals and objectives in mind, thereby taking advantage of their respective strengths and minimising their respective weaknesses with the objective of accomplishing together what cannot be achieved separately. However, once the relationship becomes adversarial, it deteriorates.
- Attractiveness principle/Growth and underinvestment: This archetype applies when growth approaches a limit that can be overcome if capacity investments are made. If a system is stretched beyond its limit, it will therefore be compensated by lower performance standards, which reduce the perceived need for investment. It also leads to lower performance, which further justifies underinvestment over time. It bears a strong resemblance to the limits to growth archetype, with the addition of multiple slowing actions; with each slowing action, there is a challenge that the firm faces and that needs to be addressed if the firm is to overcome the aggregate limits to growth. The firm has to decide which of the limits to address first or which is more attractive in terms of future benefit to the desired result being pushed by the effort or growing action (Braun, 2002; Maani & Cavana, 2007; Pruyt, 2013; Senge, 2006).

In terms of public policy, Meadows (2008) stresses that understanding system archetype problems, especially in public policy challenges, is not enough, but that understanding archetypal traps and opportunities is also important. Braun (2002) further outlines that there are many ways in which the archetypes can interact with one another, depending on what one is concerned about: growth or fixing problems. For growth concerns, limits to growth, success to the successful, tragedy of the commons, accidental adversaries and growth and underinvestment (fixed standards) are the applicable system archetypes. If the focus is on fixing the problem, shifting the burden, eroding goals, escalation, fixes that fail, accidental adversaries, and growth and underinvestment are the applicable system archetypes (Braun, 2002; Pruyt, 2013). Because the aim of this study was to find robust ways to deal with the public policy complexity facing the IRP development process, system archetypes that could be utilised to define and potentially fix this complex system, the IRP development process and its update, were explored.

2.6 The case study: IRP approach in South Africa

Ensuring a reliable and affordable supply of electricity has been at the core of South Africa's development (Department of Energy, 2009). National electricity planning, as part of energy policy, emerged internationally as the most effective way to shape the development of the electricity supply industry. The Department of Energy is responsible for developing the IEP, which is based on a general equilibrium model including the economy and an energy component (Department of Energy, 2013). This plan is relevant because of the inherent interaction among the components of the energy industry. As such, the main aim of the IEP is to incorporate the overall interaction within the energy industry, i.e. interactions between electricity, liquid fuels, coal fuels, gas fuels, etc. (Department of Energy, 2009).

In addition, the Department of Energy is responsible for the development of the IRP, which is a subset of the IEP and is described in the Electricity Regulations on New Generation Capacity published on 5 August 2009 (Department of Energy, 2009). In terms of long-term planning and related sustainability goals aimed at contributing to South Africa's sustainability transition path, the South African electricity sector is currently guided and driven by the IRP 2010–2030. The IRP has been described as a medium- to long-term plan that directs the expansion of the electricity supply over the given period (at least 20 years). Furthermore, the IRP was introduced to reduce the total cost of electricity (overall supply and associated losses or not supplied) to the consumer, given the limitations inherent in the technical aspects of the supply and non-technical considerations brought into the planning model.

The technical characteristics are meant to flow directly from the planning assumptions, whereas the non-technical considerations are derived from the policy options and scenarios, including associated externalities. The IRP was proposed as a mechanism by which key electricity systems, sustainability and government policy requirements would be met so that the following questions would be answered: What are the electrical energy requirements for South Africa? When will the capacity be needed to provide for the electrical energy requirements? What is the appropriate mix of technologies to meet the needs that achieve the required policy objectives? (Department of Energy, 2009). South Africa's first national IRP was completed by the National Energy Regulator of South Africa in 2002. The updated second national IRP was completed in 2004, and the third national IRP was completed in

2008. Eskom, the state-owned national utility, also used to develop integrated strategic electricity plans providing strategic projections of supply-side electricity options to meet Eskom's long-term electricity load forecasts (Calland & Nakhooda, 2012).

The current IRP 2010–2030 was promulgated in March 2011 (Department of Energy, 2011). In 2013, a revised IRP was published for public comment in keeping with the expectation that the IRP will be updated biennially; however, it was never approved by Cabinet. A process of updating the IRP was initiated in 2016, with stakeholder consultation commencing in December 2016; the finalisation of the IRP policy adjustments was still underway as of June 2018. The IRP has faced several challenges. The next sections focus on the processes implemented to devise the IRP 2010–2030 and its updates and on the problem identification and system characterisation phases of system dynamics to further examine challenges facing the strategic IRP development process in South Africa.

2.6.1 The IRP 2010–2030 approach

According to the Department of Energy (2011), its long-term electricity planning goal is to safeguard sustainability while taking into consideration technical, economic and social constraints and externalities. It is through the IRP that South Africa is strategically planning for electricity, while considering factors such as climate change (with national conditional targets to curb carbon emissions), scarce water resources, the role of independent power producers (IPPs), employment, regional development and integration, and security of supply.

In terms of stakeholder engagement and consultation, a two-phase approach was followed, including consultation on input parameters to the IRP modelling and on a balanced scenario for the draft IRP (Department of Energy, 2011). The Electricity Regulations on New Generation Capacity state that the process for developing the IRP should include the following (Department of Energy, 2009:1-2):

- "Adoption of the planning assumptions"
- "Determination of the electricity load forecast"[4]
- "Modelling and scenario planning based on the planning assumptions"

[4] "Two forecasting methodologies are utilised to determine the annual energy requirements and can briefly be defined as follows: first, a time series analysis of historic trends at individual customer and/or sector level, adjusted for no repeatable events. This adjustment is made through expert knowledge and judgement for known and assumed parameters that will impact future electricity consumption. Second, an econometrics model utilising economic and demographic parameters that calculates the forecast based on algorithms that utilise these parameters in the input function. To compare the forecasts that will arise from the two methodologies, the same assumptions must be used in both forecasts, where applicable. In addition to the energy forecast, it is also necessary to do an hourly demand forecast. Two methods are used to forecast this hourly profile, namely a method using the system profile and a method using sectoral profiles" (Department of Energy, 2009:3).

- "Determination of the base plan derived from a least-cost generation investment requirement"
- "Risk adjustment of the base plan, which should be based on the most probable scenarios"
- "Government policy objectives for a diverse generation mix, including renewable and alternative energies, DSM and energy efficiency"
- "Approval and gazetting of the IRP".

For timelines, the IRP proposes three time periods (Department of Energy, 2009):

- Short-term period: The plan outlines the choices that already made and the projects that will be initiated within four years.
- Medium-term period: The plan outlines options that are likely to be required in the next period, namely five to ten years.
- Long-term period: The plan develops a long-term picture considering potential risks and opportunities and identifying and examining a set of broad options.

In terms of adoption of the planning assumptions and deriving the input data set, a number of assumptions needed to be confirmed before the plan was finalised. In addition, the input data set that the plan would use also needed to be confirmed. The following were some of the input factors included (Department of Energy, 2009; 2011:2):[5]

- "Discount rate (net discount rate before tax)"
- "Future inflation figures"
- "Exchange rate"
- "Existing generator performance expectations"
- "Costs and characteristics of existing generation plant (lifecycle refurbishment and decommission)"
- "Existing fuel supply availability"
- "Costs and parameters"
- "Future technology options, costs and characteristics"
- "Future fuel supply availability, costs and parameters"
- "Water and sorbent requirement, availability, costs and parameters"
- "Demand forecasts (both energy and peak demand)"

[5] "The cost and characteristics of the future supply options would be based on benchmark information and not actual options, because future options were not yet developed to the extent that they were accurate enough to be used in an expansion study. In addition, because of the participation of private investors, it was not necessarily known which location would be specifically chosen for different technologies" (Department of Energy, 2009:3).

- "Anticipated DSM (including dispatchable DSM)".

For the planning models, the base IRP and selected scenarios were modelled on an expansion planning software tool named PLEXOS®. The base plan was taken as the least-cost plan, considering only the direct costs of the options considered. It did not consider any externalities. The additional scenarios for the risk-adjusted plans might consider externalities either as limits or explicitly modelled as additional costs for the affected technologies. The primary externality factor that would be considered in this IRP was carbon emissions (Department of Energy, 2009).

The risk adjustment of the base plan was grounded on the most probable scenarios and government policy objectives for a diverse generation mix, including alternative energies and renewable energy, DSM and related energy efficiency forecasts. Other important strategies and policies that had to be taken into considered in the scenarios for the risk-adjusted plans were those that gave direction to nuclear energy, diversity of energy sources, renewable energy mix and size, energy efficiency policy/strategy and technology solutions, imports (regional development), and climate change. As the planning process dealt with degrees of uncertainty, the developed scenarios had sensitivity scenarios utilising different demand forecasts. For the results, once the IRP was finalised, the results of the planning process were reviewed and interpreted to confirm that the favoured options had been identified and that there was a shared understanding of the implications of the decisions that needed to be made. The outputs needed to be scrutinised, including the following (Department of Energy, 2009; 2011):

- Identification of unrealistic expansion options
- Review of reserve margin impacts (reliability criteria)
- Assurance that the limits imposed by the IEP, such as load factor on gas turbines or other energy limits, had not been violated.

The identified sub-draft plans of the IRP were then subjected to input production studies[6] to ensure the reliability of each of the plans developed. This was done because the expansion plan was not as precise as each of the input production studies, but was a simplified model. As a result, each of the draft plans that passed the reliability tests would then undergo further scrutiny. This meant that each draft plan was first costed and an estimation of the tariff impact was made. These could only be broad indications, as the costs were mostly benchmark costs. In addition, the review was undertaken on the basis of whether other policy

[6] A production study is a more precise model of the problem and is an assessment in which reliability criteria or tests are utilised or applied for each of the draft plans (Department of Energy, 2011).

objectives were considered or not, specifically whether the following objectives were met: competitiveness, social development issues and localisation. Furthermore, the broader picture of other infrastructure development such as water, roads and transmission network infrastructure was considered for each draft plan of the IRP to identify potential implementation issues. A decision-making framework was then used to decide among the different plans (scenarios) and on which plans would be recommended to the Minister of Energy. The development of the IRP as proposed in the Electricity Regulations on New Generation Capacity resulted in a high-level plan identifying the required capacity, the capacity mix and the requisite timing for the capacity (Department of Energy, 2009; 2011).

The above led to the development and promulgation of the IRP 2010–2013. The IRP set concrete targets for additional new generation capacity until 2030, including renewable energy. These targets translated into new capacity of 9.6 GW of a nuclear fleet, 6.3 GW of coal, 11.4 GW of renewables (onshore wind, solar photovoltaic and concentrated solar power) and a further 11.0 GW of other generation sources (Electricity Governance Initiative of South Africa, 2013). Table 2.1 provides an overview of the energy generation share (Department of Energy, 2011). The IRP 2010–2030 is able to identify the preferred generation technology mix required to meet expected demand growth up to 2030.

Table 2.1: Energy generation share based on the IRP 2010–2030

Energy generation share as per the IRP 2010–2030 energy generation technology	**Current Percentage**	**IRP 2010–2030 percentage**
Coal	90	65
Nuclear	5	20
Hydro	5	5
Gas (combined-cycle gas turbine)	0	1
Peak (open-cycle gas turbine)	< 0.1	< 0.1
Renewables, including concentrated solar power, solar photovoltaic and wind	0	9

Source: Department of Energy (2011)

This policy-adjusted IRP also attempts to incorporate a number of government strategic objectives and plans that were developed in other government departments, namely the National Planning Commission, the Department of Environmental Affairs, the National Treasury, the Department of Water Affairs and the Department of International Cooperation (for carbon mitigation, reduced water consumption, localisation and regional development), thereby managing to produce a somehow balanced strategy towards diversified electricity generation sources and gradual decarbonisation of the electricity sector in South Africa

(Department of Energy, 2016). However, the IRP was found to be highly regulated with a lesser focus on the governance process for its development and implementation (Electricity Governance Initiative of South Africa, 2013).

2.6.2 Updating the IRP 2010–2030

The Department of Energy (2016) indicates IRP 2010–2030, promulgated in March 2011, as a 'living plan' that would continue to be revised by the Department of Energy. Moreover, because the IRP 2010–2030 was developed without an appropriate overarching energy plan that considered the interactions with other energy carriers, the Department of Energy has also been focusing on producing the IEP. The latest IRP 2016 update, in fact, focused on the electricity-related elements of the IEP that are in the process of being completed. The IRP 2010–2030 has been criticised with regard to its development process, inputs and assumptions, as well as its implementation progress (Department of Energy, 2009; 2011; 2016; Electricity Governance Initiative of South Africa, 2013).

Some of the key drivers for an updated IRP include changes in the economic and energy landscape in South Africa since its promulgation, in particular in electricity demand and the underlying relationship with economic growth, new developments in technology and fuel options (locally and globally), scenarios for carbon mitigation strategies and their specific impact on electricity supply up to 2050, and of course the affordability of electricity and its impact on demand and supply. According to the Department of Energy (2016), the update process includes the following key steps:

i. Developing a credible base case from the IRP 2010–2030 by updating the underlying assumptions based on new information such as technology costs, electricity demand projections (expected demand), new installed capacity and existing plant performance, which have changed with Eskom's adoption of a new operation and maintenance strategy. The new Eskom operation and maintenance strategy includes the new Eskom plant life, learning rates, greenhouse gas trajectory based on the allocation made in terms of the national carbon budget process towards the electricity sector, social discount rates, exchange rates and primary fuel costs.

ii. Considering different scenarios or test cases (i.e. greenhouse gas emission constraints, primary fuel tipping point, low demand trajectories, embedded generation, renewable energy annual cap removal, additional energy efficiency, Eskom plant performance, regional options and Eskom plant life extension) based on alternative government policies or strategies and differences in future economic and resource terrains.

iii. Using information from the different scenarios to inform the policy adjustment phase of the IRP with sensitivity studies on primary energy prices and the associated learning rates (including with no learning rates) or battery storage with learning rates in the case of renewables.

iv. Developing a proposed path of least regret, incorporating the benefits of flexibility by developing decision trees to indicate decisions needed before the next update.

Other developments since the promulgation of the IRP 2010–2030 include ministerial determinations that include new capacity in renewable energy, nuclear energy, coal and gas. This new capacity includes the Medupi, Kusile and Ingula power stations that are still under construction, while the flagship programme for implementing renewable energy (the REIPPPP), tasked with deploying 3 725 MW of renewable energy by 2016, has also been initiated as part of implementing the IRP 2010–2030 (Department of Energy, 2013). However, the IRP 2010–2030 remains the official government plan for new generation capacity until replaced by an updated plan (Department of Energy, 2016).

In terms of stakeholder consultation and governance process, public consultations were proposed to focus on the assumptions made, demand trajectories and scenarios considered by the update process (Department of Energy, 2009; 2011; 2016). The above process clearly illustrates the need for the IRP process to be transparent and participative, and to be endogenised into the overall South African strategic integrated national planning processes aimed at South Africa’s electricity sustainability transition path. It also requires a clear governance of the overall IRP process to ensure that the aim and objectives of the IRP process are met.

2.7 Challenges facing South Africa’s IRP approach

The IRP approach was developed as a mechanism to facilitate electricity transition in South Africa, in particular, social development to promote job creation and localisation, economic development through increasing supply and environmental sustainability through diversifying electricity supply sources. However, the IRP has faced a number of challenges, including, but not limited to, the following (Electricity Governance Initiative of South Africa, 2013; Msimanga & Sebitosi, 2014; Mqadi, Musango & Brent, 2018a):

- The Eskom monopoly and its future role in the electricity sector and in the long-term strategic IEP
- Continued ‘financialisation’ of the South African economy and its impact on the affordability of electricity and any equity-based transition
- Power of vested interests, including all the related rent-seeking issues

- Coal mining as one of the key contributors to the South African economy and its future role in the electricity sector, especially its influence in the strategic IEP
- The non-existence of an independent system operator for the electricity sector
- Emerging embedded generation factors (that will need to be dealt with through integrated grid planning)
- Lack of strategic and integrated approaches for the water, agriculture, electricity and related sectors
- Lack of governance and decision making in terms of the required upgrades of and investments in South Africa's electricity grid
- Lack of governance and transparency on the issue of the proposed nuclear fleet as an option for South Africa's electricity sustainability transition
- Lack of consideration of social and environmental impacts of the strategic IEP
- Lack of discussion of affordable electricity cost and the cost-reflective tariff, which will consider all the externalities with respect to electricity production and the role of the strategic IEP in this regard
- Lack of transparency in the IRP development process
- Lack of participative and clear governance of the IRP approach, its development process to ensure the IRP objectives to ensure alignment with other national strategic integrated plans, and its overall endogenisation into South Africa's sustainability transition path.

In addition to the abovementioned challenges, Baker et al. (2014:792) point out that the IRP implementation may result in "GHG (greenhouse gas) emissions from electricity generation increasing from 237 million tons of CO_2 in 2010 to 272 million tons in 2030" owing to the flawed assumptions promoted during the IRP development process. In addition, IRP implementation may lead to increases in electricity prices estimated at 250% in real terms from the 2010 levels, while by 2020 they are estimated to be even higher owing to higher projected inflation rates. This increase in greenhouse gas emissions and electricity prices is attributed to the doubling in electricity capacity driven by 'projected demand forecasts', specifically in the government-driven mining and minerals beneficiation programmes and coal-to-liquids technology programmes (Baker et al., 2014). It is in this context that some stakeholders raised concerns over the lack of transparency in gathering technology costs data, decreasing renewable energy costs against coal costs and related externalities, assumptions made in terms of demand forecasts and the role and influence posed by the traditional MEC players within the IRP development process. In addition, in terms of technology diversification and options, especially with regard to nuclear energy, stakeholders have highlighted the lack of consideration of capabilities of more flexible smaller modular nuclear reactors, which could be more suitable for South Africa given the uncertainty of demand and its large renewable energy resources (Energy Research Centre, 2013). Furthermore, an integrated analysis linking the power and water sectors and the economy was lacking, proving that the electricity sustainability transition objectives were not captured in totality. For example, electricity production is closely linked to the water sector, and South Africa is expected to have a deficit of 234 gigalitres by 2025 as projected in national accounts (Hedden, 2015; Pouris & Thopil, 2015). As such, this is an illustration of the many gaps that need to be considered, aligned and endogenised in the IRP policy development process.

Other major IRP shortfalls are that environmental and social impact assessments on all advocated technologies have notably been missing. In addition, the economic and financial impacts of the proposed electricity generation mix in the IRP could also have received more attention, while the contribution of the IRP and overall energy policy to peripheral government objectives (social, environmental and industrial) has been marginal (Montmasson-Clair & Ryan, 2014).

Furthermore, renewable energy driven by IPPs and small-scale embedded generation ‘behind meters’, which are currently playing an increasing role and would eventually result in a more decentralised and intermittent electricity supply for South Africa, is currently lacking a clear governance process or framework to ensure overall alignment with the country’s long-term strategic planning (Msimanga & Sebitosi, 2014). The proposed IPP institutional and governance structures, including related existing barriers to renewable energy deployment in South Africa, are not sufficiently defined. Hence, enforcing implementation mechanisms or rules and regulations becomes challenging (Montmasson-Clair & Ryan, 2014). While this is expected to affect various electricity sector actors, it is not explicitly considered in the IRP development process. Furthermore, IPPs have continually indicated that limited attention is given to grid planning in terms of where, geographically, future electricity will come from or who will produce it, including the geographical location of demand (Hedden, 2015). These deficiencies further highlight the insufficiencies within the IRP policy development process and its misalignment with overall national strategic and integrated planning, such as the Transmission Development Plan for South Africa and the Strategic Grid Plan (Govender, 2017).

Baker (2016b) further underscores political planning dynamics and influences by various stakeholders in the way in which the IRP was negotiated, as this revealed the electricity sector’s political economy dynamics driven by the ‘traditional minerals-energy complexity’ in South Africa. This refers specifically to the technical advisory group that provided inputs into the modelling process, which was heavily criticised for largely consisting of representatives from coal miners, the Energy Intensive Users Group, Eskom and government. Therefore, this participatory nature of the IRP public consultation process has been heavily criticised (Baker, 2016b).

In the 2016 updated IRP (Department of Energy, 2016), although the issues of load-centric distributed generation and short-term decentralised provision were addressed, there is still a lack of detailed studies on the subject. This is exemplified by the distributed generation definition, regarded as vague, while the long-term effects of short-term planning and short-term provision were not investigated (Rycoft, 2017). In addition, the planning and impact of construction times of smaller plants (in particular distributed generation) were not considered. Questions relate to whether these plants will be centralised or localised, and whether a centralised planning for distributed generation would be required (Rycoft, 2017). As such, this further highlights the lack of a governance framework within which the IRP development process and its subsequent updates can be undertaken to ensure transparency, alignment, endogenisation and overall contribution of the IRP as an approach for South Africa's electricity transition path.

To 'fix' some of the abovementioned challenges and complexities, the Department of Energy initiated the process of updating the IRP 2010. Yelland (2016) notes the incorrect and inconsistent technology costs utilised in the draft IRP 2016. He proposes an IRP process that starts with an unconstrained, least-cost, base-case scenario, using correct and up-to-date technology costs, to establish the associated least-cost, unconstrained, base-case technology mix up to 2050, and that the associated cost of this base-case scenario should be followed. Moreover, other scenarios using various imposed constraints (e.g. carbon constraints or water availability or electricity demand constraints) to establish the relevant energy mixes calculated in the IRP model for each of the alternative scenarios together with the associated additional costs up to 2050 will need to be considered (Yelland, 2016). This would allow relevant stakeholders to understand the cost implications of the various constraints over and above the least-cost, base-case scenario to obtain a meaningful view of the additional cost versus the resulting benefit or policy objective of the IRP (Yelland, 2016). In addition, stakeholder consultation for the IRP 2016 was flawed and critiqued for only allowing the public 10 to 14 days' comment on the draft document. Only Department of Energy policy makers had access to the costing of the various scenarios, including any new scenario information identified by stakeholders, affected parties and the public during the public participation process (Yelland, 2016). Again, this further highlighted the lack of a framework to guide an inclusive process for IRP development.

In this section of the study, complexity challenges facing the IRP (i.e. the problem) were identified, including boundaries of the problem, i.e. social, economic, environmental and political dimensions influencing national strategic integrated planning; the IRP approach challenges; and the current ‘fix’ promoted by the Department of Energy that has led to unintended consequences, thereby further exacerbating complexity challenges facing the IRP. The next section therefore reports on the examination of these systemic challenges faced by the IRP approach for the electricity sector utilising CLDs and systems archetypes.

2.8 Application of system dynamics: The IRP approach in South Africa

The above section outlined the complexity challenges facing the approved IRP 2010–2030 and the IRP 2016 update, and it is in this context that the problem for this study was formulated and conceptualised. Based on the challenges identified, Table 2.2 presents endogenous,[7] exogenous[8] and excluded[9] variables identified to define South Africa’s IRP approach and its challenges.

Table 2.2: Identified variables for the causal loop diagrams

Endogenous variables	Exogenous variables	Excluded variables
Electricity generation from coal	Electricity transition in South Africa	Sustainability transition initiatives in South Africa
IRP complexity challenges	IRP aim and objectives	National strategic integrated plans
Resistance towards IRP adoption and implementation	Regulatory environment	
Review and update of the IRP by the Department of Energy	IRP stakeholders	
IRP policy development process	Stakeholder acceptance of new transition framework	
Integrated electricity sustainability transition framework	IRP stakeholder involvement influenced by MEC challenges	

Source: Researcher’s conceptualisation

The identified variables in Table 2.2 were therefore utilised to develop CLDs to examine the complexity challenges facing the IRP with a focus on stakeholder involvement and other IRP

[7] These variables were relevant and influenced by the causal linkages defining the core problem addressed in the CLDs.
[8] These variables fell outside the boundary of the CLDs and were determined by factors outside of the system.
[9] These variables were considered important to the qualitative assessment of this study, but were excluded from the CLDs, as they were outside the scope of the analysis.

challenges; the current fix, which is the IRP review and update by the Department of Energy; and the continued resistance to the IRP, even after each update.

Figure 2.1 shows the feedback loop of the initial objective of electricity sustainability transition in South Africa, which entails transition from mainly coal electricity generation to more renewable energy as driven by South Africa's IRP policy development process, represented as a balancing feedback loop, B1.

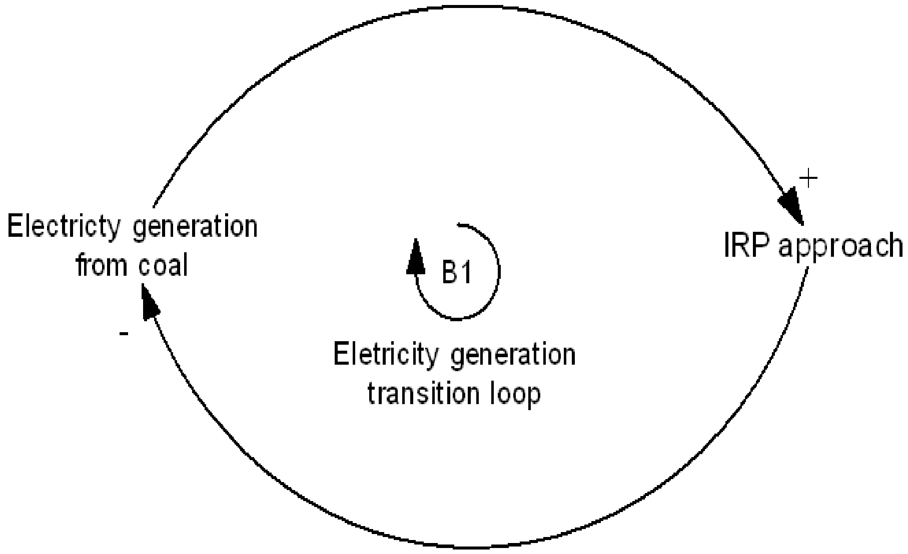


Figure 2.1: Electricity generation transition loop

Source: Researcher's conceptualisation

However, the IRP approach was confronted with tensions, challenges and doubts, creating an uncertain environment regarding achieving its intended objectives. The complexity challenges facing the IRP policy development process created an uncertain environment for future energy development planning in South Africa. This has in turn created resistance towards IRP adoption and implementation, hence reversing the effect of the initial IRP objectives to promote electricity sustainability transition, i.e. reducing coal electricity generation in South Africa over time. This is endogenously captured as an unintended consequence in Figure 2.2, represented as a reinforcing loop, R1.

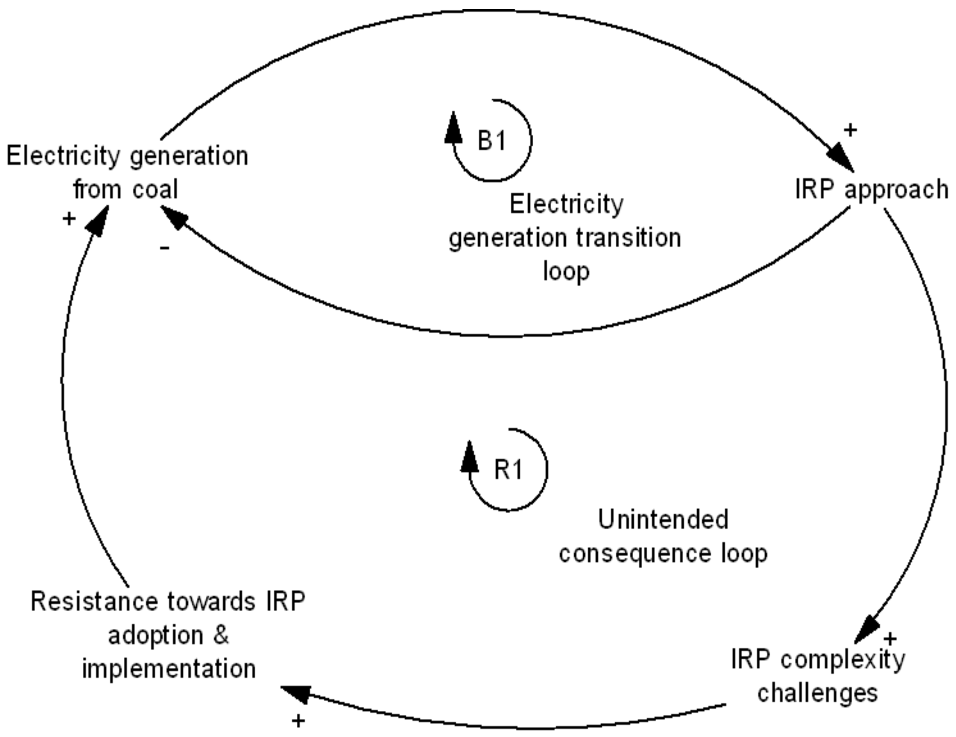


Figure 2.2: Unintended consequence loop

Source: Researcher's conceptualisation

Figure 2.2 highlights that in order to facilitate electricity sustainability transition, the IRP was introduced as a policy planning development approach within the electricity sector, represented by the electricity generation transition loop (B1). However, the IRP and its adoption and subsequent implementation faced various challenges due to the policy and political dynamics within the electricity sector in South Africa, leading to various unintended consequences – mainly resistance towards the IRP development process and its adoption – thereby reverting South Africa's electricity to its initial situation of relying on coal electricity generation, or a slow electricity transition in South Africa, represented by R1, the unintended consequence feedback loop.

Furthermore, Figure 2.3 illustrates the fixes that fail system archetype, which shows that a quick-fix solution can have unintended consequences (i.e. resistance towards the IRP development process, adoption and implementation), which can further aggravate the problem. It hypothesises that the problem symptom (i.e. the IRP complexity challenges) will diminish for a short while and then return to its previous level or become even worse over time (Braun, 2002).

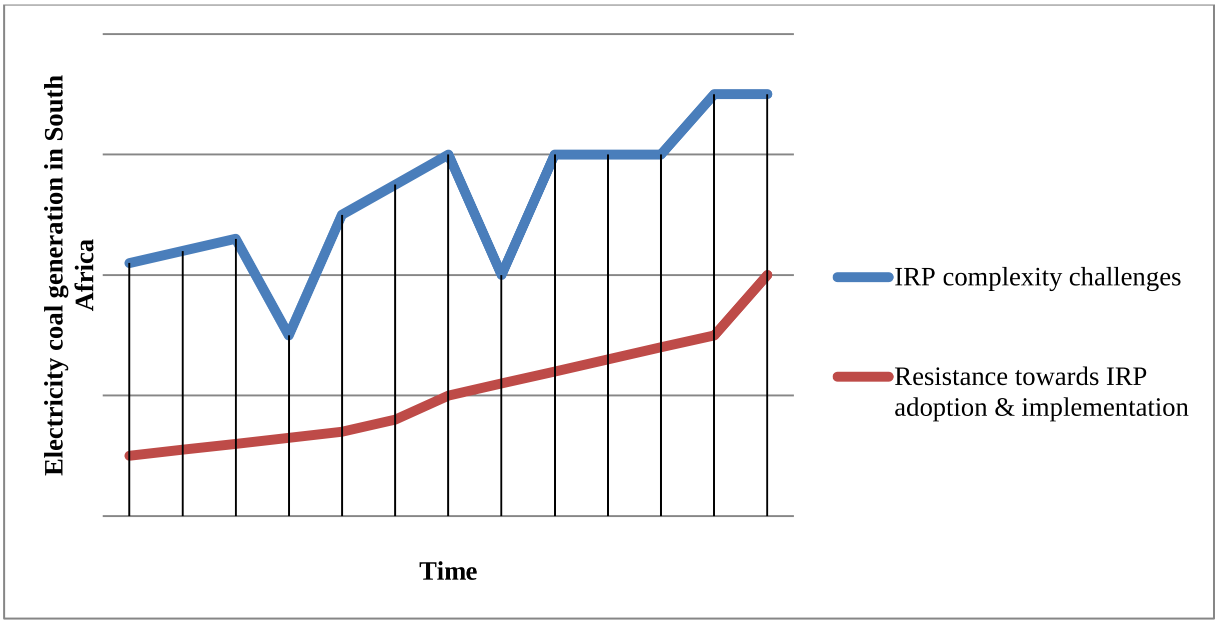


Figure 2.3: Fixes that fail system archetype: Electricity coal generation (i.e. slow transition) over time in South Africa

Source: Researcher's conceptualisation

Owing to the slow electricity transition described in Figure 2.3, the Department of Energy has continuously responded by reviewing and updating the IRP to transition to electricity generation from coal; however, only some temporary improvement in performance is experienced. This is what can be considered as quick-fix solution feedback loop (B2), indicated in Figure 2.4.

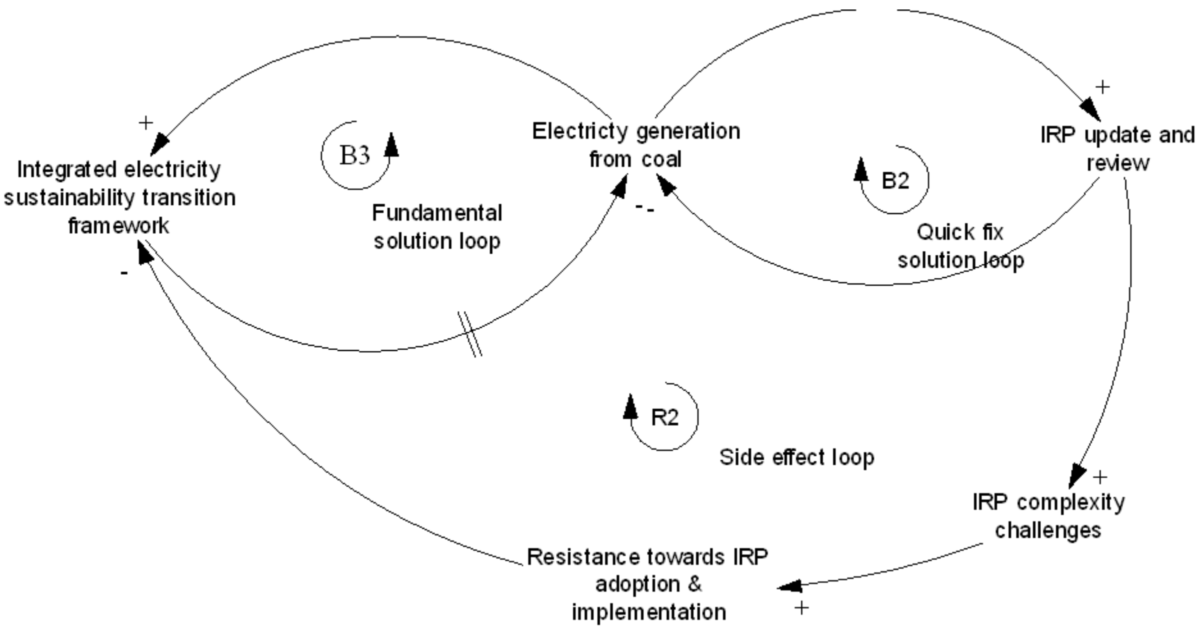


Figure 2.4: Shifting the burden characteristics of the IRP policy development process

Source: Researcher's conceptualisation

Figure 2.4 therefore indicates that the Department of Energy's review and update of the existing IRP is only a quick fix, which alleviates the problem symptom and reduces the pressure to seek a fundamental solution that will deal with the dominant challenges relating to resistance towards IRP development, adoption and implementation. As the initial objective of electricity transitioning worsens, there is a tendency to resort to the quick-fix solution instead of the fundamental solution that encompasses integrated electricity sustainability transition. This is because the effects of the fundamental solutions occur after a longer delay, represented by a double line on the arrow of the fundamental solution loop (B3). The greater the reliance on quick-fix solutions, the worse the situation becomes, and therefore over time, the fundamental solution becomes indispensable. Hence, the fundamental solution feedback loop (B3) introduces the integrated electricity sustainability transition framework aimed at transition from coal electricity generation.

Figure 2.5 illustrates the shifting the burden system archetype, which shows how management interventions work. Each time there is an intervention in the form of a review and update of the IRP by the Department of Energy to transition electricity generation from coal, only some temporary improvement in performance is experienced, until a fundamental solution is presented; in this case, an integrated electricity sustainability transition framework, which assumes a well-planned intervention.

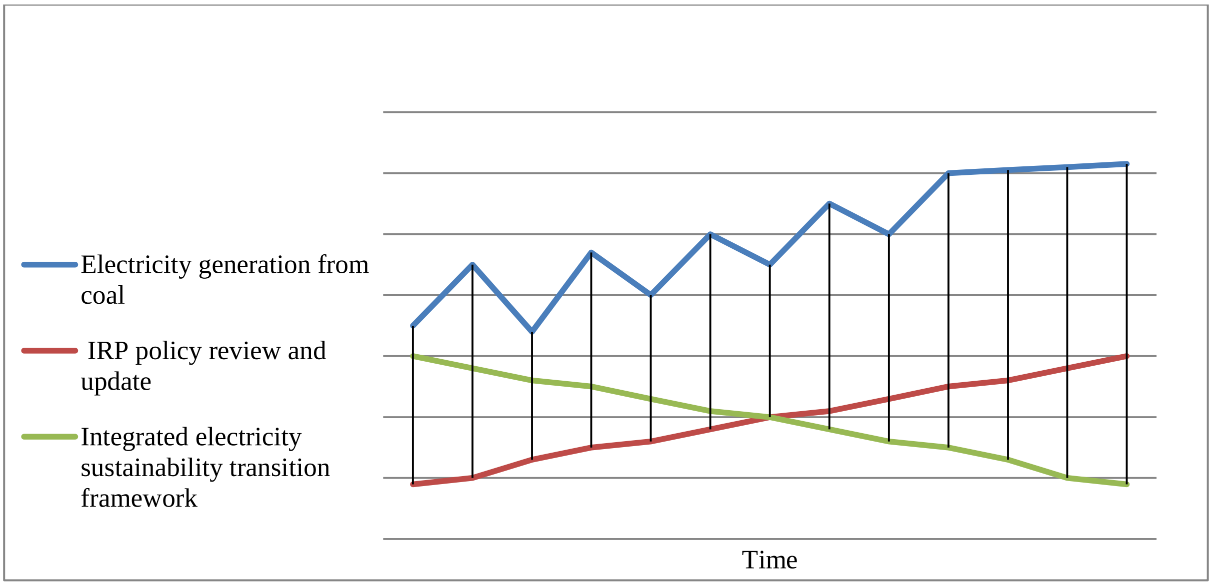


Figure 2.5: Shifting the burden system archetype: Management interventions and the impact on electricity transition in South Africa over time

Source: Researcher's conceptualisation

This chapter has attempted to apply the fixes that fail and shifting the burden system archetypes advocated action steps in figures 2.3 and 2.5 respectively. Chapter 4 further elaborates on these action steps through surveys and questionnaires with an aim to gather views from various stakeholders on these CLDs.

2.9 Summary

This chapter reviewed the different ways in which public policy development dynamics and associated politics impact on and contribute to the governance of electricity sustainability transition. In this instance, long-term planning and specifically the public policy development process of the IRP would also experience all the related complexities. The study found that the IRP public policy development dynamics and the associated politics had resulted in resistance towards the IRP development process and its update by various stakeholders, leading to misalignment of the electricity long-term plan, the IRP, with other national strategic plans and to minimal endogenisation of this long-term plan into existing governance frameworks, including institutional processes aimed towards South Africa's electricity transition. A qualitative system dynamics approach utilising CLDs and associated system archetypes was the method utilised to assess and explain the complexity faced by South Africa's IRP approach. By utilising CLDs, the resistance towards the IRP and the related IRP challenges, represented by a reinforcing loop, emphasises the system's inability to achieve its objectives with the quick-fix solution, hence the need to focus on a long-term fundamental solution. Chapter 3 explains the development of a conceptual framework to facilitate strategic electricity planning and its challenges.

CHAPTER 3: CONCEPTUAL FRAMEWORK TO FACILITATE STRATEGIC SUSTAINABILITY PLANNING FOR THE ELECTRICITY SECTOR IN SOUTH AFRICA[10]

3.1 Introduction

This chapter is based on Sub-objective 2 of this study, which was to develop an electricity transition framework to facilitate alignment and endogenisation of the IRP. Therefore, this chapter presents a conceptual framework that took into consideration strategic planning theory, sustainability transition theory, complexity theory and the related governance approaches. South Africa's historical political economy context, the MEC that defines the electricity sector and the sustainability transition agenda are presented, while the current IRP complexity challenges are outlined. A proposal for a conceptual electricity sustainability transition framework for South African electricity planning is introduced, aimed at facilitating alignment with other national strategic plans. It is further intended to bring about the endogenisation of long-term electricity planning processes and outputs into South Africa's energy policy and institutional governance processes, especially other key strategic national plans and policies aimed at meeting national sustainability goals. The developed framework is argued to complement the existing strategic IRP approach by providing a policy development process platform that could be utilised to build capacity for addressing the complex challenges facing the IRP as a planning process.

3.2 Strategic planning

Strategic planning is defined as an organised process of foresight with set procedures to maximise and formulate the potential success of any plan (Bouhali, Mekdad, Lebsir & Ferkha, 2015; Flaherty, 2014). There are numerous approaches to strategic planning, with a common theme being the responsiveness and effectiveness of each plan to the user or recipient while keeping a clear vision of each institution and commitment to the overall mission (Flaherty, 2014; Hudson, Galloway & Kaufman, 1979). Although strategic planning is associated with problem solving, its distinctive characteristic is related to clusters of interrelated decisions. The problem that it addresses is coordination (Faludi, 1973; 2013).

The general theory of strategic planning has three pillars: goal formulation, problem definition and the associated social context (Rittel & Webber, 1973). In defining the dilemmas faced by this theory, Rittel and Webber (1973) emphasise that strategic planning challenges are

[10] Mqadi, L., Musango, J.K. & Brent, A.C. 2016. Rethinking strategic sustainability planning for the electricity sector in South Africa. Unpublished paper presented at the 22nd International Sustainable Development Research Society Conference, School of Science and Technology, Universidade Nova de Lisboa, Lisbon, 13–15 July; Mqadi, L., Musango, J.K. & Brent, A.C. 2018. Rethinking strategic sustainability planning for the electricity sector in South Africa. *The South African Journal of Industrial Engineering*, 29(1):63–73.

inherently 'wicked', especially those of policy planning, as they are well defined and rely on elusive power struggles and influences for resolution. These problems are defined as complex situations that cannot be described as true or false or good or bad; often the advocated solutions cannot be tested and, most importantly, there are no enumerable options for solutions to these complex challenges (Cilliers, 2000; Hudson et al., 1979; Rotmans & Loorbach, 2009).

In response to wicked problems, to define the strategic planning theory, 'clumsy solutions' have been advocated. These solutions propose not-so-perfect solutions to uncertain, complex and normative problems and search for viable solutions that are less perfect but responsive to different rationalities (Hartmann, 2012; Rittel & Webber, 1973). Strategic planning theorists constantly discuss different approaches to coping with wicked problems, and these discussions identify uncertainty, complexity and normativity as inherent in strategic planning processes (Friedmann & Hudson, 1974; Hartmann, 2012).

The synoptic approach dominates planning practice, especially development planning programmes (Forester, 2004). Synoptic planning consists of four classical elements: goal setting, identification of policy alternatives, evaluation of means against ends and implementation of decisions (Hudson et al., 1979). Other schools of strategic planning or theories that depart from the limits of the synoptic approach include incremental, transactive, advocacy and radical planning, and other varying forms of contemporary planning traditions (Friedmann & Hudson, 1974; Hartmann, 2012).

There is currently potential and opportunities provided by the various approaches to dealing with the complexities and uncertainties of today's strategic planning, especially for delivery of sustainable electricity services such as DSM and IRP. However, the literature underscores that the proposed approaches still face challenges regarding long-term planning, especially when it comes to evolving public policy development processes and their related governance of the processes aimed at meeting sustainability goals. This requires modification of the existing strategic planning approaches, such as the IRP, to fit the new evolving public policy development environment, including their related governance for sustainability purposes (Cormio et al., 2003; D'Sa, 2005; Malik & Sumaoy, 2003). Against this backdrop, this study proposes a planning approach intervention that could be incorporated into the existing IRP as a way of building capacity for addressing the complexities (both historical and current) of and gaps in the electricity sector specifically. The proposed planning framework focuses on the IRP as a planning process.

3.3 Research Method: Scope of the proposed planning framework

Some of the gaps identified and observed in the IRP as a strategic planning process are based on supply bias, stemming from the belief that augmenting generation capacity is the only effective way of meeting projected electricity demand. Consequently, forecasting electricity capacity development in the IRP assumes future capacity without demand reduction potential through increased efficiency (D'Sa, 2005). The competing roles and objectives of various institutions with a direct impact on the electricity sector result in further misalignment and lack of coordination. In this case, related subjects are treated as different sectors and the controlling government departments are separate entities with related programmes planned independently of one another. Within the planning process, the inclusion of external costs for electricity generation (externalities) has become extremely prevalent. The IRP as a planning process therefore had to include costs and benefits caused by air pollution, water quality impacts, water consumption and pricing, greenhouse gas emissions, health expenditure and the socio-economic benefits of electrification. However, governance structures and processes to ensure the appropriate identification, assessment and management of some of these externalities are still lacking (Bakken & Lucas, 1996; Spalding-Fecher & Matibe, 2003; Vollans, 1994).

Owing to the role played by electricity utilities, specifically in developing countries, preoccupation with other competing complex transition policy objectives within the economy is also important, especially where restructuring of the electricity system is in progress and changes are expected in the position and jurisdiction of utilities. While the long-term forecasts traditionally used for integrated planning seem partly impracticable, restructuring tends to preoccupy those in authority to the exclusion of other important stakeholders and longer-term issues (Hu, Wen et al., 2010; Prasad et al., 2014). Furthermore, limited coordination between energy demand and supply programmes contributes to the challenges faced by the IRP implementation process (Dixit et al., 2014; Montmasson-Clair & Ryan, 2014). The prevalent financial difficulties plaguing electricity utilities and consumers have resulted in troubled and debt-ridden electricity utilities that have resorted to stop-gap measures rather than long-term planning (Davidson & Mwakasonda, 2004; Rudd et al., 2008).

As indicated by previous studies, conventionally, the IRP as a strategic planning process for the delivery of electricity services poses complexities regarding its practical development and subsequent implementation. The challenges to and gaps in the IRP as an approach discussed in Chapter 2, Section 2.7 therefore shaped the scope of the proposed conceptual framework. The next sections explore sustainability transition and complexity theories focused on dealing with governance challenges with the aim of providing a context for the proposed framework in this study. A qualitative content analysis approach and literature review research methods were utilised for this process.

3.3.1 Sustainability transition approaches

Haxeltine, Whitmarsh, Bergman, Rotmans, Schilperoord and Kohler (2008), Kern and Smith (2008), Markard et al. (2012) and Safarzyńska et al. (2012) highlight that sustainability transitions are fundamental system changes, as they entail closely connected barriers and opportunities associated with vested interests, myopia, group behaviour, the introduction of major technical innovations and changing prevailing practices and structures. One aspect of sustainability transition is that governance often plays a very important and particular role (Markard et al., 2012; Safarzyńska et al., 2012).

Strategic niche management (SNM), the multilevel perspective (MLP) on socio-technical transition, the technological innovation system (TIS) approach and transition management (TM) governance-based frameworks are the four dominant approaches utilised to study sustainability transition. The four frameworks adopt systemic views of far-reaching transformation of socio-technical systems (Kern & Smith, 2008; Markard et al., 2012). According to Markard et al. (2012), other relevant theoretical approaches that have been used to study and explain the particularities of transitions include the evolutionary economic theory and the actor network theory, as well as approaches with a more specific focus on technology, such as social construction of technology, constructive technology assessment, long-wave technology future studies, reflexive governance and sociology of expectations. There are also related strands of research on 'green issues', such as the literature on sustainability sciences, ecological modernisation, green management and corporate social responsibility, industrial ecology and eco-innovation (Markard et al., 2012; Safarzyńska et al., 2012).

The TIS sustainability transition approach is concerned with the emergence of novel technologies and the institutional and organisational changes that go hand in hand with technology development, including the systemic interplay of firms and other actors under a particular institutional infrastructure as the essential driver behind the generation, diffusion and utilisation of technological innovation. TISs are intended to inform policy making, which is why the identification of drivers and barriers to innovation is a typical task performed in TIS studies (Kern & Smith, 2008; Markard et al., 2012).

Safarzyńska et al. (2012) and Vasileiadou and Safarzyńska (2010) highlight that the MLP sustainability transition approach provides a conceptual framework that has been mostly applied to analysing historical studies of transition, including transition towards mass production and automobile systems, with three interdependent nested levels of hierarchy, namely niche, regime and landscape, which further consist of elements from various social systems. Kern and Smith (2008) and Markard et al. (2012) define the MLP approach as a coevolution of niches that are protected spaces that are a locus of innovation whereby new practices and technological innovations occur. Regimes are established practices and rules that enable and constrain incumbent actors in relation to existing systems. Landscapes are the external factors or 'external structural context' for the regime level that influence the development of each system and are made up of social and physical factors, such as broad powerful and influential coalitions, socio-cultural norms, paradigms and economic growth. Furthermore, Kuzemko et al. (2016) highlight that technologies still in the niche phase tend to have poor technical performance and are relatively expensive; investment and long-term commitment to research, development and innovation are therefore necessary in this phase. Therefore, niches can be understood as having the potential for revolutionary socio-technical change. According to Vasileiadou and Safarzyńska (2010), the SNM sustainability approach is related to the MLP approach and is referred to as a deliberate creation in support of such niches and has been suggested early on as a way to trigger regime shifts. Therefore, in the MLP approach, sustainability transition studies, niches, landscapes and regimes can be adopted to understand system innovations or transitions (Kern & Smith, 2008; Markard et al., 2012).

Markard et al. (2012) further reiterate that the TM sustainability approach is also a governance approach, but one that is focused on steering long-term societal change from a broader perspective than SNM, as it involves formulating long-term sustainability goals (visions) at the strategic level and facilitating the creation of new coalitions and networks of relevant stakeholders at the tactical level (Markard et al., 2012). Moreover, the TM sustainability approach is aimed at influencing and directing sustainability transition and has its roots in complex systems theory and evolutionary theory (Sengers, Wieczorek & Raven, 2016). At the operational level, the TM sustainability approach devotes considerable attention to the creation of niches for setting up experiments and steering the directions of experimenting, learning, innovation and adaptation (Markard et al., 2012). As a result, the SNM and TM approaches have many features in common, which is why integration of SNM into TM has recently taken place to some extent (Vasileiadou & Safarzyńska, 2010).

Markard et al. (2012) and Sengers et al. (2016) in their analyses of sustainability approaches highlight that sustainability transition requires decisive interventions from state and non-state actors because prevailing socio-technical systems are characterised by inertia and lock-in. The authors also point out that there is little experience with policies oriented towards fundamental, system-wide changes, while the SNM and especially TM approaches are designed specifically to address this need for 'game-changing' policy interventions, as the actual policy rationales still rely primarily on advice from neoclassical economics or from innovation systems thinking at best. In addition, TM sustainability transition approach studies have been developed to address persistent, complex structural problems unsolved by traditional short-term policy approaches in systems such as the electricity sector. The TM sustainability transition approach is therefore based on insights from technological transitions, governance and complex systems theory as much as on practical experiment and experience. This approach further discriminates among different types of governance activities that influence long-term change while being a prescriptive approach towards governance as a basis for operational policy models. It is explicitly a normative model by regarding sustainable development as a long-term endeavour. Furthermore, guiding principles for TM are derived from conceptualising existing sectors as complex, adaptive societal systems and understanding management as a reflexive and evolutionary governance process (De Gooyert et al., 2016; Kern & Smith, 2008; Loorbach, 2010; Markard et al., 2012; Mqadi, Musango & Brent, 2016). The focus of this study was therefore on the TM approach as one of the most prevalent approaches currently used to ground the governance of sustainability transition.

3.3.2 Theoretical Framework: Complexity and governance

According to Loorbach (2010), an emerging paradigm for analysis of persistent problems is complex systems theory,[11] which originated from systems theory.[12] While a single complex systems theory does not exist, it has implications for the way in which the structures of each wicked problem are conceived and managed (Cilliers, 2000; Rotmans & Loorbach, 2009). Complexity theory is regarded as only a unifying principle and not a unifying theory that can help to understand and support transitions to sustainability. It therefore serves as a theoretical framework for integrating various sustainability-based theories with various modelling methodologies for assessment to address diverse and complex challenges while further matching the adaptive management requirements (plurifocal, multiscale, multilevel

[11] Complex systems theory is the theory of multi-agent systems. Agency is attributed to all systems, subsystems and subsystem components and not just to actors within a system (Peter & Swilling, 2014).

[12] Systems theory refers to a universal language to address complex patterns of interaction among different components in complex adaptive systems and offers a conceptual lens to analyse and understand societal and governance complexity (Cilliers, 2000).

and adaptive) for transition to sustainability (Loorbach, 2010; Peter & Swilling, 2014; Rotmans & Loorbach, 2009).

The persistent problems in complex systems theory are the superlative form of wicked problems related to system failures.[13] Those problems are characterised as complex, as they are embedded in societal structures, and uncertain, owing to their hardly reducible structural uncertainty. Peter and Swilling (2014) define the role of complexity theory as an overarching way of thinking while understanding and acting on persistent problems, especially those relating to the process of transition to sustainability. In addition, persistent problems tend to be difficult to manage (owing to a variety of actors/stakeholders with diverse interests and objectives), hard to grasp (as they are difficult to interpret) and highly ill structured (Loorbach, 2010; Rittel & Webber, 1973; Rotmans & Loorbach, 2009).

According to Loorbach (2010) and Peter and Swilling (2014), certain complex systems display certain qualitative characteristics more prominently than others. Complex systems have a large number of simple elements that interact dynamically, resulting in very non-linear interactions. The interactions, defined as direct and indirect feedback loops, are rich and have the ability to harness volatility and uncertainty for gain and not merely to withstand these. Elements within each complex system have a creative capacity for innovation, and their effect is propagated throughout each system. Elements also have a history and memory that are of cardinal importance to the behaviour of the system and are distributed throughout (Cilliers, 2000; Meadows, 2008). Complex systems are open, as they exchange information with their environment, operate at conditions far from equilibrium and are very heterogeneous and unpredictable. They also have adaptive characteristics, indicating that they can self-organise or self-disorganise, especially in relation to their internal structure, controls, functions and processes, without intervention of an external agent. Self-organisation refers to the ability to develop a new system structure as a result of the system's internal constitution rather than external management. This system behaviour is determined by the nature of the interactions, not by what is contained within the elements (Peter & Swilling, 2014).

An understanding of these characteristics provides greater insight into such a complex adaptive system (CAS). In governance processes, stakeholders and their competing varying objectives coevolve with these broader societal system dynamics (Rotmans & Loorbach, 2009). In terms of policy development (in this case, planning), governance frameworks focus

[13] These include technology bias, institutional barriers, path dependencies, competing views, and so forth (Rotmans & Loorbach, 2009).

on understanding and facilitating network processes in terms of the formulation and implementation of policy-persistent problems in the short and medium term. In the long term, approaches give special attention to learning, interaction, integration and experimentation on the level of society instead of policy alone (i.e. understanding the CAS dynamics) (Loorbach, 2010).

In this context, Rotmans and Loorbach (2009), Loorbach (2010) and Peter and Swilling (2014) propose the recognition of certain principles to define a system of governance based on complexity. The principles include flexibility and adjustability at system level, the dynamics of the system necessary to create feasible and non-feasible means and insights into how the system works as an essential precondition for effective management. In addition, long-term thinking can shape short-term policy in the context of persistent societal problems, while the timing issues of each intervention are to be strategic. As managing a CAS means using disequilibria and equilibria, relatively short periods of non-equilibrium should offer opportunities to direct the CAS in a desirable direction (towards a new attractor). Creating space for agents to build up alternative regimes is crucial for innovation; therefore, stakeholders should be provided with a protected environment for innovation to take place. Lastly, a focus on (social) learning about different actor perspectives and a variety of options (requiring a wide playing field) are prerequisites for change. Participation by and interaction among stakeholders form a necessary basis for developing support for policies and for engaging actors in reframing problems and solutions through social learning. These principles provide an analytical lens to assess how various stakeholders can deal with complex societal issues at different levels, but also develop and implement strategies to influence governance processes (Loorbach, 2010; Peter & Swilling, 2014; Rotmans & Loorbach, 2009).

Taking into consideration CAS characteristics and the principles for governance of a typical CAS, Rotmans and Loorbach (2009) and Loorbach (2010) propose four governance spheres (see Figure 3.1) as pillars of a TM framework:

- A strategic sphere: aimed at integrating and institutionalising long-term governance activities into the realm of policy making
- An operational sphere: aimed at encouraging innovation of societal, technological, institutional and behavioural practices that introduce or operationalise new structures, cultures, routines or actors
- A tactical sphere: aimed at identifying interest-driven activities related to the dominant structures (regime) of societal (sub) systems with the aim to drive integrated long-term governance

- A reflective sphere: aimed at monitoring, assessing and evaluating ongoing policies and societal changes.

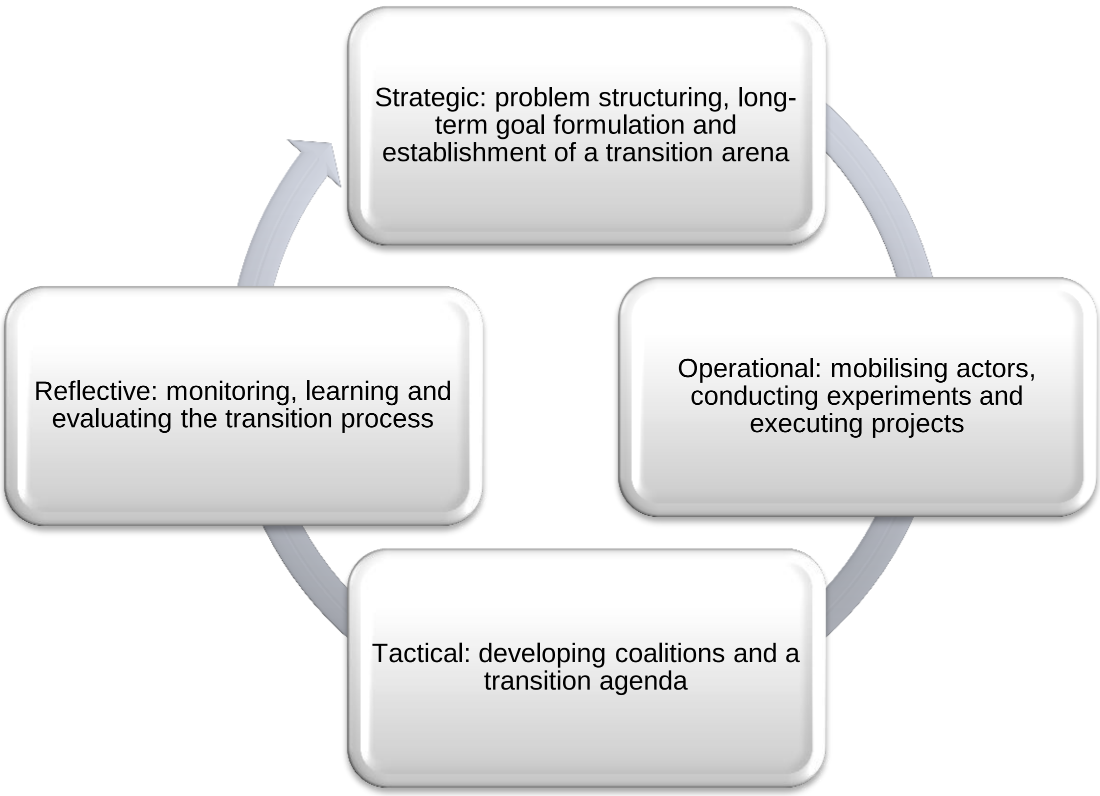


Figure 3.1: Transition management framework based on governance

Source: Loorbach (2010)

The TM framework based on governance provides a practical approach to managing the transition of typical CASs, in this case, planning development approaches. For the IRP, this framework will aim to reshape this process through the introduction of a novel and practical planning intervention to guide the core IRP process, especially in developing countries faced with governance challenges due to different, competing and complex sustainability policy objectives. This framework was adapted as the basis for developing a conceptual framework for South Africa's electricity planning governance process.

3.3.3 South Africa's political economy: Minerals-energy complex

The origins of South Africa's electricity sector at the beginning of the 20th century were driven primarily by the requirements of the booming mining industry. The country was dependent on abundant coal resources and cheap labour for the generation of cheap electricity for the minerals-based, export-oriented industry (Bell & Farrell, 1997). This core structural complex economic system, due to the dominance of its socio-political regime, referred to as the MEC, contextualised the country's politics of electricity sustainability transition (Spalding-Fecher, 2002). The South African electricity sector had been involved in core political and economic interests, which gave rise to a historically specific system of accumulation that constituted the essence of the country's MEC. In its earlier stages, South Africa's MEC consisted of the interrelationship among coal, electricity and gold mining (as core sectors) and later expanded into 'more complex relationships' among mining, electricity, (minerals) beneficiation, and crude oil- and coal-based petrochemicals industries (Baker, 2015; 2016a; Baker et al., 2014).

Some authors, such as Bell and Farrell (1997), Spalding-Fecher (2002), Baker et al. (2014) and Baker (2016a), argue that in no other country in modern economic history has the mining sector and energy sector had a symbiotic relationship which has had such a great influence on the path of development over such a long period. In addition, with abundant coal reserves, South Africa has a distinct comparative advantage in energy supply that has contributed to growth opportunities for the economy as a whole, while state-promoted developments in the MEC manufacturing sectors have also represented important and necessary steps towards full-scale industrialisation for the country (Bell & Farrell, 1997; Spalding-Fecher, 2002).

However, these major distinguishing features are also widely and convincingly challenged in studies of the South African economy (Eberhard & Gratwick, 2011; Fine & Rustomjee, 1996). It is argued that the MEC as a system of accumulation has had a determining and retarding effect on South African industrialisation and has led to the historical influence of a small number of large resource-based conglomerates on policy, now internationalised with privileged access to cheap energy, tax breaks and infrastructure (Baker, 2016a). The key sectors are still highly influential in the state and direction of the economy and are attached institutionally to a highly concentrated structure of corporate capital, state-owned enterprises and other organisations that have themselves reflected the underlying structure and balance of economic and political power (Baker, 2016b).

To highlight how the MEC still characterises South Africa's electricity sector and continues to impact the contemporary politics of energy transition, Baker et al. (2014), in their analysis of the IRP 2010–2030, highlight how the role of coal in the electricity plan has contributed to an increase in greenhouse gases, owing to an increase in coal mining due to export markets and long-term uncompetitive coal mining contracts. This has resulted in increased electricity prices for the country to cover the true costs of generation. The role of new IPPs and the extent to which they can compete for resources and have access to the grid, especially while there are other players with vested interests, remains doubtful, as some players have more access to and influence on government decision makers. The current national industrial demand is still based on fundamentally unaltered energy-intensive end-user practices. Despite changes in the generation mix, the 'uniquely electricity-intensive' nature of South Africa's coal-fired economic growth strategy has not changed.

To highlight the overall complexity of electricity planning, Baker et al. (2014) illustrate that an apparently technical exercise such as electricity modelling can be inherently political, thereby revealing the level of institutional power that traditional MEC stakeholders have, expressed as privileged access to decision makers, and the influential role that the regime incumbents continue to play in South African electricity policy making despite the incremental steps to enter the regime that have been taken by emerging renewable energy players and the nuclear industry. The next section presents an overview of the IRP as a complex system, thereby providing context to an approach that considers the two theories on complexity and electricity sustainability transition in its analysis, resulting in a conceptual framework based on the two theories.

3.3.4 The IRP as a complex system

Bale et al. (2015) refer to a complex system as typically adaptive or evolutionary and influenced by social, political economy and physical processes. They argue that energy systems can be understood as CASs in that they have interrelated, heterogeneous elements (agents and objects) with no autonomous control over a whole system, resulting in self-organised emergent behaviour that cannot be predicted by understanding each of the elements separately.

Energy systems further exhibit complex social and technological dynamics. From a complexity perspective,[14] energy systems are made up of agents interacting through networks under the influence of institutions, which gives rise to emergent properties and co-evolutionary dynamics. They include objects, such as technologies and infrastructures that are relatively stable in the short term but whose adoption is dynamic; the environment, which provides resources; and established social, political economy-based scenarios and cultural scenarios in which the energy system operates (Bale et al., 2015).

To highlight the overall complexity of electricity planning in South Africa, Table 3.1 presents each of the characteristics and drivers of complexity and then defines them in the South

[14] Zahariadis (2013) highlights that complexity has two dimensions: issue and institutional. Issue complexity refers to the number and nature of informational linkages and may be operationalised as the degree of information overload. Therefore, issue complexity is obviously a politically contestable concept whose value varies across actors, solutions and problems. Institutional complexity can be defined as the multitude of rules governing close interactions among a high number of structurally differentiated units across different organisational levels (Zahariadis, 2013).

African context of electricity planning. As a complex system, the IRP therefore represents a multiscale, self-organising, dynamic and adaptive complex electricity planning system for South Africa. It also shows a network of dynamic, non-linear interactions and self-organising agents, elements and subsystems involved in the IRP process in South Africa.

Table 3.1: Characteristics and drivers of complexity in South Africa's IRP process[15]

Characteristics and drivers of complexity	South Africa's IRP process
Agents	The agents involved in the IRP process include (but are not limited to): • Department of Energy • National Energy Regulator of South Africa • Technology developers and providers • National utility (Eskom) • Other government departments • Civil society • Non-governmental organisations • Lobby groups • Private sector • IPPs • Municipalities • End users (consumers).
Networks and elements	Some of the networks and elements include: • The IRP process as led by the Department of Energy • Eskom's role in the process in terms of lobbying, making input requirements, technical modelling and as a stakeholder • Civil society in the process: the influence it has as a stakeholder, inputs into the modelling process and decision making • Energy-Intensive Users' Group (EIUG) in the process: the influence it has as a stakeholder and in decision making, especially in the context of the MEC • South Africa's generation capacity: off-grid and grid-connected • Transmission network • Distribution network, including municipal networks • National Energy Regulator stakeholder processes

[15] Researcher's analysis of the IRP to define its complexity characteristics.

	• Energy modelling process: demand forecasts and technology choices based on costs, impacts and feasibility, including the influence of lobby groups in the decision-making process • National targets for climate change and carbon constraints on the plan • Alignment and coordination of the plan with other national strategic plans, especially with the NDP.
Dynamics	The dynamics of the agents and elements involved in the South African IRP process are non-linear and do not operate in equilibrium. South Africa's electricity planning system has changed structurally over time, with changing demand requirements, technologies and costs due to the agents and elements involved in the system.
Self-organisation	Decisions are taken at multiple levels. Therefore, each agent responds to changing environments, while each element within a system will self-organise and adapt to the changing environment.
Path dependency	Occurs in energy systems where the base load is generated through ageing infrastructure utilising non-renewable energy resources.
Emergence	Future electricity demand cannot be accurately predicted based on historical and current information because of the effect of multiple non-linear feedback due to new interactions or changed behaviours, especially by the South African economy, impacts of energy efficiency programmes, the introduction of IPPs within the electricity system, etc.
Coevolution	Each system coexists within the electricity system, competing for resources and survival. These include technologies selected for the IRP, government, Eskom, end users, lobby groups, energy-intensive users, energy efficiency programmes in place for electricity pricing and markets that coevolve.
Learning and adaptation	Some of the challenges that face the IRP are attributed to this trait, as the process has become too immersed in political economy dynamics.

Source: Developed by researcher based on Cilliers's (2000) characteristics and drivers of complexity

3.3.5 Electricity sustainability transition in South Africa

Despite the MEC, the green economy discourse since the onset of the global economic crisis in 2007/2008 as well as that on sustainability transition has gained momentum and generated a major discussion of the next wave of South Africa's development cycle (Swilling, Musango & Wakeford, 2015). Programmes are converging to force the issue of the sustainability of South Africa's electricity generation path. South Africa is already undergoing a transition from abundant electricity generation resources to restraint imposed by sustainability constraints, including the REIPPPP; wind energy programmes; participation in the United Nations Framework Convention on Climate Change's Clean Development Mechanism under the Kyoto Protocol; the Energy and Environment Partnership; the Industrial Strategy Action Plan II; the Department of Science and Technology Energy Grand Challenge; the South African Energy Research, Development and Innovation Strategy; the Renewable Energy Market Transformation Project; the assigning of carbon budgets to various energy-intensive sectors; the development of the Carbon Tax Policy process; and various environmental levies (Baker et al., 2014; Department of Energy, 2016). This transitional shift in policy development and implementation has been termed 'low-carbon growth' or 'transitioning to a low-carbon economy' (Winkler & Marquard, 2009).

The above examples illustrate that unlike the orderly and managed processes for electricity sustainability transition observed in some of the literature, the transition in South Africa has begun, but in an unstructured manner. In addition, it is also facing intense policy resistance with less contribution to sustainability goals (Baker et al., 2014). In this instance, sustainability transition refers to structural changes required for long-term and complex reconfigurations of technology, policy, infrastructure, scientific knowledge and social, political economic and cultural practices to ensure South Africa's sustainability goals. According to Swilling et al. (2015), sustainability transition can only be envisaged if the state facilitates a long-term structural transformation process resulting in socio-technical transition to more sustainable modes of production and consumption, with special reference to decarbonisation, resource efficiency and ecosystem restoration (Baker et al., 2014; Swilling et al., 2015).

3.4 Proposed conceptual framework for South African electricity planning

Baker et al. (2014) suggest that national electricity plans potentially afford an opportunity for precisely the kind of integrated goal-oriented management plan that sustainability transition literature encourages (Baker et al., 2014). According to the Department of Energy (2011), South Africa's governance process for developing the IRP consists of three major stages: (i) agreement on input parameters, (ii) modelling scenarios and analysis and (iii) development of the IRP, based on the outcome of the analysis.

In terms of stakeholder engagement and consultation, a two-phase approach is followed, which includes consultation on input parameters for the IRP modelling scenarios and analysis of and consultation on the favoured balanced scenario that becomes the draft IRP. Despite these consultations as part of its development process, the South African IRP as a strategic planning approach still faces persistent and complex challenges. The proposed conceptual framework (see Figure 3.2) is to be embedded in the existing key IRP process. It provides a governance-based approach to the existing South African strategic electricity planning process, taking into consideration South Africa’s MEC challenges, and it is aimed at focusing on learning, interaction, integration and experimentation on the level of society instead of policy alone. Independent facilitation of this framework will contribute to the success of the overall strategic IRP process.

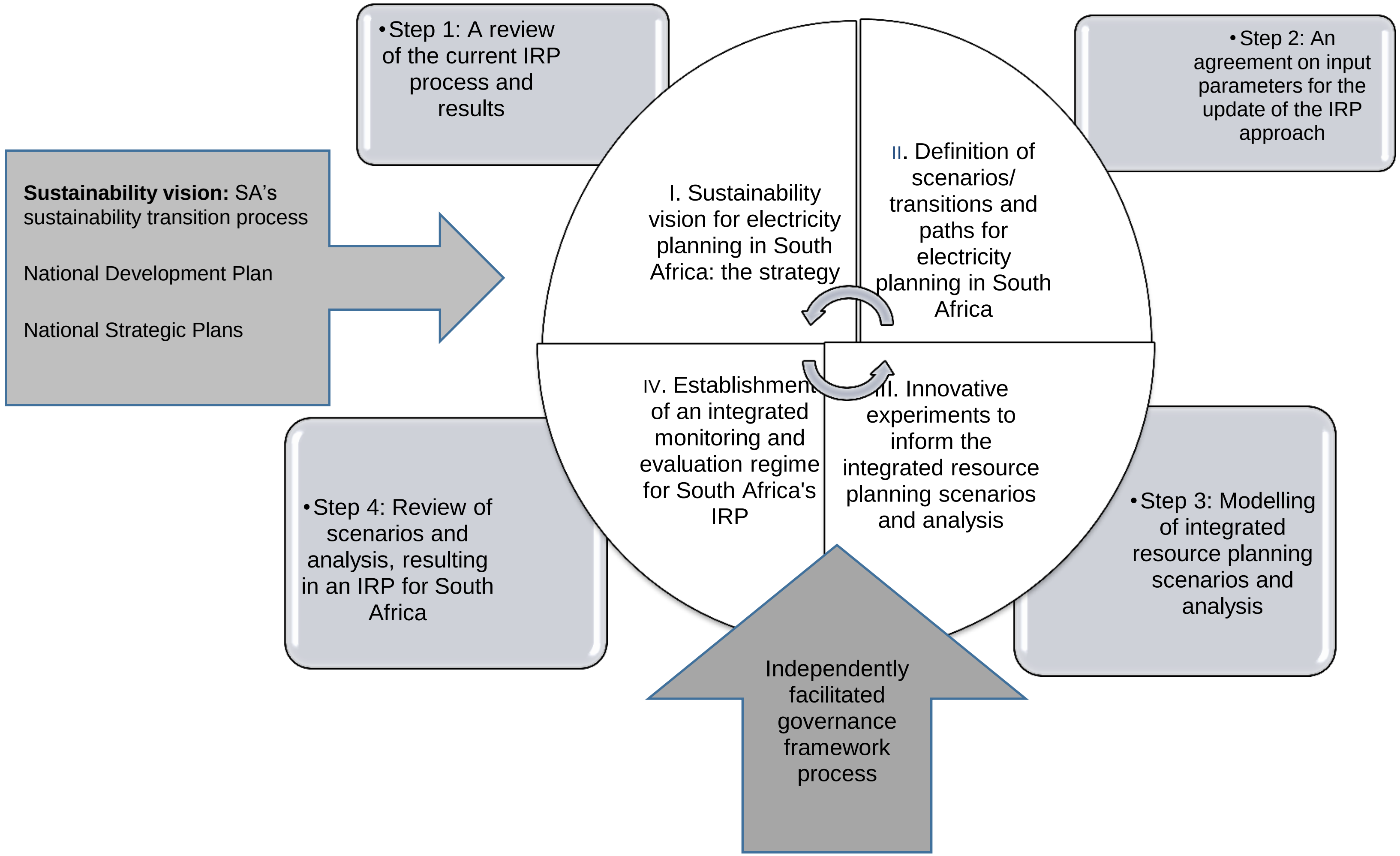


Figure 3.2: The conceptual electricity sustainability transition framework for South Africa

Source: Researcher's conceptualisation

Phase I: Sustainability vision for electricity planning in South Africa: the strategy: This level contributes to and form part of Step 1 of the IRP process. The South African sustainability vision should be defined as it relates to electricity planning in terms of the country's long-term NDP and other national strategic plans and policies (see tables 1.1 and 1.2). This level also focuses on the key electricity sector stakeholders with different backgrounds, within which the various perceptions of long-term planning and possible directions for sustainability transition can be deliberately confronted with one another and subsequently integrated. It is understood that stakeholders have different perceptions of South Africa's sustainability transition from their specific backgrounds and perspectives (e.g. national government, coal companies, private sector coalitions, business interests, Eskom and civil society). It is proposed that stakeholders should participate on a personal basis and not as representatives of their institutions or based on their organisational backgrounds. Loorbach (2010) proposes that stakeholders should be able to consider complex problems at a high level of abstraction. They should also be able to look beyond the limits of their own discipline and background to enjoy a certain level of authority within various networks and to establish and explain visions of sustainability within their own networks. They should moreover be willing to work in teams where there might be different views and should be open to innovation instead of already having specific solutions in mind.

During this process, the key stakeholders should be brought together to review the current complex persistent problems faced by the IRP overall development process and to define a sustainability vision to guide South Africa's electricity planning process. Ways and options for endogenising the IRP into the existing energy sector governance frameworks and overall electricity sustainability transition agenda should be defined by the stakeholders. This would include identification of all other national strategic plans with which alignment should be established. Furthermore, the aim of defining a sustainability vision will allow stakeholders to define short- and long-term objectives, action points, related projects and instruments to realise these objectives. This level can be utilised to contribute to and shape the IRP review process and its previous results.

Phase II: Definition of scenarios/transitions and paths for electricity planning in South Africa: This level contributes to and forms part of Step 2 of the IRP process, which focuses on data collection and updates of input parameters. As part of the latter, a consideration of current barriers (regulatory, institutional, economic, consumer routines, electricity supply and demand issues, physical infrastructures, cost of specific technologies and externalities) to planning will be prioritised. This level can be utilised to inform related scenarios for further exploration through developing transition scenarios based on South Africa's sustainability vision. Again, ways and options for endogenising the IRP into the existing governance frameworks and overall transition path should be explored by the stakeholders. This should also include an outline of how alignment with other national strategic plans should be established within the transition context. At this level, the stakeholders involved should have the capacity to 'translate' the defined electricity sustainability transition vision and its consequences to the transition agenda of their own constituencies.

Phase III: Innovative experiments to inform the integrated resource planning scenarios and analysis: This phase contributes to and forms part of Step 3 of the IRP policy development process. Here various strategic initiatives, projects and actions should be carried out to broaden and scale up existing and planned initiatives and actions, with the aim of practically contributing to setting feasible scenarios and elaborating required IRP analysis. The focus should be on scenarios in the context of defined electricity sustainability transition visions to ensure a clear portfolio of related transition experiments that complement and strengthen one another, which could also contribute to the electricity sustainability transition objectives, which could be significantly, scaled up and made measurable.

Phase IV: Establishment of an integrated monitoring and evaluation regime for South Africa's IRP: In this context, a review of scenarios and analysis, resulting in an IRP for South Africa, takes place. This phase can contribute to and forms part of Step 4 of the IRP process. At this level, the focus should be on reflecting collectively on the IRP process, considering all the previously mentioned challenges regarding improved governance of the IRP process while taking into consideration the role of the IRP in South Africa's electricity sustainability transition path, including future approaches towards the IRP approach to ensure its alignment with all related sustainability transition policies. The anticipated results should contribute directly to the reviewed IRP modelling and analysis processes, while also providing a consolidated process with clear direction on future monitoring and review processes, in this case the update process.

3.5 Summary

The chapter developed a governance-based electricity transition framework to facilitate alignment and endogenisation of the IRP as part of Sub-objective 2 of this study. To meet this objective, theoretical gaps in the current strategic integrated electricity planning process illustrated the need to rethink the current electricity planning approach theory and practice, with South Africa's IRP as case study. A combination of the strategic planning theory and theories on complexity and sustainability transition was reviewed, together with a focus on the TM framework approach as basis for managing the transitioning of current persistent societal governance problems facing the IRP, grounded in South Africa's MEC system. This conceptual transition framework defined South Africa's IRP as a CAS and proposed a complexity-based governance process approach to ensure alignment of different, competing, complex sustainability policy objectives within the electricity planning process, thereby leading to the endogenisation of the IRP approach into existing energy governance frameworks in South Africa, for example the IEP, which is also aimed at driving South Africa's transition path.

In addition, the proposal was to have the conceptual framework embedded in the existing IRP policy development process. It proposed four phases to be considered as part of the IRP approach. These include sustainability vision for electricity planning in South Africa, the strategy; the definition of scenarios/transitions and paths for electricity planning in South Africa; the definition of the sustainability vision for South African electricity planning, the definition of transition paths and scenarios for South African electricity planning, the innovative experiments to inform the integrated resource planning scenarios and analysis and the establishment of an integrated monitoring and evaluation regime for South Africa's IRP. Finally, this framework attempted to manage diverse and varied constituencies, including their associated coalition interest groups, which had led to complex and persistent problems of misalignment and poor coordination in South Africa. The next chapter evaluates the effectiveness and relevance of a governance-based electricity transition framework.

CHAPTER 4: TOWARDS IMPLEMENTING AN INTEGRATED ELECTRICITY SUSTAINABILITY TRANSITION FRAMEWORK WITHIN SOUTH AFRICA'S INTEGRATED RESOURCE PLAN PROCESS: A STAKEHOLDER PERSPECTIVE[16]

4.1 Introduction

The global transition towards a clean and sustainable energy future is well under way (Pfenninger, 2017). However, many technical, political and economic uncertainties remain, especially with regard to data and the models used to underpin policies aimed at energy transition (Pfenninger, 2017; Pfenninger et al., 2018). While these uncertainties urgently require open discussion, it is also important to highlight that energy strategies to support this global transition are based on research not open to scrutiny (Pfenninger, 2017). Pfenninger et al. (2018) further confirm that energy system planning is primarily closed, as it is pursued mostly by research institutions, government agencies and large, vertically integrated utilities with no obligation to reveal their modelling assumptions or methodologies. In addition, some of the reasons outlined for this 'secrecy' in energy system planning include business confidentiality, concerns about the security of critical infrastructure, a desire to avoid exposure and scrutiny, worries about data being misrepresented or taken out of context and the lack of time and resources (Pfenninger et al., 2018). As such, most assumptions, systems models and data used to determine energy policy cannot be verified, discussed or challenged, which has led to distrust in these processes (Pfenninger, 2017; Pfenninger et al., 2018).

Similarly, Martin (2016) affirms that energy planning, investment and power sector planning in South Africa are treated with high strategic value politically, economically and socially. Furthermore, the lack of transparency in the policy updates has been subjected to vocal and contested debate in the media and among ordinary South Africans. Both internationally and locally, the electricity sector operates within a dynamic environment where energy planning and regulatory and governance transitions are taking place. Domestic and global disruptive technologies, global megatrends and governance concerns are similarly challenging existing paradigms and long-term planning outcomes (Department of Planning, Monitoring and Evaluation & National Planning Commission, 2018).

It is in this context that the strategic IRP development, implementation and adoption have faced challenges (Mqadi et al., 2018a). In Chapter 2, the qualitative content analysis and literature review revealed that the IRP development, adoption and overall implementation planning process faced several challenges, and this had negatively contributed to South

[16] A journal paper has been prepared for submission to a peer reviewed Journal.

Africa's electricity sustainability transition agenda, and hence an electricity sustainability transition framework was introduced (Mqadi et al., 2018a). In Chapter 3, the need to apply and endogenise the integrated electricity sustainability transition framework into the existing overall IRP policy development, adoption and implementation planning process in South Africa was discussed. This resulted in a conceptual framework informed by literature on energy planning, complexity theory and sustainability transition theory, specifically the governance-based TM theoretical framework (Mqadi et al., 2018b). The knowledge gained in chapters 2 and 3 was then utilised to inform the process of answering the third research sub-objective of this study, namely to evaluate the implementation feasibility and relevance of the developed framework within the IRP approach, which was the focus of this chapter.

4.2 Methodology

This study was informed by the informed constructivist grounded theory, which is an abductive qualitative research method. Thornberg (2012) and Howard-Payne (2016) define abductive qualitative research as involving the selection or invention of a hypothesis that explains a particular set of data better than any other candidate hypotheses, while ensuring that the adoption of the hypothesis is not based on it being true, verified or confirmed, but as being a worthy candidate for further investigation. In addition, a researcher who uses abductive reasoning constantly moves back and forth between data and pre-existing knowledge or theories and makes comparisons and interpretations in the search for patterns and best possible explanations. Consequently, the informed constructivist grounded theory research method requires the researcher to address a set of common characteristics, which can be classified as theoretical sensitivity, theoretical sampling, treatment of the literature, constant comparative methods, coding, the meaning of verification, identifying the core category, memoing and diagramming, and the measuring of rigour (Mills et al, 2006; Thornberg, 2012).

According to Thornberg (2012), the informed constructivist grounded theory research method refers to a product of a research process as well as to the research process itself, in which both the process and the product have been thoroughly grounded in data by grounded theory methods, while being informed by existing research literature and theoretical frameworks. In addition, as a logical consequence, informed constructivist grounded theorists advocate recognising prior knowledge, literature reviews and theoretical preconceptions while subjecting them to rigorous scrutiny, thereby ensuring reflectivity and grounded reflexivity (Carmichael & Cunningham, 2017; Thornberg, 2012).

This research methodology was selected as it involves a focus on qualitative data analyses, concept labelling, categorising, identifying core categories, finding relations among categories and generating substantive theory or test theory from such relationships as a final result (Cho & Lee, 2014; Mayring, 2000). In terms of data analysis, the coding process[17] for the informed constructivist grounded theory uses three types of coding: open, focused and theoretical. During open coding, the researcher develops categories of information, while focused coding is a process designed to narrow down initial codes to frequent and important codes. Theoretical coding comprises a process used to find relationships between codes and categories, thereby merging concepts into themes or groups, and has the potential to result in a theory (Cho & Lee, 2014).

4.2.1 Research Design

For the purposes of this study, a case study research design was the framework which guided the use of abductive qualitative based research method and the analysis of the subsequent data. The next section focuses on the research methods utilised in this study.

4.2.2 Data collection

This study utilised an online survey, one-on-one interviews, a focus group discussion and content analysis as research techniques to collate data. Purposive sampling was utilised with a focus on specialists involved with sustainability transition, the electricity sector and specifically electricity planning in South Africa. Annexure A categorises the expertise of all the respondents/stakeholders who participated in the online survey, detailed one-on-one interviews and the focus group discussion. In addition, it should be noted that the respondents who provided views on the survey and those who participated in the study were specialists in their respective fields and therefore provided informed views on the challenges facing the IRP approach especially the governance thereof; international developments with regard to energy planning and system modelling; national policy and regulation developments, electricity modelling and pricing; project implementation, planning, monitoring and evaluation at city levels; energy research and development; the Eskom business model; IPPs; the restructuring of Eskom, etc.

Furthermore, Figure 4.1 provides the data-collection and data-analysis process for the informed constructivist grounded theory research method utilised in this chapter.

---

[17] Coding in qualitative inquiry is described as a word or short phrase that symbolically assigns a summative, salient, essence-capturing and/or evocative attribute to a portion of language-based or visual data. Coding may take place during and after collection as an analytic ploy (Saldaña, 2009).

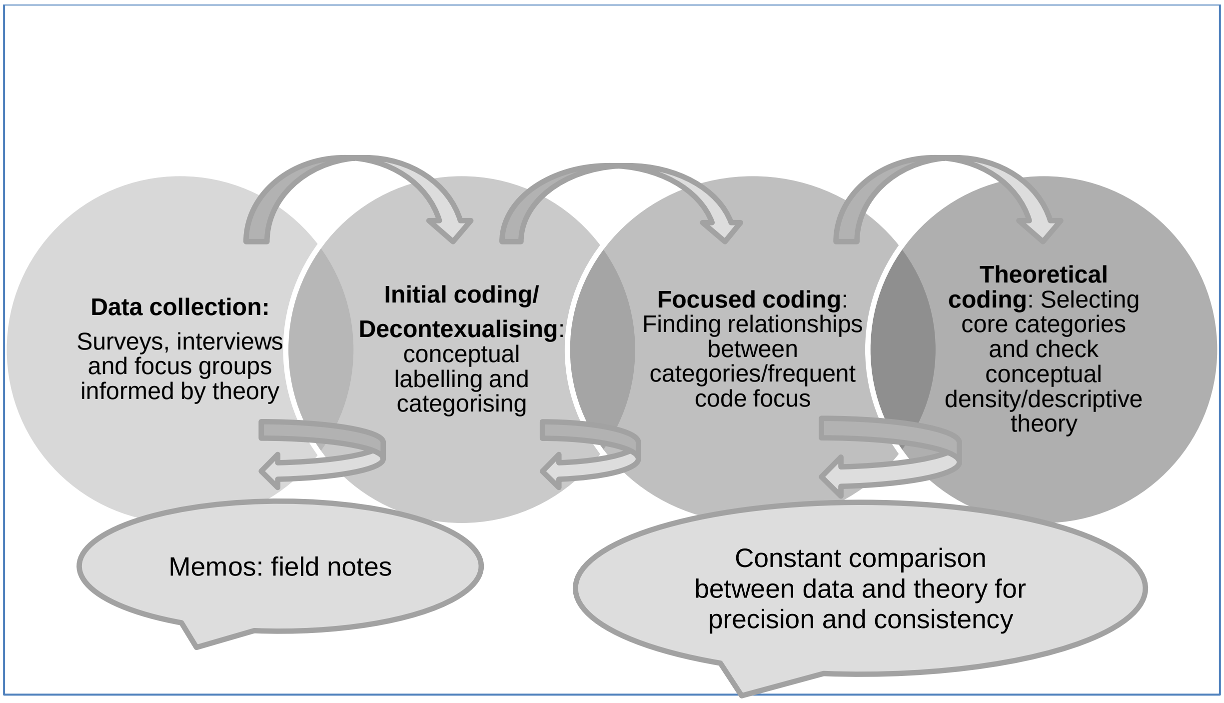


Figure 4.1: Data-collection and analysis procedure

Sources: Carmichael and Cunningham (2017), Cho and Lee (2014), Mayring (2000) and Thornberg (2012)

4.2.2.1 Online survey

An online Google form survey questionnaire was sent to 80 potential respondents in the fields of sustainability transition, the electricity sector and specifically electricity planning, those involved in the IRP process in South Africa, and those associated with electricity projects or activities. Forty-two responses were received from the respondents between November 2017 and March 2018. The specific questions posed to the respondents through the online survey are listed in Annexure B. The intent of the questions was to gather the respondents' views on the challenges facing the IRP planning process and on potential interventions to improve the IRP challenges, and their opinions on the feasibility and relevance of the proposed framework, and especially on the themes that comprise the conceptual framework.

4.2.2.2 Detailed one-on-one interviews

One of the questions in the survey requested the respondents to avail themselves for a detailed one-on-one interview to gather further detailed views. Of the 42 respondents, 18 of the respondents made themselves available for 30–45-minute recorded Skype calls. A copy of an e-mail sent to the 18 respondents is provided in Annexure C. Out of the 18 respondents invited for a detailed interview, 15 were eventually interviewed.

Annexure C of this study presents a list of the open-ended and closed questions posed to the experts. The semi-structured nature of the questions further allowed for deeper probing and exploration in terms of challenges facing the IRP planning process, and how the process could be improved, including whether the proposed conceptual framework themes could improve its development, adoption and eventual implementation. Monitoring and evaluation indicators were also discussed at length with the experts, including their personal professional experiences of the IRP updates and reviews, which further informed their views. All the responses during the detailed one-on-one interviews were recorded and transcribed.

4.2.2.3 Focus group discussion

One focus group discussion was held to review the feedback received from the online survey, detailed interviews and submissions made to the Department of Energy by various stakeholders. The focus group participants constituted of six energy researchers, energy engineers and energy planning modellers who had been involved in the development of the IRP process in South Africa, and who were currently involved with the National Planning Commission in terms of improving energy planning in South Africa, mainly from a research perspective. At this focus group meeting, additional views were gathered, which were informed by the conceptual framework. There was a discussion of the various categories and related relationships to further analyse and classify the data.

4.2.2.4 Submissions made to the Department of Energy

A review of all presentation submissions made to the Department of Energy (see http://www.energy.gov.za/IRP/irp-2016.html) was undertaken. This included submission presentations made in Bloemfontein (5), Mmabatho (3), Nelspruit (4), Polokwane (2), Kimberley (3), Durban (2), Port Elizabeth (3), Cape Town (20) and Gauteng (19). In each of the presentation submissions, an assessment in terms of challenges highlighted and intervention suggestions was made. It should be noted that not all presentation submissions provided challenges and/or interventions, as some provided insights in terms of how the IRP planning process, adoption and implementation could be improved, including study cases of and justification for certain technologies, for example nuclear or biomass.

4.2.3 Data-analysis process

The following research techniques were utilised to analyse and interpret the data with the aim to examine, inform and improve the feasibility and relevance of the proposed conceptual framework:

- Descriptive statistics, to summarise and analyse patterns of the coded categories
- Content analysis, to analyse documents with the aim of constructing emerging categories and themes

- Entering all focused coding results with categorised data into a word cloud generator that produced a figure with different-sized words or concepts. The size of each word in the figure depends on its frequency, that is, the number of times it appears. Therefore, the larger a concept or word appeared, the more that concept was repeated by various groups, indicating that it is of importance to the respondents.
- Coding, done as follows:
  - All the results of the online survey were initially coded in terms of challenges and potential interventions.
  - All the transcribed data were also initially coded in terms of challenges and potential interventions before they were combined with the online survey responses.
  - All the submissions were then initially coded in terms of challenges and potential interventions before they were combined with the online survey responses.

The coding process for the qualitative data was informed by the pre-existing knowledge based on the developed conceptual integrated electricity sustainability transition framework. As such, there was also a constant comparison between the data and the proposed conceptual integrated electricity sustainability transition framework during the data analysis for precision and consistency. In addition, initial and focused coding was utilised to identify prominent categories in the data collected that would inform conceptual framework themes. Table 4.1 provides an example of how the coding of qualitative data for sustainability transitions challenges facing the IRP approach in this study was done with initial coding, focused coding and eventual theoretical coding results.

Table 4.1: Data coding of online survey results

Sustainability transition challenges (initial coding)	**Sustainability transition challenges (focused coding)**	**Primary sustainability transition challenge categories (theoretical coding)**
Corruption and vested interests	Vested interests	Vested interests and political economy
Lack of information, lack of participation by relevant stakeholders, social and economic inequalities	Lack of information, stakeholders challenges	Stakeholder engagement
No integration and coherence throughout, conflicting policies, vested interests, no integrated vision and roadmaps	Vested interests, no integrated vision, no road maps	Policy and governance
Technologies viewed in isolation should take an energy-in and energy-out approach to fully understand impact on sustainability transition, vested interests and lack of trust of the data, the lifecycle view of technologies should be used as well to calculate the cost of decommissioning	Vested interests, lack of transparency, incorrect costing	Alignment
State capture, nuclear agenda, weak carbon emissions strategy	State capture, nuclear agenda, weak carbon emissions strategy	Vested interests and political economy
Lack of clarity and support for IRP outcomes is creating policy and investment uncertainty; vested interests of Eskom, coal and uranium mining industries are stalling development; corruption and a lack of transparency and accountability	Policy uncertainty, vested interests, no transparency and accountability	Policy and governance
A coal legacy that is ingrained in the DNA of energy production and employs thousands of people – how is it ‘shut down’, a lack of belief that renewables can provide baseload power, insufficient leadership in state organs to break the paralysis the above two cause and move forward, tough but correct decisions need to be taken and current leadership does not have the required skill and will	Political economy, issues on baseload, lack of leadership	Policy and governance
Coal displacement, management of legacy assets, lack of leadership	Political economy, lack of leadership	Vested interests and political economy

Source: Researcher’s conceptualisation

4.3 Findings and discussion

For this study, the conceptual framework proposes embedding a sustainability transition framework into the existing IRP planning process, implementation and adoption. It proposes an integration of a framework to guide the existing IRP approach and its update process. The conceptual framework comprised four main themes, namely:

- Integrating and institutionalising long-term policy and governance activities
- Encouraging innovation within the integrated resource planning scenarios and analysis
- Identifying the required stakeholder or interest-driven activities
- Monitoring, assessing and evaluating the IRP approach policies.

4.3.1 Participation in sustainability transition planning and the IRP planning process

To gain familiarity with the exposure of respondents to South Africa's sustainability transition planning[18] agenda and specifically the IRP approach, including its adoption and implementation, the online survey initially probed all the respondents in terms of their participation in these processes (see Figure 4.2).

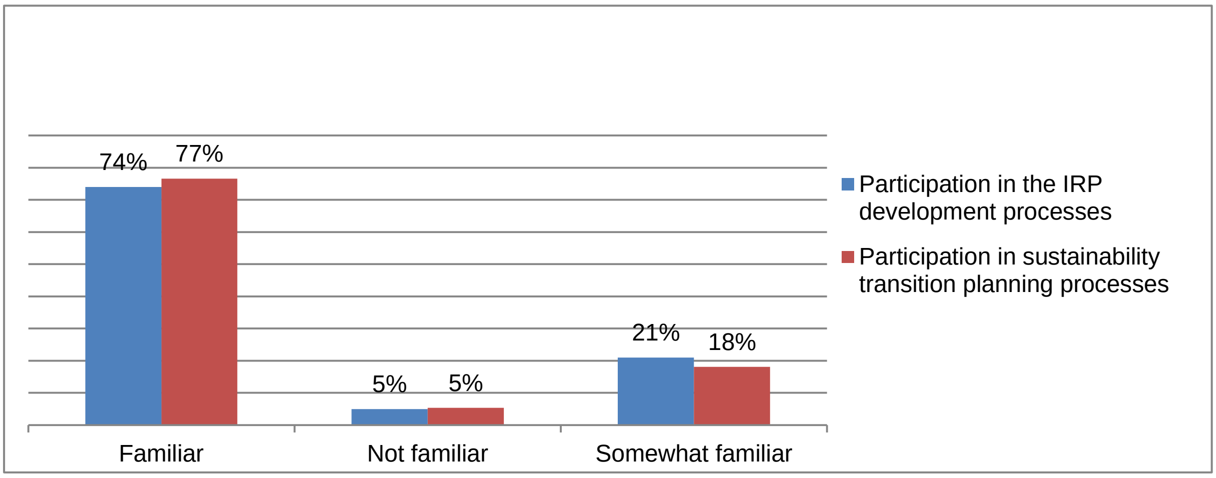


Figure 4.2: Participation in sustainability transition planning processes and the IRP development processes

Source: Researcher's conceptualisation

[18] Sustainability transition planning in South Africa refers to a set of policy processes that are aimed at fundamentally shifting its coal-based economy, including all related socio-technical systems, with far-reaching changes along different dimensions which may be technological, material, organisational, institutional, political, economic and socio-cultural (Energy Research Centre, 2013; Loorbach, 2010; Markard et al., 2016).

Of the respondents, 77% and 74% participated in both sustainability transition planning processes and the IRP development processes, respectively. This further provided context in terms of knowledge held by the respondents of sustainability transition underway in South Africa; how the IRP planning process, its adoption and implementation contribute to South Africa's sustainability transition agenda; and the overall IRP approach, including its associated challenges.

4.3.2 Categories emerging from data: Challenges and interventions

In terms of coding, that is, the focused coding of the respondents' views, the following categories emerged in terms of challenges and associated interventions. Table 4.1 provided an example of sustainability challenges and associated interventions coded as the following categories:

- **Category 1: Policy and governance:** This relates specifically to sustainability transition planning and the IRP planning processes in South Africa. In this instance, the respondents highlighted institutional arrangements; the lack of policy and governance to ensure that an independent institution with no commercial interest in the outcome of the IRP develops it; the lack of policy and governance to establish independent platforms to drive long-term scenario planning that would inform the IRP planning process; the lack of policy levers to drive implementation; and the lack of policy and governance to outline the future role of the electricity system, including the role of all spheres of government, especially in the generation and distribution of electricity in South Africa and within the region, including regional integration.

- **Category 2: Vested interests and the political economy:** This includes MEC issues that drive technology choices; dominance of certain stakeholders in the processes; role and bias of Eskom in the IRP development and implementation; issues on state capture and its impact on the adoption of the IRP and policy adjustment outcomes; and the roles of and fluctuations in various ministers, which affect the IRP process, its transparency and overall decision making.

- **Category 3: Stakeholder engagement:** This includes the impact of dominant stakeholders such as Eskom on the IRP planning process and specifically its implementation; lack of a platform to coordinate an ongoing dialogue between the relevant stakeholders, thereby ensuring a high level of transparency; and help with public support of the IRP planning process, its adoption and subsequent implementation.

- **Category 4: Alignment of overall policy processes and approaches:** This includes misalignment or lack of alignment of the IRP development and implementation process with other sustainability transition policies and plans at national and regional levels and lack of alignment of policies and regulation with the energy sector.

Additionally, specific IRP approach challenges and interventions in the context of sustainability transitions emerged and they were coded according to the following categories:

- **Category 5: Transparency of the IRP approach:** This includes lack of transparency in the actual IRP modelling process and assumptions made; technology costs and choices; the availability of open-source codes to allow for replication of the modelling process; lack of an independent review and benchmarking process to ensure technical credibility of the overall technological optimisation of the IRP process; transparency in the stakeholder engagement processes; and transparency during the policy adjustment process.
- **Category 6: IRP technical development:** This includes challenges of and interventions in the IRP modelling process, assumptions made, inputs, demand and supply forecasts, technology choices and costs, electricity pricing, establishment of annual updates required for the IRP and lack of IRP investment plans to support the long-term electricity transition targets for electricity planning.

4.3.3 Sustainability challenges facing the IRP approach in South Africa

Figure 4.3 reveals a snapshot of the following sustainability challenges: lack of policies and governance aimed at sustainability transition, the role of Eskom in the IRP policy development process and in the overall sustainability transition in South Africa, continued use of coal-based electricity and its role in sustainability transition, affordability and the role of renewable energy in sustainability transition, vested interests and political economy, leadership, policy integration and alignment.

Figure 4.3: Consolidated sustainability transition challenges

Source: Researcher's conceptualisation

Figure 4.4 indicates that sustainability transition challenges were due to lack of policy and governance (36%), vested interests and political economy (33%), non-alignment of policies (15%), lack of transparency (12%), and to a lesser extent, stakeholder engagement (4%). An emphasis on policy and governance as key to sustainability challenges was anticipated in the study owing to the state of the electricity sector in South Africa at the time of the study. This study was undertaken during the time when the country was going through the 'state capture' allegations, while Eskom was facing serious governance and corruption issues and its uncertain future role was still not being officially discussed from a policy and political perspective. Closely linked to issues of policy and governance were the issues of vested interests and political economy. As expected, issues raised in the state capture saga involved political discussions within government, as well as in Parliament. When the new president assumed his duties on 15 February 2018, one of the priorities was that of appointing new ministers for the departments of Energy and Public Enterprises, who would ensure that long-term electricity planning issues were addressed.

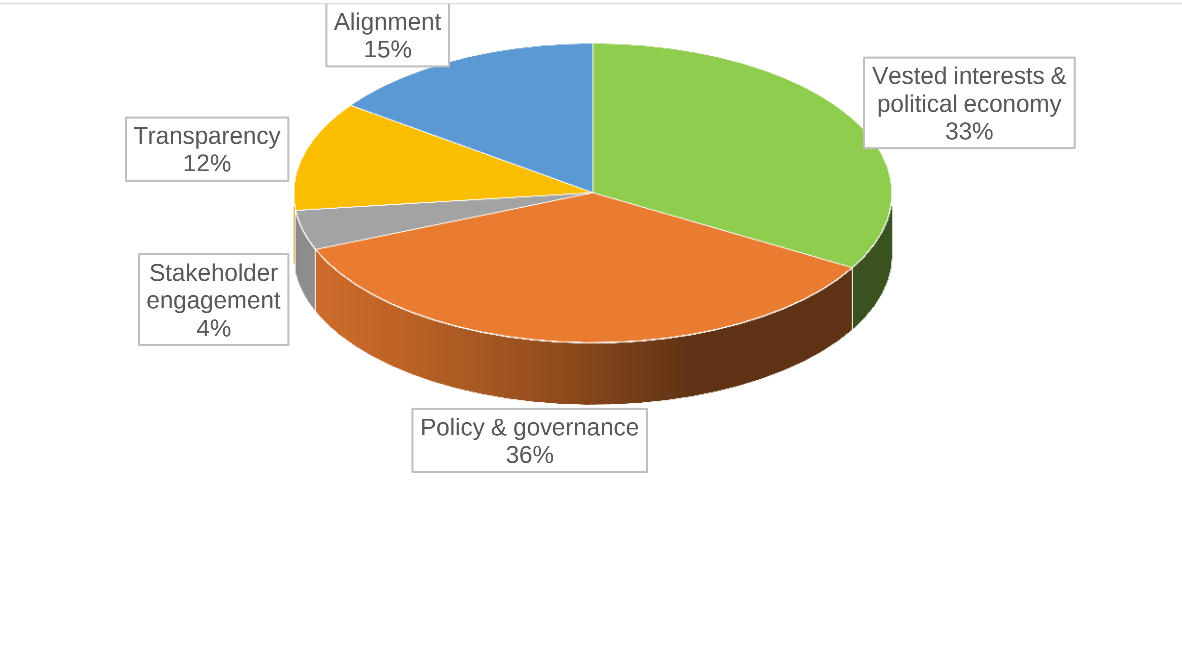


Figure 4.4: Analysed sustainability transition challenges

Source: Researcher's conceptualisation

In addition, linked to sustainability challenges, the respondents were specifically asked to provide their views on key issues regarding the IRP policy development process approach in the context of sustainability transition. The views on the following informed the proposed conceptual framework;

- The influence of the IRP on South Africa's sustainability transition vision
- The alignment of the IRP with South Africa's sustainability transition vision.

4.3.3.1 The influence of the IRP approach on South Africa's sustainability transition vision

Figure 4.5 shows that 67% of the respondents highlighted that the IRP approach indeed had an influence on South Africa's sustainability transition path, thereby further confirming its importance. This view can be attributed to the fact that most of the respondents were aware of the IRP policy objectives in the context of sustainability transition, while in terms of implementation, some of the projects emerging from the IRP were contributing directly to South Africa's transition, for example, the South African REIPPPP. However, 13% of the respondents did not agree on the influence posed by the IRP approach on South Africa's sustainability transition agenda owing to its current challenges and the Department of Energy's failure in ensuring the full adoption and implementation of the IRP in a transparent manner. Only 20% of the respondents viewed this as having moderate influence.

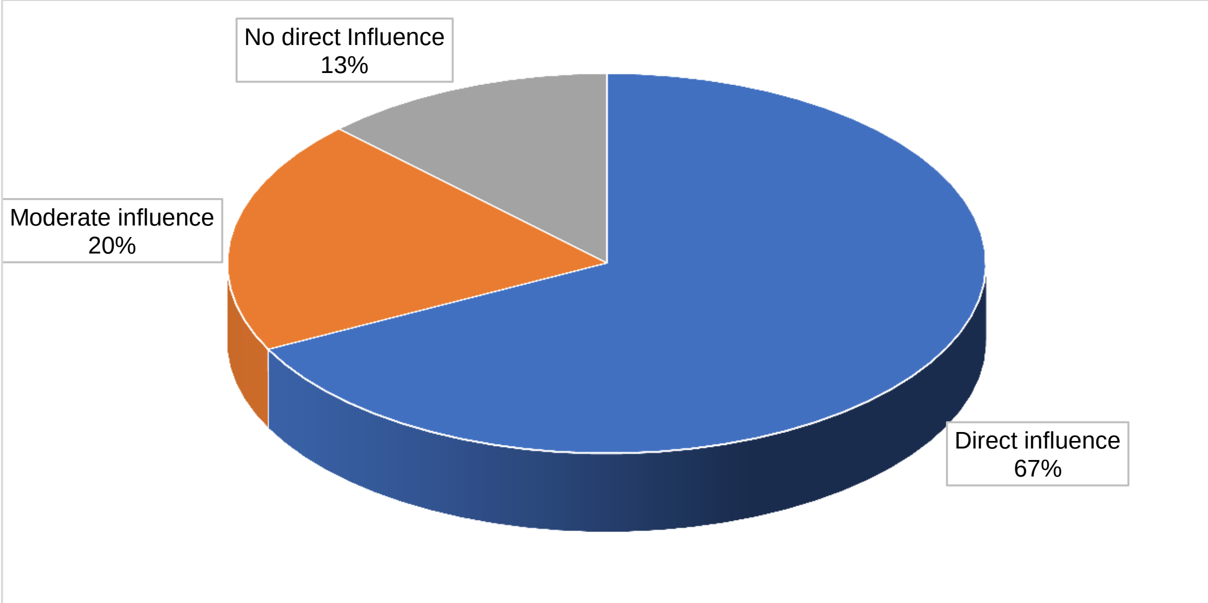


Figure 4.5: Influence of the IRP approach on South Africa's sustainability transition vision

Source: Researcher's conceptualisation

4.3.3.2 The alignment of the IRP approach with South Africa's sustainability transition vision

With reference to the current IRP approach being aligned with South Africa's sustainability transition vision, Figure 4.6 shows that only 20% of the respondents agreed that the IRP approach was aligned with South Africa's sustainability transition vision, while 24% of the respondents did not agree with this and still viewed the current IRP approach as not aligned with the sustainability transition agenda owing to its challenges. A high 56% of the respondents regarded it as moderately aligned, with room for improvement.

This lack of alignment could be attributed or linked to the lack of transparency within the IRP approach, which emerged from the data. For the respondents, this lack of transparency made it difficult for them to define it as aligned, as there was no clear process that illustrated how alignment with other relevant policies and plans was undertaken and considered by the IRP approach, including how updates and reviews were undertaken in this regard.

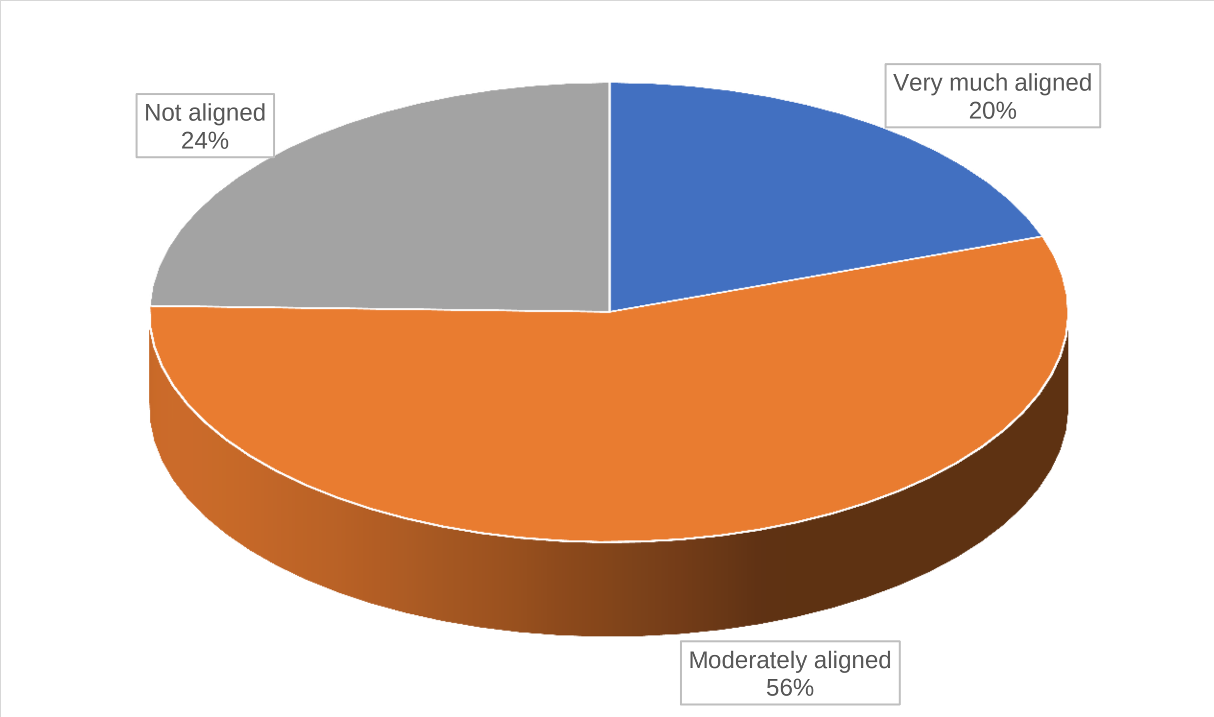


Figure 4.6: Alignment of the IRP approach with South Africa's sustainability transition vision

Source: Researcher's conceptualisation

Even though there was considerable agreement by the respondents on the influence of the IRP approach and alignment, there was still some perception of its lack (figures 4.5 and 4.6). These findings provided input into the proposed framework, whereby an insistence on transparent discussion on a sustainability vision for electricity to ensure the integration and institutionalisation of long-term policy and governance activities was prioritised. This would tackle the challenge raised on policy and governance in the context of sustainability transition (figures 4.3 and 4.4.). In addition, the aim of the inclusion of these themes was to ensure an increased direct influence by the IRP approach on South Africa's transition path, while ensuring alignment of the IRP approach with South Africa's sustainability vision.

To ensure the improvement of the views indicated in figures 4.5 and Figure 4.6, while taking into consideration the challenges illustrated in figures 4.3 and Figure 4.4, the conceptual framework was revised to include the following themes:

- Establishing a permanent high-level ETP to facilitate dialogue on overall electricity planning in South Africa, thereby ensuring transparent stakeholder engagement during the IRP approach
- Establishing an aligned sustainability vision for electricity sector planning

- Outlining transparency and governance requirements for transparent electricity planning.

The inclusion of these themes therefore confirmed the feasibility and relevance of these themes in guiding the IRP approach in South Africa.

4.3.4 The IRP approach in South Africa

Figures 4.7 and 4.8 represent challenges in the IRP approach. The indication was that the lack of transparency in the development of IRP was critical (25%); close to this was the IRP technical development (24%), followed by vested interests and political economy (17%), policy and governance (13%), stakeholder engagement (12%) and alignment (9%).

Figure 4.7: Consolidated IRP challenges

Source: Researcher's conceptualisation

Figure 4.8 highlights the strong views (25%) held on the transparency of the IRP policy development process and on IRP technical development (24%), which could be attributed to the assumptions made during the development of the IRP. These views further illustrate how the IRP approach has struggled to show how the following was undertaken:

- Inputs made into the plan in terms of forecasts and costs specifically
- The process of modelling itself and the timing of stakeholders' inputs
- Eskom's role in the development process
- Lobbying by stakeholders with vested interests in the outcomes
- Leadership during the development process due to frequent ministerial changes
- Independent evaluation of the process

- Leadership in ensuring transparency of the IRP planning process.

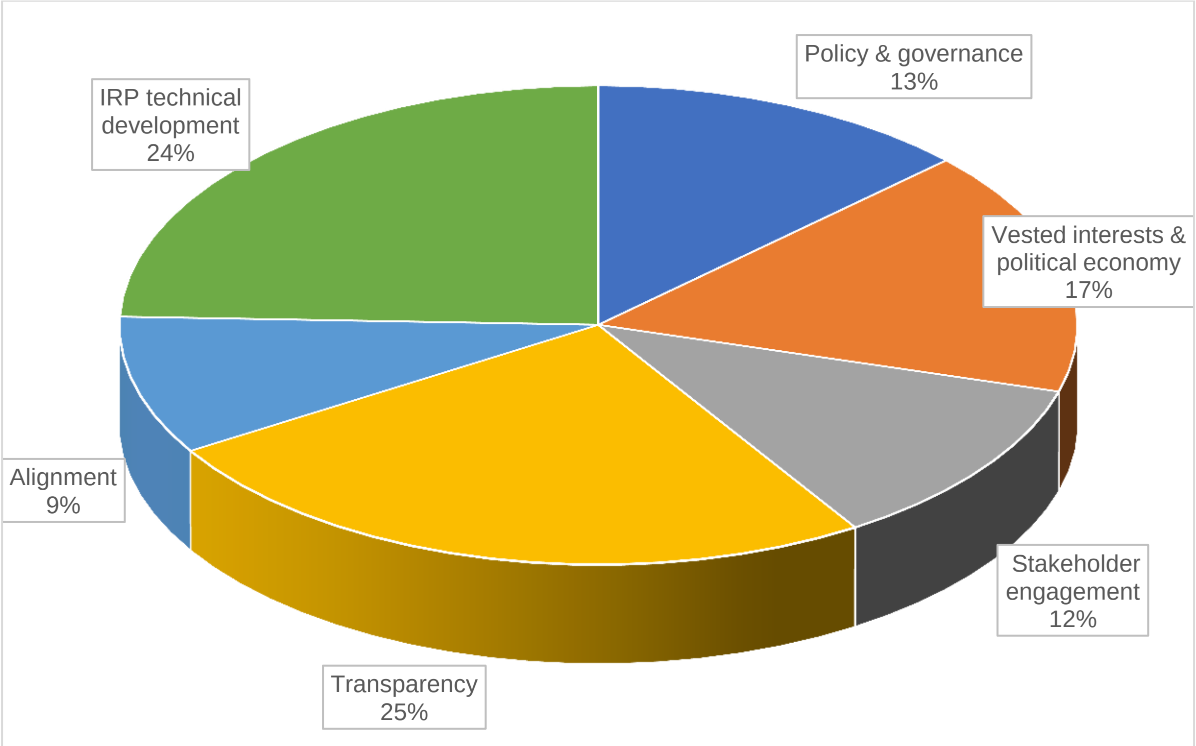


Figure 4.8: Analysed IRP development challenges

Source: Researcher's conceptualisation

Linked to IRP development challenges, the respondents were specifically asked to provide their views on key issues regarding the IRP policy development process approach itself. The views on the following informed the proposed conceptual framework:

- Transparency in developing the IRP approach.
- Feasibility of the IRP approach scenarios.

4.3.4.1 Transparency in developing the IRP approach

As shown in Figure 4.9, only 5% of the respondents viewed the IRP approach as a highly transparent in terms of inputs and assumptions, while 69% thought it was moderately transparent. The 69% moderate transparency can be attributed to the view by some respondents that at least there were platforms created by the Department of Energy to discuss these issues, while some of the studies were also publicly available on the Department of Energy's website, for example the CSIR demand forecast studies (Wright, Bischof-Niemz, Calitz, Mushwana, Van Heerden, & Senatla, 2017). In addition, the low percentage of respondents accrediting the IRP process as being highly transparent could be attributed to some of the respondents being involved in the development of the actual IRP or who had contributed to the development of some of the assumptions and input studies for the IRP. It should also be noted that the respondents had also stressed that transparency of the IRP approach in terms of inputs and assumptions was a very considerable challenge facing the overall IRP approach (figures 4.7 and 4.8). Therefore, any framework proposed for the improvement of the IRP approach had to illustrate how this would be tackled. The proposed framework therefore introduced themes that would focus on outlining transparency and governance requirements for transparent electricity planning and modelling of IRP scenarios, and overall monitoring and evaluation for electricity transition of the IRP approach.

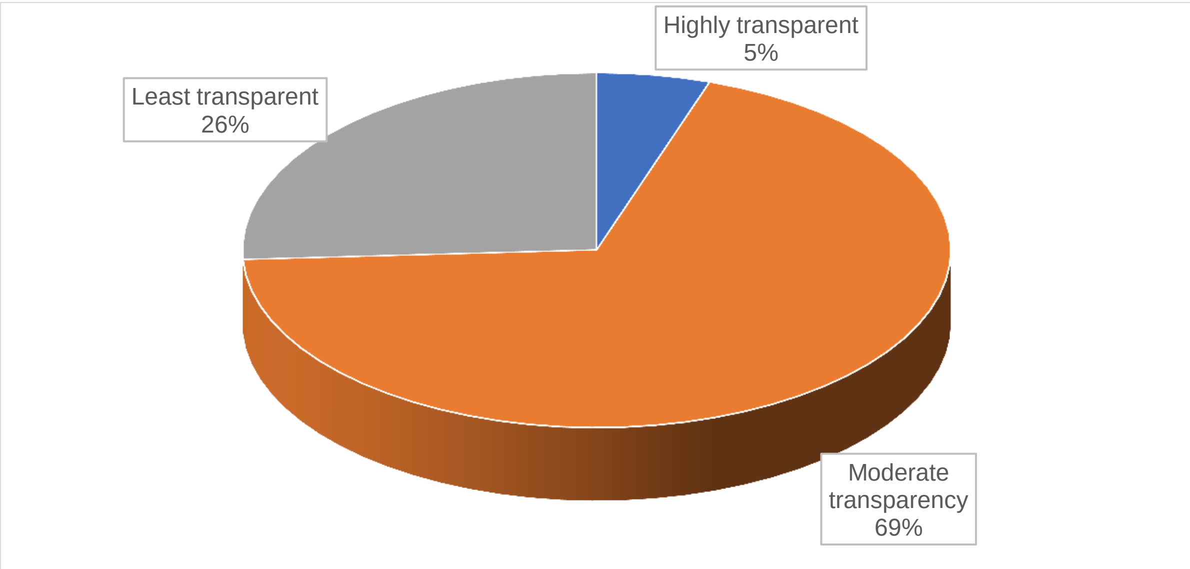


Figure 4.9: Transparency of inputs and assumptions in the IRP process

Source: Researcher’s conceptualisation

4.3.4.2 The feasibility of the IRP approach scenarios

Figure 4.10 illustrates that only 18% of the respondents confirmed the feasibility of the IRP development scenarios within the IRP approach, while 13% asserted that there was no feasibility at all, with the highest number of 69% highlighting the moderate level of feasibility in the IRP development scenarios within the IRP approach. Feasibility of the IRP development scenarios can be directly linked to the views highlighted in terms of transparency with regard to the inputs and assumptions of the IRP, as they form part and parcel of the scenarios forecasted during the IRP approach. In addition, the feasibility of the IRP scenarios spoke to the IRP approach and its contribution to South Africa’s sustainability vision, thereby outlining the various projected scenarios for the future of the electricity sector. With transparency and a sustainability vision being crucial in the development of IRP development scenarios, the proposed conceptual framework ensured that a theoretical theme focused on transparent modelling of IRP scenarios was introduced.

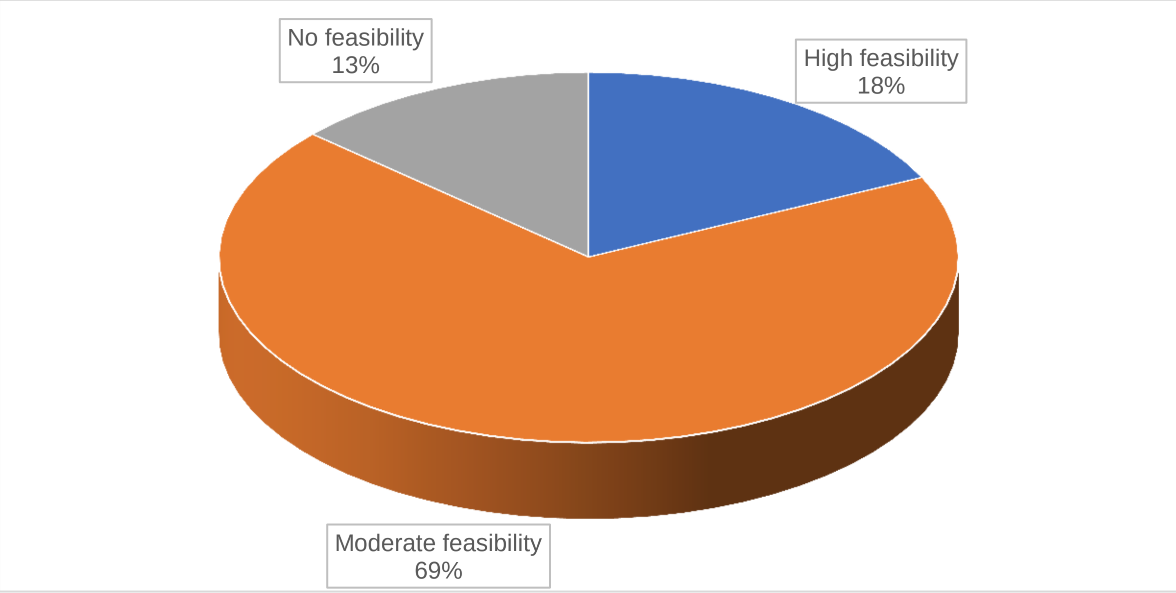


Figure 4.10: Feasibility of IRP development scenarios

Source: Researcher's conceptualisation

The insights provided by figures 4.7 to 4.10 were an input into the proposed framework. As a result, an inclusion of specifically the transparency safeguard as part of the overall IRP approach was also made priority. The framework was therefore made feasible and relevant by the inclusion of the following themes:

- Establishing a permanent high-level ETP to facilitate dialogue on overall electricity planning in South Africa, thereby ensuring transparent stakeholder engagement during the IRP approach.
- Outlining transparency and governance requirements for transparent electricity planning.
- Ensuring transparency in modelling IRP scenarios.

4.3.5 Proposed interventions for the IRP approach in South Africa

Figures 4.11 and 4.12 are analyses of proposed interventions. Indications are that policy and governance (32%) is the most critical, followed by IRP technical developments (22%), transparency (19%), stakeholder engagement (12%), vested interests and political economy (8%) and alignment (7%).

Figure 4.11: Consolidated proposed interventions

Source: Researcher's conceptualisation

Thirty-two per cent of the respondents advised that once policy and governance of the overall process were prioritised, alignment of policy and programmes would be a minor issue, while increased transparency and independence of the process would also address issues relating to vested interests and political economy. Good governance implies that policies are regularly reviewed and are transparent to the end users and other stakeholders.

This could be observed in the high percentage of the results, namely 32% and 19% respectively. The findings also reveal that the IRP technical development interventions (22%) were also critical. IRP technical development implies that the long-term plan has to have identifiable outputs, impacts and outcomes. This would require a clear monitoring and evaluation process. As a result, further views from the respondents were solicited on monitoring and evaluating the IRP approach (Figure 4.13).

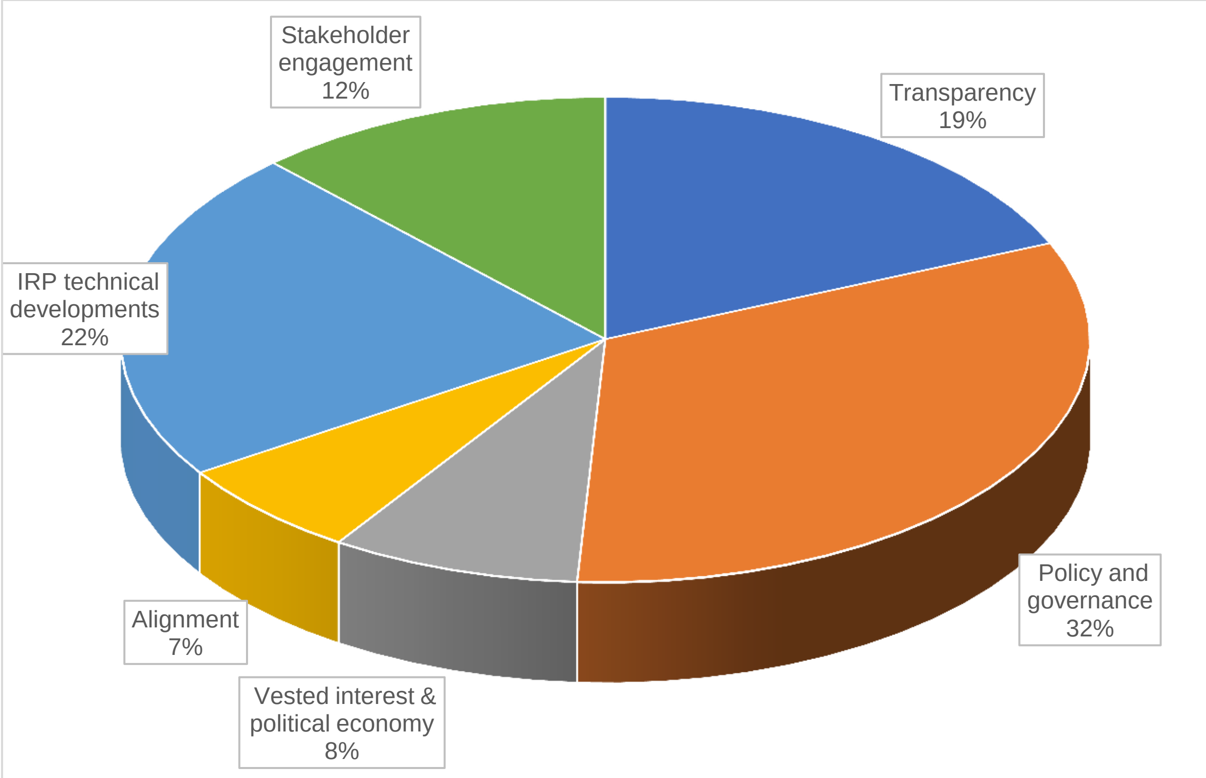


Figure 4.12: Analysed proposed interventions

Source: Researcher's conceptualisation

4.3.5.1 Monitoring and evaluation process for IRP approach review and update

In terms of the current monitoring and evaluation process to ensure a thorough review and update of the IRP approach, Figure 4.13 shows that only 12% of the respondents viewed the current process as having a fully established and highly transparent monitoring and evaluation theme, while 51% of the respondents provided a view that monitoring and evaluation were neither established nor transparent, thereby contributing to challenges facing the IRP approach. These views could be directly attributed to the fact that it had taken the Department of Energy approximately six to eight years to review and update the existing promulgated IRP, while during those six to eight years minimal implementation of the IRP had taken place. As a result, this view highlighted the need for a theoretical theme dedicated to monitoring and evaluation with clear guidelines or indicators to ensure the feasibility and relevance of the framework.

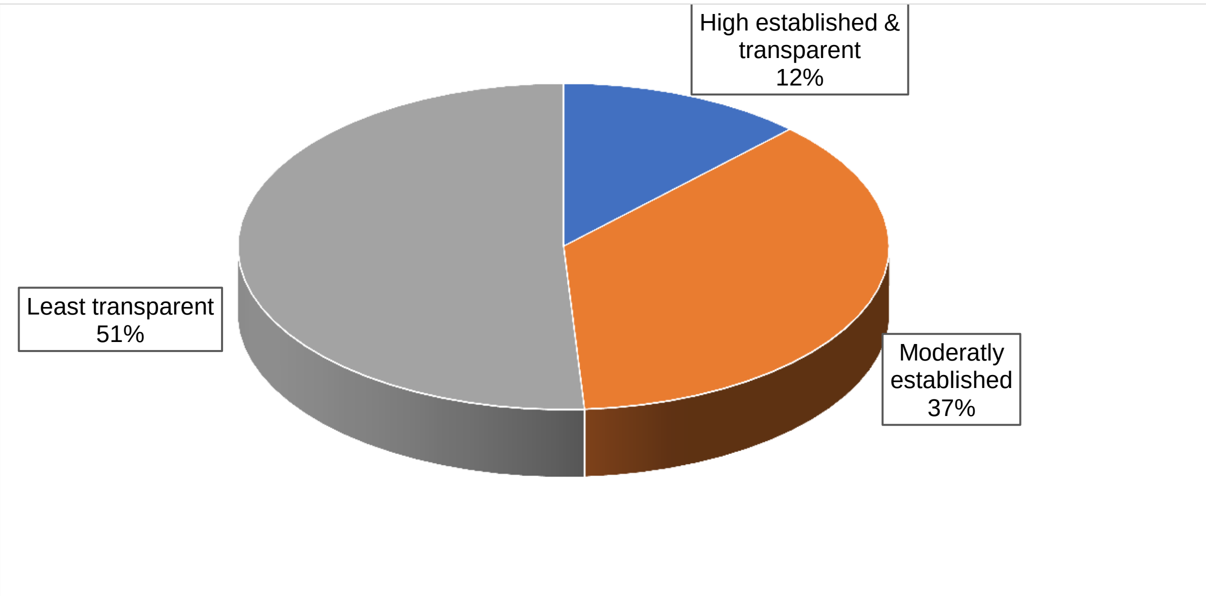


Figure 4.13: An established monitoring and evaluation process that ensures a thorough IRP review and update process

Source: Researcher's conceptualisation

The views on sustainability challenges, influence and alignment of the IRP approach issues, IRP approach challenges, transparency of the IRP approach including IRP scenarios and required interventions and views on monitoring and evaluation of the IRP approach provided inputs into the proposed framework.

This presentation of views was undertaken with an aim to critically discuss the results from the online survey, submissions made to the Department of Energy, the focus group discussion and detailed one-on-one interviews, while providing insights on how to improve the proposed framework, thereby examining its feasibility and relevance. The framework was therefore made feasible and relevant by the inclusion of the following themes:

- Establishing a permanent high-level ETP to facilitate dialogue on overall electricity planning in South Africa, thereby ensuring transparent stakeholder engagement during the IRP approach
- Establishing an aligned sustainability vision for electricity sector planning
- Outlining transparency and governance requirements for transparent electricity planning
- Ensuring transparency in modelling IRP scenarios
- Monitoring and evaluating electricity transition.

4.4 Recommended integrated electricity sustainability transition framework

In terms of energy governance, South Africa has a central energy planning paradigm in which a strategic energy planning framework is defined by an overarching IEP that informs resulting plans, roadmaps and policy. For the electricity sector, the IRP informs policy direction and resulting investments in the electricity sector. In terms of a business model, the electricity sector is a single-buyer model, with IPPs being contracted by a vertically integrated, state-owned company, complemented by municipal distributors; there is no wholesale (or retail) competition in the supply of electricity. In addition, there is no current promulgated IEP, while the existing promulgated IRP is more than six years old. Both drafts of the IEP and IRP were published by the Department of Energy in late November 2016 for public consultation (Department of Planning, Monitoring and Evaluation & National Planning Commission, 2018).

The Department of Energy's process for the update of the IRP has four key milestones: (i) settling the key assumptions, (ii) developing a base case (starting point), (iii) modelling and analysing the various scenarios and (iv) developing the final plan, considering the various scenarios and policy positions (Department of Energy, 2017).

It is against these milestones of the Department of Energy that during the detailed one-on-one interviews, the respondents further provided views on what the proposed framework should entail to make it feasible and relevant (see Annexure C). In terms of overarching views regarding the feasibility and relevance of this framework, the respondents highlighted how this framework should be multidimensional to be able to deal with all the fragmentation facing electricity transition in South Africa. International benchmarking of the overall transition approach was viewed by most respondents as key to providing solutions and driving electricity planning in South Africa. The UK, Australian, New Zealand, Chinese and South Korean models were noted by various respondents. Other respondents further highlighted these international benchmarking models to illustrate the flexibility of electricity planning, in some cases where a national plan was non-existent (e.g. Australia and New Zealand) but was being proposed, where a national plan was only available to provide guidance to policy and regulation (e.g. the UK), or where a long-term national plan was available to guide long-term policy and investments (e.g. China). Most of the respondents highlighted the importance of central energy planning in South Africa, especially for long-term infrastructure planning and investments, while others emphasised that the IRP should not inform all decision making or be prescriptive within the electricity sector, but should only be a point of reference for policy making. Views also focused on the role of the IEP as a "not well-run" process, which was detrimental to the overall energy planning process in South

Africa. Furthermore, with no promulgated IEP and IRP, the respondents highlighted that this led to inappropriate procurement decisions for the future, which might also lead to insufficient and inefficient energy and electricity services.

Other crucial plans mentioned by the respondents included the Transmission Development Plan, viewed as the key driver in long-term planning, especially for the inclusion of new IPPs; promotion of decentralisation, including the promotion of embedded generation; and new distribution centres, while ensuring current and future energy supply and access to meet the required demand and predicted demand.

Views on the long-term planning timeframes were also emphasised by the respondents; that is, the framework should provide a platform on ‘time-framing’ for long-term planning, which includes long-term scenario-based plans for the energy sector that would show the long-term direction and trends in line with the IEP. This long-term IRP would be a guiding document and not a binding document, and a short-to-medium term ‘investment plan’ that would prescribe in much more detail than the IRP what to do in the next five to eight years, that is, what to decommission, what to build, when, and potentially even where (i.e. grid and spatial aspects). A binding investment plan would be implemented in competitive auctions, therefore every year a new IRP process would be run, and each year would be added to the end of the five- to eight-year investment plan.

Other generic views provided by the respondents included the necessity of establishing a transparent platform for increased stakeholder engagement, with an established monitoring and evaluation process/indicators to address both sustainability transition challenges and IRP planning process challenges. Furthermore, a monitoring system for overall electricity transition was suggested, with the IRP implementation process being part of it, as this would allow a transparent review of the implementation progress and ensure that all long-term, medium-term and short-term transitions and IRP developments targets were met, including whether additional action was required. Views further emphasised the necessity of independent monitoring stakeholder experts who would only provide scientific opinion on the overall monitoring process. Furthermore, regarding the IRP approach governance challenges, the respondents emphasised the need for a focus on transparency in the development of the IRP. The respondents also emphasised the importance of a reliable process that applied the principles of least-cost augmented quantitatively, with the relevant dimensions identified up front as part of the reliable and transparent process.

The respondents also focused on the required institutional arrangements for electricity transition and long-term planning, which focused on the increased role of the National Planning Commission. The next section outlines how each of the themes of the proposed framework can be embedded in the existing IRP approach with the aim of driving electricity transition and intervening in all the related outlined challenges.

To initiate the process and implementation of this electricity sustainability transition framework, a permanent high-level ETP, led by the National Planning Commission and the Department of Energy, would be set up to facilitate the overarching dialogue to drive South Africa’s electricity transition policy planning process. This platform would oversee and coordinate dialogue between the relevant stakeholders on South Africa’s electricity transition and short- to long-term planning requirements for electricity planning within the IEP context to further ensure alignment and transparency and assist in gathering public support for and creating public awareness of South Africa’s electricity transition.

Figure 4.14 presents a framework that has been tested for its feasibility and relevance through the views gathered from various respondents who participated in the study. The framework is aimed at enabling the IRP approach to contribute, influence and align with South Africa’s electricity sustainability transition vision, with clear targets and priorities for the country.

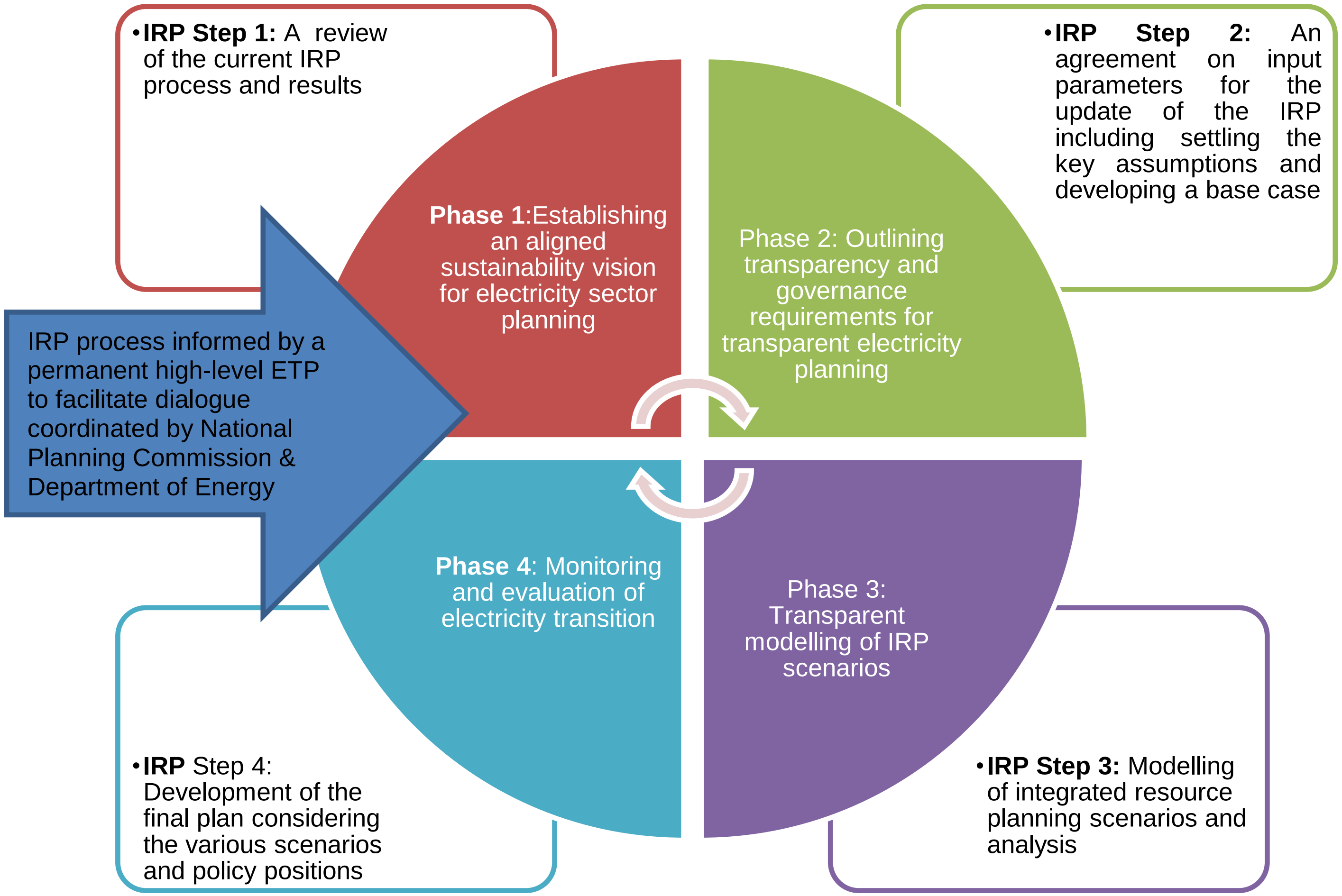


Figure 4.14: The recommended electricity sustainability transition framework for electricity planning in South Africa

Source: Researcher's conceptualisation

Phase 1: Establishing an aligned sustainability vision for electricity sector planning

During this phase in the IRP approach, the sustainability vision and long-term planning structure for South Africa should be defined. During this phase, the ETP should ensure that clear objectives and targets for the sector are set in line with the country's sustainability vision and other national plans, for example energy efficiency targets. Targets would be long-term and high-level (in line with the country's international pledges, where applicable), for example "95% universal electricity access by 2030".

During this phase, all long-, medium- and short-term scenarios to inform the national planning vision, the IEP and specifically the IRP should be discussed. There would be a focus on institutional arrangements during this phase. This would include the establishment of independent IRP policy development experts/developers, IRP approach reviewers and independent monitoring experts. An agreement on the timelines specifically for the IRP approach would be set with clear targets and priorities. A review of previous IRP challenges would also be dealt with during this phase to prevent repetition and provide long-term solutions. During this phase, stakeholders could also highlight all the required electricity regulatory reforms and legislative changes.

Phase 2: Outlining transparency and governance requirements for transparent electricity planning

Views from the respondents suggested that during this phase, the ETP should ensure extensive stakeholder engagement to ensure that a transparent debate on key assumptions and the IRP base case process could be held. This should include differentiation in terms of long-term vision on electricity planning, medium-term investment plans, and annual revisions and updates. The ETP would also be required to provide governance guidelines to ensure that all input data model codes and results summaries are publicly shared and published timeously for all stakeholders prior to the modelling process.

Phase 3: Transparent modelling of IRP scenarios

Views from the respondents suggested that during this phase, the results from phases 1 and 2 should be presented to inform all related modelling of the integrated resource planning scenarios, while consideration of all IRP technical challenges raised during the review process (Phase 1) is done. The ETP would ensure that all the technical work is done by an independent stakeholder entity with no commercial interests in the energy sector, which is technically capable and well equipped. Again, in this phase, all the technical work would have to be 100% open source; this would include the final model input assumptions, the model source code and all model outputs. The respondents in the study highlighted the importance of socio-economic implication assessments for each technology choice made as part of the proposed framework, including a focus on the direct supplier, indirect and induced job creation potential, greenhouse gas emissions, water usage and other identified externalities not already accounted for. These implication assessments could then be included in planning process outcomes to inform policy discussion and adjustments.

In addition, views from the respondents suggested that the ETP should ensure that all the technical work is reviewed for technical correctness by independent parties, preferably by a group of independent national, regional and international experts simultaneously, with the publication of all input data, technical modelling and scenario outcomes. A discussion of the output of the model scenarios and analysis will have to take place at ETP level after completion of all the reviews.

Phase 4: Monitoring and evaluation of electricity transition

During the detailed one-on-one interviews, the respondents provided views on indicators/guidelines that can be utilised to guide the monitoring and evaluation of electricity transition and all themes of the framework. The indicators include the following:

- Reliability of supply issues
- Environmental impacts
- Socio-economic impacts
- Costs (where cost is the objective function)
- Representation of stakeholders
- Transparency of the processes
- Policy and governance to safeguard issues of vested interests and political economy
- Alignment of the IRP with all other national strategic integrated plans
- Effectiveness of an established and transparent monitoring and evaluation process that ensures a thorough review and update of the IRP.

According to the respondents, the abovementioned indicators could drive all the related modelling themes within the IRP planning process from a techno-economic perspective. In addition, it is envisioned that the results of the modelling scenarios can then be reported on a number of additional themes, such as trade balance implications, job numbers in the different scenarios, ease of implementation, technology choices and costs, and localisation. These would further be part of the full description of ‘a scenario’, so that the various stakeholders at ETP level and policy makers can get a holistic view of the possible implementation scenarios and be enabled to make appropriate decisions.

Lastly, a proposal for an annual monitoring report, in conjunction with the IRP approach, was made to continuously drive the electricity transition process in South Africa. This monitoring report would be issued through the ETP by an independent commission of experts, who would provide a scientific opinion on the monitoring report. This report would highlight the status of electricity transition in South Africa, including the urgent requisite adjustment to the existing IRP policy implementation process, defining the scope for deeper IRP or long-term electricity planning analysis, identifying new trends and further providing the status on long-term goals for South Africa. Lastly, this monitoring and evaluation process would also be aimed at rating progress on the IRP approach while ensuring that all emerging challenges are addressed as part of the policy planning process.

4.5 Summary

The chapter considered the IRP approach to guide South Africa's electricity sustainability transition. An informed constructivist grounded theory research method provided a basis for qualitative data collection and analysis. Various research techniques were utilised to collate and analyse the empirical evidence from specialist respondents. As a result, views on sustainability transition challenges, IRP challenges, sustainability transition and the IRP and proposed interventions were solicited from the respondents involved with sustainability transition and electricity planning in South Africa. The respondents highlighted an overall challenge of policy and governance in addition to the specific IRP technical development and transparency challenges. These challenges triggered the need for interventions geared towards them, hence the recommended integrated electricity sustainability transition framework. The next chapters focuses on the synthesis and theoretical contribution of the study, key insights from the results, the limitations of the study and recommendations for future research.

CHAPTER 5: CONCLUSIONS AND CONTRIBUTIONS OF THE STUDY

5.1 Introduction

This chapter starts by outlining and restating the research objective and its sub-objectives of this study with the aim of examining if the research objectives have been achieved. It further elaborates on how each of the research objectives has been answered through research efforts. Thereafter, the contributions this research has made to new knowledge are given.

In more details, to respond to the first research objective namely; "To examine governance challenges facing the strategic IRP approach", qualitative system dynamics research method as described in Section 2.5 has been applied. Knowledge gained in Chapter 2 is used as described in Section 3.3 to respond to the second objective namely; "To develop an integrated electricity sustainability transition framework to facilitate alignment and endogenisation of the IRP approach". Lastly, a an informed constructivist grounded theory as described in Section 4.2 to respond to the third research objective namely; "To evaluate the implementation feasibility and relevance of the developed framework within the IRP approach".

5.2. Research objectives of this study

The overall objective of this study was to examine how a sustainability transition framework can be conceptualised to address the challenges facing strategic integrated electricity planning aimed at low carbon electricity transitions in South Africa. This was achieved through the following sub-objectives:

i. To examine governance challenges facing the strategic IRP approach
ii. To develop an integrated electricity sustainability transition framework to facilitate alignment and endogenisation of the IRP approach
iii. To evaluate the implementation feasibility and relevance of the developed framework within the IRP approach.

The IRP approach is a complex system faced with several political economy dynamics that have led to some policy resistance in terms of its development, adoption and overall implementation. As such, this policy resistance has contributed negatively to South Africa's electricity sustainability transitions agenda. Further, this study has confirmed that current solutions merely deal with symptoms rather than the root causes.

5.2.1 Research objective 1

This research objective has been achieved through the utilisation of a qualitative system dynamics research method to examine challenges facing the IRP approach in South Africa. In terms of qualitative system dynamics, Sterman (2001) confirms that system dynamics seeks endogenous explanations for phenomena, with endogenous referring to “arising from within”. As such endogenous theory generates the dynamics of a system through the interaction of the variables and agents represented. In supporting this view, Richardson (2011) confirms that the foundation of system dynamics is its endogenous point of view which is also very pertinent for organisational learning. In this context, qualitative system dynamics through causal loop diagrams have examined how complexity (mainly governance) challenges facing the IRP approach have led to further policy resistance in terms of adoption and implementation which has negatively impacted South Africa’s electricity transitions (i.e. electricity generation from coal). Section 2.8 provides details on these findings. The IRP’s current symptomatic solution has been identified and defined as the continued review and update of the IRP by the Department of Energy. Thus, this has been the case with the IRP updates of 2013, 2016 and the latest in 2018.

As a result, a fundamental solution, an integrated sustainable electricity transitions framework has been proposed to address the complexity challenges facing the IRP approach to ensure positive contribution of the IRP approach towards South Africa’s electricity transitions which is the main research objective for this study. This framework is directly aimed at dealing with the governance challenges facing specifically the IRP approach whilst facilitating its alignment and endogenisation in South Africa’s low carbon electricity transitions. To further meet this research objective of this study, the defined governance challenges (See Section 2.7), highlight the need for a sustainability vision to inform the integration and institutionalisation of strategic electricity planning to ensure low carbon electricity transitions, a focus on the transparency and openness towards IRP scenarios utilised in the IRP approach, a new role for stakeholders to ensure the introduction of various strategic initiative, projects and actions and a requirement for monitoring and evaluation could solve and streamline some of the key issues within IRP approach process.

5.2.2 Research objective 2

This research objective has been achieved through the utilisation of qualitative content analysis and literature review research method (See Section 3.3.) focused on sustainability transitions approaches, a review on complexity and sustainability transitions, South Africa's political economy, the MEC within the context of strategic planning specifically the IRP as a complex system within South Africa's electricity transitions context. This review resulted in a focus on the Transitions Management Framework approach as basis for managing the transitioning of current persistent societal governance problems facing the IRP approach, grounded in South Africa's political dynamics facing the electricity sector defined in Section 2.7 and Section 3.6 of this study. Research objective 1 outcomes thus informed the development of the conceptual sustainable electricity sustainability transition framework for South Africa presented in (Figure 3.2).

A conceptual sustainable electricity sustainability transition framework for South Africa proposes a complexity-based governance process approach to ensure alignment of different, competing, complex sustainability policy challenges within the electricity planning process, thereby leading to the endogenisation of the IRP approach into existing energy governance frameworks in South Africa, for example the Integrated Energy Plan and the National Development Plan, which are both also aimed at driving South Africa's transition path.

5.2.3 Research objective 3

Lastly, to respond and achieve the 3rd research objective, namely; "to evaluate the implementation feasibility and relevance of the developed conceptual framework" in Figure 3.2. As part of this evaluation, through empirical research, governance challenges facing strategic IRP process have been revisited. It is on this basis that interventions were proposed by respondents. In this context the conceptual framework has then been revisited and improved resulting in a recommended electricity sustainability transition framework for electricity planning in South Africa (Figure 4.1.4) thus confirming its implementation feasibility and relevance.

In terms of governance challenges facing strategic IRP, through an online survey, one-on-one interviews, a focus group discussion and qualitative content analysis of submission made to DOE, empirical evidence has been collated whilst an informed constructivist grounded theory research method have been utilised to further assess collated data on challenges and associated recommended interventions for IRP approach in South Africa. In terms of the findings, firstly, the respondents have highlighted an overall challenge of policy and governance in addition to the specific

IRP technical development and transparency challenges respondents as the main challenges facing the IRP approach in South Africa.

Aligned to overall policy, governance and transparency challenges, respondents have highlighted institutional arrangements; the lack of policy and governance to ensure that an independent institution with no commercial interest in the outcome of the IRP develops it; the lack of policy and governance to establish independent platforms to drive long-term scenario planning that would inform the IRP planning process; the lack of policy levers to drive implementation; and the lack of policy and governance to outline the future role of the electricity system, including the role of all spheres of government, especially in the generation and distribution of electricity in South Africa and within the region, including regional integration.

With regards to specifically IRP technical development and transparency challenges, respondents highlighted; the lack of transparency in the actual IRP modelling process and assumptions made; technology costs and choices; the availability of open-source codes to allow for replication of the modelling process; lack of an independent review and benchmarking process to ensure technical credibility of the overall technological optimisation of the IRP process; transparency in the stakeholder engagement processes; and transparency during the policy adjustment process. Other challenges focused on the IRP modelling process, assumptions made, inputs, demand and supply forecasts, technology choices and costs, electricity pricing, establishment of annual updates required for the IRP and lack of IRP investment plans to support the long-term electricity transition targets for electricity planning.

Other overarching challenges highlighted by respondents included vested interests and the political economy dynamics. This includes Mineral Energy Complex (MEC) issues that drive technology choices; dominance of certain stakeholders in the processes; role and bias of Eskom in the IRP development and implementation; issues on state capture and its impact on the adoption of the IRP and policy adjustment outcomes; and the roles of and fluctuations in various ministers, which affect the IRP process, its transparency and overall decision making. Others included challenges on the lack of elaborate stakeholder engagement and misalignment or lack of alignment of the IRP development and implementation process with other sustainability transition policies and plans at national and regional levels and lack of alignment of policies and regulation with the energy sector.

All these views from respondents on sustainability challenges, influence and alignment of the IRP approach issues, IRP approach challenges, transparency of the IRP approach including IRP scenarios and required interventions and views on monitoring and evaluation of the IRP approach provided inputs into the improvement of the conceptual proposed framework resulting in "A recommended sustainable electricity sustainability transition framework for South Africa" (Section 4.4).

Through the recommended framework, this study has therefore been able to achieve its overall objective namely; "how a sustainability transition framework can be conceptualised to address the challenges facing strategic integrated electricity planning aimed at low carbon electricity transitions in South Africa".

5.3 Contributions of the study

Firstly, in Section 2.6, this study contributed to the examination of challenges facing the IRP approach in South Africa, while exploring potential opportunities that could be utilised to better understand the complexity challenges, including potential interventions. In this context, different ways in which public policy development dynamics and associated politics impact could contribute to the governance of electricity sustainability transition were reviewed. As a result, this study contributed to the assessment of strategic integrated long-term planning and specifically the public policy development process dynamics and associated politics aimed at electricity sustainability transition in South Africa.

Secondly, in Section 2.8, this study utilised qualitative system dynamics (See Figure 5.1), specifically CLDs. Although several studies are familiar with systems dynamics, none include the causal relations and feedbacks existing within the electricity sector, electricity transitions, long-term planning and the IRP approach in South Africa, including how these relations and feedbacks might be addressed through a system dynamics approach. As a result, qualitative system dynamics was the proposed dynamic systems approach that could guide the process of examining governance challenges facing strategic integrated long-term electricity planning in South Africa.

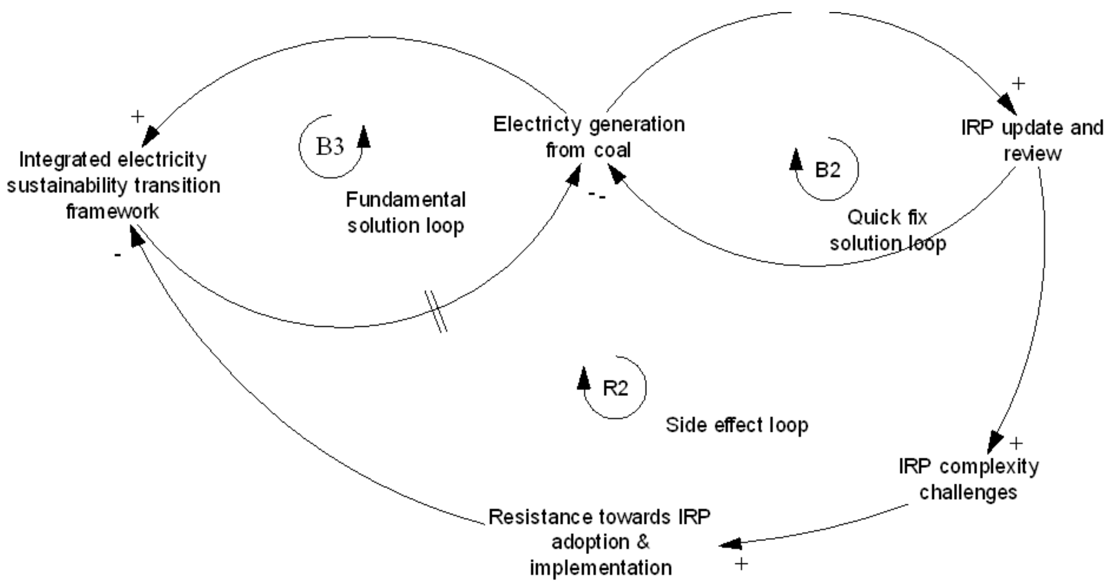


Figure 5.1: Qualitative system dynamics contribution: IRP approach governance challenges and the need for an integrated sustainable electricity transitions framework

Source: Researcher's conceptualisation

Thirdly, the examined governance challenges facing the IRP approach identified the need for:

i. A sustainability vision to inform the integration and institutionalisation of strategic electricity planning to ensure low carbon electricity transitions,

ii. A focus on the transparency and openness towards IRP scenarios utilised in the IRP approach,

iii. A new role for stakeholders to ensure the introduction of various strategic initiative, projects and actions and a requirement for monitoring and evaluation could solve and streamline some of the key issues within IRP approach process.

As a result, in Section 3.4, this study contributed to the development of a conceptual framework, termed the electricity sustainability transition framework for South Africa, to address these challenges with an aim to improve IRP approach so that it could contribute positively towards low-carbon electricity transition in South Africa. (See Figure 5.2).

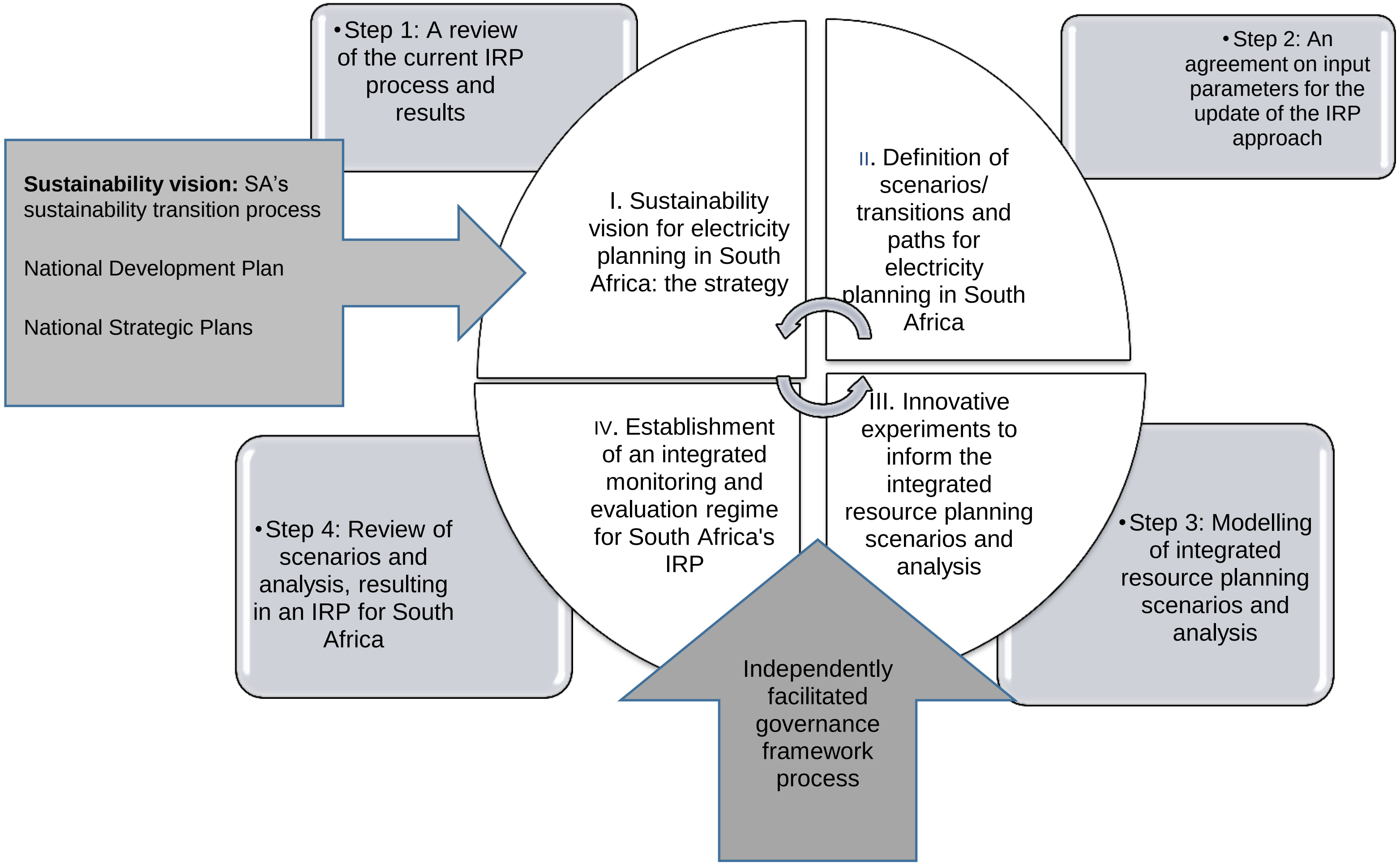


Figure 5.2: The conceptual electricity sustainability transition framework for South Africa

Source: Researcher's conceptualisation

The conceptual electricity sustainability transition framework for South Africa comprises of four main “Phases” aimed at directly responding to initial governance challenges highlighted through research objective 1. These phases include:

- **Phase 1 of the conceptual framework**: Sustainability vision for electricity planning in South Africa which focuses on integrating and institutionalising long-term policy and governance activities aimed at low carbon electricity transitions. This level also focuses on the key electricity sector stakeholders with different backgrounds, within which the various perceptions of long-term planning and possible directions for sustainability transition can be deliberately confronted with one another and subsequently integrated.
- **Phase 2 of the conceptual framework:** Encouraging innovation within the integrated resource planning scenarios and analysis. This level can be utilised to inform related scenarios for further exploration through developing transition scenarios based on South Africa’s sustainability vision. This should also include an outline of how alignment with other national strategic plans should be established within the transition context. At this level, the stakeholders involved should have the capacity to ‘translate’ the defined electricity sustainability transition vision and its consequences to the transition agenda of their own constituencies.
- **Phase 3 of the conceptual framework:** Identifying the required stakeholder or interest-driven activities. Here various strategic initiatives, projects and actions should be carried out to broaden and scale up existing and planned initiatives and actions, with the aim of practically contributing to setting feasible scenarios and elaborating required IRP analysis.
- **Phase 4 of the conceptual framework:** Monitoring, assessing and evaluating the IRP approach policies. This phase focuses on the establishment of an integrated monitoring and evaluation regime for South Africa's IRP approach. The anticipated results should contribute directly to the reviewed IRP modelling and analysis processes, while also providing a consolidated process with clear direction on future monitoring and review processes, in this case the update process.

Fourthly, in Section 4.2, this study utilised an informed constructivist grounded theory, which is an abductive qualitative research method for data collection and data analysis. Although several studies are familiar with an informed constructivist grounded theory, as far as the researcher is aware, very few have utilised this research method in a South African context within the electricity sector to examine challenges facing the IRP approach in South Africa including its associated political dynamics including how these challenges may be addressed through a recommended governance based electricity sustainability transitions framework.

Fifthly, in Section 4.4, to further make an empirical theoretical contribution, empirical evidence was collated to evaluate the feasibility and relevance of the conceptual integrated electricity sustainability transition framework. This was undertaken to improve and inform the proposed conceptual framework. As a result, a theoretical construct and proposition of a policy and governance-based electricity sustainability transition framework is recommended in Figure 5.3.

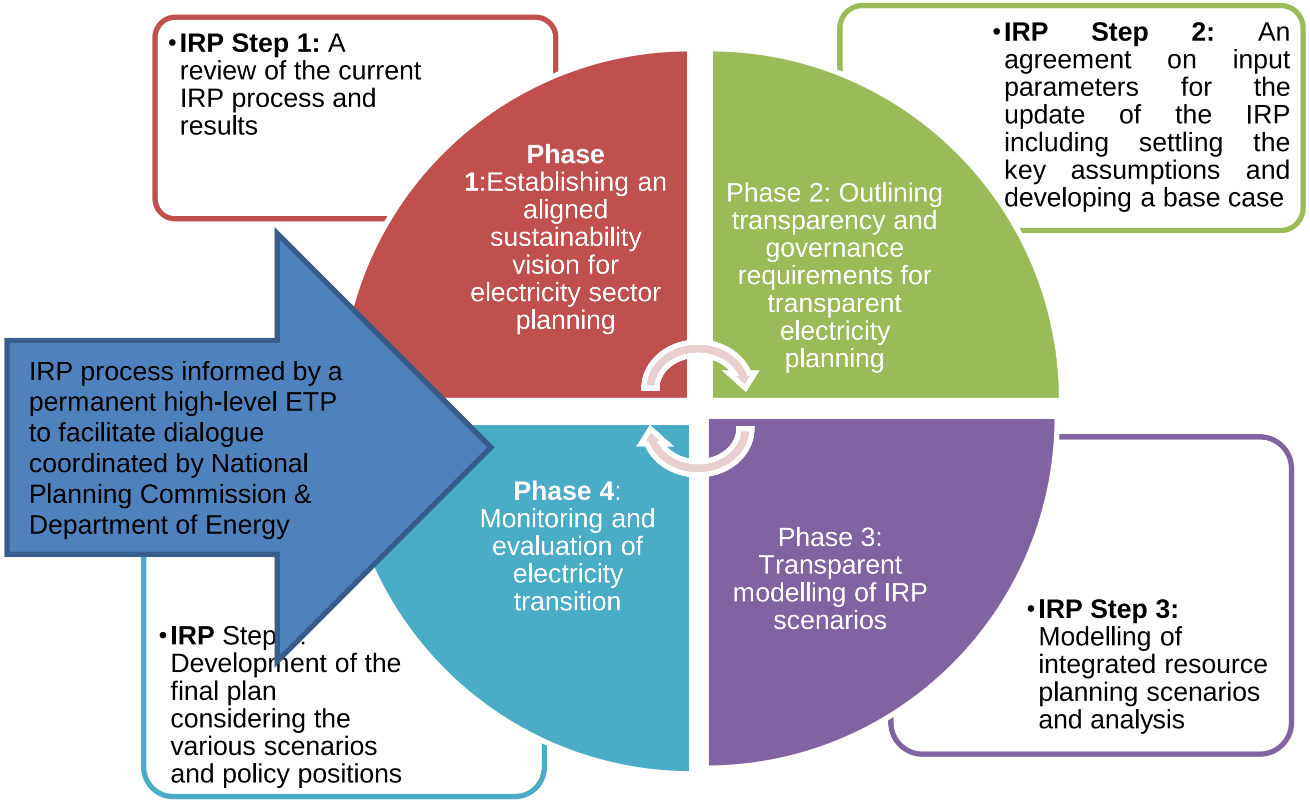


Figure 5.3: The recommended electricity sustainability transition framework for electricity planning in South Africa
Source: Researcher's conceptualisation

This recommended electricity sustainability transition framework for electricity planning in South Africa proposed the inclusion of the following framework themes to be embedded in the existing IRP approach to further ensure implementation feasibility and relevance of the proposed conceptual framework:

Phase 1 of the Recommended framework: Establishing an aligned sustainability vision for electricity sector planning: During this phase in the IRP approach, the sustainability vision and long-term planning structure for South Africa would be defined. Also, during this phase, all long-, medium- and short-term scenarios to inform the national planning vision, the IEP and specifically the IRP would be discussed. A review of previous IRP challenges would also take centre stage.

Phase 2 of the Recommended framework: Outlining transparency and governance requirements for transparent electricity planning: During this phase the ETP should ensure extensive stakeholder engagement to ensure that a transparent debate on key assumptions and the IRP base case process could be held including differentiation in terms of long-term vision on electricity planning, medium-term investment plans, annual revisions, updates and further provide governance guidelines.

Phase 3 of the Recommended framework: Transparent modelling of IRP scenarios: During this phase, the ETP would ensure that all the technical work (on 100% open source basis) is done by an independent stakeholder entity with no commercial interests in the energy sector, which is technically capable and well equipped. A focus on the socio-economic implication assessments for each technology choice made as part of the proposed framework, including a focus on the direct supplier, indirect and induced job creation potential, greenhouse gas emissions, water usage and other identified externalities not already accounted for would be deemed necessary. Lastly, the ETP would lead all discussions of the output of the model scenarios and analysis.

Phase 4 of the Recommended framework: Monitoring and evaluation of electricity transition: During this phase, the use of the following indicators would be deemed necessary as they would drive all the related modelling themes within the IRP planning process from a techno-economic perspective:

- Reliability of supply issues
- Environmental impacts
- Socio-economic impacts
- Costs (where cost is the objective function)

- Representation of stakeholders
- Transparency of the processes
- Policy and governance to safeguard issues of vested interests and political economy
- Alignment of the IRP with all other national strategic integrated plans
- Effectiveness of an established and transparent monitoring and evaluation process that ensures a thorough review and update of the IRP.

An annual monitoring report through the ETP focusing on progress made, assumption updates and all emerging governance related challenges are dealt with, with an aim to continuously drive the electricity transition process in South Africa would also be important. In terms of comparisons between conceptual framework and the recommended, firstly, the recommended framework has been made feasible and relevant firstly by the inclusion of the:

i. Establishment of a permanent high-level ETP to facilitate dialogue on overall electricity planning in South Africa, thereby ensuring transparent stakeholder engagement during the IRP approach.

Also, by confirming and by adding the following phases to the conceptual framework, the implementation feasibility and relevance of the developed conceptual framework was confirmed by this study:

i. Establishing an aligned sustainability vision for electricity sector planning. During this phase in the IRP approach, the sustainability vision and long-term planning structure for South Africa should be defined.
ii. Outlining transparency and governance requirements for transparent electricity planning.
iii. Ensuring transparency in modelling IRP scenarios.
iv. Monitoring and evaluating electricity transition

Lastly, through the recommended electricity sustainability transition framework for electricity planning in South Africa, this study has made a practical contribution through empirical evidence towards the improvement of the IRP approach in South Africa and has contributed to the sustainability transition body of knowledge in the context of public policy and policy governance processes in South Africa. It also specifically contributes to the body of knowledge on electricity sustainability transition in South Africa as specified in Section 4.4 of this study.

CHAPTER 6: SUMMARY OF RESEARCH FINDINGS, IMPLICATIONS AND FUTURE RESEARCH OPPORTUNITIES

6.1 Summary of research findings

The key research findings aimed at achieving the overall objective of this study, namely; "to examine how a sustainability transition framework can be conceptualised to address the challenges facing strategic integrated electricity planning aimed at low carbon electricity transitions in South Africa" are presented in this section.

A first research finding for this study is that through system dynamics, the study revealed that the resistance towards the IRP approach and the related IRP challenges, represented by a reinforcing loop, emphasised the system's inability to achieve its objectives with the quick-fix solution. The IRP's current quick-fix solution or symptomatic solution, namely the review and update of the IRP by the Department of Energy, and the proposed fundamental solution, each formed a 'balancing' loop with the problem symptom, as the main plan was to transition from primarily coal-based electricity generation (or a current electricity business model in South Africa). Further, the analyses highlighted that current solutions merely dealt with symptoms rather than the root cause of the IRP challenges. This further highlighted the need to focus on a long-term fundamental solution, namely a proposed conceptual integrated electricity sustainability transition framework. In addition, the proposed conceptual potential intervention would influence and improve the challenges facing the IRP approach, including its governance process. These results established a hypothesis that illustrated that resistance to IRP development, adoption and overall implementation due to various challenges had contributed negatively to South Africa's electricity sustainability transition agenda.

A second key research finding for this study revealed theoretical and practical gaps that required South Africa to rethink its current integrated strategic electricity planning practice, while considering the country's socio-political economy. As a result, this study proposes a planning approach intervention that could be incorporated into the existing IRP approach as a way of building capacity for addressing the complexities (both historical and current) of and gaps in the electricity sector specifically. The conceptual framework provides a platform for informed decision making to further develop and implement future strategic plans and, specifically, future electricity IRPs. Further, it supports the endogenisation of long-term electricity planning processes and outputs into South Africa's energy policy frameworks, associated institutional governance processes and the overall South African electricity transition agenda.

A third research finding for this study was that views from stakeholder specialists were collated, thereby allowing for a more holistic understanding of the IRP approach challenges. Furthermore, specific views on the proposed conceptual framework themes and the required interventions to tackle the challenges with an aim to evaluate implementation feasibility of the proposed conceptual framework were collated. From the process of analysing the responses from the stakeholder specialists, six categories emerged:

- Policy and governance challenges and potential interventions
- Vested interests and political economy challenges and potential interventions
- Stakeholder engagement challenges and potential interventions
- Challenges and potential interventions in terms of transparency in policy processes and approaches
- Alignment-related challenges and potential interventions
- IRP technical development challenges and required interventions.

Utilising the above categories, the following were the most important findings:

a) Contribution of the IRP to sustainability transition in South Africa

The IRP approach considers a full range of power sector investments to meet the new demand for electricity, not only in new generation sources, but also in transmission, distribution and, importantly, demand-side measures such as energy efficiency on an equal basis. The IRP plans use long-term (20–30-year) planning horizons and include careful consideration of risk. Best practice IRPs integrate environmental and other external costs and benefits (Electricity Governance Initiative of South Africa, 2013; Energy Research Centre, 2012). It is also important to note that when done properly, the IRP approach provides a structure and an opportunity for utility systems and stakeholders to learn and to develop plans in a co-operative atmosphere. Ultimately, better decision-making processes result in power plans being more closely aligned with societal goals. The findings of this study (based on the views of 67 of the respondents) were that the IRP approach indeed had an influence on South Africa’s sustainability transition path, thereby further confirming its importance. However, the study indicated that while a few of the respondents (20%) were convinced that the current IRP approach was aligned to the sustainability transition agenda, 56% of the respondents regarded it as moderately aligned with room for improvement. The study further confirmed that while the comprehensive IRP approach required a comprehensive assessments and analysis, it would also lead to better outcomes, namely lower-cost electricity, lower risk from price volatility and lower sustainability challenges.

b) Sustainability challenges in South Africa

The findings revealed that the sustainability transition challenges were largely affected by policy and governance as well as vested interests and political economy (36% and 33%, respectively). An emphasis on policy and governance as key to sustainability challenges was anticipated in the study owing to the state of the electricity sector in South Africa at the time of the study. In 2011, South Africa's first IRP for the electricity sector was promulgated following a prolonged and contested consultation process throughout 2010. This plan anticipated that renewable energy will constitute 20% of installed generation capacity by 2030, which would deliver approximately 9% of electricity supply. In addition, coal would retain the greatest share alongside a potential yet uncertain nuclear fleet. Baker (2016b) states that despite the creation of a successful renewable energy 'niche', the coal-fired 'regime' is also being reinforced and the electricity mix under analysis is fuelling an unsustainable trajectory of production and consumption. The findings in this study therefore confirmed the importance of good governance for sustainability transition.

c) IRP approach challenges

The findings in the present study provided strong views on the importance of transparency: 25% on the transparency of the IRP approach and 24% on IRP technical development. The findings also revealed that the respondents believed that the IRP approach could have been more transparent than it was. Indeed, a relatively large percentage (69%) of the respondents had the view that at least there were platforms created by the Department of Energy to discuss these issues, while some of the studies were also publicly available on the Department of Energy's website, for example the CSIR demand forecast studies.

Transparency in the IRP approach, including its technical development, implied that the overall process should be run as an open book and this further spoke to, among other issues, access of information and assumptions, transparency on how decisions are made, rules of engagement in terms of consultation, information on clear timelines for the IRP approach, the role of the Department of Energy minister and all relevant stakeholders, the role of independent reviewers and monitoring and evaluation protocols with regard to both the process and the overall output of the IRP.

d) Respondents' proposed interventions

In terms of proposed interventions, indications were that policy and governance (32%) was the most critical category in terms of interventions, followed by IRP technical developments (22%), transparency (19%), stakeholder engagement (12%), vested interests and political economy (8%) and alignment (7%). As such, 32% of the respondents advised that once policy and governance of the overall process were prioritised, alignment of policy and programmes would be a minor issue, while increased transparency and independence of the process would also address issues of vested interests and political economy. These findings further confirmed the lack of policy and governance as the main challenge facing the IRP approach in addition to the specific IRP technical development challenges and the transparency challenges facing the IRP approach in South Africa.

6.2 Theoretical and practical implications of the study

This study highlighted some key implications for theory development and pragmatic application of the study. These were found to be as follows:

i. A qualitative system dynamic approach utilising CLDs and associated system archetypes was the method utilised to assess and explain the complexity faced by South Africa's IRP approach. By utilising CLDs, the resistance towards the IRP approach and the related IRP challenges, represented by a reinforcing loop, emphasised the system's inability to achieve its objectives with the quick-fix solution, hence the need to focus on a long-term fundamental solution. As a result, this study contributed to the assessment of the complexity challenges facing the IRP approach and its update and the governance thereof.

ii. A governance-based sustainability transition management framework informed by literature on energy planning, complexity theory and sustainability transition theory was conceptualised in this study. In this context, the study contributed by providing a governance-based sustainability transition approach for the existing South African strategic electricity planning process, taking into consideration South Africa's MEC challenges.

iii. The knowledge gained in chapters 2 and 3 of this study was also utilised to inform the process of evaluating the feasibility and relevance of integrating and implementing an electricity sustainability transition framework into the existing IRP approach. As such, theory development and pragmatic application of the study highlighted that the recommended framework could be extended and tested for other strategic integrated long-term planning in the context of sustainability transition in South Africa.

6.3 Recommendations for future research

Having analysed the contributions and the related findings, including the theoretical and practical implications of the study, limitations and recommendations for future research are now presented:

i. Issues of ethics, influence, corruption, state capture, national electricity supplier's influence and role (Eskom), role of the current national ruling party the African National Congress (ANC) and overall political economy dynamics in the context of electricity sustainability transitions in South Africa have not been directly tackled in this study even though they are mentioned. This is a very important element missed by this study and will have to form part of future studies in the context of energy policy and planning development in South Africa.

ii. In the context of South Africa's sustainability transition agenda, it focused only on the electricity sector within the energy sector and specifically the IRP approach. Therefore, overall sustainability transition dynamics and contributions by other sectors were not considered. Due to this limitation, it is proposed that this study forms a foundation for future studies in which a review of the status of sustainability transition within South Africa's energy sector (i.e. in addition to the electricity sector) and the testing and applicability of the recommended integrated sustainability transition framework by this study in other subsectors within the energy sector are undertaken. In addition, future studies should look closely at the role of other sectors such as transport, health, industrial productions and mining.

iii. Purposive sampling was utilised with a focus on specialists involved with sustainability transition, the electricity sector and specifically electricity planning in South Africa. As a result, a limited number of 42 stakeholders responded to the online survey, only 15 detailed interviews were held, while only six specialists in total participated in the focus group discussion aimed at evaluating the views collated and the proposed conceptual framework. It should also be noted that only three of the specialists interviewed were directly involved with sustainability transition and the energy or electricity sector at provincial and local (city) levels, thereby highlighting the bias of the study towards a national perspective. Due to this limitation, it is proposed that this study forms a foundation for future studies in which a wider range of specialists with experience in sustainability transition, the electricity sector and specifically electricity planning at international, national, provincial and city levels are requested to participate in such a similar study.

iv. For data analysis, a subjective coding process informed by the informed grounded theory research method was utilised to define categories for the challenges and proposed interventions. In addition, descriptive statistics, word generator and qualitative content analyses were guided by and based on the subjective categories which the researcher outlined. Due to this limitation, it is proposed that this study forms a foundation for future studies in which an extensive participatory coding process is undertaken to reduce the subjectivity of the results.

v. The timeline for the collation of views from the stakeholder specialists was limited to six months. It is supposed that if the study was taken over a longer period, more stakeholder specialist views would have been collated to further confirm (and even challenge some of) the challenges and interventions identified by the study that informed the feasibility and relevance of the proposed conceptual framework.

vi. The lack of comparative research and dearth of literature in South Africa and within the African continent on electricity transition and long-term planning made it difficult to compare and benchmark the overall approach and research methods for the study. Due to this limitation, it is proposed that this study forms a foundation for future studies focused on other key sectors, including subsectors within the energy sector aimed at promoting South Africa's or Africa's sustainability transition or even studies aimed at testing and applying the recommended integrated electricity sustainability transition framework.

vii. This study had a focus on the national policy development process, the governance and specifically the related institutional arrangements to manage the future IRP approach taking into consideration the recommend framework from this study. However, the following research areas that are deemed important in the context of electricity transition in South Africa were not covered by this study:

- The future role of Eskom in the development and implementation of the IRP
- The future role of the National Planning Commission in the development and its influence in terms of ensuring alignment of the IRP approach , its eventual adoption by various government departments and its overall implementation
- The future role of the Independent System Operator in the adoption and implementation of the IRP approach

- The future role of National Energy Regulator in the development, adoption and implementation of the IRP approach , including its influence on the pricing of various fuels and electricity
- The future role of the Department of Energy in the development, adoption and implementation of the IRP approach
- The role of electricity pricing in electricity transition in South Africa
- The role of cities and local government in driving electricity transition in South Africa.

6.4 Conclusion

In this study the emphasis has been on the following:

i. The importance and urgency of addressing the alignment of the IRP with other strategic policies
ii. Maximisation of the endogenisation of long-term electricity planning processes and outputs into South Africa’s energy policy frameworks
iii. The optimisation of associated institutional governance processes and overall South African electricity transition policy process.

In addition to the above emphasis, this study has noted that South Africa has experienced a period of strain with regard to electricity supply and overall electricity transition. Despite the creation of a successful renewable energy programme, the country has not moved away from the intensive use of coal and consumption and from political interferences. This leads to an unsustainable path in terms of electricity sustainability transition. It is important to highlight that this study proposes and recommends continued centralised energy planning in South Africa. It also proposes that this centralised planning through the IRP approach should not be prescriptive within the electricity sector, but should only be a point of reference for policy making, especially for long-term infrastructure planning and investments. In addition, the findings of this study demonstrated the need for transparency in the IRP approach and its overall technical development and, indeed, the issue of transparency in any public entity is not negotiable. In this context, the study recommends that the future IRP approach should run in parallel with the IEP process to ensure appropriate inclusive governance of this policy process. This would also promote appropriate procurement decisions for the future to ensure sufficient and efficient energy and electricity services.

To further ensure good governance and effective institutional arrangements, this study promotes the establishment of a permanent high-level ETP to facilitate dialogue on overall electricity planning in South Africa, thereby ensuring transparent stakeholder engagement during the IRP process. This platform would also ensure the alignment of the IRP approach, its eventual adoption by various government departments and its overall implementation. In this platform, the future role of Eskom as a baseload company will have to be planned accordingly, while the increased future role of other private generation and distribution players would be promoted. The establishment of the Independent System Operator, which will own and manage the transmission system, will be crucial. This would require a policy intervention by the Department of Energy. In addition, the National Energy Regulator will continue to ensure transparent licensing processes, including the promotion of competitive pricing regimes within the electricity sector due to the change in various institutional arrangements, i.e. the introduction of various players for the generation, transmission and distribution of electricity in South Africa. Lastly, the role of cities and local government in overall planning to drive electricity transition in South Africa, including the effective monitoring and evaluation of sustainability transition, will be crucial. This would also include the development of new entities by cities in terms of generation and distribution to promote sustainable access and competitive electricity pricing. As a result, policy interventions by the National Treasury and the departments of Energy and Cooperative Governance and Traditional Affairs would be required.

REFERENCES

Alton, T., Arndt, C., Davies, R., Hartley, F., Makrelov, K., Thurlow, J. & Ubogu, D. 2012. *The economic implications of introducing carbon taxes in South Africa*. WIDER working paper no. 2012/46. Pretoria: United Nations University.

Baker, L. 2015. Renewable energy in South Africa's minerals-energy complex: A 'low carbon' transition? *Review of African Political Economy*, 42(144):245–261.

Baker, L. 2016a. *Post-apartheid electricity policy and the emergence of South Africa's renewable energy sector*. WIDER working paper no. 2016/15. Pretoria: United Nations University.

Baker, L. 2016b. Sustainability transitions and the politics of electricity planning. In H.G. Brauch, U.O. Spring, J. Grin & J. Scheffran (eds.). *Handbook on sustainability transition and sustainable peace*. Cham: Springer, 793–809.

Baker, L., Newell, P. & Phillips, J. 2014. The political economy of energy transitions: The case of South Africa. *New Political Economy*, 19(6):791–818.

Bakken, J.I. & Lucas, N. 1996. Integrated resource planning and environmental pricing in a competitive and deregulated electricity market. *Energy Policy*, 24(3):239–244.

Bale, C.S.E., Varga, L. & Foxon, T.J. 2015. Energy and complexity: New ways forward. *Applied Energy*, 138:150–159.

Bell, T. & Farrell, G. 1997. The mineral-energy complex and South African industrialisation. *Development Southern Africa*, 14(4):596–613.

Bengtsson, M. 2016. How to plan and perform a qualitative study using content analysis. *NursingPlus Open*, 2:8–14.

Bouhali, R., Mekdad, Y., Lebsir, H. & Ferkha, L. 2015. Leader roles for innovation: Strategic thinking and planning. *Procedia - Social and Behavioral Sciences*, 181:72–78.

Braun, W. 2002. *The system archetypes.* Retrieved from http://www.albany.edu/faculty/gpr/PAD724/724WebArticles/sys_archetypes.pdf [Accessed 20 October 2016].

Bryman, A., Bell, E., Hirschsohn, P., Dos Santos, A., Du Toit, D. & Masenge, A. 2014. *Research methodology: Business and management contexts*. Cape Town: Oxford University Press Southern Africa.

Calland, R. & Nakhooda, S. 2012. Participatory democracy meets hard rock of energy policy: South Africa's National Integrated Resource Plan. *Democratization*, 19(5):912–931.

Carmichael, T. & Cunningham, N. 2017. Theoretical data collection and data analysis with gerunds in a constructivist grounded theory study. *Electronic Journal of Business Research Methods*, 15(2):59–73.

Cho, J.Y. & Lee, E.H. 2014. Reducing confusion about grounded theory and qualitative content analysis: Similarities and differences. *Qualitative Report*, 19(32):1–20.

Cilliers, P. 2000. Knowledge, complexity and understanding. *Emergence*, 2(4):7–13.

Cormio, C., Dicorato, M., Minoia, A. & Trovato, M. 2003. A regional energy planning methodology including renewable energy sources and environmental constraints. *Renewable and Sustainable Energy Reviews*, 7(2):99–130.

Coyle, R.G. 1983. The technical elements of the system dynamics approach. *European Journal of Operational Research*, 14(4):359–370.

Coyle, R.G. 2000. Qualitative and Quantitative modelling in system dynamics:Some research questions.*System Dynamics Review.* 16 (3): 225-244.

Coyle, R.G. 2001. Maps and models in system dynamics : Rejoinder to Homer and Oliva.*System Dynamics Review.* 17(14): 357-363.

Creswell, J. 2003. *Research design: Qualitative, quantitative and mixed methods approaches*, 2nd edition. Thousand Oaks, CA: Sage.

Crotty, M. 1998. The Foundations of Social Research: Meaning and Perspective in the Research Process. Sage Publications, London.

Davidson, O. & Mwakasonda, S.A. 2004. Electricity access for the poor: A study of South Africa and Zimbabwe. *Energy for Sustainable Development*, 8(4):26–40.

Davies, M., Musango, J.K. & Brent, A.C. 2016. A systems approach to understanding the effect of Facebook use on the quality of interpersonal communication. *Technology in Society*, 44:55–65.

Davies, M., Swilling, M. and Wlokas, H.L. 2018. Towards new configurations of urban energy governance in South Africa's Renewable Energy Procurement Programme. *Energy research & social science,* 36:61-69.

De Gooyert, V., Rouwette, E., Van Kranenburg, H., Freeman, E. & Van Breen, H. 2016. Sustainability transition dynamics: Towards overcoming policy resistance. *Technological Forecasting and Social Change*, 111:135–145.

De Vos, D. 2014. Analysis: How much more electricity generating capacity does South Africa need?. *Daily Maverick*, 15 July 2014. Retrieved from https://www.dailymaverick.co.za/article/2014-07-15-analysis-how-much-more-electricity-generating-capacity-does-south-africa-need/ [Accessed 23 July 2018].

Department of Energy. 2010. *Energy Efficiency and Demand Side Management Policy.* Pretoria.

Department of Energy. 2009. *Proposed IRP planning process*. Pretoria.

Department of Energy. 2011. *Integrated Resource Plan for Electricity, 2010–2030*. Pretoria.

Department of Energy. 2013. *Draft 2012 integrated energy planning report*. Pretoria.

Department of Energy. 2016. *Integrated Resource Plan update: Assumptions, base case results and observations*. Pretoria.

Department of Energy. 2017. *Proposed IRP planning process*. Pretoria.

Department of Energy. 2016. *Draft National Energy Efficiency Strategy of the Republic of South Africa.* Pretoria.

Department of Energy. 2011. *Energy Efficiency Building Regulations.* Pretoria.

Department of Energy. 2016. *National Gas Infrastructure Development Plan.* Pretoria.

Department of Environmental Affairs. 2016. Carbon Budgets 2016-2020 *for South African organisations*.Pretoria.

Department of Environmental Affairs. 2017. Carbon Budgets 2016-2020 *for South African organisations*.Pretoria.

Department of Environmental Affairs. 2017. *Climate Change Legal Framework Draft Policy.* Pretoria.

Department of Environmental Affairs. 2017. *GHG Reporting and Pollution Prevention Plans for South Africa.* Pretoria

Department of Environmental Affairs. 2018. *GHG Emission Pathways Study for South Africa.* Pretoria

Department of Environmental Affairs. 2017. *National Adaptation Strategy for South Africa*.Pretoria.

Department of Environmental Affairs. 2017. *National Employment Vulnerability Assessment Policy Study for South Africa*. Pretoria.

Department of Environmental Affairs. 2010. *National Strategy for Sustainable Development and Action Plan (NSSDAP1) 2011–2014*. Pretoria

Department of Environmental Affairs. 2009. *Long Term Mitigation Scenarios for South Africa.* Pretoria.

Department of Environmental Affairs. 2014. *Mitigation Potential Analysis Study for South Africa.* Pretoria.

Department of Environmental Affairs. 2011. *National Climate Change Response White Paper*. Pretoria.

Department of Environmental Affairs. 2016. *South Africa's Nationally Determined Contribution submission to the United Nations Framework Convention on Climate Change.* Pretoria.

Department of Environmental Affairs and Tourism. 2008. *A national framework for sustainable development in South Africa*. Pretoria.

Department of Minerals and Energy. 1998a. *White Paper on the Energy Policy of the Republic of South Africa*. Pretoria.

Department of Minerals and Energy. 2003a. *Integrated Energy Plan for the Republic of South Africa.* Pretoria.

Department of Minerals and Energy. 2003b. *White Paper on the Renewable Energy Policy of the Republic of South Africa*. Pretoria.

Department of Minerals and Energy. 2005. National Energy Efficiency Strategy of *the Republic of South Africa*. Pretoria.

Department of Minerals and Energy. 2009. First Review October 2008. National Energy Efficiency Strategy of *the Republic of South Africa*. Pretoria.

Department of Minerals and Energy. 2007. *Energy Security Master Plan – Electricity, 2007–25*. Pretoria.

Department of Planning, Monitoring and Evaluation & National Planning Commission. 2018. *Discussion paper on energy.* Retrieved from www.dpme.gov.za/news/Pages/National-Planning-Commission-Releases-Discussion-Paper-on-Energy-as-part-of-NPC-Economy-Series.aspx [Accessed 23 March 2018].

Department of Trade and Industry. 2015. *Industrial Policy Action Plan (IPAP) 2015/16 – 2017/18*. Pretoria.

Department of Science and Technology. 2018. *Low-Carbon Technology Stocktake Study for South Africa*. Pretoria.

Department of Water Affairs. 2013. *National water resource strategy*. Second edition. Pretoria.

Department of Transport. 2017. *Green Transport Draft National Policy*. Pretoria.

Dixit, S., Chitnis, A., Jairaj, B., Martin, S., Wood, D. & Kundu, A. 2014. *10 questions to ask about integrated resource planning*. Working paper. Washington, DC: World Resources Institute.

Doukas, A. & Ballesteros, A. 2015. *Clean energy access in developing countries: Perspectives on policy and regulation*. Washington, DC: World Resources Institute.

Doukas, H., Patlitzianas, K.D., Kagiannas, A.G. & Psarras, J. 2008. Energy policy making: An old concept or a modern challenge? *Energy Sources*, Part B, 3(4):362–371.

D'Sa, A. 2005. Integrated resource planning (IRP) and power sector reform in developing countries. *Energy Policy*, 33(10):1271–1285.

Eberhard, A. & Gratwick, K.N. 2011. IPPs in sub-Saharan Africa: Determinants of success. *Energy Policy*, 39(9):5541–5549.

Eisenhardt, K.M. & Graebner, M.E. 2007. Theory building from cases: Opportunities and challenges. *Academy of Management Journal*, 50(1):25–32.

Economic Development Department. 2017. *National Employment Vulnerability Assessment Policy Study for South Africa*. Pretoria.

Economic Development Department. 2010. *The new growth path: The framework.* Pretoria.

Edomah, N., Foulds, C. & Jones, A. 2017. Policy making and energy infrastructure change: A Nigerian case study of energy governance in the electricity sector. *Energy Policy*, 102:476–485.

Electricity Governance Initiative of South Africa. 2013. *Smart electricity planning: Fast-tracking our transition to a healthy, modern, affordable electricity supply for all*. Cape Town.

Elliott, N. & Higgins, A. 2012. Surviving grounded theory research method in an academic world: Proposal writing and theoretical frameworks. *Grounded Theory Review*, 11(2):1–12.

Energy Research Centre. 2013. *Towards a new power plan*. Cape Town.

Forrester,J.1958. Industrial Economics: A major breakthrough for decision makers.*Harvard Business Review,*36 (4):37-66.

Faludi, A. 1973. *A reader in planning theory*. New York, NY: Pergamon.

Faludi, A. 2013. *Essays on planning theory and education*. New York, NY: Elsevier.

Fine, B. & Rustomjee, Z. 1996. *The political economy of South Africa: From minerals-energy complex to industrialisation*. Johannesburg: Witwatersrand University Press.

Flaherty, M.G. 2014. Strategic planning for success. In M. Spatz (ed.). *The Medical Library Association guide to providing consumer and patient health information*. Lanham, MD: Roman & Littlefield, 27–36.

Forester, J. 2004. Reflections on trying to teach planning theory. *Planning Theory and Practice*, 5(2):242–251.

Friedmann, J. & Hudson, B. 1974. Knowledge and action: A guide to planning theory. *Journal of the American Institute of Planners*, 40(1):2–16.

Geels, F.W., Berkhout, F. and van Vuuren, D.P., 2016. Bridging analytical approaches for low-carbon transitions. *Nature Climate Change*, 6(6):576.

Ghaffarzadegan, N., Lyneis, J. & Richardson, G.P. 2011. How small system dynamics models can help the public policy process. *System Dynamics Review*, 27(1):22–44.

Govender, T. 2017. Keynote address and setting-the-scene. Presented at the Eskom Transmission Development Plan 2018 to 2027 (TDP 2017): Public Forum, Johannesburg, 19 October.

Grossman, P.Z. 2015. Energy shocks, crises and the policy process: A review of theory and application. *Energy Policy*, 77:56–69.

Hartmann, T. 2012. Wicked problems and clumsy solutions: Planning as expectation management. *Planning Theory*, 2(3):242–256.

Haxeltine, A., Whitmarsh, L., Bergman, N., Rotmans, J., Schilperoord, M. & Kohler, J. 2008. A conceptual framework for transition modelling. *International Journal of Innovation and Sustainable Development*, 3(1/2):93–114.

Hedden, S. 2015. *Gridlocked: A long-term look at South Africa's electricity sector*. African Futures Paper no. 15:24. Pretoria: Institute for Security Studies.

Hess, D.J. 2014. Sustainability transitions: A political coalition perspective. *Research Policy*, 43(2):278–283.

Hirst, E., Tonn, B. & Bauer, D. 1995. The future of IRP and other public goods in a market-driven world. *The Electricity Journal*, 8(3):74–84.

Howard-Payne, L. 2016. Glaser or Strauss? Considerations for selecting a grounded theory study. *South African Journal of Psychology*, 46(1):50–62.

Hu, Z., Tan, Y., Yang, F., Yang, M., Wen, Q., Shan, B. & Han, X. 2010. Integrated resource strategic planning: Case study of energy efficiency in the Chinese power sector. *Energy Policy*, 38(11):6391–6397.

Hu, Z., Wen, Q., Wang, J., Tan, X., Nezhad, H., Shan, B. & Han, X. 2010. Integrated resource strategic planning in China. *Energy Policy*, 38(8):4635–4642.

Hudson, B.M., Galloway, T.D. & Kaufman, J.L. 1979. Comparison of current planning theories: Counterparts and contradictions. *Journal of the American Planning Association*, 45(4):387–398.

Inglesi, R. & Pouris, A. 2010. Forecasting electricity demand in South Africa: A critique of Eskom's projections. *South African Journal of Science*, 106(1/2):50–53.

Kaldellis, J.K., Anestis, A. & Koronaki, I. 2013. Strategic planning in the electricity generation sector through the development of an integrated Delphi-based multi-criteria evaluation model. *Fuel*, 106:212–218.

Katz-Suchy, J. 2014. Planning and economic growth. In C.R. Rao (ed.). *Essays on econometrics and planning*. Oxford: Pergamon, 267–270.

Kemp, R., Rotmans, J. & Loorbach, D. 2007. Assessing the Dutch energy transition policy: How does it deal with dilemmas of managing transitions? *Journal of Environment Policy and Planning*, 9(3/4):315–331.

Kern, F. & Howlett, M. 2009. Implementing transition management as policy reforms: A case study of a policy initiative in the Dutch energy sector. *Policy Sciences*, 42(4):391–408.

Kern, F. & Smith, A. 2008. Restructuring energy systems for sustainability? Energy transition policy in the Netherlands. *Energy Policy*, 36(11):4093–4103.

Kuzemko, C., Lockwood, M., Mitchell, C. & Hoggett, R. 2016. Governing for sustainable energy system change: Politics, contexts and contingency. *Energy Research & Social Science*, 12:96–105.

Laes, E., Gorissen, L. & Nevens, F. 2014. A comparison of energy transition governance in Germany, the Netherlands and the United Kingdom. *Sustainability*, 6(3):1129–1152.

Løken, E. 2007. Use of multi-criteria decision analysis methods for energy planning problems. *Renewable and Sustainable Energy Reviews*, 11(7):1584–1595.

Loorbach, D. 2010. Transition management for sustainable development: A prescriptive, complexity-based governance framework. *Governance: An International Journal of Policy, Administration, and Institutions*, 23(1):161–183.

Maani, K.E. & Cavana, R.Y. 2007. *Systems thinking & modelling: Understanding change and complexity*. Auckland: Pearson Education.

Malik, A.S. & Sumaoy, C.U. 2003. A case study of local integrated resource planning. *Energy*, 28(7):711–720.

Martin, B. 2016. The politics of electricity planning in South Africa: A review of dominant advocacy coalitions seeking to influence the Integrated Resource Plan of 2010 (IRP2010), and its update in 2013. Unpublished MPhil dissertation. Cape Town: University of Cape Town.

Mayring, P. 2000. Qualitative content analysis. *Forum: Qualitative Social Research*, 1(2), Art. 20. Retrieved from http://www.qualitative-research.net/index.php/fqs/article/view/1089/2385 [Accessed 7 May 2018].

Markard, J., Raven, R. & Truffer, B. 2012. Sustainability transitions: An emerging field of research and its prospects. *Research Policy*, 41(6):955–967.

Markard, J., Suter, M. & Ingold, K. 2016. Socio-technical transitions and policy change: Advocacy coalitions in Swiss energy policy. *Environmental Innovation and Societal Transitions*, 18:215–237.

Meadowcroft, J. 2011. Engaging with the politics of sustainability transitions. *Environmental Innovation and Societal Transitions*, 1(1):70–75.

Meadows, D.H. 2008. *Thinking in systems – a primer*. White River Junction, VT: Chelsea Green.

Mills, J., Bonner, A. & Francis, K. 2006. The development of constructivist grounded theory. *International Journal of Qualitative Methods*, 5(1):25–35.

Montmasson-Clair, G. & Ryan, G. 2014. *Repositioning electricity planning at the core: An evaluation of South Africa's Integrated Resource Plan*. Pretoria: Trade and Industrial Policy Strategies for the National Economic Development and Labour Council.

Morris, M. & Martin, L. 2015. *Political economy of climate-relevant policies: The case of renewable energy in South Africa*. IDS Evidence Report 128. Sussex: University of Sussex.

Mqadi, L., Musango, J.K. & Brent, A.C. 2016. Rethinking strategic sustainability planning for the electricity sector in South Africa. Unpublished paper presented at the 22nd International Sustainable Development Research Society Conference, School of Science and Technology, Universidade Nova de Lisboa, Lisbon, 13–15 July.

Mqadi, L.J., Musango, J.K. and Brent, A.C., 2018a. Challenges Facing South Africa's Electricity Sector 'Integrated Resource Plan: A Qualitative System Dynamics Approach. *Administratio Publica,* 26(2):118-137

Mqadi, L., Musango, J.K. & Brent, A.C. 2018b. Rethinking strategic sustainability planning for the electricity sector in South Africa. *The South African Journal of Industrial Engineering*, 29(1):63–73.

Msimanga, B. & Sebitosi, A.B. 2014. South Africa's non-policy driven options for renewable energy development. *Renewable Energy*, 69:420–427.

Musango, J.K. & Brent, A.C. 2011. A conceptual framework for energy technology sustainability assessment. *Energy for Sustainable Development*, 15(1):84–91.

Musango, J.K., Brent, A.C. & Tshangela, M. 2014. Green economy transitioning of the South African power sector: A system dynamics approach. *Development Southern Africa*, 31(5):744–758.

National Business Initiative. 2013. *Grid Emission Factor Review for South Africa*. Johannesburg.

National Planning Commission. 2012. *National Development Plan 2030*. Pretoria.

National Treasury. 2018. *Carbon Tax Draft Legislation*.Pretoria.

Nichols, D. & Von Hippel, D. 2012. *Best practices guide: Integrated resource planning for electricity*. Boston, MA: Tellus Institute.

Ogano, N.O. 2017. A system dynamics approach to managing project risks in the electricity industry in Sub-Saharan Africa. Unpublished PhD thesis, University of Pretoria, Pretoria.

Ostrom, E. 2011. Background on the institutional analysis and development framework. *Policy Studies Journal*, 39(1):7–27.

Pasimeni, M.R., Petrosillo, I., Aretano, R., Semeraro, T., De Marco, A., Zaccarelli, N. & Zurlini, G. 2014. Scales, strategies and actions for effective energy planning: A review. *Energy Policy*, 65:165–174.

Peter, C. & Swilling, M. 2014. Linking complexity and sustainability theories: Implications for modelling sustainability transitions. *Sustainability*, 6(3):1594–1622.

Pfenninger, S. 2017. Energy scientists must show their workings. *Nature*, 542(7642):393.

Pfenninger, S., Hirth, L., Schlecht, I., Schmid, E., Wiese, F., Brown, T., Davis, C., Gidden, M., Heinrichs, H., Heuberger, C., Hilpert, S. et al. 2018. Opening the black box of energy modelling: Strategies and lessons learned. *Energy Strategy Reviews*, 19:63-71.

Priest, H., Roberts, P. & Woods, L. 2002. An overview of three different approaches to the interpretation of qualitative data. Part 1: Theoretical issues. *Nurse Researcher,* 10(1):30–42.

Pouris, A. & Thopil, G.A. 2015. *Long-term forecasts of water usage for electricity generation: South Africa 2030*. Report no. 2383/1/14. Pretoria: Water Research Commission.

Powell, J.H. & Coyle, R.G. 2005. Identifying strategic action in highly politicized contexts using agent-based qualitative system dynamics. *Journal of the Operational Research Society*, 56(7):787–798.

Prasad, R.D., Bansal, R.C. & Raturi, A. 2014. Multi-faceted energy planning: A review. *Renewable & Sustainable Energy Reviews*, 38:686–699.

Probst, G. & Bassi, A.M. 2014. *Tackling complexity: A systemic approach for decision makers.* Sheffield: Greenleaf.

Pruyt, E. 2013. *Small system dynamics models for big issues: Triple jump towards real-world complexity*. Delft: TU Delft Library.

Richardson, G. 2011. Reflections on the foundations of system dynamics. *System Dynamics Review*, 27(3):219–243.

Reddy, A.K.N. & Sumithra, G. 1997. Integrated resource planning. *Energy for Sustainable Development*, 3(6):14–16.

Republic of South Africa. 2006. *Electricity Regulation Act No. 4 of 2006*. Pretoria: Government Printer.

Republic of South Africa. 1999. *Nuclear Energy Act, No. 46 of 1999.* Pretoria: Government Printer.

Republic of South Africa. 2002. *Gas Act, No. 48 of 2001.* Pretoria: Government Printer

Republic of South Africa. 2003*. Disaster Management Act, No. 57 of 2002.* Pretoria: Government Printer

Republic of South Africa. 2005. *National Energy Regulator Act, No. 40 of 2004.* Pretoria: Government Printer

Republic of South Africa. 2006. Electricity Regulation *Act, No. 4 of 2006.* Pretoria: Government Printer

Republic of South Africa. 2008. *National Energy Act, No. 34 of 2008.* Pretoria: Government Printer

Rittel, H.W.J. & Webber, M.M. 1973. Dilemmas in a general theory of planning. *Policy Sciences*, 4(2):155–169.

Rogge, K.S. & Reichardt, K. 2016. Policy mixes for sustainability transitions: An extended concept and framework for analysis. *Research Policy*, 45(8):1620–1635.

Rotmans, J. & Loorbach, D. 2009. Complexity and transition management. *Journal of Industrial Ecology*, 13(2):184–196.

Rudd, J.M., Greenley, E.G., Beatson, A.T. & Lings, I.N. 2008. Strategic planning and performance: Extending the debate. *Journal of Business Research*, 61(2):99–108.

Rycoft, M. 2017. *Mike musings: Short term plans and long term consequences*. Retrieved from http://www.ee.co.za/article/mike-musings-short-term-plans-long-term-consequences.html [Accessed 15 February 2017].

Safarzyńska, K., Frenken, K. & Van den Bergh, J.C.J.M. 2012. Evolutionary theorizing and modeling of sustainability transitions. *Research Policy*, 41(6):1011–1024.

Saldaña, J. 2009. *The coding manual for qualitative researchers*. London: Sage.

Sampaio, H.C., Dias, R.A. & Balestieri, J.A.P. 2013. Sustainable urban energy planning: The case study of a tropical city. *Applied Energy*, 104:924–935.

Schweikert, A., Chinowsky, P., Kwiatkowski, K. & Espinet, X. 2014. The infrastructure planning support system: Analyzing the impact of climate change on road infrastructure development. *Transport Policy*, 35:146–153.

Senge, P.M. 2006. *The fifth discipline: The art and practice of the learning organization*. Second edition. New York, NY: Currency/Doubleday.

Sengers, F., Wieczorek, A.J. & Raven, R. 2016. Experimenting for sustainability transitions: A systematic literature review. *Technological Forecasting and Social Change*. [In press.]

Sovacool, B.K. 2011. An international comparison of four polycentric approaches to climate and energy governance. *Energy Policy*, 39(6):3832–3844.

Spalding-Fecher, R. 2002. *Energy and sustainable development in South Africa*. Sustainable Energy Watch 2002 Report. Paris: Helio International.

Spalding-Fecher, R. & Matibe, D.K. 2003. Electricity and externalities in South Africa. *Energy Policy*, 31(8):721–734.

Sterman, J.D. 2000. *Business dynamics: Systems thinking and modelling for a complex world.* Boston, MA: Irwin/McGraw-Hill.

Sterman, J.D. 2001. System dynamics modeling: Tools for learning in a complex world. *California Management Review*, 43(4):8–25.

Swilling, M., Musango, J. & Wakeford, J. 2015. Developmental states and sustainability transitions: Prospects for a just transition in South Africa. *Journal of Environmental Policy & Planning*, 18(5):650–672.

Thornberg, R. 2012. Informed grounded theory. *Scandinavian Journal of Educational Research*, 56(3):243–259.

Turnheim, B., Berkhout, F., Geels, F., Hof, A., McMeekin, A., Nykvist, B. and van Vuuren, D. 2015. Evaluating sustainability transitions pathways: Bridging analytical approaches to address governance challenges. *Global Environmental Change*, 35:239-253.

Vasileiadou, E. & Safarzyńska, K. 2010. Transitions: Taking complexity seriously. *Futures*, 42(10):1176–1186.

Vollans, G.E. 1994. With DSM, who needs IRP? *Utilities Policy*, 4(4):261–266.

Wang, C.H. & Min, K.J. 1998. An integrated resource planning model for utilities with quantified outage costs. *International Journal of Electrical Power and Energy Systems*, 20(8):517–524.

Winkler, H. & Marquard, A. 2009. Changing development paths: From an energy-intensive to low-carbon economy in South Africa. *Climate and Development*, 1(1):47–65.

Winz, I., Brierley, G. & Trowsdale, S. 2009. The use of system dynamics simulation in water resources management. *Water Resources Management*, 23(7):1301–1323.

Wolstenholme, E.F. 1999. Qualitative vs quantitative modelling: The evolving balance. *Journal of the Operational Research Society*, 50(4):422–428.

Wolstenholme, E.F. & Coyle, R.G. 1983. The development of system dynamics as a methodology for system description and qualitative analysis. *Journal of the Operational Research Society*, 34(7):569–581.

World Energy Council. 1992. *Energy dictionary*. London.

Wright, J.G., Bischof-Niemz, T., Calitz, J., Mushwana, C., Van Heerden, R. & Senatla, M. 2017. *Formal comments on the Integrated Resource Plan (IRP): Update assumptions, base case and observations 2016*. Retrieved from www.csir.co.za/sites/default/files/Documents/20170331CSIR_EC_DOE.pdf [Accessed 2 May 2018].

Yelland, C. 2016. Analysis: The Draft 2016 Integrated Resource Plan – lightweight, superficial and downright dangerous. *Daily Maverick*, 30 November. Retrieved from https://www.dailymaverick.co.za/article/2016-11-30-analysis-the-draft-2016-integrated-resource-plan-lightweight-superficial-and-downright-dangerous/#.WPoJ-U0aLIU [Accessed 20 April 2017].

Yeo, K.T. 1995. Planning and learning in major infrastructure development: Systems perspectives. *International Journal of Project Management*, 13(5):287–293.

Zahariadis, N. 2013. Building better theoretical frameworks of the European Union's policy process. *Journal of European Public Policy*, 20(6):807–816.

ANNEXURE A: RESPONDENT'S EXPERTISE

Respondents	Online Survey	Detailed one on one	Focus Group
Respondent 1	Energy research and sustainability transitions	Energy research and sustainability transitions	National planning Commission, energy planning and electricity modelling
Respondent 2	International climate change, carbon markets and energy	international climate change, carbon markets and energy	Energy Policy and energy planning
Respondent 3	Energy research and sustainability transitions	Energy research and sustainability transitions	Independent Power Producer's Office
Respondent 4	Sustainability transitions, energy policy and projects	sustainability transitions, climate change mitigation policy, energy planning, electricity modelling, national policy regulation	Climate Change and Sustainability transitions
Respondent 5	Energy research and technology, IPPS	Restructuring of Eskom, Independent Power Producers, international energy policy and regulation	Sustainability transitions, national policy and regulations
Respondent 6	Energy planning, national policy and regulation, electricity transitions	Grid planning, national policy and regulation	National planning Commission, energy planning and electricity modelling
Respondent 7	Energy planning, electricity modelling, sustainability transitions, national policy and regulation	Energy planning & system modelling, science and technology, international and national policy and regulations	
Respondent 8	Sustainability transitions, national policy and regulation	electricity modelling and pricing, national policy and regulation	
Respondent 9	Independent Power Producer, Eskom restructuring, national policy and regulation & Renewable energy	Sustainability transitions, energy planning & system modelling, science and technology, international and national policy and regulations	
Respondent 10	Energy research and development, sustainability transitions	Eskom business model, Restructuring of Eskom, energy planning & electricity modelling ,national regulation and policy	
Respondent 11	Energy planning	Sustainability transitions, energy planning & system modelling	
Respondent 12	Sustainability transitions, climate change mitigation policy, energy planning, electricity modelling, national policy regulation	Eskom business model, Restructuring of Eskom	

Respondent 13	sustainability transitions, national policy and regulation	International energy planning, energy research, science and technology
Respondent 14	Eskom restructuring , Independent Power Producers, energy research and policy	Eskom restructuring , Independent Power Producers, energy research and policy
Respondent 15	Sustainability transitions, energy planning, electricity regulation energy policy and regulation	Energy research and development, sustainability transitions
Respondent 16	International energy policy, energy planning & electricity modelling, electricity transitions	
Respondent 17	Independent power producers, National policy and regulation & renewable energy	
Respondent 18	Independent Power Producers and Renewable energy	
Respondent 19	Eskom business model, restructuring of Eskom, energy planning & electricity modelling, national regulation and policy	
Respondent 20	grid planning	
Respondent 21	energy planning, national policy and regulation, electricity transitions	
Respondent 22	energy research and development, sustainability transitions	
Respondent 23	Restructuring of Eskom, Independent Power Producers, international energy policy and regulation	
Respondent 24	Electricity pricing and modelling, national policy and regulation	
Respondent 25	Restructuring of Eskom, Independent Power Producers, energy policy and regulation	
Respondent 26	Eskom business model, Restructuring of Eskom, energy planning & electricity modelling, national regulation and policy	
Respondent 27	Grid planning, national policy and regulation	
Respondent 28	Electricity modelling and pricing, national policy and regulation, electricity transitions	

Respondent 29	Sustainability transitions, national policy and regulation
Respondent 30	sustainability transitions, energy planning &electricity modelling, monitoring & evaluation, Project implementation, planning, monitoring and evaluations at city levels;
Respondent 31	Eskom business model, Restructuring of Eskom
Respondent 32	Grid planning, national policy and regulation
Respondent 33	Energy planning and electricity planning, interested in Eskom's restructuring and Independent Power Producer
Respondent 34	Energy planning & system modelling, science and technology, international and national policy and regulations
Respondent 35	Electricity modelling and pricing, national policy and regulation
Respondent 36	Sustainability transitions, energy planning & system modelling, science and technology, international and national policy and regulations
Respondent 37	Renewable energy, Independent power producer, Eskom business model
Respondent 38	Sustainability transitions, energy planning & system modelling
Respondent 39	Sustainability transitions, national policy and regulation
Respondent 40	International energy planning, energy research, science and technology
Respondent 41	Energy research and development, sustainability transitions
Respondent 42	Renewable energy, Independent power producer, Eskom business model

ANNEXURE B: RESEARCH QUESTIONS: SURVEY

Survey: Strategic integrated electricity planning: A case study of electricity transitions in South Africa

The purpose of this survey is to obtain your views and suggestions on long-term strategic integrated electricity planning in South Africa with a focus on an Integrated Resource Plan (IRP), a policy planning approach for long-term planning within the electricity sector. In this study, the preliminary investigation suggested that owing to the challenges facing the development of the IRP and its approval by all relevant stakeholders, there had been increased misalignment with other national strategic plans and minimal endogenisation (i.e. directly influencing or affecting them) within other related strategic plans and policies. In this context, this study proposes an integrated sustainable electricity transitions framework to improve the IRP development process, to ensure its alignment, including its endogenisation, into the overall long-term sustainability agenda for South Africa, herein referred to as a sustainability transitions path. For this study, a sustainability transitions path (i.e. electricity transitions) can be described as long-term radical transformative scientific, technological, societal, economic and political processes for a sustainable low-carbon economy (green economy) owing to a number of persistent problems facing the South African electricity sector. No names will be provided, personal views will be utilised solely for study purposes, and in the case of contact details, these will be used solely to share study results. Your participation is crucial, as multiple perspectives are needed to improve the IRP development process. Lastly, your participation shapes the overall results of the study, which will contribute towards South Africa's sustainability transitions discourse currently underway, especially within the complex electricity sector.

Research questions: Survey

1) I confirm that I have read and understood the information provided for the current study (see email for informed consent).

2) I agree to take part in this survey (see email for informed consent agreement).

3) How do you identify your organisation?

4) Are you familiar with the notion and policies aimed at South Africa's sustainability transitions agenda?

5) Have you participated in any of South Africa's national strategic integrated planning processes?

6) Have you participated in South Africa's Integrated Resource Plan (IRP) development process?

7) If not, would you like to participate in South Africa's IRP development process?

8) If not, what role and contribution would you focus on in the context of energy planning in general and specifically the IRP?

9) If you have participated in South Africa's IRP development process, how do you think the IRP development process rates in terms of the following indicator?

    a. Representation of various stakeholders.

10) If you have participated in South Africa's IRP development process, how do you think the IRP development process rates in terms of the following indicator?

    a. Transparency of inputs and assumptions utilised in developing the IRP.

11) If you have participated in South Africa's IRP development process, how do you think the IRP development process rates in terms of the following indicator?

    a. Alignment with other national strategic integrated plans and South Africa's sustainability transitions path.

12) If you have participated in South Africa's IRP development process, how do you think the IRP process rates in terms of the following indicator?

    a. Direct influence which the IRP development process has on other strategic plans and South Africa's sustainability transitions path.

13) If you have participated in South Africa's IRP development process, how do you think the IRP development process rates in terms of the following indicator?

    a. Level of integration with other energy/electricity policies aimed at South Africa's sustainability transitions path.

14) If you have participated in South Africa's IRP development process, how do you think the IRP development process rates in terms of the following indicator?

    a. Feasibility of the proposed scenarios within the IRP.

15) If you have participated in South Africa’s IRP development process, how do you think the IRP development process rates in terms of the following indicator?

    a. A transparent monitoring and evaluation process which ensures a thorough review and update of the IRP.

16) In your own personal view, please list the top 3 challenges facing South Africa’s energy planning process and specifically the IRP development process in South Africa.

17) In your own personal view, please list the top 3 challenges facing South Africa’s sustainability transitions in South Africa.

18) Are you available for a one-on-one (45-minute) in-depth interview focused on discussing the results of this survey and the proposed integrated sustainable electricity transitions framework for this study?

ANNEXURE C: RESEARCH EMAIL AND QUESTIONS: DETAILED ONE ON ONE INTERVIEWS

Email Request

Dear ………,

Thank you for responding to a survey on strategic integrated planning in South Africa for the electricity sector: The Integrated Resources Plan (IRP).

In this survey, you indicated your availability to further engage on this study for a 30-45 minute one on one detailed interview via Skype or telephone.

Would you be available on the following dates:……….

If the above is not possible, please suggest a date suitable to you.

Looking forward to your response.

Thank you

Detailed Research Questions

1) How important do you think integrated strategic electricity planning is in South Africa's path towards a sustainability transition? (1–5 – not important to important)
2) Are you familiar with the IRP's development process?
3) Have you been involved? Do you think it's a good process? Why/why not? What would you improve?
4) These are some indicators by which I am evaluating the IRP process. Please give me your perspectives on:
   i. Representation of stakeholders.
   ii. Transparency of the IRP process.
   iii. Alignment with other national strategic government departments.
   iv. Alignment with other national strategic integrated plans and sustainability.
   v. Alignment of scenarios of the IRP with South Africa's national strategic integrated plans.
   vi. Level of integration/endogenisation with other national policies aimed at South Africa's sustainability vision/transition.

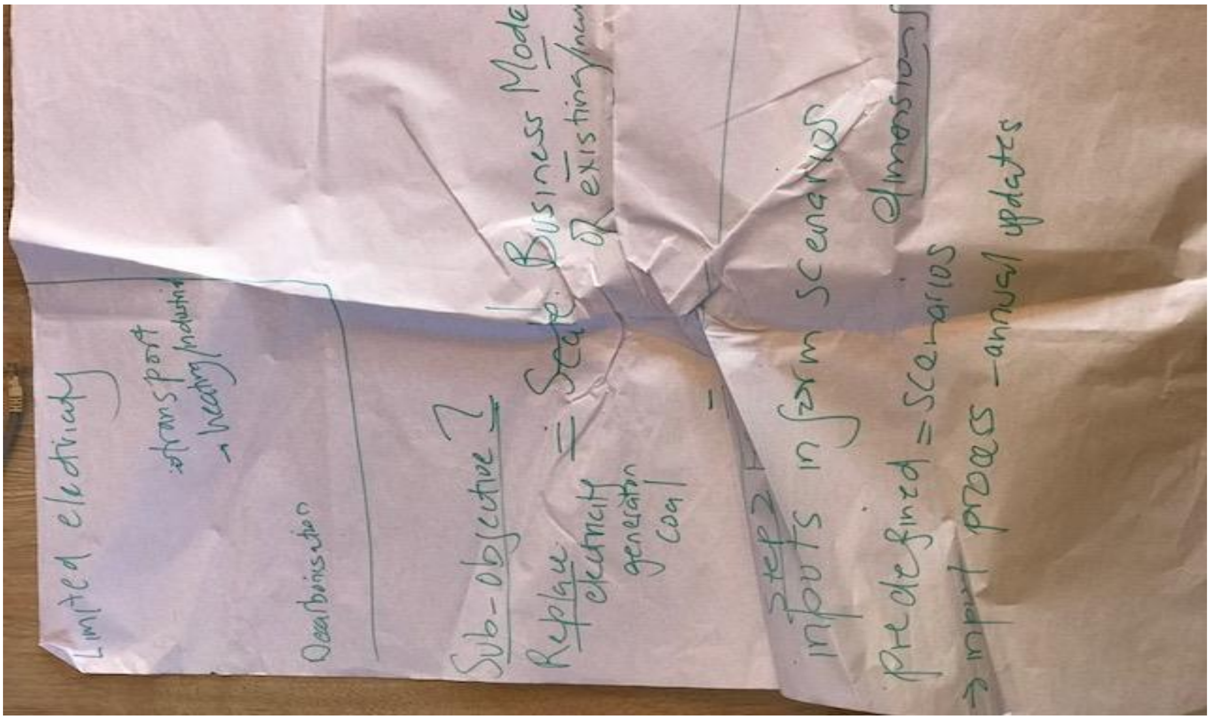
vii. Level of integration/endogenisation with other energy/electricity national policies aimed at South Africa's electricity sustainability vision.

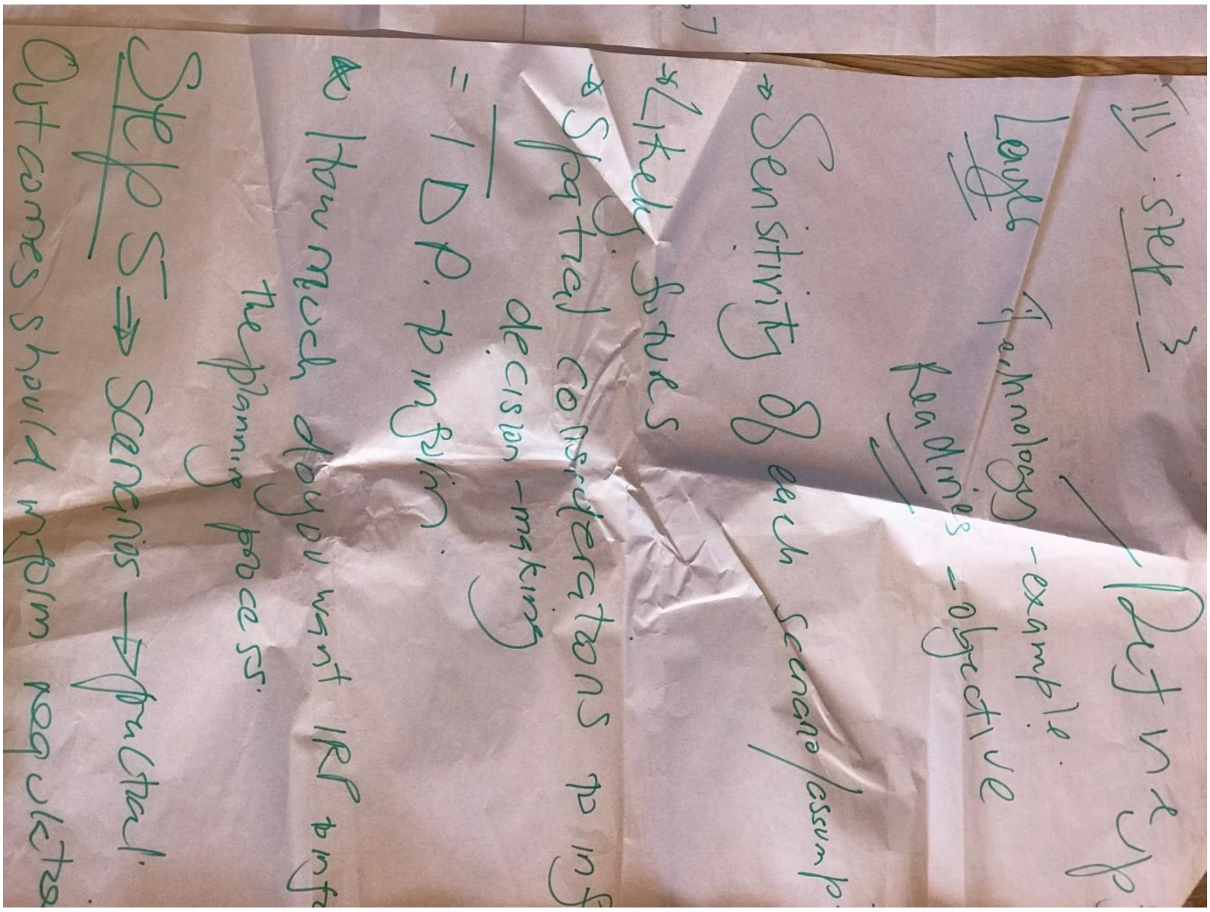
viii. The IRP has an established and transparent monitoring and evaluation process which ensures a thorough review and update of the IRP.

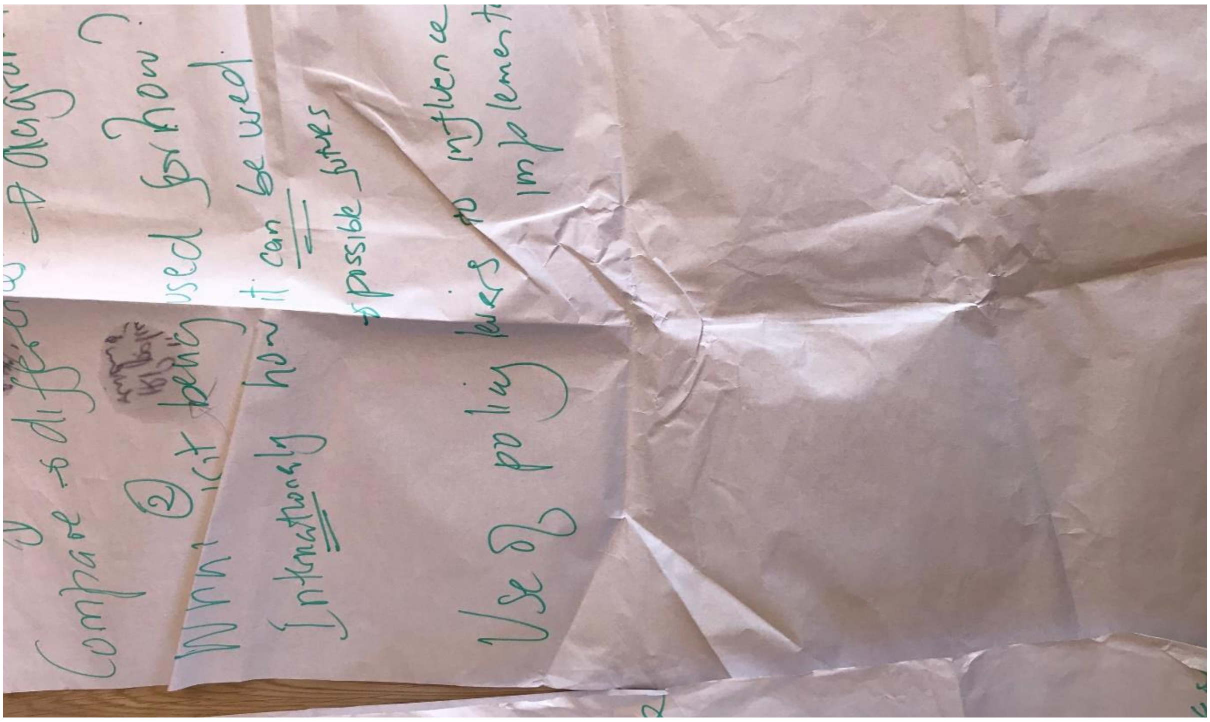
5) How frequently should the IRP be updated and what should drive each update and review of the IRP?
6) What scenarios should the IRP process consider, and what should be the basis for those scenarios? Please list them.
7) What key challenges or barriers to the IRP process would you identify? (These should focus on the promulgated IRP 2010–2030 and the new process underway for the update of the IRP 2010– 2030 initiated in December 2016.) Please list them.
8) What sectors and their strategies should the electricity sector consider as part of its long-term planning? Please list them.
9) What 'key indicators' should the government consider for future IRP monitoring and evaluation processes? Please list them.
10) What innovative case studies should be considered to inform the modelling and analysis of the IRP process? Please list them.
11) What potential actions and related projects outside government processes (including international case studies) could be considered or utilised to improve the IRP process in South Africa? Please list or define them.

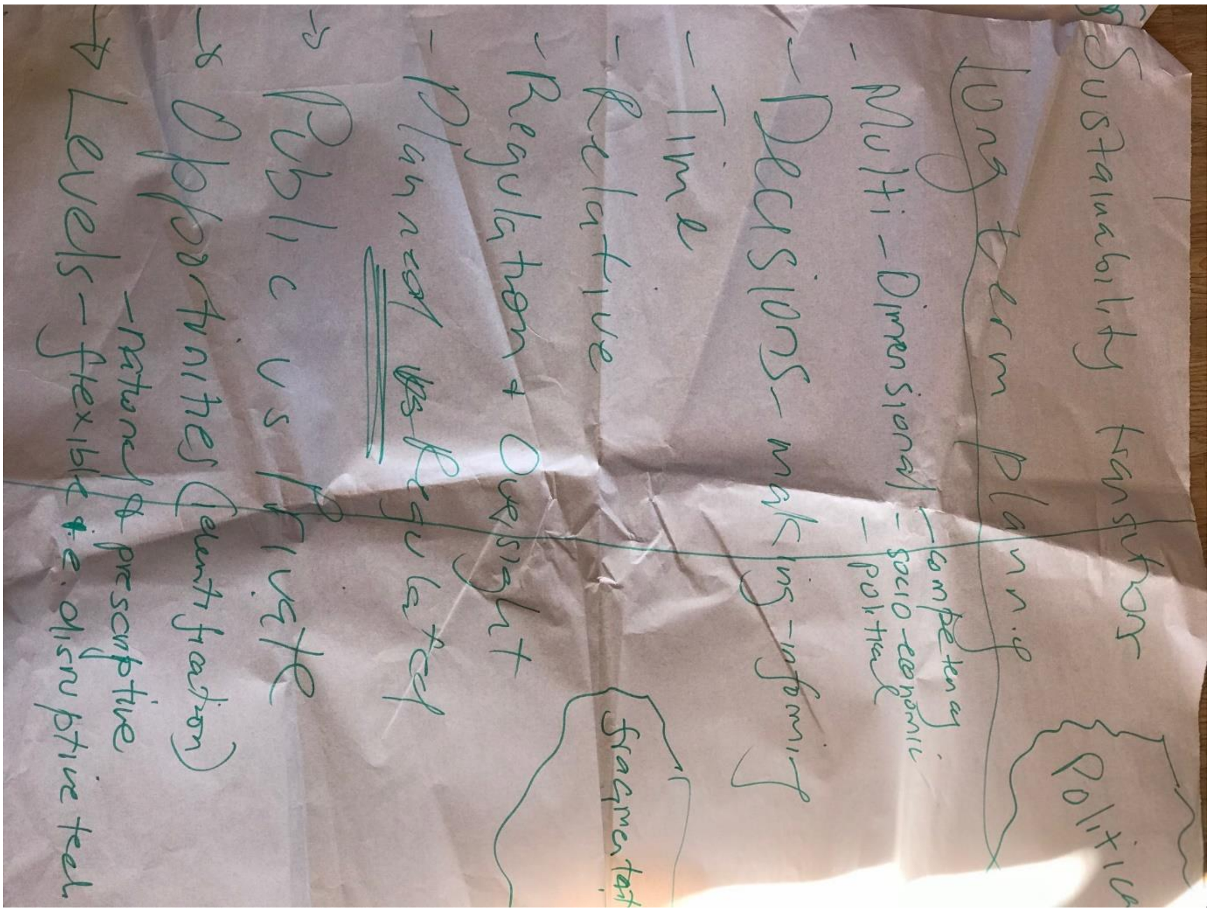
Thank you

ANNEXURE D: FOCUS GROUP MEETING NOTES






Compare & differ alignment
② Which is it being used for how?
Internationally how it can be used.
→ possible futures
Use by policy makers to influence implement


Sustainability transitions
Long term planning
- Multi-Dimensional - competency:
- socio-economic
- political
- Decisions-making - informing
- Time
- Relative
- Regulation + Oversight +
- Planning vs Regulated
→ Public vs Private
→ Opportunities (identification)
- reactive & prescriptive
→ Levels - flexible i.e. disruptive tech
Politics
fragmentation