Technological capability building and major policy change in the South African renewable energy industry

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ABSTRACT

South Africa has made a public and global commitment to address the issue of climate change through the mitigation of greenhouse gas emissions and the deployment of renewable energy as a cleaner alternative for the energy sector. Being a middle-income economy, the country is also faced with pressing socio-economic issues that relate to poverty, job scarcity and unreliable electricity supply. Given South Africa's stern commitment to transitioning from conventional heavy emitting energy sources to cleaner renewable sources, the country still has a long way to go with regards to growing technological capabilities domestically for renewables and the policy environment for the enablement of this goal plays a significant role. Moreover, the actors within the energy sector can themselves be organised in a manner that leads policy change through displaying intent and proactivity to grow their technological capabilities in the sector.

The purpose of the research is to explore how South Africa is building technological capabilities as they relate to learning as understood in the innovation perspective and to analyse the relationship between learning and major policy change. For the purposes of the research, the study explores the South African energy sector. The research objectives were to identify the actors involved in renewable and conventional energy within the sector and perform a comparative case study analysis between the coalitions to explore the conditions for major policy change with respect to technological capability building. Furthermore, a retrospective view of the South African policy environment for the energy sector was undertaken over the past decade to discuss how external shock events may have triggered policy change toward renewable energy. Subsequently a projected view was applied to discuss how actors in the South African energy sectors can seize opportunities to influence policy change through emphasising their endeavors for technological capability building.

The primary data for the research has been collected using semi-structured interviews and the research method that is used is qualitative methodology to conduct in-depth analysis on the topic of technological capability building within the South African renewable energy sector and to assess policy change within the sector.

Secondary data was gathered using policy documents and reports to gather more insights on the relevant government departments, their pro-conventional and/or pro-renewable agenda, as well as their beliefs and intentions for technological capability building within the energy sector. The data was analysed through manual coding of the data and identification of themes and interpretation of the main descriptions gathered from the data.

The research findings indicate that the pro-renewable coalition is receiving more support when compared to the pro-conventional coalition. This is due to the inherent nature of the energy industry which has been monopolised by a select few actors in the conventional energy space before the inclusion on alternative energy producing capabilities. Moreover, some of the conventional energy actors have since encompassed renewable energy capabilities as part of their business model in an attempt to reduce their greenhouse gas emissions (policy push) and invest in renewables which are the projected future trend in the energy sector (economic pull). Although the pro-conventional energy coalition is smaller in the number of actors, their political influence is more solid due to the fact that the country is still coal-dependent and possesses strong capabilities in avenues such as the nuclear energy front, which, in the face of the current pressures with energy shortages in the country, are the nation's muscle.

Technological capability building seems to be a desirable goal for both the pro-renewable and pro-conventional coalitions in South Africa, although current factors associated with financial resource constraints, a lack of technical expertise, political corruption and a lack of trust by foreign investors, ineffective mechanisms for accessing new knowledge and inefficient mechanisms for disseminating and utilising the acquired knowledge, form hindrances to achieving this. Policy bias for mass-producing energy options and a focus at low-costs during the procurement process also provides an unconducive environment for building technological competencies given that policy does not adequately incentivise nor reward such efforts. Government recognises this shortfall in its procurement regulatory frameworks and is currently faced with the task to redesign these instruments in a manner that will stimulate innovation and localisation.

In addressing the matter of policy change, this research identifies the 2009 – 2011 period in South Africa as giving rise to radical institutional change in in favour of renewables following the country's public declaration for reducing emissions and transitioning towards renewables, as an aim to follow the international norms. With the current national energy crisis, some institutional changes have taken place with the introduction of more independent power generators in the grid, although with limited possibility for this to improve domestic technological competencies within the energy sector. It is anticipated that emerging external shocks such as a rapid adoption of disruptive technologies might invigorate the need for policy to be shaped in favour of achieving the required localisation of expertise and subsequent building of technological capabilities.

The limitations with this research include data that is not exhaustive given the time constraints associated with this type of research, and given that participation was further restricted due to the current challenges on people's availability as imposed by the national lockdown restrictions. The research also focuses on one sector in South Africa and does not appreciate other parts of the economy where technological capability building might be taking place more readily. Future studies may also focus on addressing the topic of learning as understood in innovation systems from an organisational and policy learning point of view in order to expand on the learning phenomenon as explored by this research.

DECLARATION

I, ________________________________, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the field of Innovation Studies at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Signature:

Signed at …………………………………………………………..

On the ……… day of ………………………….…… 20…….

DEDICATION

"So, whether I eat or drink or whatever I do, I do it all for the glory of God."
(1 Cor. 10v31).

Soli Deo Gloria – To God alone, be the glory!

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CONTENTS

List of Tables

List of Figures

List of Abbreviations

Name	Description
ACF	Advocacy Coalition Framework
CE	Conventional Energy
GVC	Global Value Chain
ETIS	Energy Technology Innovation System
NIS	National Innovation System
RE	Renewable Energy
TCB	Technological Capability Building

1. CHAPTER ONE: INTRODUCTION

The introductory chapter presents the synopsis of the study by outlining the purpose of the study, the background context to the study and the problem statement, as well as the significance of the study. Consideration is also given to the limitations of the study. The chapter ends by providing definitions of key terms used in this research and provides a layout of the overall research report.

1.1 Purpose of the Study

The purpose of the study is to analyse the relationship between policy and learning as understood in the systems of innovation. The study reflects on the nation's growth potential through the improvement of technological expertise and knowledge in the energy sector in light of the established national policy agendas. South Africa has displayed strong intentions to transition towards the unconventional renewable energy option with the aim to increase energy supply whilst being cognisant of the issue of climate change. However, the country's current capabilities for renewable energy technologies does not necessarily match up to its aspiration for renewable energy sources. This research provides an opportunity to explore the role of actors in the energy sector in creating a conducive policy environment for growing innovation capabilities through the transfer and assimilation of foreign knowledge and new technology acquisition.

Research Objectives

The research objectives for the study are as follows:

- To identify and characterise actors in the energy sector on the basis of their belief system as coalitions advocating for either renewable or conventional energy. Furthermore, to identify those actors (from both coalitions) that are emphasising the need for technological upgrading and are proactive in technological capability building.
- To assess which rival actors can potentially converge on the basis of their beliefs relative to technological capability building and reconcile for the purposes of policy change that is in favour of technological capability building in the energy sector.
- To assess how external shocks in the past have shaped policy for renewable energy with the intent to inform coalition actors on how they can mobilise

themselves in order to seize windows of opportunity provided by emerging external shocks for the purposes of influencing policy change.

1.2 Context of the Study

Energy is a fundamental resource for the economy and a basic need for households particularly in developing countries where economic development is paramount. Mjimba (2016) described the “sustainable provision of appropriate, adequate and reliable stock of infrastructure in a manner that addresses social, environmental and economic inequities and related concerns as a major economic development and growth challenge of the twenty-first century”. South Africa attests to this statement as it faces socio-economic challenges with regards to unequal distribution and access to basic needs, including energy. South Africa’s residential sector alone consists of about 16 million households, a figure that is expected to increase to approximately 19-20 million by 2030 (DoE, 2016a).

The increasing demand on energy also threatens the longevity of natural resources that are currently stretched to meet the energy demands, with the intense use fossil fuel-based energy generation also being associated with greenhouse gas emissions (GHGs) (Asumadu-Sarkodie & Owusu, 2016). To date, fossil fuels have been the primary source of energy in South Africa and the demand for energy with rising population will instil pressure on the country’s natural resources. Thus, reducing the reliance on fossil fuels (through energy-efficient operations) and promoting distributed generation from renewable energy sources has both climate change and energy security benefits (Cherp et al., 2012). Through policy, government has established plans for the ramification of energy shortages as well as for addressing environmental concerns of climate change and the depletion of natural resources.

Climate change has become a defining issue of our generation that requires attention at global level (where the effects are more obvious) as well as national levels (where the damage is either being done or is being mitigated). Economies that were previously carbon-based are now taxed with the responsibility of reversing the effects (where feasible) and are being regulated towards more environmentally friendly initiatives. The rising and urgent awareness on climate change in developing economies (which are generally still carbon-based and have become more energy-intensive) has also taken centre stage. This reaction is appropriate considering the detrimental effects that climate change can have on the physical environment and consequently on its inhabitants through extreme weather conditions which propagate concerns such as recurrent wildfires and droughts. It is therefore significant that while policy seeks to secure energy supply, that it also aligns with the global dialogue on climate change and set an agenda that will transmit into action.

Energy efficiency methods measure and encourage energy saving while renewable energy offers more environmentally benign alternatives which encourage a shift towards a more sustainable approach (DME, 2003b). Although there is commonly an overlap between renewable energy and energy efficiency technologies, this study separates the two terms in order to analyse the opportunities for technological capability building that are introduced by either type of technologies. Consequently, policies supporting the development of energy-efficient technology initiatives are required in order to ensure that energy supply scales, however, without posing unacceptable risks to human health and the environment.

1.3 Problem Statement

The connection between policy-oriented learning and policy change has been identified in literature (Sabatier & Jenkins-Smith, 1993). However, scholars have provided differing interpretations on the nature of this connection, which is said to be either strong (Munro (1993); McBeth, Shanahan, Arnell, and Hathaway (2007)), weak (Eberg (1997) ; Nohrstedt (2005)), or even illegitimate considering the methods used to measure it (Bandelow, 2006). On the other hand, the connection between the process of learning as understood in innovation systems (which includes technological, economic, organisational and policy learning) and innovation outcomes has been consistently observed as a significant one (Lundvall and Johnson (1994); Viotti (2002); Lundvall and Ø (2008); Lundvall (2016)). Considering the conclusive nature of the latter connection, it is worth assessing the possibility for policy change to be specifically linked to (and affected by) learning as understood in innovation systems, rather than policy learning in its broader sense.

The paper studies the evolution of energy policies in South Africa with respect to how policy has addressed the need for technological learning and innovation over the past two decades (from the 1998 White Paper to the 2019 Integrated Resource Plan). The advocacy coalition framework (ACF) which has been utilised over various research applications and sceneries globally to analyse for policy change over extended periods (Weible, Sabatier, & McQueen, 2009), is adopted in this study. The ACF is used in first assessing the rival coalitions by evaluating key actors in the energy sector and whether they are advocating for the renewable or conventional energy agenda. Secondly the ACF is used to examine the belief systems of actors from both coalitions in relation to learning, characterised by their commitment to building innovation capabilities and their past performance in propelling learning. The secondary innovation framework, which analyses the path for domestic firms to catch-up in latecomer economies (Wu, Ma, Shi, & Rong, 2009), is applied to evaluate competencies for learning. Furthermore, the strategic orientation of firms is evaluated by identifying the conditions qualifying the latecomer firms to catch up and take advantage of their latecomer status (Mathews, 2002).

A retrospective approach is applied to assess how the coalitions have previously organised themselves in the face of external system events with the aim to provide insight on how they can seize windows of opportunity provided by external system events. The predictive abilities of the ACF then informs a forecast on policy change for renewable energy as it relates to technological capability building, in light of the emerging external shock within the South African energy space.

1.4 Significance of the Study

The South African government has committed to a number of policy plans and national strategies with the aim to improve energy supply and the reliability thereof, while transitioning towards more environmentally benign energy production options. In 2003, the government (Department of Minerals and Energy) made plans to improve the energy mix with the aim for South Africa to procure more renewable energy (DME, 2003b), at a time where fossil fuels were contributing 92% of the energy being produced (Eskom, 2003). By 2015, the traditional fossil-fuel contribution had decreased to 83% (Eskom, 2015) and has since been projected to contribute less than

30% of the energy that will be supplied by 2040 and less than 20% by 2050 (DoE, 2018).

With the deliberate plans to include a significant amount of renewable energy to the grid in the near future (DoE, 2019), this study contributes to studies on technological capability building, innovation and energy policy in South Africa. Technological capability is a major part of the policy debate with regards to national development (energy security) and climate change in South Africa (Rennkamp & Boyd, 2013).
The study also provides insight on partnerships, linkages and interactions between the key actors in the energy sector. The need for technological capacity building is further exacerbated by the fact that renewable technologies involve trajectories of increasingly complex skills and are more knowledge than labour intensive (Oslen, 2010). Moreover, gaining domestic technological capabilities also positions the country for local industry development, job creation and therefore poverty reduction in the long run (Rennkamp & Boyd, 2013), which are already priority plans in the government's policy agenda.

The results of this study provide an indication on the state of readiness of the renewable energy sector in South Africa to sustainably build technological capability in this industry. This study is useful in understanding how government strategies such as the Integrated Resource Plan (IRP) and the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) can influence outcomes in domestic technological capabilities within the energy sector. Subsequently the results could potentially assist policy makers in developing countries who are also undergoing learning, as understood in innovation systems, in order to formulate better policies and programmes aimed at improving domestic technological capability.

The research offers a retrospective overview on how government's agenda for green energy has been perpetuated within the twenty-year period, and subsequently, how much consideration government has given to fostering the required innovation. In the face of what seems to be another external shock with government approving the independent procurement of electricity, the study informs coalitions on how they can pre-emptively mobilise themselves with regards to technological capability building in order to seize this emerging window of opportunity.

1.5 Delimitations of the Study

The study focuses on energy as it relates to its generation, but for the purpose of ease of access to information, does not include other avenues. Any findings and/or recommendations derived from the study are only applicable to the energy sector and particularly renewable energy. For the purposes of meeting the stipulated timelines, the region of the study is limited to South Africa. The study does not attempt to closely interrogate the factors influencing learning as understood in systems of innovation, given that it is not identified part of the research problem by the researcher and therefore the study does not aim to contribute towards this.

For the purposes of access to the required information, the study is limited to a broad view of policy which will include publicly available legislations, laws and frameworks at the time of conducting the study. The study references policies that are relevant to the study and published by the South African government departments (namely the Department of Mineral Resources and Energy, the Department of Science and Innovation, and the Department of Trade, Industry and Competition).

Considering the time and participant availability constraints concerned with the research which was conducted under restrictive Covid-19 pandemic circumstances, the participants were limited to the number of fifteen interviewees and the conducted interviews were not exhaustive but extensive enough to gather information that is closely aligned to the objectives of the research.

1.6 Assumptions

The study is based on the assumptions that:

- Interview participants responded to the best of their knowledge during the interviews.
- Records of policies, reports, or plans published by the relevant government departments are accurate and up to date.

1.7 Definitions of Key Terms

Innovation is defined by Goffin and Mitchell (2017) based on Schumpeter (1934b) as: (a) the introduction of a new product (good) which is not yet known by the end users or one that increases the quality of the good that already exists. (b) A new method of production which is new to a specific branch of industry. This does not have to be based on scientific discovery but may exist in other sectors. (c) Creation of new markets – which the specific organisation has not entered. (d) New sources of supply whether the source is new or existing. (e) New industry which involves restructuring of the competitive environment and industry (Schumpeter, 1934a).

Policy is widely defined as a set of guidelines or a plan that is utilised as a basis for making decisions or taking action. It can be in form of a law, regulation or procedure that is put together by an institution such as government. For the purposes of this study, **policy** refers to published government policies, legislations, bills, laws and governing frameworks that have been passed on by the country-specific government. **Policy change** refers to incremental shifts in existing structures, or new and innovative policies (Bennett, 1992). When a policy is modified and adjusted in some way over time, then the process of policy change has occurred. **Policy learning** is an important aspect of policy change and refers to 'relatively enduring alterations of thought or behavioural intentions which result from experience and which are concerned with the attainment (or revision) of policy objectives' (Heclo, 1974).

Learning is defined as a process of purposefully acquiring knowledge, technical skills, as well as through reflection, experience, or instruction (Brookes, 1995). The process of learning as understood in innovation systems includes technological, economic, organisational and policy learning (Lundvall and Johnson (1994); Viotti (2002); Lundvall and Ø (2008); Lundvall (2016)). The definition that is relevant for this study is that *learning* is "the process of technical change achieved by diffusion (in the perspective of technology absorption) and incremental innovation" (Viotti, 2001).

According to the World Bank's classification, **a developing country** is defined as a lower middle-income or an upper middle-income country. A developing country/economy is also referred to as a late industrialising country/economy.

According to the Merriam-Webster dictionary, **capability** is defined as the quality or state of being capable or able to do or accomplish something. **Technological capability** can be defined as the ability to develop, use, invest, produce, and implement technology in a firm where it is supported by an enabling environment (Lall, 1992). **Technological capability building** is defined as the process of assembling or accumulating technological know-how (capability) and is regarded as providing an investment opportunity for firms (Malerba, 2005).

Energy Efficiency describes the amount of useful output obtained divided by the energy used to produce that output. This is the reciprocal of a quantity generally referred to as "energy intensity." For the purpose of the government strategy, "energy intensity" generally implies the use of monetary units of measuring outputs (DoE, 2016b) [The ratio between the theoretical minimum energy requirement for performing a task and the amount of energy actually used (small-scale definition).

Renewable energy is energy sourced from natural resources (such as the sun, wind and ocean current energy) which vary in availability depending on time and weather and are constantly replenished (Shinn, 2018). Renewable energy is also known as clean energy due to its non-detrimental effects on the environment.

1.8 Research Questions

In order to address the research problem outlined above, the study poses the following research questions:

1. Who are the key actors in the energy sector that are advocating for either the renewable or conventional methods for energy production in South Africa?

2. Which of the actors are advocating for technological upgrade (beyond the renewable/conventional energy debate) and are participating in elevating domestic innovation capabilities?

3. a) In the past two decades, how have external system events influenced policy change towards renewable energy and how much emphasis did policy place on technological learning and innovation that is necessary to support the transition?

   b) In the face of what seems to be an emerging external shock, how are the coalitions (both conventional and renewable energy) organising themselves in order to seize this window of opportunity and take advantage of influencing policy change?

1.9 Outline and Structure of the Report

The research report is presented in the following manner over the six chapters:

Chapter 1: Introduction
The introduction chapter provides a basis for the topic at hand and outlines the "*why*" behind the topic of choice.

Chapter 2: Literature Review
The literature review provides an academic foundation to the topic for the study and give a theoretical and conceptual perspective to the topic at hand. This includes a discussion on the global and local trends in energy technologies and setting the scene for the policy frameworks developed in South Africa over the period of study. The chapter also surveys literature on the theoretical frameworks for the study, which have been used to inform the conceptual framework.

Chapter 3: Research Strategy and Methodology
The research methodology section presents the research design and strategy, the techniques used for gathering the data, the chosen modelling approach for the data, as well as the presentation and analysis of the data. This chapter also provides justification for the chosen approach of research.

Chapter 4: Presentation of Results
The results section includes the presentation of the data of the study and make use of visual and verbatim statements for describing the data.

Chapter 5: Analysis of Results and Discussion

This chapter presents the analysis of the data using qualitative research method, in order to address the research problems stated in Chapter 1.

Chapter 6: Conclusions and Recommendations

This chapter provides conclusions and recommendations as derived from the findings of the study, however, taking into account the stated limitations and assumptions for the study.

2. CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to provide a critical review of the relevant literature on policy change and innovation capability building. The literature review kicks off by discussing the global and local trends in energy technologies within the objectives of energy supply and combating climate change. The literature then examines the theoretical background on the central aspects of the research question: coalitions advocating for or against renewable energy and how they are building innovation capabilities in South Africa. The review provides an analysis of public policy associated with energy supply (promoting energy efficient technologies) and climate change (promoting renewable energy solutions) in the context of South African policies. A framework for analysing policy change is also reviewed. Concepts associated with the national innovation systems approach and building innovation capabilities within a developing country are reviewed. Finally, the chapter reviews the conceptual framework specific to this study as informed by the outlined theoretical background.

2.2 Global and Local Trends in Energy Technologies

The demand for energy is a global challenge which is anticipated to increase with time. Over three billion people in the world live in 83 countries that import more than 75% of the oil products for energy consumption and China's oil import alone is projected to increase from the current 53% to 84% in 2035 (Cherp et al., 2012). With natural resources at a risk of depletion, fossil fuels may also not be a sufficient rescue plan for energy production. Since climate change is affecting water availability, hydroelectric power production is also perceived as insecure (Cherp et al., 2012).
If alternatives such as nuclear energy can address energy security, they still raise issues of social and political controversies (Cherp et al., 2012). Furthermore, highly advanced and unconventional energy technologies are likely to be accessible to more developed countries as a result of the difficulty of technology transfer and infrastructural capabilities within less developed economies.

The 2030 Agenda for Sustainable Development and the Sustainable Development Goals, agreed in September 2015 was developed with the goal of increasing access to electricity (UN, 2018). Within the agenda is a target “to increase substantially the share of renewable energy in the global energy mix” by 2030 through ensuring universal access to affordable, reliable, sustainable and modern energy supply (UN, 2018).

There are three generations that are used to describe the evolution of renewable energy technology. The International Energy Agency (IEA, 2006) categorises energy technologies into three subsets:

- First-generation energy technologies: These are the mature and economically competitive technologies (Lopez, 2015) such as hydro- electric power, biomass, geothermal energy
- Second-generation energy technologies: These are the technologies that are undergoing consistent development and growing rapidly such as solar energy, wind power, and modern forms of bio-energy
- Third-generation technologies: These are the technologies that are currently undergoing research and are being developed and not yet practical (Lopez, 2015) such as concentrating solar power, ocean energy, improved geothermal and integrated bio-energy.

According to the IEA, the amount of renewable energy share that will be meeting global energy demands between 2018 and 2023 is expected to grow by one-fifth to reach 12.4% (IEA, 2019). This predicted increase will be instrumental for promoting long-term global sustainability goals and for combating the issue of climate change.
When applying a local lens, the reliability of electricity supply remains a serious concern locally, especially in developing countries (Cherp et al., 2012). South Africa, being a developing country, is also faced with the challenge of unreliable electricity supply, with load shedding (electricity blackouts) becoming a norm in the typical South African household. Approximately three-quarters of low-income countries experience load shedding on average for more than 24 hours per month, and half of low-income countries experience load shedding at least 10 times a month (Cherp et al., 2012).

Although climate change is mostly a global concern, energy security is primarily a national concern (Cherp et al., 2012) which therefore requires national intervention to promote sustainable development. While unrenewable reserves (i.e. fossil fuels) remain the primary source of energy supply in South Africa, government is realising the need for a shift to more renewable solutions.

2.3 Landscape for Energy and Climate Change Policy in South Africa

South Africa's policy environment within the energy sector has been under focus over the years with the intention to address pressing socio-economic and environmental challenges in this sector. In his research, Mjimba (2016) explores current and potential role of innovation in supplying sustainable electricity to power the economic, social and environmental development aspirations of Nigeria and South Africa. Among the primary conclusions drawn from his research, Mjimba (2016) highlights the role of policy and institutional regimes and their need to be adjusted in such a manner that caters for existing (social and economic) realities for sustainable electricity supply.

The policies mentioned below map out government strategies for addressing energy demands and climate change mitigation in South Africa starting from the publication of *The White Paper* in 1998 to the 2019 Integrated Resource Plan. Over the twenty-year period, the country has adapted various plans aimed at achieving sustainable energy resourcing, improving energy efficiencies and integrating green energy alternatives whilst reducing the emissions of harmful gases to the environment.

The White Paper on Energy Policy (1998)

The South African Department of Minerals and Energy (DME) (2003) released a national energy policy (*White Paper on Energy Policy of the Republic of South Africa, 1998*) based on The Constitution (Act No. 108 of 1996). The objective for the paper was to ensure adequate energy resources through sustainable production and distribution for the betterment of citizens in South Africa (DME, 1998). The main objectives outlined in the DME (1998) paper are as follows:

- Increasing access to affordable energy services across the board;

- Improving overall energy governance in the country;
- Stimulating South Africa's economic development;
- Managing environmental impacts around energy-related activities; and
- Securing energy supply through diversity.

The White Paper on Renewable Energy (2003)

The subsequent *White Paper on Renewable Energy* highlighted the significance of renewable energy on government's vision for the energy sector and how its objectives will be achieved. The main aim of *The White Paper* was reported as the creation of conditions for the development and commercial implementation of renewable technologies (DME, 2003b), which would then foster ventures into new spaces in the energy sector of South Africa.

In order to meet the long-term goal of sustainable renewable energy industry, the South African government set a 10-year target for renewable energy of 10 000 Gigawatt-hours (GWh) (equivalent to 0.8Mtoe) renewable energy contribution (produced mainly from biomass, wind, solar and small-scale hydro) to final energy consumption by 2013 (DME, 2003b).

National Integrated Energy Plan (2003)

The Integrated Energy Plan (IEP) of 2003 was developed from *The White Paper on Energy Policy* (1998) which stated that the DME "will ensure that an integrated planning approach is adopted for large investment decisions by energy suppliers and service providers in terms of which comprehensive evaluations of the economic, social and environmental implications of all feasible supply and demand side investments will have to be undertaken" (DME, 1998).

As outlined in the document, the purpose of the IEP is to act as a framework for specific energy development decisions in order to balance energy demand with supply resources whilst considering safety, health and the environment (DME, 2003a). The document outlines energy efficiency and renewable energies as follows:
Energy Efficiency: Improved economic and environmental performance are brought about by sustained energy efficiency measures, including end-use fuel switching.

Renewable Energies: Although the introduction of renewable energies has higher costs over the planning horizon, it is important to promote renewables for environmental reasons and for diversification of supply and to establish an infra-structure in South Africa that can develop to the extent where renewable energies can contribute significantly to energy supply on an economic basis.

National Energy Efficiency Strategy (2005)

In March 2005, the first ever Energy Efficiency Strategy was put in place in response of The White Paper (1998) which mandates the DME to promote energy efficiency and linking government initiatives for the energy sector development with national socio-economic development plans (DME, 2005).

Initially the strategy had set a national target for energy saving of at least 12% by 2015 (as well as several sectoral targets) based on a modelled value from the IEP (2003) which used energy consumption data for the year 2000 (DME, 2005). Energy efficiency was set to be improved through enabling instruments and interventions including economic and legislative means, information activities, energy labels, energy performance standards, energy audits, energy management and the promotion of efficient technologies (DME, 2005).

In the Post-2015 National Energy Efficiency Strategy (2016), significant progress was observed in 2000 and 2012 in improving energy intensity which was a result of a combination of autonomous change, technological advancements and deliberate interventions for improving energy efficiency (DoE, 2016a).

Integrated Resource Plan (2011)

In March 2011, the government of South Africa published the Integrated Resource Plan (IRP) which covered the period 2010-2030, and was informed by the Electricity Regulation Act, 2006.55. The aim of the IRP is to direct the expansion of electricity supplies through local and regional private, and public generation projects (DoE, 2011). The plan was largely driven by a 10 000 GWh target that was to be realised by 2013 through a target mix of electricity sources that include hydro power, solar energy, biomass, gas, nuclear and wind, the IRP seeks to ensure that South Africa has electricity supplies that enable it to meet its sustainable development objectives (Mjimba, 2016). Consequently, the 2013 updated plan seeks to ensure that electricity is generated through an appropriate mix of technologies that can: (1) meet its climate change management objectives; (2) ensure an adequate and reliable supply of electricity; (3) ensure sustainable use of its local and regional resources; and (4) create a local manufacturing base, among other objectives (Mjimba, 2016). The plan set out that by 2030, 17,800MW of electricity will be from renewable energy sources.

In response to energy supply constraints highlighted in the NDP (2010) and IRP (2011), the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) was established to enhance a public-private partnership model in order to encourage renewable energy initiatives whilst taking the load off Eskom. The REIPPPP is to secure electrical energy from private sector via renewable energy sources (e.g. solar, onshore wind, concentrated solar power (CSP), biomass, small-scale hydro and landfill gas) in order to add to the national grid (IPPO, 2018).

National Climate Change Response Policy White Paper (2011)

The White Paper (2011) sets out South Africa's climate change response strategy to achieve the National Climate Response Objective in a manner that follows strategic priorities such as risk reduction and management, mitigation actions with significant outcomes, policy and regulatory alignment, technology research, development and innovation (DEA, 2011).

The White Paper defines a benchmark range, the 'Peak, Plateau and Decline' (PPD) trajectory, for national Greenhouse Gas (GHG) emissions associated with climate change. The policy maps the Desired Emissions Reduction Outcomes (DEROs) for the long (2050), medium (2030) and short (2020) terms (DEA, 2011). Long term DEROs, expressed as a range, will be aspirational, while short term DEROs will be more realistic and based on currently available technology. DEROs will be absolute GHG reductions at the sector and sub-sector level. The policy paper describes two mechanisms to achieve these DEROs. The first is the implementation of carbon budgets for sectors and companies that typically emit large amounts of greenhouse gases. The second a mix of government policy measures, called the 'Mix of

Measures', which may include regulatory instruments (typically energy efficiency regulations and standards) and economic instruments (such as incentives and taxes). The overall mitigation process is shown in Figure 2-1 below.

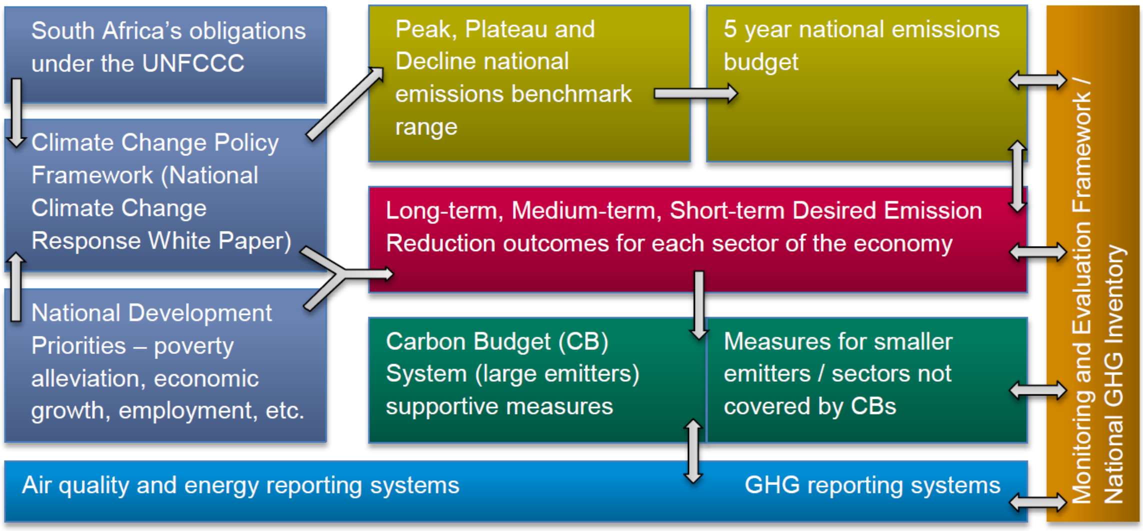


Figure 2-1: South Africa's Mitigation Process (adapted from DEA (2014))

Climate Change Bill (2018)

The Department of National Treasury of South Africa alongside the Department of Environmental Affairs enacted a carbon tax bill (2016 and 2017) to regulate greenhouse gas emissions by imposing carbon tax liability. Through the evolving climate change regulations in South Africa, the government is putting in place measures to mitigate global climate change and transition the country to a lower carbon economy and to remain carbon constrained.

The bills pose emissions limits on industry in South Africa in the form of a carbon budget which is the allowance of GHG emissions based on targets that have been set for the entire country and divided among different economic sectors.

Integrated Resource Plan (2019)

The integrated resource plan (IRP) documents the infrastructure development plans for South Africa to ensure reliable electricity supply through the use of a diverse energy mix and the minimization of environmental impact (DoE, 2019). The IRP offers plans to further develop energy generation capacity following the initiatives undertaken with guidance from the IRP 2011.

Although coal is planned to continue generating a significant amount of South Africa's energy, the IRP mentions transition towards other alternatives. This includes the addition of 1 860MW of nuclear power which will be commissioned by 2024, following the extension of the design life of the Koeberg Power Station and its nuclear safety license (DoE, 2019). Plans to procure about 6 000MW of new solar PV capacity and 1 4400MW of new wind power capacity are in place and will be commissioned by 2030. Gas to power production is estimated at 1000MW by 2023 and 2000MW by 2030 and ESKOM is planned to play a vital role in this goal through the conversion of the diesel-fired power plants to gas.

Beyond local capabilities, South Africa has secured a treaty for the development of a hydro power plant in the Democratic Republic of Congo which is intended to transmit electricity to South Africa (DoE, 2019).

2.4 Theoretical Frameworks

2.4.1 Introduction

The chapter outlines the theoretical frameworks that are relevant in exploring the study at hand and in setting out the context of the energy/climate change discourse as it relates to technological capability building. The chapter entails discussions on the advocacy coalition framework, the systems of innovation approach, as well as the global value chain hypothesis. The chapter ends by compiling a conceptual framework that is adopted for the purposes of addressing the study at hand.

2.4.2 Advocacy Coalition Framework

The advocacy coalition framework (ACF) has been adopted for the purposes of the study. The ACF is a policy theory that studies the interactions between coalitions while also taking into account their external environments. An advocacy coalition consists of "people from a variety of positions (elected and agency officials, interest group leaders, researchers) who share a particular belief system—i.e. a set of basic values, causal assumptions, and problem perceptions—and who show a non-trivial degree of coordinated activity over time" (Sabatier, 1988). The advocacy coalitions are glued together by three sets of belief systems:

- Deep core beliefs (coalitions): Actors' underlying personal philosophy/beliefs upon which the coalitions are founded on. These beliefs are not prone to change.
- Policy core beliefs (policy sub-systems): These regard fundamental policy positions (Lodge, 2015) and can only be changed by external shocks.
- Secondary beliefs (expert/knowledge forums): These include a multitude of instrumental propositions to achieve policy goals within the subsystem (Sabatier, 1998). These can be changed by policy learning as new information becomes available to the coalitions.

The ACF is a means for understanding coalition formation, stakeholder behaviour and policy outcome (Weible, 2006). In a review of the status of policy theory, Sabatier (1999) considers the ACF as a theoretical framework that simplifies the complexity of social and political systems with the aim to understand key and various drivers of policy change within various levels. The policy outcomes are centred on policy oriented learning (where scientific and technical knowledge play within the coalitions which may result in policy change over a period of a decade or more).

Coalitions interact within policy subsystems (Lodge, 2015). A policy subsystem is a relevant scale for analysing policy processes over time (Weible, 2006). The subsystem consists of between two and four coalitions with sharing similar belief systems. Policy participants are actors who are experts in the field (Markard, Suter, & Ingold, 2016) who are regularly seeking to impact policy change related to an issue in their area of expertise or influence. These actors have some degree of specialization in the policy area and include legislators, researchers, journalists, and actors drawn from government agencies, non-profits, businesses, and interest groups (Henry, Ingold, Nohrstedt, & Weible, 2014).

Policy subsystems are within a wider system which outline relatively stable parameters over the time period (which are the basic attributes of the issue and the constitutional structure); resources and constraints; long-term coalition opportunity structures; as well as external system events (such as socioeconomic change, or a change in government) (Lodge, 2015). The ACF flow diagram presenting the system is shown in Figure 2-2 below.

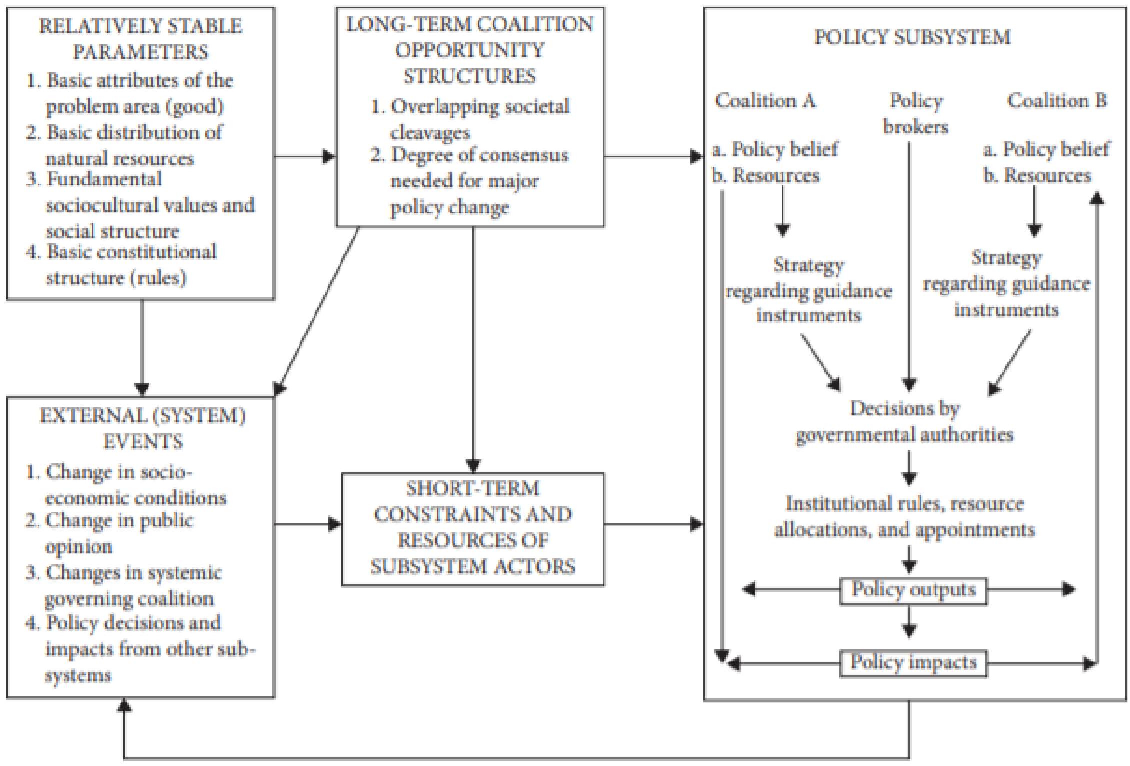


Figure 2-2: The ACF Flow Diagram (source: (Weible et al., 2009))

2.4.3 Policy Learning and Policy Change

The ACF has been used widely as a theoretical approach to learning across different geographies and policy environments (Sabatier (1987), Sabatier and Jenkins-Smith (1993), Sabatier (1998)). Bandelow (2006) illustrates how the concepts of policy learning, political learning, social-learning, lesson-drawing and other connected concepts have all played a role in shaping the assumptions about the what are the causes and results of policy-oriented learning. Considering the various definitions of learning, Bandelow (2006) notes that the concept is more broadly used to explain the learning process of individuals and actors collectively as they change their beliefs due to the introduction of or exposure to new information.

There has been a significant amount of research conducted with the aim to expound on policy oriented learning and its effects on policy change. In his literature, Sabatier (1987) integrated knowledge utilization and policy change by seeking to understand the role of policy analysis/information in policy learning, and ultimately, policy change. The author defined policy oriented learning as “improving one’s understanding of the state of variables defined as important for by one’s belief system” or “refining one’s understanding of logical and causal relationships internal to a belief system” (Sabatier, 1987). Such learning has been linked with policy changes particularly in secondary and policy core beliefs (Eberg, 1997).

A study on the Californian water politics suggests a significant connection between policy learning and policy change (Munro, 1993). In a discussion on narrative policy analysis and policy change, McBeth et al. (2007) also reports a strong implication of learning in either strengthening core beliefs within a coalition or in altering core beliefs across coalitions over time. Eberg (1997) exclaims that little contribution is played by learning in policy change when considering a study on the waste management policy in the Netherlands and Bavaria. Likewise, Nohrstedt (2005) also sees learning as less prominent than other factors (such as short-term political interests) which are more significant in explaining the effects on policy change.

It is evident that researchers have observed a connection between policy learning and policy change in various measures of significance. However, Bandelow (2006) identifies the problem of empirical examination in such studies that aim to theorise learning and points out to the methods of measuring or understanding learning as being unreliable, and thus, not as effective in their findings as they intend to be.

2.4.4 Systems of Innovation Approach

The study adopts the systems of innovation approach and this section briefly defines innovation and the different types of innovation systems that were considered for this study. Schumpeter (1934a) defined innovation as the introduction of a new product (good) to an end user, or a new method of production to a specific branch of industry. (Marcelle, 2012) mentions the view of Sutz (2012) in that innovation in developing countries includes processes that are purposefully used to “design and produce new products or processes, or to significantly modify existing ones.” Innovation systems offer a systemic lens which can be applied across various levels including national, regional and sectoral levels, as elaborated further below. Within these levels are various actors that are in interaction within the system of innovation.

National Innovation System

Innovation within an economy involves the interaction of multiple players operating within a complex system referred to as National Innovation System (NIS). Freeman (1987) defined NIS as “the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies” and later on emphasised that national and regional systems of innovation are an essential domain of economic analysis (Freeman, 1995). Lundvall (1992) was more specific on the institutions involved by mentioning all aspects of the economy including institutions which affect learning, searching and exploring as well as aspects pertaining to production, marketing and finance, where learning regarding innovation can occur. The Organisation for Economic Co-operation and Development (OECD, 1999) examined different innovation systems in Europe using the innovation system and showing all the players and their interlinkages on a meso-level (outside of firms) and micro-level (within firms) scale, as illustrated in Figure 2-3 below.

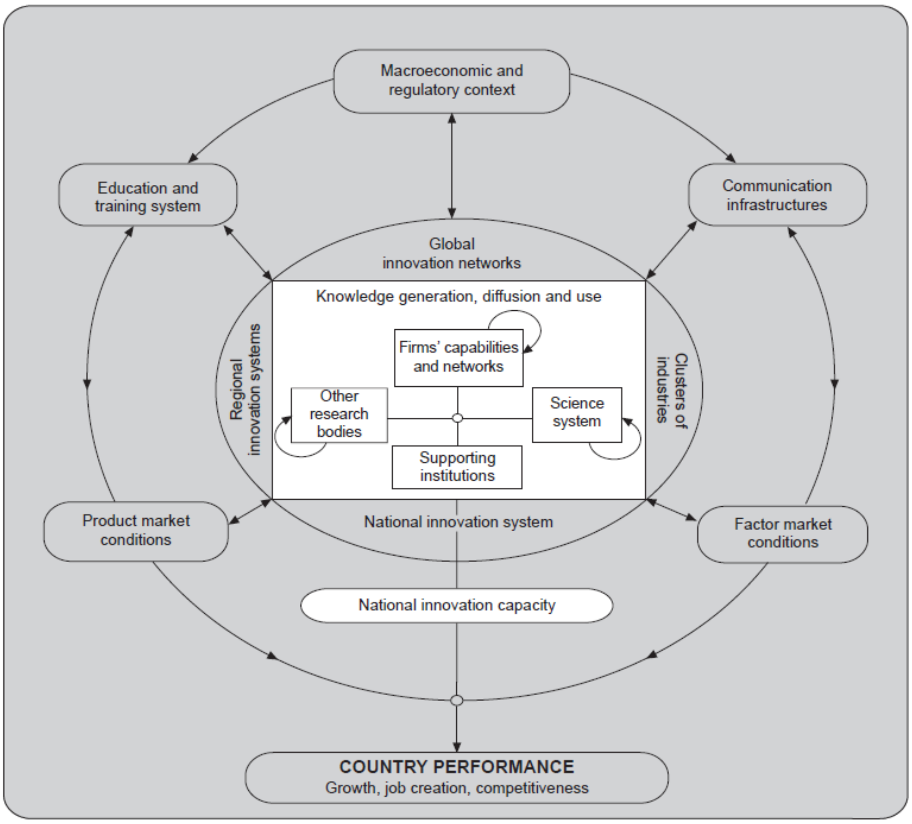


Figure 2-3: Actors Within a NIS and Their Linkages (Source: OECD (1999))

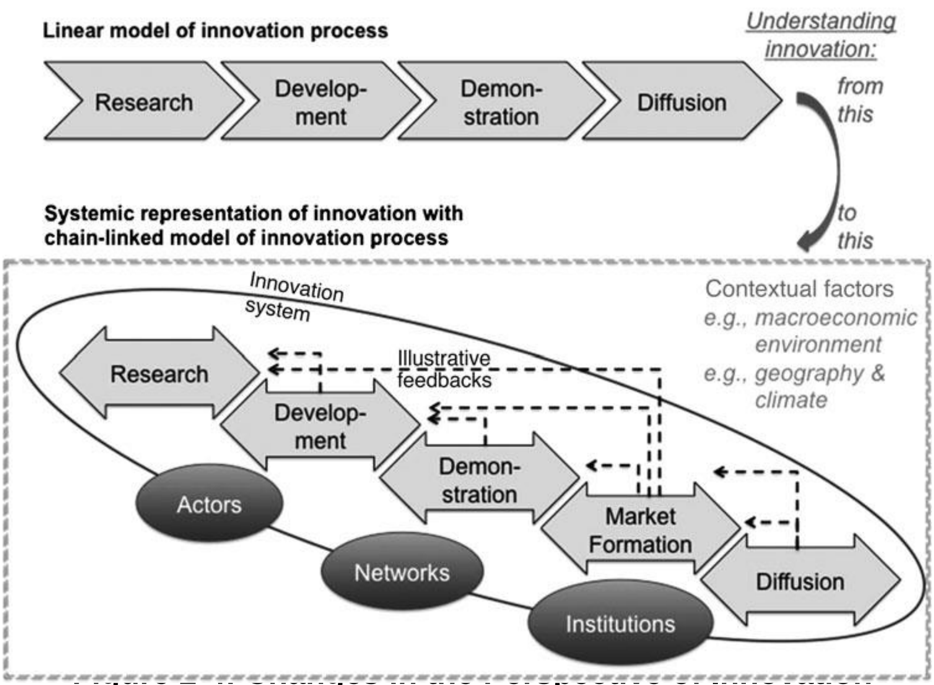
Sectoral Systems of Innovation

Systems can also be approached with a narrow view and described on the basis of their function or sector. Malerba (2002) defined a sectoral system as, "a set of new and established products for specific uses and the set of agents carrying out market and non-market interactions for the creation, production and sale of those products". This concept was further discussed by Fagerberg, Mowery, and Malerba (2009) who added the building blocks of sectoral systems (i.e. knowledge, technological domains, and sectoral boundaries; actors, relationships, and networks; and institutions).

For the purposes of this study, technological innovation system (TIS), which has similar traits to that of a sectoral systems of innovation, was also considered a probable framework. Carlsson and Stankiewicz (1991) described TIS as consisting of different players acting in collaboration with others under some institutional framework to innovate in a specific technology. The two systems differ in that, in a specific sector different technologies might be involved, for instance, the renewable energy sector may encompass different technologies (i.e. ranging from solar to wind to ocean technologies), and so sectoral systems of innovation offer a much broader view than TIS, which has a specific function and usually focused on a specific technology (Ndlhovu, 2016). It must also be noted that the two systems have different benefits, where a TIS can span several sectors, and a sectoral innovation system can include several technologies.

Energy Technology Innovation System (ETIS)

More specific to the chosen sector for this study is the energy technology innovation system (ETIS). Gallagher et al. (2012) defined ETIS as the application of a systemic perspective on innovation to energy technologies comprising all aspects of energy systems (supply and demand); all stages of the technology development cycle; and all innovation processes, feedbacks, actors, institutions, and networks (Gallagher et al., 2012). The perspective on innovation has progressed from being traditionally linear in flow (from research, to development, to demonstration phase and then diffusion), to being more interactive in nature (see
Figure 2-4 below).



Processes (Source: Gallagher, Grübler, Kuhl, Nemet, and Wilson (2012))

The key features of the ETIS framework are a) knowledge and learning (publicly available or tacit knowledge and the process of transferring knowledge through learning); b) economies of scale (cost reductions as unit size or production expands); and c) actors and institutions (their role in influencing innovation processes and public policy objectives) (Gallagher et al., 2012).

Addressing innovation with a systemic view-point allows one to account for the fact that innovation involves many actors, activities and knowledge feedback between the different actors. An important notion of innovation processes also includes that they are influenced by their institutional settings and corresponding incentive structures, including the market as well as government policy (Gallagher et al., 2012). The ETIS framework is therefore useful in offering integrative analysis from large-scale supply-side technologies to dispersed end-use technologies within the energy system and from early stage R&D through market formation to diffusion activities (Gallagher et al., 2012).

The main weaknesses of the ETIS framework are that it is relatively a new concept which is yet to be grounded in academia especially since empirical evidence of systemically dealing with innovation is largely biased to national level (as opposed to sectoral)(Gallagher et al., 2012). The systemic approach also reveals a mismatch between public innovation investments and diffusion needs. Feedbacks between different components of the innovation are also poorly linked in certain areas (Gallagher et al., 2012).

Overall, there are various frameworks introduced by literature that can be adopted for the purposes of this study. However, their limitations are to be noted in choosing the applicable framework to be used. Given this, the national innovation system is appropriate for this study as it allows for the interrogation of the principle of learning, as understood in the innovation space, and within multiple actors.

2.4.5 Learning in the Innovation Systems Perspective

From the reviewed literature on innovation systems it is evident that learning plays an important role in the system. The proposed definition for *learning* is “the process of technical change achieved by diffusion (in the perspective of technology absorption) and incremental innovation” (Viotti, 2001). Learning is therefore understood as the adoption of existing technologies in regions whereby those technologies did not exist before and the subsequent modifications done in order to ensure that the systems/procedure of the acquired technologies are suitable for use under a different scenario. In retrospect, developing economies (such as in the context of this study) undergo technological learning as opposed to innovation, with innovation being understood in the original Schumpeterian meaning as the production of *something new* (be it a product, process, system or organisation) (Schumpeter, 1934b).

Although technical change is at the core of the national innovation system, according to Viotti (2001), the framework does not suitably address the process of technical change particularly in developing countries. Viotti (2001) provides a narrow approach to the NIS framework on the basis that the majority of the NIS researchers characterise innovation based on scientific and technical activities which are R&D intensive and therefore, making the NIS framework more relevant to industrialised economies. Although Viotti (2001) restricts the concept of NIS to developed economies of the Global North and suggest that developing economies are rather focused on learning (through incremental innovation and diffusion activities), Lundvall, Joseph, Chaminade, and Vang (2009) broadened the definition of NIS to include even small countries to be considered as innovative (not just as *learning*) countries.

It is worth noting that the process of learning is not static but is interactive in nature and therefore gets affected by the institutional set up of the economy (Lundvall & Johnson, 1994). Subsequently the government is a key actor in either supporting or crippling the learning process in how it relates to the means, the incentives and the capability to learn (Lundvall & Johnson, 1994). Rennkamp and Boyd (2013) analysed the enabling environment for low-carbon technologies and the implementation of clean technologies in South Africa and upon their findings, they concluded that government lacks support for developing technological capability through regulatory frameworks and policies.

Secondary Innovation

The concept of secondary innovation is focused on firms within a catching-up country and their organizational learning and knowledge accumulation for the purposes of innovation capacity building. The secondary innovation model is a useful tool in analysing the interactions within the system and the external environments to gain understanding of systems of learning, innovation and capability building in developing countries (Wu, Ma, & Xu, 2009).

Bell and Pavitt (1993) define technological capabilities as a process traversing from production capabilities (operation and maintenance of existing products/processes) and evolving to innovation capabilities (creation of new products/processes) (Bell & Pavitt, 1993). Secondary innovation is based on the acquisition of technological expertise from developed economies which are then further used to develop technological abilities in the local context of the developing economy. The diagram below (Figure 2-5) which connects Foster's S-curve framework with Abernathy and Utterback's dynamic model of industrial innovation and is used to analyse the dynamics of technology acquisition and potential sources of latecomer advantage (Wu, Ma, & Xu, 2006).

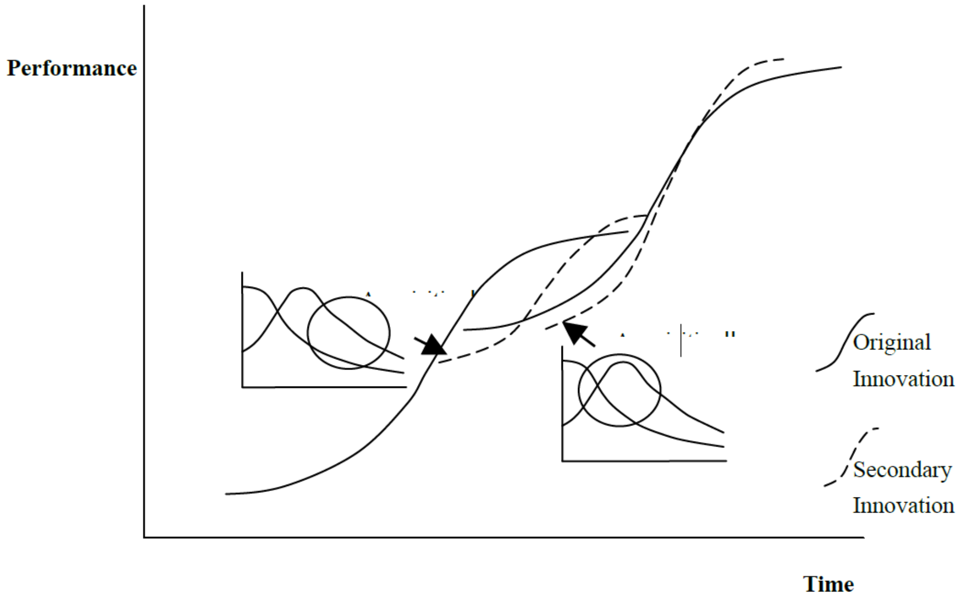


Figure 2-5: Technology Trajectories of Secondary Innovation (Source: Wu, Ma, and Xu (2009))

From the diagram showing the technology trajectories of secondary innovation, two patterns of secondary innovation are identified, namely, the standard secondary innovation which is based on the acquisition (whereby developing countries selecting mature technologies from developed countries), and post-secondary innovation which is based on the acquisition Ⅱ (whereby developing economies select emerging technologies from developed countries) (Wu, Ma, & Xu, 2009).

Technological capability is crucial role in secondary innovation and is defined by Kim (1997) as the ability of an organization to 'make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies' or the ability to 'create new technologies and develop new products and processes in response to changing economic environment.

Although the term, technological ability may be used to mean absorptive capability, Cohen and Levinthal (1990) had initially defined absorptive capability as the firm's ability to value, assimilate and apply new knowledge. Kim (1997) suggested that a level of effort, learning capability and problem-solving skills is required for absorptive capacity to be exercised. Kim (1998) further elaborated that learning capability is the capacity to assimilate and utilise knowledge (for the purpose of imitation), whereas problem-solving skills offer the opportunity to create new knowledge (for the purpose of innovation).

It is useful to note that secondary innovation is not a kind of innovation but rather a set of innovations (Wu, Ma, Shi, et al., 2009) where the four stages of secondary innovation are identified as: duplicative imitation, creative imitation, exploitative innovation and explorative innovation (Wu, Ma, Shi, et al., 2009). The diagram below (Figure 2-6) maps out the dimensions of technological capability as characterised by their patterns of problem-solving (whether knowledge is being utilised through imitation or created through innovation) and the orientation of problem solving as it refers to the different stages of secondary innovation.

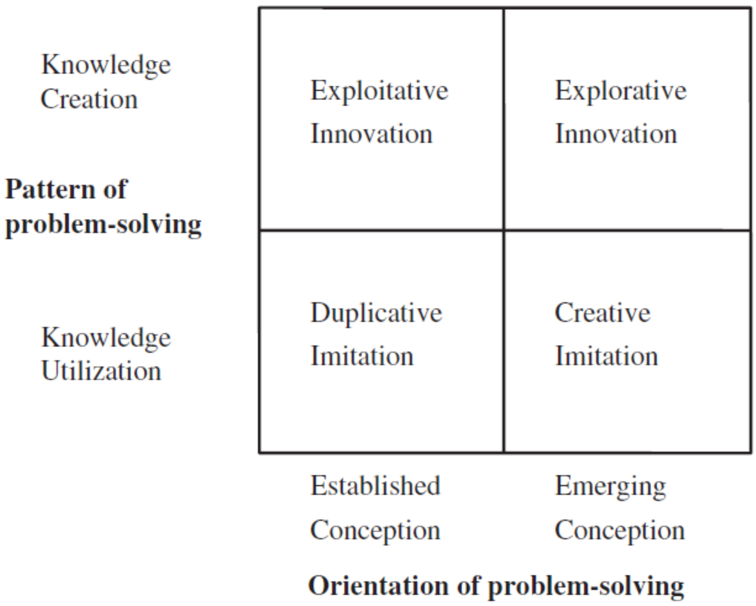


Figure 2-6: Taxonomy of Technological Capabilities (Source: Wu, Ma, Shi, et al. (2009))

Global Value Chain

Value chain refers to the practices that an organisation applies in order to add value to raw material as it moves from production to the marketing and commercialization stages. The concept of global value chain offers a useful framework in understanding the linkages between international supply chains and for mapping out economic interactions between nationalities at various levels (globally, nationally, regionally, locally) (Gereffi, 2014). The aim of these activities and interactions is to increase value-add.

Lee, Szapiro, and Mao (2017) presented a hypothesis stating that if catching-up firms join the global value chain (GVC) at the initial growth stages, they can potentially improve their technological capabilities through learning foreign knowledge and production skills before exiting the GVC at the middle-income stage (in order to gain independence and getting established locally), and then later on reintegrating back to the GVC. This hypothesis is based on an “in-out-in” approach whereby catching-up firms rely more or less on GVC depending on which growth stage they’re on, in order for countries to strategically increase value-add. This trend has been viewed successful particularly in Korea, Taiwan and China, which are all catching-up economies (Lee et al., 2017). However, it is worth noting the difficulties and risks associated with breaking from the GVC to achieve independence and Lee et al. (2017) offers solution around these as such as the building of in-house capabilities in marketing and technological innovation (Lee et al., 2017).

Lundvall (1992) defined innovation systems as the interactions that play a role in the production, diffusion and use of knowledge at national, sectoral and firm levels. The Schumpeterian view of innovation is more focused on interaction within a nation whereas the global value chain concept considers the external and internationally broad variables that can potentially affect economic growth (Lee et al., 2017).

2.5 Conceptual Framework

This section explains the conceptual framework for the study. The conceptual framework helps set a stage for presenting the research question behind the study (Bordage, McGaghie, & Shea, 2001). The conceptual framework for the study draws from two theoretical approaches in literature. The advocacy coalition framework is used as a lens to address the policy discourse by firstly identifying the coalition actors that are advocating for either renewable energy (RE) or conventional energy (CE). Coenen, Diaz, and Fernando (2008) clearly emphasise that a systemic approach is necessary in eco-innovation studies regardless of what theoretical framework is being adopted.

The systems of innovation approach, particularly secondary innovation, is used to analyse the firm's strategic intent and record for developing local technological capabilities within either coalition. This systemic approach aims to examine how the identified coalitions are positioned for building innovation capabilities in an industrialising economy. Since the ACF is a predictive tool, the framework is used to forecast the policy outcome should the rival coalitions take opportunity introduced by the emerging external shock and converge for the purposes of promoting technological capability building (TCB) through policy. Figure 2.7 below provides an illustration of the adopted conceptual framework.

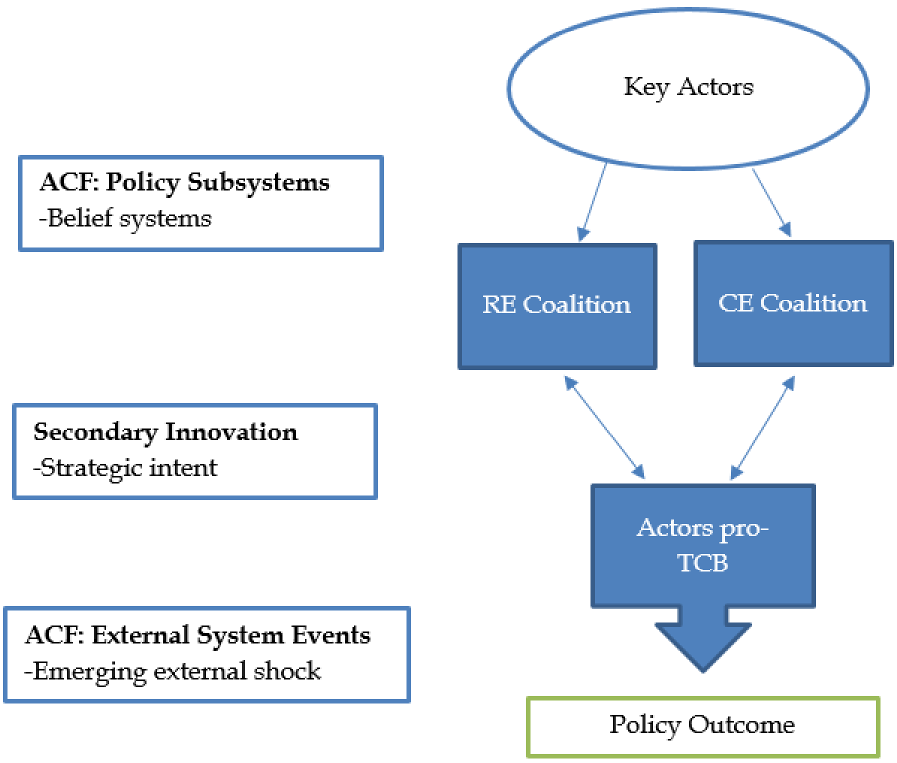


Figure 2-7: Conceptual Framework Adopted for the Study

2.6 Statement of Propositions

This section defines the propositional statements made in this study as they relate to the posed research questions in *Section 1.8*. In addressing the first research question (1) on who are the key actors that are advocating for either the renewable or conventional methods for energy production in South Africa, the first statement of proposition is that the main actors in the South African energy sector are advocating for conventional coal-based fuel production over the renewable option. In knowing that there is still a significant amount of coal to secure energy production for a long time does not put pressure on political actors (Rennkamp & Boyd, 2013) or any other major actor to aggressively promote the transition towards renewables in the near future. The subsequent lag in the nation's plans towards renewables is due to powerful coalitions of coal-related industries and their lobbies who have managed to constrain institutional change in South Africa and delay the implementation of carbon pricing measures (Rennkamp, 2019).

The second statement of proposition addresses the second research question (2) pertaining to which actors are advocating for and are participating in technological upgrade, and suggests that the actors in the renewable energy sector are the ones advocating for technological upgrade and are participating in elevating domestic innovation capabilities more evidently than those in the conventional energy sector. This domestic capability building is encouraged by programmes such as the current REIPPPP which only allows for producers to bid for renewable energy while also stipulating that a portion of their equipment be produced locally (Rennkamp & Boyd, 2013).

The third statement of proposition is linked to the final research questions (3a and 3b) that addresses how external system events have influenced policy change in the past and applies a prospective lens on how actors can influence future policy change through their response to emerging external shocks. The proposition is that if firms upgrade their learning capability, they stand a better chance to influence policy change by converging for the purposes of technological capability building (as opposed to solely concentrating on either the renewable or conventional energy agenda). In the energy sector, technology has been observed to play a key role in the design and implementation of abatement strategies in public policy against emissions (Christiansen, 2001). Programs such as the REIPPPP have shown that institutional change is possible and can be managed even in fossil-fuel dependent economies, provided that they offer advantages (such as technological advancement) that attract powerful actors (Rennkamp, 2019).

3. CHAPTER THREE: RESEARCH STRATEGY AND METHODOLODY

3.1 Introduction

In this section, the research strategy and methodology that were undertaken for the study are discussed. The research design outlines the plan and procedure for answering the proposed research questions. The research methodology describes data collection and analysis. The section also highlights the limitations of the study, the ethical considerations that were taken into account and also shares how the findings were tested for validity and reliability.

3.2 Research Strategy and Design

A qualitative research methodology was adopted for this study in order to provide answers to the research questions being addressed by the study. This research method was chosen in order to get a deeper meaning and significance of human behaviour and experience from words (Yin, 2003) as opposed to relying on statistical analysis for meeting the objectives presented in the study. The benefit of using a qualitative research method for a study is that it allows the researcher to provide a complete understanding to the research question (Creswell, 2014). This research method is also useful for providing an in-depth understanding of a specific situation (Cooper & Schindler, 2011).

Qualitative research includes techniques such as interviews, case studies and surveys (Salkind, 2012) in order to delve in to the underlying principles and reasoning behind certain phenomena. The study at hand makes use of primary data in the form of semi-structured interviews which is an approach that allows the participants an opportunity to share information without restriction to their individual perspective (DiCicco-Bloom & Crabtree, 2006). Moreover, secondary data collection in the form of document analysis was also deemed useful for providing insight to the study at hand. Following the data collection process, the data was interpreted using the applicable methods of analysing qualitative data in order to extract data that is useful for the purposes of the study.

A comparative case study approach was used for examining major policy change with respect to building technological capabilities in renewable energy in South Africa. Creswell and Creswell (2018) describe a case study as a qualitative design used to explore, in depth, a program, event, activity, process, or one or more individuals. Furthermore, a case study has a specified time boundary and the researcher studies an activity over a sustained period of time (Creswell & Creswell, 2018) and subsequently this study spans over a twenty year period. Yin (2003) also views a case study as a tool for empirical inquiry that investigates a phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. Looking at the energy sector in South Africa allowed for the collection, investigation and analysis of data (which is readily available) in conjunction with insight from respondents' experiences, with the aim of contributing to the general understanding of the research on policy change. Considering that the topic on energy transition is currently one of political and scientific interest both locally and globally, using it as a case study was profitable for the purposes of this study.

3.3 Selection of Participants

Qualitative research requires a purposeful selection of participants or documents that are best suited to help the researcher in understanding the problem (Creswell & Creswell, 2018). Moreover, the selection of key actors is a crucial step when applying the advocacy coalition framework (Sabatier & Weible, 2007). For the purposes of this study, the participants were selected using purposive or convenience sampling whereby the researcher purposefully approached members that would best and most broadly provide the required information (Sargeant, 2012). These participants were generally those who are influential in the energy sector in South Africa and those that are involved in the energy policy decision-making process. The different groups of participants included the relevant government departments, industry associations, energy associations, as well as research and development organisations (experts in energy technologies).

3.4 Research Methodology

In order to meet the objectives of the research, interviews were used as a research instrument for addressing the components posed by the research questions and documents were included as a secondary source of data.

3.4.1 Primary Data: Semi-structured Interviews

Qualitative interviews refer to the face-to-face, telephonic, or focus group engagements conducted by the researcher with the participants (Creswell & Creswell, 2018). Interviews provide various options for gathering data and allows the researcher the opportunity to conduct the study in a suitable and practical manner. This method of data collection, however, can lead to the information being articulated and perceived in a different manner as well as bias responses due to the presence of the interviewer (Creswell & Creswell, 2018).

A semi-structured interview is a qualitative data collection strategy in which the researcher asks the participants a series of predetermined but open-ended questions (Given, 2008). A semi-structured interview provides the researcher more control of the interview than an unstructured interview.

In this study, semi-structured interviews were conducted remotely on the basis of respecting social distancing protocol (enforced due to the COVID-19 pandemic) and the participants were provided enough content and opportunity to answer freely and without restraint. The semi-structured interviews included a prepared list of questions and provide an opportunity for the participants to provide additional information that is important to the study (Longhurst, 2003). This exercise was beneficial for confirming information on technological capability building and innovation in order to verify how each of the actors are positioned relative to their intentions and activity on technological capability building.

3.4.2 Secondary Data: Policy Documents and Reports

Secondary data collection entails the utilisation of existing data which was originally collected as primary data for another purpose (Johnston, 2017). Although secondary data is compiled and readily accessible, it still requires a systematic method with procedural and evaluative steps for collecting and evaluating the data, just as in primary data (Johnston, 2017). Secondary data can include both qualitative and quantitative data collected in various forms of materials such as reports, administrative and public documents (Saunders, Lewis, & Thornhill, 2009).

Some advantages for collecting data using document analysis include access to the data at any time that is convenient for the researcher; the information is presented in the original language and words of participants; and, it saves the researcher time and expenses related to transcribing the data since it is already saved as a written document (Creswell & Creswell, 2018). On the other hand, the selected documents may not be sufficiently authentic, or accurate, or complete, or easily accessible and thus, may require the researcher to search deep in order to find usable information. Like any other analytical methods for qualitative research, document analysis requires that data be examined and interpreted in order to gain understanding and develop empirical knowledge (Corbin & Strauss, 2008), and this process may lead to dissimilar interpretations and perceptions of the data.

For the purposes of this study, existing literature on energy policy was used to identify key actors in the energy sector to be used in the conceptual framework. The next step included looking at published policy documents and reports of the relevant government departments to characterise key actors on the basis of their belief system as coalitions advocating for either renewable or conventional energy. Following the coalitions being identified, the documents were used to gather insight on the actors' viewpoint and activity on technological capability building in order to support the primary data collected via interviews. Policy documents were also used retrospectively for assessing how external shocks have, over the years, shaped policy towards the renewable energy agenda.

3.5 Data Analysis

When considering data analysis, the research data should be analysed in a manner applicable to the database (Creswell, 2014). The following section outlines the approach that was applied for data analysis for the primary and secondary data collected.

3.5.1 Interview Data Analysis

The data collected from the interview process was analysed in order to extract key content and summarise passages of the transcript. The bottom-up, hierarchical, linear approach that is suggested by Creswell and Creswell (2018), as shown in the figure below (Figure 3-1), was used for analysing the data for this study.

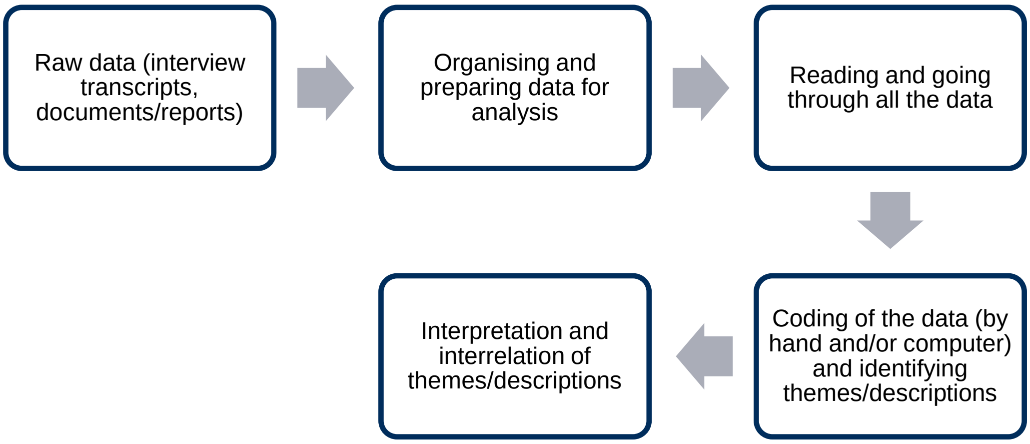


Figure 3-1: Proposed Data Analysis for Qualitative Research (Adapted from Creswell and Creswell (2018))

The overview of the data analysis process comprised the collection of raw data (through an interview protocol) before transcribing the data, organising and preparing the data, coding the data manually, identifying the themes and mapping commonalities and relationships between those themes. The data was then validated using the collected secondary data from policy documents and reports.

3.5.2 Document Analysis

A document analysis method was selected for identifying and categorizing the actors within the conventional and renewable energy coalitions. Document analysis is commonly used for qualitative research studies. Bowen (2009) defines document analysis as a systematic procedure for reviewing or evaluating documents which can be printed and/or electronic.

Although there is a general lack of literature to define a specific process for secondary data analysis, Johnston (2017) proposes a process that begins with the development of the research questions for the study (which this study addresses in Section 2), then the identification of the dataset (using the literature review), and thorough evaluation the dataset to ensure the appropriateness for the research topic (Johnston, 2017).

An analysis of publicly available government policy and strategy documents was conducted to further assess the belief systems of the relevant actors in light of the renewable energy discourse and secondly, their interest in the building of innovation capabilities. These documents were publicly accessed from the websites of various departments/organisations.

3.5.3 Comparative Case Study Analysis

A case study method is useful in studying certain phenomena and for understanding a present circumstance of a certain individual or group (Yin, 2014). In using this research method, the researcher can focus on a certain case while being able to retain the full sense of the environment and conditions around the case. Case studies are useful in theory development as they provide an opportunity to evaluate and reassess the effectiveness of the theory in use. A case breaks down the identified problem to promote understanding of the problem in view of the applied framework, and in the process, can help develop and refine the framework even further in order to maximise its ability to scrutinise the case study at hand (Alexander & Bennett, 2007).

A comparative case analysis is based on showcasing differences between case studies. This type of analysis aims “to gather comprehensive, systematic and in-depth information about each case of interest” (Patton & Patton, 2002). Instead of solely focusing on one dimension, the comparative case study approach attends to simultaneously focus on macro, meso, and micro dimensions of case-based research (Bartlett & Vavrus, 2017) and makes comparison on numerous levels and accounts. The comparative case research method can inform policy or even suggest alternative policy approaches when addressing policy issues which are similar in nature (Krehl & Weck, 2019)

This study explores the conditions for major policy change toward renewable energy in South Africa by performing a comparative case study between coalitions for renewable and conventional energy. Each case consists of the identified advocacy coalition for renewable energy and conventional energy respectively. This was done by analysing the collected data and relevant documents before evaluating the data in light of the proposed research questions. The study maps out any similarities, differences and patterns within the two groups to analyse emergent explanations and themes with respect to advocacy coalitions and innovation capabilities. Although the findings cannot be generalised, the insight retrieved from the case study analysis can potentially be transferable to similar policy situations as the one covered in the study.

3.6 Limitations of the Study

The limitations of a study are often dependent on the methods or research instruments applied by the study and may present a weakness in the research that the researcher is aware of (Creswell & Creswell, 2018). This type of study relies strongly on the researcher as the interviewer and the key participants as the interviewees. Due to financial and safety constraints for the study, face-to-face interviews were too costly considering the difference in geographic settings of all the participants that were interviewed, and not permitted under the current national lockdown restrictions due to the Covid-19 pandemic. Given the time constraints for the study, the selection and number of actors was based on the availability of actors to participate. Although the interview protocol was intentional in minimising bias, participants might have provided answers that are biased to the researcher's expectations (Creswell, 2014).

3.7 Ethical Considerations

The researcher submitted a letter requesting clearance from the university's ethical committee prior to the interviews being held. The researcher also requested permission from the participants to conduct the interview and explicitly stated the objectives of the interview as well as how the interviews will be conducted. The interviews were voluntary to all the participants and the participants were made aware of how the information gathered from the interviews will be utilised going forward.

3.8 Reliability and Validity

It is imperative that the research and its findings are credible in order to ensure that they are reliable for use. According to Creswell (2009) validity in qualitative research and validity in quantitative research do not carry the same meaning. Generally, validity concerns arise when the researcher applies the explanatory sequential research method (Creswell, 2014), and therefore careful consideration is required to fulfil its validity. Qualitative researchers therefore apply member checking, triangulation, thick description, peer reviews, and external audits, with in one or more of these procedures being employed (Creswell & Miller, 2000).

Creswell (2009) mentions different procedures to ensure validity and these procedures were applied in this study:

- The transcripts were inspected for any errors that may have occurred during transcription.
- Regular verification of the codes was conducted with the actual data.
- The codes were validated against the codes generated to identify any unique codes.

Literature review and secondary data was used as supplementary evidence for the interpretation of the themes and relationships between the themes. The data that was collected from the existing documents and reports helped improve the reliability of the study.

4. CHAPTER FOUR: PRESENTATION OF FINDINGS AND RESULTS

4.1 Introduction

This chapter presents the results from the fieldwork undertaken, comprising conducted semi-structured interviews with chosen informants in the energy industry, as well as a document analysis of available official documents that were recommended during the data collection phase of the research. The semi-structured interview questionnaire is shown in *Appendix A* of this report and was used to gather relevant information to characterise technological capability building and how it is enhanced by the different actors in the energy sector. The same questions were used for all the participants, with the follow-up questions modified during the course of the interviews in line with the respondents' expertise and type of organisation.

The results are presented according to the research question they aim to address, which are as follows:

1. Who are the key actors in the energy sector that are advocating for either the renewable or conventional methods of energy production in South Africa?

2. Which of the actors are advocating for technological upgrade (beyond the renewable/conventional energy debate) and are participating in elevating domestic innovation capabilities?

3. a) In the past two decades, how have external system events influenced policy change towards renewable energy and how much emphasis did policy place on technological learning and innovation that is necessary to support the transition?

   b) In the face of what seems to be an emerging external shock, how are the coalitions (both conventional and renewable energy) organising themselves in order to seize this window of opportunity and take advantage of influencing policy change?

4.2 Respondent Profile and Interview Process

This section presents the background profile of the respondents who were approached for the study as well as the interview process.

The semi-structured interviews were conducted with respondents involved in the energy sector and those who are positioned to play a critical role in the national systems of innovation in terms of building domestic technological capabilities.

All interviews were conducted virtually in compliance with the health and safety regulations during the Covid-19 pandemic. Prior to conducting the interviews, respondents were provided with a research information sheet which detailed how the interview would be conducted, including the recording of the interviews while assuring the respondents' confidentiality and anonymity. Respondents were given an opportunity to provide information on their general profile, such as their current position, the number of years in the position, and the means of funding their work. The respondents were selected from industry, energy associations, research institutions and government agencies that are relevant for the purposes of the study. A total of 15 respondents were interviewed from the different groups, with eight respondents from industry; one respondent from industry associations, four respondents from research institutes and two respondents from government agencies. These respondents were approached mainly because of their senior or management position within their respective organisations, and their consequent knowledge in strategic initiatives.

The semi-structured interview questionnaire is shown in *Appendix A* of this report and it addressed pertinent questions seeking to analyse how actors are positioning themselves to build technological capabilities as well as to characterise their coalition status in accordance to their underlying beliefs. The same questionnaire was used for all the parties involved as it was presented in a generic manner to be applicable to all participants while capturing the essence of what was required. It was also modified during the course of the interviews in line with the respondent's type of organisation and expertise.

Table 4-1: Summary of Respondent Profile

Sector	Participant Reference	Position	Source of Funding
Industry	IP-1	Director	Government support funding; international finding
	IP-2	Technology Strategy Manager	Revenue
	IP-3	Executive Head Projects and Technology	Revenue
	IP-4	Senior Technical Advisor	Revenue
	IP-5	Director	Revenue
	IP-6	Founder/CEO	IDC; banks; international funding
	IP-7	Director	Revenue
	IP-8	Managing Director	Revenue
Advocacy Group	AP-1	Technology Programme Officer	Membership fee; external funding agents
Research Institute	RP-1	Head of Energy Centre	Government support funding; private sector
	RP-2	Senior Scientist	Government support funding
	RP-3	Centre Manager	Government support funding; external funding agents
	RP-4	Professor	None – with funding for training in science and technology
Government Agency	GP-1	Chief Director	Government support funding
	GP-2	Director	Government support funding

4.3 Presentation of Results

This section presents the data collected through the semi-structured interview sessions held virtually with 15 participants. The presentation of data is guided by the research themes they sought to address which were as follows:

- Advocacy coalition
- Strategic intent
- Secondary innovation
- Level of innovation

The data is presented according to the research themes and is formatted in both narrative and graphic formats. The order of presentation is as follows:

- An introduction of the major section and sub-section section. For each sub-section, the factors or sub-times being explored are introduced, followed by an overview of the results.
- Data relating to the interviews presented and/or statements corresponding to the sub-themes or factors and the respective participants.
- A narrative discussing the data including some verbatim statements from participants and key informants.

4.3.1 Actors within the South African Energy Sector

Actor Involvement in the South African Energy Sector

Key actors in the South African energy sector were categorised according to their involvement in the sector, as well as their efforts towards technological capability building in the renewable energy and/or conventional energy industries.

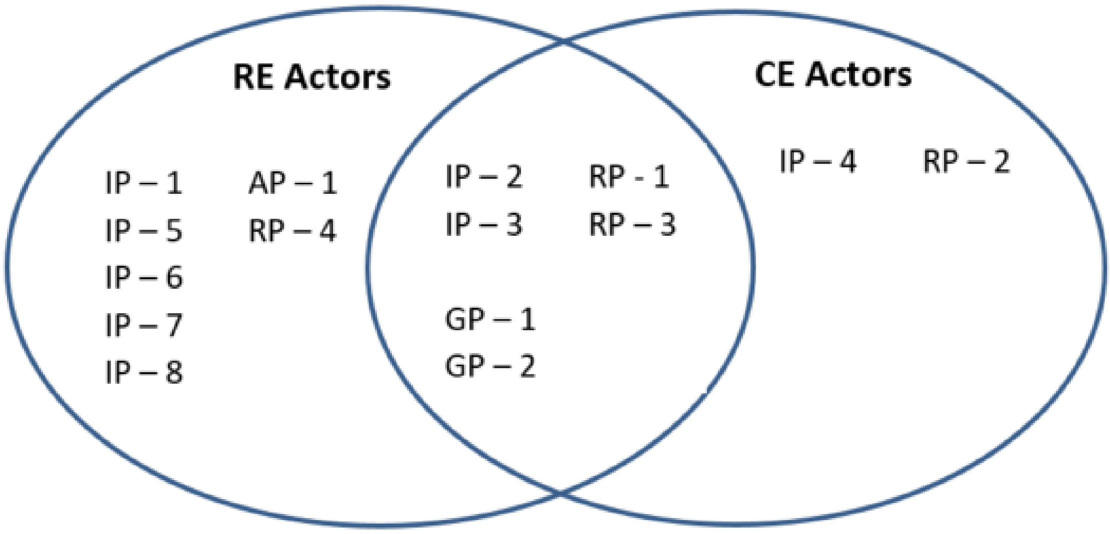


Figure 4-1: Actor Involvement and Overlap in the RE and CE Industries

Actors' Efforts Towards Technological Capability Building

This section presents the findings associated with the actors' current efforts in contributing to technological capability building. It must be noted that IP-7 and RP-4 are not involved in the process of building technological capabilities nor are they aspiring towards it. The role of IP-7 in the energy sector is mainly focused on selecting a suitable technology and packaging pre-existing components for the wind energy sector. The organisation is not particularly interested in developing, improving or manufacturing technologies but is rather focused on the supply and distribution of identified technologies. The research institute RP-4 is mainly focused on research associated with the transition processes from conventional to renewable energy in order to ensure that the country becomes more sustainable. The institute is not particularly involved in building technological capabilities for supporting this transition.

The rest of this section deals with those actors that were identified as playing a role in technological capability building and with intentions to advance in this regard. Industry participants IP-1, IP-3, IP-6 and IP-8, who are all involved in the renewable energy production industry, mentioned that their current focus is on providing green energy as an alternative energy source in South Africa, using international expertise. These participants are at the stage of exploring pre-existing technologies and imitating their use while also considering the local context in which these technologies are being applied to. Some of the actual statements that the respondents mentioned are highlighted below:

- IP-6: *We are actually using old technology (which backdates to the 1950's) that's been marginally overlooked in the South African context*.
- IP-8: *The technology that we initially used to build the plant is from Denmark. We had to adapt the technology to work in a local context. We didn't really have the experience so we had to listen to what we were being told, and over the years, we have been able to see what works in the local environment. So that's where we are able to value engineer and improve on the technology that was put forward to us, and it's an ongoing process. We also brought in skills from local universities and that's how we're able to build local expertise*.

Industry participant IP-3 is mainly involved in supplying coal for conventional energy production and their intention for including a renewable energy wing for power generation is for the purposes of internal use. The outcome of this venture has been the gain of technological capabilities in the renewable energy space through incremental improvements being applied to their wind power generation. The response from IP-3 in this regard is captured below:

- IP-3: *Our previous CEOs identified that fossil fuel and demand going forward might be a risk given the climate change being one of the biggest global risks, and identified an opportunity for the company to participate in the renewable energy sector of the country, of which the company won a bid for two wind farms… It's a transition strategy, so we build up capacity to have more emphasis on the renewable space which is a global space. We're running the windfarms and always trying to squeeze out more megawatts out of the machine than the previous year… by making incremental improvements on the wind turbines, although the main assets remain the same… We are not interested in developing new technologies to produce wind farms, our goal is to produce energy for the South African market… We rather rely on partnerships than trying to do it (ourselves) from a research point of view*.

Although some of the actors shared some aspiration for technological capability building, their organisations are relatively new in the market (less than five years in operation), and are still looking to gain the relevant expertise required to build capabilities.

Moreover, the current demand for the country to procure electricity also favours specific kinds of renewable energy production which can be mass produced (such as wind and solar) over other alternatives (such as biogas).

- IP-6: *Our technology for production has been overlooked given the current context that we have to capacitate very quickly in terms of our energy security needs in South Africa, given our current electricity challenges*.

The short-term plans for some of the actors generally involve increasing their market (sales drive), getting more established in the industry and also providing value add to their clients by growing their portfolio of services. Improving technologies and building technological capabilities is a long-term aspiration that the actors anticipate to bring added benefit for them in the long-run, once they have garnered sufficient resources and expertise in this regard.

- IP-1: *I think for us aspirations is based on a green alternative fuel. That is what we want to put out to the market specifically for the heating sector… We tried to develop technology patents and then realised that will take us 10 years to generate serious revenue (for it) …We want to take existing international technology and then tweak it for ourselves… We found it's a lot faster than trying to build from scratch because the first time that we did a monitoring device from scratch, it took a while*.
- IP-6: *Our short-term goal is to acquire a number of clients by the end of the year as a new start-up business… we need to hire an engineer to manage our biogas projects and then we do not need to heavily rely on external consultants who in some context may become our competitors or they may have time constraints or capacity constraints. Most appropriate and lucrative goal would be to build our own biogas plant on each client site… that would reduce a lot of operational costs*.

Efforts towards building technological capabilities are a current pursuit for some of the actors who are investing considerably towards attaining it. These organisations are well integrated in the energy sector and have set up well-structured programs to assist with the processes of scanning for new technologies, conducting in-house research and development, demonstrating technologies as fit for purpose as well as assessing technologies based on their technical and economic viability in order.

- IP-5: *We do have an internal R&D team where we spend a lot of time and I wouldn't necessarily say trying to develop the end-product, but we focus on the engineering and the design side. We try to be innovative in terms of finding new solutions for new applications that would be both technically efficient as well as cost effective for clients… We do pilot projects internally as well*.
- RP-1: *A lot of the time we're providing an enabler for mature technologies to be implemented in South Africa for competitive advantage. So our role in those cases is not to proverbially reinvent the wheel. We are going to essentially understand the technologies and the relevance and suitability and potential for application in South Africa. And part of what we do is the techno-economic modelling of all the different options and technologies and then assessing according to the South African energy landscape... Considering our end-users of energy, our local natural resources, our cost of capital and what is it that we could and should do to reduce the cost of energy that might in turn, improve energy security*.
- RP-3: *We pilot technologies and demonstrate technologies at scale to prove that technology that is available is fit for purpose… Something that works in Europe might not necessarily work in South Africa without a bit of tweaking, so we can't always just adopt a technology. We also have to adapt technologies… we see how it functions here, and then we look at how we can adapt it to function the based in South Africa*.

Some of the actors have gained a level of technological capacity and are now at the stage of using the acquired technological know-how to advance their business, and therefore, their current aspiration is to become more competitive in the market. Government organisations that are involved in the energy sector also fall under this category given their mandate to continually seek to maximise domestic capabilities and to grow South Africa into a technologically and economically competitive nation.

- IP-3: *I think our aspiration is to be a leading or quite a significant leader of energy provision in the country. We have started already with the two wind farms, but those are two smaller wind farms … Volume is always a big issue. The bigger the volume, the lower the cost that you can produce any good, so that type of competitiveness will come into play when you build up your volume of production. So I think because your overheads then come down because you have a central team that looks at, for example, five wind farms compared to two. So your competitiveness will be build up as you strategically implement those strategic projects that bulk up the volume over time*.
- IP-8: *Our aspirations are to target most of the major cities and for companies and people to reduce their requirement on the utility and also on diesel generators… Our efforts are based on improving efficiencies and productivity… Because we have consolidated our understanding of the technology, now we want to replicate, and so our focus is on growing the business and building a portfolio of projects*.

The table below summarises the discussion above on the actors' involvement in building technological capabilities within the energy sector as well as their future aspirations in this regard. In summary, two of the participating actors (IP-7 and RP-4) are not involved in building technological capabilities as stated above, given the type of service offering and role they play in the energy sector. Three of the participating actors (IP-1, AP-6 and AP-1) are aspiring towards technological capability building although there are currently not fully embarking on it mainly because of their start-up status, and in the case of the industry association, their involvement in strategic lobbying enables them to provide support on all levels. The majority of the participating actors responded that have invested in well-structured programs for building technological capabilities (either through R&D, internal support, or policy frameworks) and are at the stages of exploring the acquired technological know-how and aspiring towards gaining competitive advantage.

Table 4-2: Summary of Findings on Current Status and Aspirations for Technological Capability Building

Current Status and Level of Aspiration towards Technological Capability Building	**Actors**
Currently lack technological capability building, with no future aspirations towards it	IP-7, RP-4
Currently low on technological capability building, but it is a future aspiration	IP-1, 1P-6, AP-1
Currently possess some level of technological capability building, with aspirations to improve competitiveness	IP-2, IP-3, IP-5, IP-8, AP-1, RP-1, RP-2, RP-3, GP-1, GP-2

Level of Aspirations for Competitiveness of Actors

This section illustrates the level at which the participants aim to being competitive at when it comes to technological capability building. The majority of the participants are aspiring to gain competitiveness at a domestic and regional level, particularly since the organisations involved in the renewable energy sector are relatively starting up in the industry, even if they are established organisations that are now venturing to build their renewable energy portfolio.

Those participants who have established a domestic presence in the energy sector are aspiring towards further expanding regionally as well as taping into the international market. Participants RP-2 and GP-1 responded in light of building technological capabilities in the nuclear space and both participants expressed that South Africa is already leading in the region with regards to technological capabilities in the nuclear space and hence their aspiration is now at an international level. The participants also raised the important role played by policy in fostering continued growth and intentionality towards the nuclear space in order to ensure that South Africa does not lose its competitive advantage in this field.

- RP-2: *Africa looks to South Africa (for nuclear expertise), after having participated in the nuclear industry for a long time. This is quite big and therefore we need to strive to assist. Also the collaboration that we have with (for example) the International Atomic Energy shows that the African Commission on Nuclear*

Energy, AFCONE, and all those arrested organisations, it shows that our competitiveness will improve with the right policies, with the right strategy and with the right support of government.

- GP-1: *We are the only country that has nuclear power in the whole of Africa by virtue of us having a bigger nuclear new build program. When it started in the 1950s we were part of it. So we are a respected country when it comes to technology development. Now we are the most respected global player, but if we're not careful, if we're not going to spend money on resident development in this field, we are going to regret it and we're going to go back so we need to keep the momentum going by pumping money into research and development and ensuring that we remain on the leadership role… We are very competitive intentionally*.

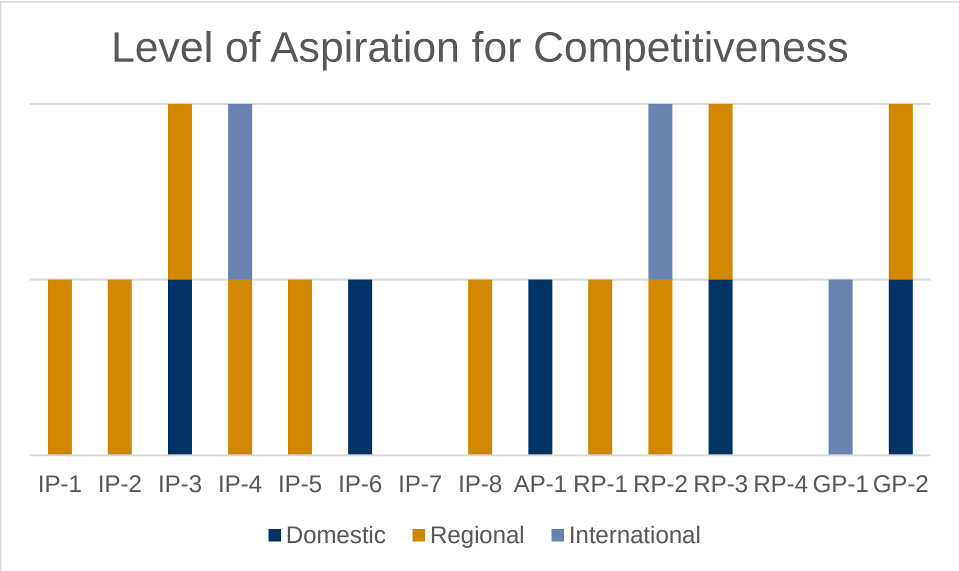


Figure 4-2: Level of Aspiration for Competitiveness of Actors

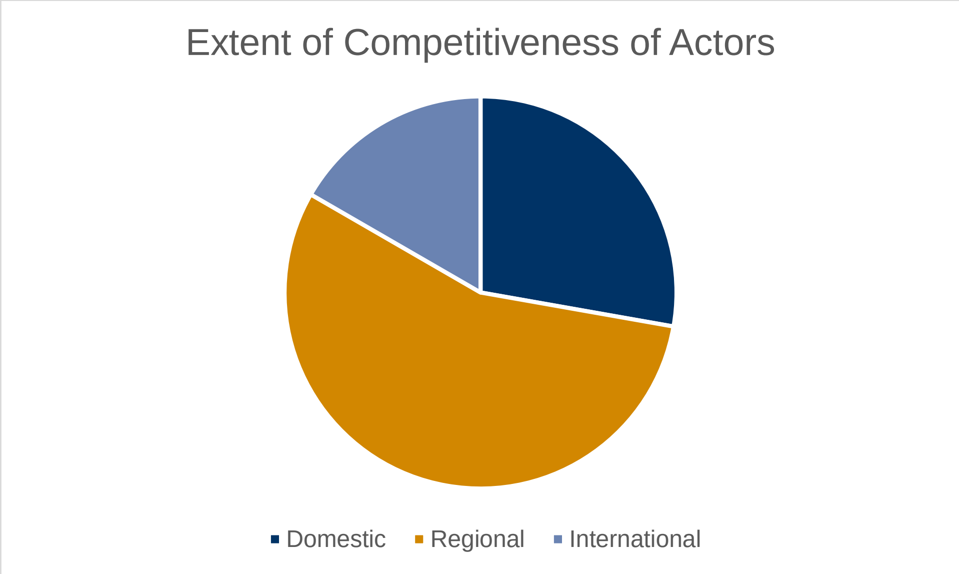


Figure 4-3: Categories and Proportions for the Extent of Competitiveness

As described above, Figure 4-2 and Figure 4-3 are visual presentations of the data relating to the participants' aspirations for gaining competitiveness, whether domestically, regionally, or internationally. The majority of the participants are seeking domestic competitiveness which can then translate at a regional level. The participants who are mainly invested in the conventional energy industry seek international competitiveness given that these are well-established organisations with extensive expertise in the energy industry.

Collaborations and Partnerships with Stakeholders

The majority of the participants indicated that they collaborate and engage with stakeholders in the academic space via partnerships with national and international university institutions, research institutions and science councils. The role of the academic players in the upgrade of technological capabilities in the energy sector was reported by the participants as involving research and development support for resolving technical and engineering issues that the participants may have. The research participant RP-1 was mentioned by the industry and government participants as playing a significant role in providing technical expertise through their support in technological development and natural resources assessments.

The participant IP-4 mentioned that their organisation no longer collaborates with the academic sector as in the past, although the organisation partners with RP-1 since they are technology and knowledge suppliers. The organisation is reported as relying on internal database gathered over many years as the central means for their employees to access technological knowledge.

- IP-4: *Currently there is no partnership with academic institutions. It's not as extensive as it was in the past… We do have a library as an organisation which is also where if you need certain information and you can't find it through the normal searches, you know there's a number of database that we are part of, similar to University knowledge database access*.

The participant, IP-7, raised the matter that part of their lack of aspiration to invest in technological capabilities or to form partnerships with research and development institutes is due to it being a futile exercise particularly in the South African context where there is a lack of support from government for managing complex processes for technological development nor any incentives for it.

- IP-7: *The way the IPP bid is structured doesn't leave room for coming up with a lot of ways to do things, it's very cookie-cutter and everyone has to do the same thing so it doesn't incentive you to come up with intelligent solutions for problems. There's no real purpose for us to cooperate with other sectors such as academia because there's nothing we can feed in from them*.

In the business front, all the participants responded to mention that they do partner with other actors in the industry, either through advisory opportunities from other companies; or partnerships with original equipment manufacturers (OEMs) and global project developers; or through consultative support from local and international consultancies. Participant IP-4 which is an incumbent in the industry reported that their partnership with other business partners is limited due to the issue of competition. The organisation engages other business players in order to access information or expertise by issuing a request for information (as and when required) and the businesses with the applicable competencies would then be afforded the opportunity to collaborate with the organisation.

The participant IP-8 mentioned that their company prioritises the use of technological expertise available locally before looking to source it internationally. Their company also incorporates technological knowledge acquired by the mining sector in South Africa (given the nation's extensive knowledge in this sector) and they then find ways to apply it in their own operations in the waste-to-energy sector.

- IP-8: *We find technologies internationally and then we would try and source it locally… Instead of ordering equipment for operation from the (overseas) supplier we ask some local companies to do the cost and make it locally. So there is a mix between where we have local expertise, we prefer to work with obviously, and where we can't, we source it internationally… We don't have enough local expertise but it is being built locally at the universities. The equipment that we use in the biogas plant is similar to the one they use for waste handling in the mining sector and so we do have a lot of equipment (locally) and we don't necessarily have to buy from overseas*.

With respect to the participants' partnerships with government entities, all the participants mentioned that they have a relationship with government agencies which include government research councils, enterprise development agencies, as well as the relevant municipal and national departments. Apart from partnerships with research councils, the main purpose for the actors' interaction with government agencies was not tied to technological upgrading, but was rather focussed on funding, business development and regulatory needs.

- IP-7: *We do coordinate with government agencies but that mostly to find out what they're plans are, whether they're changing regulations, when they are planning to implement things. It's not really based on technologies because they aren't really any. The way the bid is structured doesn't leave room for coming up with a lot of ways to do things*.

All participating actors from the research institutes and government departments reported their collaborative efforts with international development agencies and other countries both regionally and internationally when it comes to gaining technological capabilities.

Resources Required for Strengthening Technological Capability Building

The participating actors raised three resources that they perceived as being necessary for improving technological capability building in the South African energy sector. Funding was the frequently mentioned resource that the actors require due to the financial burden associated with research and development activities as well as the need to upskill people and provide the necessary training to groom them in becoming the local subject matter experts.

Policy support (which encompasses funding opportunities mentioned above) was also frequently raised as a tool that requires sharpening in order to facilitate technological capability building within the energy industry. The actors mentioned the fact that other countries that are now leading in the energy technology space are at that level because they're being rightfully and effectively supported by their national policies.

- AP-1: *The European and American markets are well established and have surpassed some of the issues we are experiencing in developing technological capabilities. Their roles are much modified and impactful because the development of the industry is supported by the respective governments much more, and there's much more collaboration than policy walls*.

Finally, some of the participants mentioned the need for strengthened private-public partnerships within the sector as a means to improving technological capabilities.

- IP-4: *When you work with universities or other technology suppliers then obviously, you want to leverage from their tacit knowledge about the particular area. For instance, we are not experts in renewable energy technologies, and so you bring in the companies that are advancing in that space and then you build from there*.
- GP-2: *There are people that we allow to go and get exposed in the international laboratories and work with some of our (private sector) partners. There will also be times where we bring people in and we try and understand their challenges*

and as part of solving their challenges, we strengthen our alliances or relationships.

4.3.2 Level of Knowledge Exploration

Activities for Technological Capability Building

This section presents the findings associated with the actor involvement in building technological capabilities in the energy industry. The activities were categorised as either being production-oriented in the sense that the actors are interested in acquiring technologies to boost energy production; and/or the activities include manufacturing components for use in the energy sector, and/or if efforts are research and development oriented. Furthermore, the actors shared whether the kinds of activities they are focused on are aimed at improving sales or whether the driving factor is to assist the organisation in the internal diffusion of technological know-how that has been adopted from elsewhere.

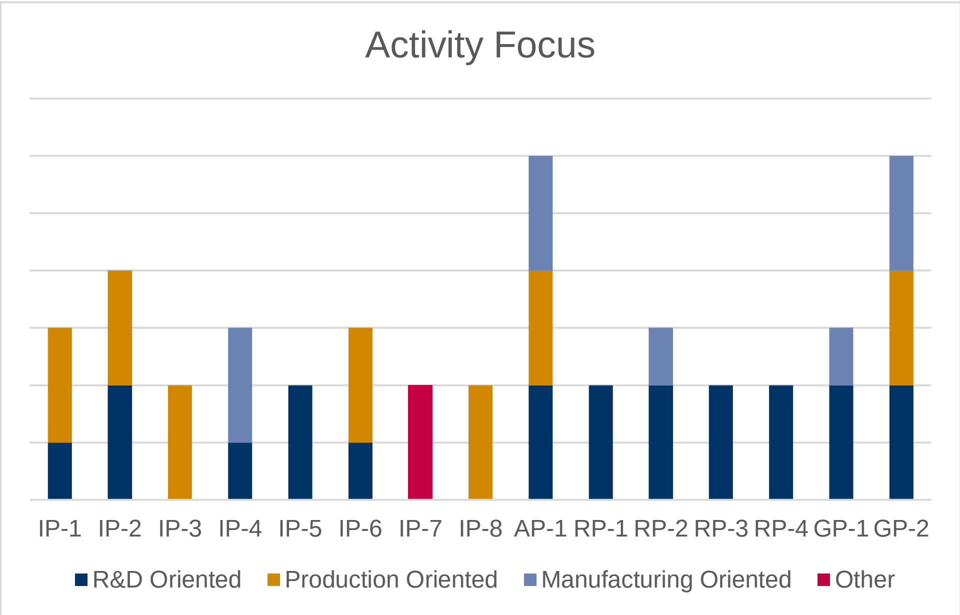


Figure 4-4: Type of Activity the Actors are Focused on

The information gathered from the participating respondents showed that the majority of the respondents do put in efforts towards research and development and production activities, as shown in Figure 4-4 above. Research institutions reported a strong focus on research and development given that it is at the core of their operations. The energy association and government entities generally support multiple levels of activities in the sector given their respective advocacy and regulatory roles. Although this is the case, the energy association AP-1 did indicate that there’s currently more focus on production in the sector and subsequently, they provide support to it. From the industry participants, IP-5 was the only reported organisation that has a strong focus on R&D activities, and similar to other industry participants, their R&D is based on existing technologies.

- IP-5: *We don't really have the capabilities, well, at the scale where we can focus on production and manufacturing of technologies in the sector. So a lot of it is on the R&D side and its more application based R&D in the sense that we spend time trying to do designs and engineering using available or cutting edge technology that is already in the market to find where we can then offer commercialised solutions to clients*.

The industry participants were reported to not have an intense focus on research and development, and mentioned that it takes place in small pockets, as and when required, and there are no intentions for the actors to strengthen their involvement in R&D given financial and capacity constraints and/or a pull towards focusing on improving sales.

- IP-1: *I would say right now we are at the production stage. We just want to produce now. We started off being research and development orientated too. But then realised that that’s the long way. We (now) have R&D, I think through each phase. Research and development takes a long time when you don't have funding*.
- IP-3: *Where are buying off-the-shelf production-oriented type of machines that already can produce the amount of energy that we want. We are not in the manufacturing space of energy technology at all… The research and development, all of that is done external to South Africa. We don't have the skills and capability yet in South Africa (for manufacturing), so none of the South African players have that*.

Manufacturing activities seem to be the scarcest activity among the participating actors in the energy sector mainly due to a lack of local manufacturing capabilities. The well-established industry participant IP-4 is reported to have manufacturing capabilities for the conventional energy wing (which is the crux of their business), but uses an external supplier for the renewable energy production. Both the organisations involved in the renewable and conventional energy generally outsource manufacturing and the best efforts towards technological capabilities is through the use of local manufacturers for the components that can be manufactured locally. R&D capabilities seem to be constrained to improving activities related to their production processes mainly, and some manufacturing processes where available.

- IP-2: *We are mainly production oriented. We have R&D capabilities that scan and evaluate new technologies and if they're promising, then we involve pilot and demo experts before application and roll-out*.
- IP-4: I *think at the moment because we're doing a lot of continuous improvement and an optimisation, hence our acquisition will be manufacturing orientated. We're not doing massive investments in new production technologies. Our optimisation efforts involve some research, but it's not that research focused. It's more counting the different technologies or it is even research to try and improve. It's not as intense on the new technology side. We are not necessarily bringing new technologies into the sector*.

With regards to the driving factor behind the activities that the participating actors expressed, the dominating driver was to improve sales, as presented in Figure 4-5 below. Industry participants are mainly looking to establish their businesses in the renewable energy industry. Although the participating actors showed an interest in diffusing technological capabilities within their organisations, the main purpose for acquiring this was linked to gaining competitiveness in the market.

The participating actors that had an interest in improving the level of technological capabilities were the research and government institutes whose chief aim is to improve development in the country through providing research and regulatory support to the energy sector.

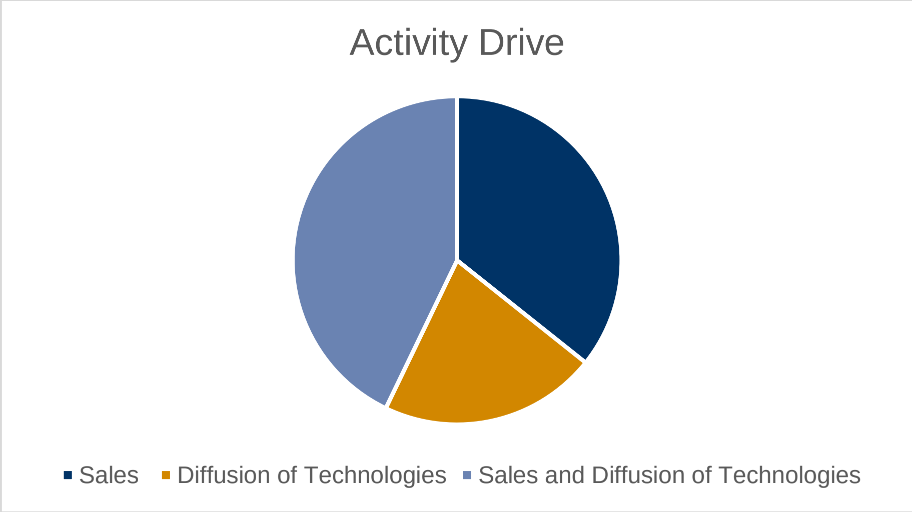


Figure 4-5: Primary Driver for the Activities the Actors are Focused on

Intentionality for Building Technological Capability

This section illustrates the intentions of the actors to acquire knowledge that would be beneficial for the purposes of technological capability building. The findings were gathered through investigating whether the actors currently have designated experts for technological capability building and also considering their roles in improving the acquisition of technological knowledge. Any efforts useful for retaining and protecting knowledge within the company were also assessed from an organisational level.

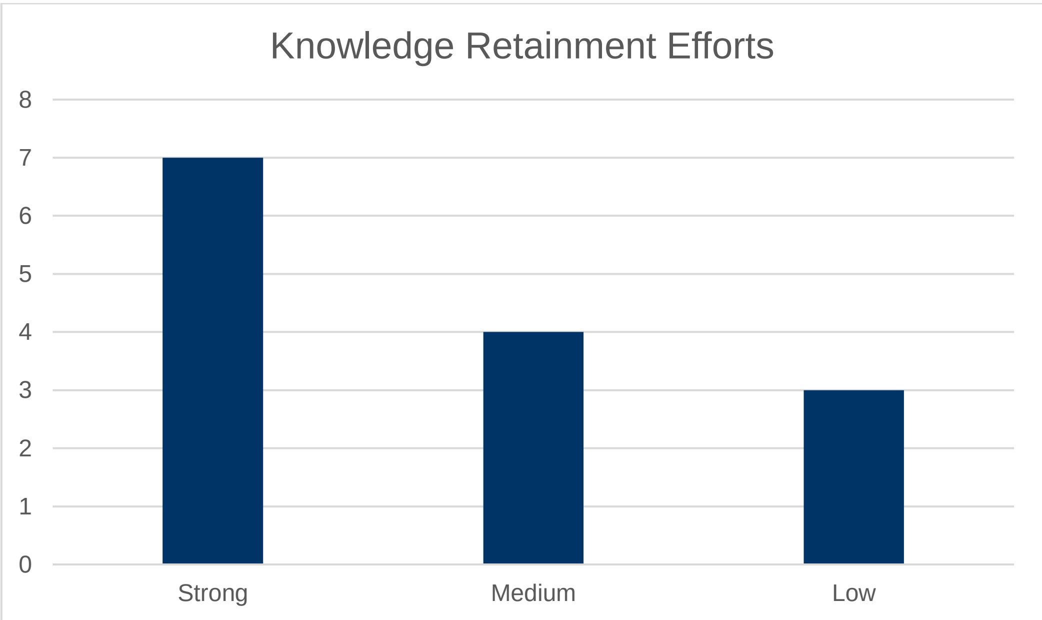


Figure 4-6: Level of Knowledge Retainment Efforts by the Actors

The actors that were identified to have robust programs in place for knowledge acquisition and protection include IP-3, IP-5, AP-1, RP-1, RP-3, GP-1 and GP-2., and these actors fall under the "strong" category in Figure 4-6 above. Some of the responses from the participants are captured below:

- IP-3: *The organisation clearly communicates and instils the vision and culture of the company from the recruitment stages. There is a committee dedicated to training professionals and helping them discover where they best fit in line with their skill set, aspirations, personality within the organisation in order for them to contribute effectively. We also have internal bursary schemes and a 10-year plan for developing engineers, which include personal succession planning and development*.
- RP-3: *The organisation offers study bursaries and it would have to be in a direction that supports your position at the organisation. So if for example you are a project manager in the energy efficiency program, then you would be able to apply for a bursary that would help you improve your studies in that direction. What they also do is this sort of a capacity building strategy that allows staff to attend workshops and trainings and so forth. So if it's not only the formal university bursary, but also workshops and trainings and things like that*.

The actors with the least programs in place for acquiring and retaining knowledge and are subsequently prone to losing internal skills and expertise are IP-2, IP-4 and IP-7, and these actors fall under the "Low" category in Figure 4.6 above. Some of the responses are shown below:

- IP-2: *No efforts towards retaining of staff. The company is currently downscaling, and offering early retirement packages due to losses in revenue. There have been cuts to further studies for employees, and no efforts to retain even critical skills at the moment*.
- IP-4: *We don't necessarily have a program for now for stimulating, attracting, retaining, improving talent. I think people have been struggling to get study funding now. I don't think we are so good at the moment… There used to be*

innovation expo's, but in the past, but right now we seem to be slacking a bit in that front.

Processes for Learning and Technological Capability Building

This section presents the findings relating to how the actors that were engaged for the purposes of this research organise themselves with respect to learning and building technological capabilities. The figure presented below (Figure 4-7) illustrates the processes that the actors have in place to facilitate learning.

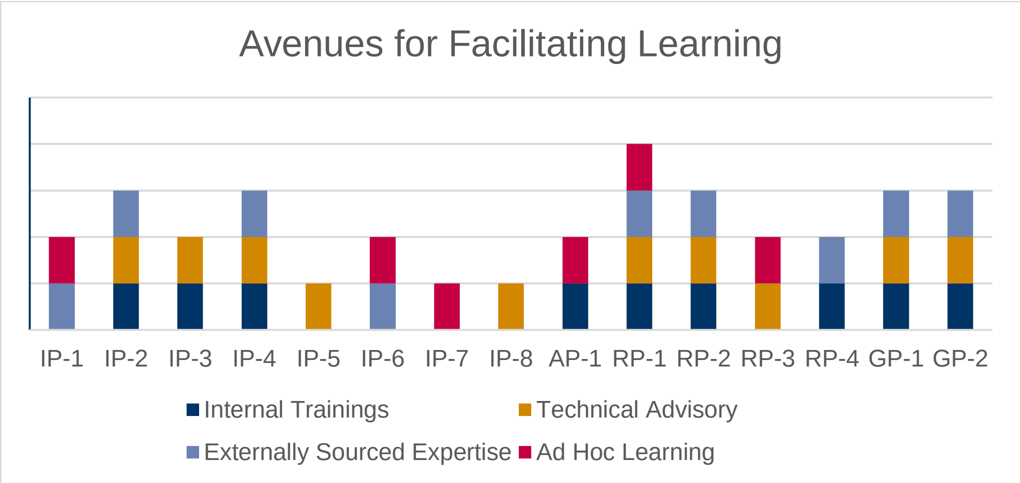


Figure 4-7: Avenues Deployed by Actors for Facilitating Learning

The established industry participants IP-2, IP-3 and IP-4 seem to have capabilities to host internal trainings within their organisations, along with providing technical advisory services and also sourcing external expertise for the benefit of the business. The relatively newer industry participants mainly rely on either technical advisory services through partnerships with experts in the industry and/or through outsourcing the required expertise. Ad hoc learning includes research that can be done by the organisation as and when required, on project-specific matters, as well as learning that can be acquired through interactions with suppliers and original equipment manufacturers.

Mechanisms for Accessing Technological Knowledge

This section presents the findings relating to the processes and the different platforms that the actors utilise in order to gain access to technological knowledge outside of their own organisations. These platforms are useful for the organisations to keep abreast with the upcoming technologies in the energy sector and to assist the organisations in closely following trends set by players leading in innovation and technology.

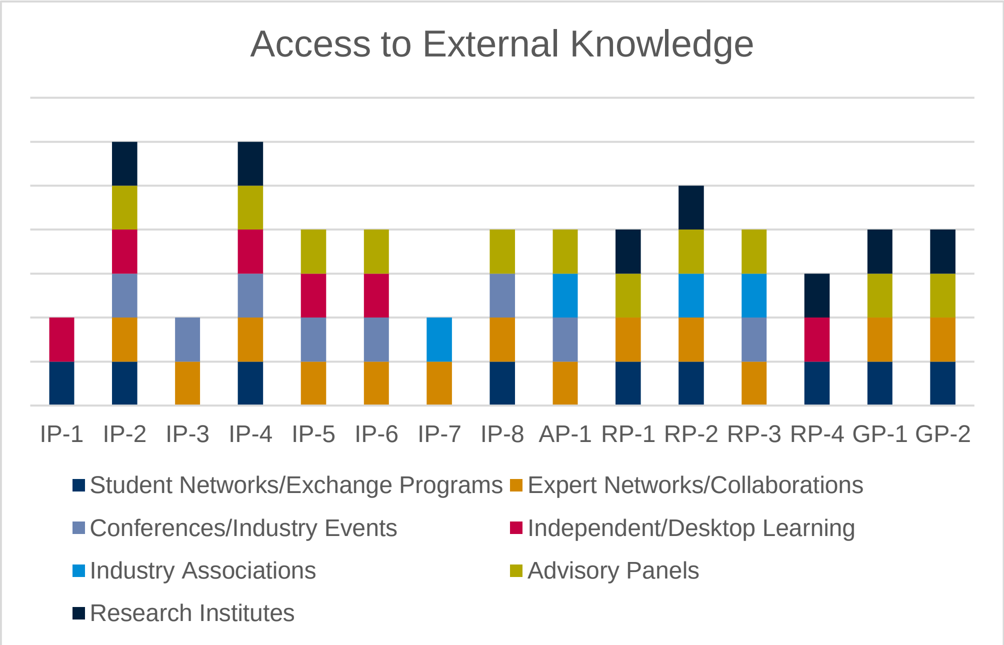


Figure 4-8: Mechanisms Used by Actos for Accessing External Knowledge

The information gathered from the participating actors and presented in Figure 4-8 above, showed that the actors have various forms of accessing knowledge from outside their organisations. The majority of the participating actors seem to utilise advisory panels for gaining expertise and also via networking with other experts in the industry. The feedback portrays that learning is effectively facilitated by collaborative efforts and partnerships which subsequently results in knowledge spill-overs within the industry.

Over the many years of operation, industry participants IP-2 and IP-4 have established various platforms for accessing knowledge and keeping abreast with the technological trends in the industry. Government participants are also enable to gain access to knowledge concerning the industry which should enable the policy makers and influencers within government to make informed policy decisions.

4.3.3 Level of Knowledge Exploitation

Mechanisms for Disseminating Technological Knowledge

This section illustrates the mechanisms that are put in place by each of the actors to assist with disseminating new and/or externally accessed knowledge to their staff. The figure below (Figure 4-9) displays the data gathered per actor, and the next figure summarises the frequency of use of each of the mechanisms by the entire group of actors that were interviewed.

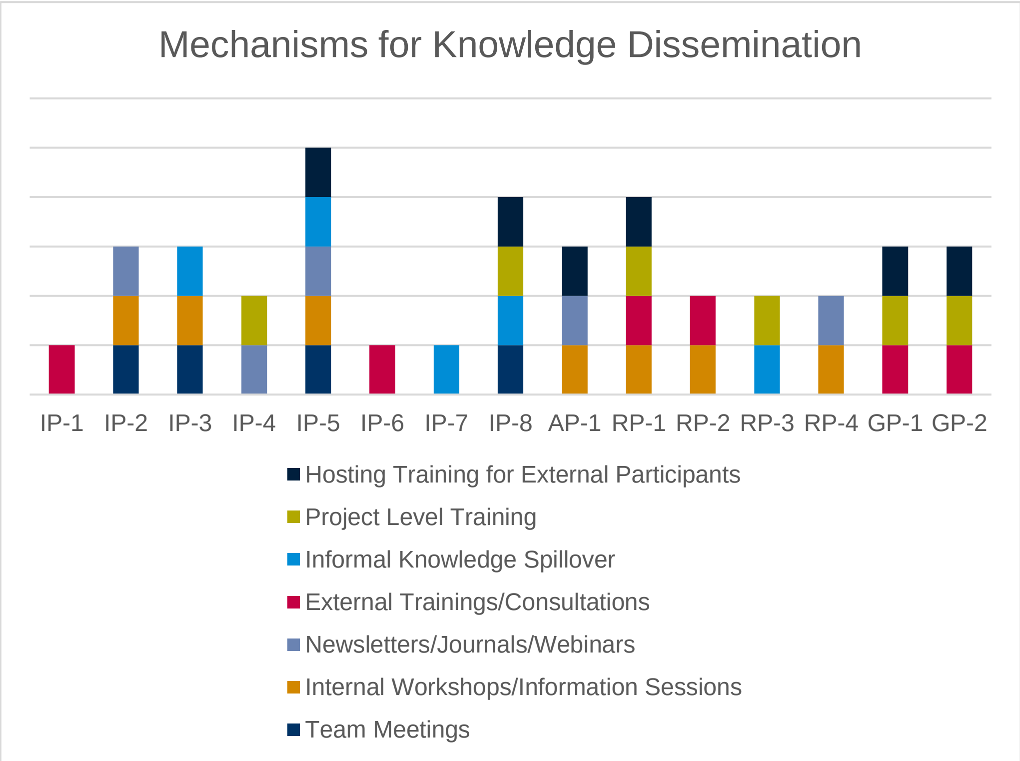


Figure 4-9: Mechanisms Used by Actos for Disseminating Knowledge

The presented data shows that participating actors IP-5, IP-8 and RP-1 have strong programs in place for disseminating knowledge within their organisations. A response from participant IP-5 in regard to the data is outlined below and highlights how distributing knowledge to all sectors of their business and across different levels of professions is of importance to them:

- IP-5: *We do have a common knowledge sharing platform within a cloud based system that we have in place specifically targeting all industry technology, which is the responsibility of one person in the company… The aim is to try and have company-wide knowledge sharing with contributions from different people in the* *company, which ranges from people who are busy with only doing the designs and insulation in engineering together with part of the team doing practical onset installations as well as people who are involved in management and administration setting. It's a collective platform where we try to include even with those were not so technical technically involved, but you know you get insights from different people in the company for different parts of the application that are quite useful to the company. At the end of the day, you might not think of something from a user perspective or from an administrator's perspective when considering technology which sometimes happens when you focus on it just from a pure engineer's point of view. So I think in that sense the knowledge sharing is the common knowledge sharing platform. It is quite a valuable thing that we that we can state within the organisation*.

Although participating actors IP-2 and IP-4 reported the highest platforms for accessing and exploring new knowledge, the organisations do not utilise that many mechanisms for the disseminating and sharing of the knowledge that has been gained. Subsequently the rate of accumulating external knowledge by these organisations is expected to be higher relative to their efforts at effectively diffusing the knowledge within their organisations. A comment from participating actor IP-4 in this regard has been mentioned below:

- IP-4: *The work that the strategy team does, you know, chances are it's not being exploited because it's something that is coming on a daily basis. To facilitate new exploitations, I don't think we're doing well and not just us, but a number of organisations are not. This speaks very well with things of knowledge spill-overs and stuff like that where you want to have the capability to capture even things that we were not thinking about and find ways to drive them forward… especially for such an organisation where you have mapped out such an effective way to store the database. But as to what happens from then on, it could be the difference between taking leverage and leading versus continually just solving problem by problem. But there's also, I think, so many untapped markets just because people are not taking the time or the opportunity to look at what they already have internally and then try to exploit it further*.

The presentation below summarises the frequency with which each of the mechanisms for knowledge dissemination are utilised by the interviewed actors. The data shows that the most popular form of sharing knowledge within their organisations is through setting internal workshops and information sessions for the employees. Trainings at project level which are provided when a certain project that requires training arises, are also popular within organisations. Moreover, organisations seem to benefit by strengthening their own expertise while providing training to other stakeholders outside of their own organisations.

Considering Figure 4-10 below, the data gathered from the participating actors shows that internal databases, along with formal trainings which are hosted internally and/or by external educators, are just as important as informal mechanisms of learning which include knowledge spill overs during collaborative efforts and engagements with other stakeholders in the industry.

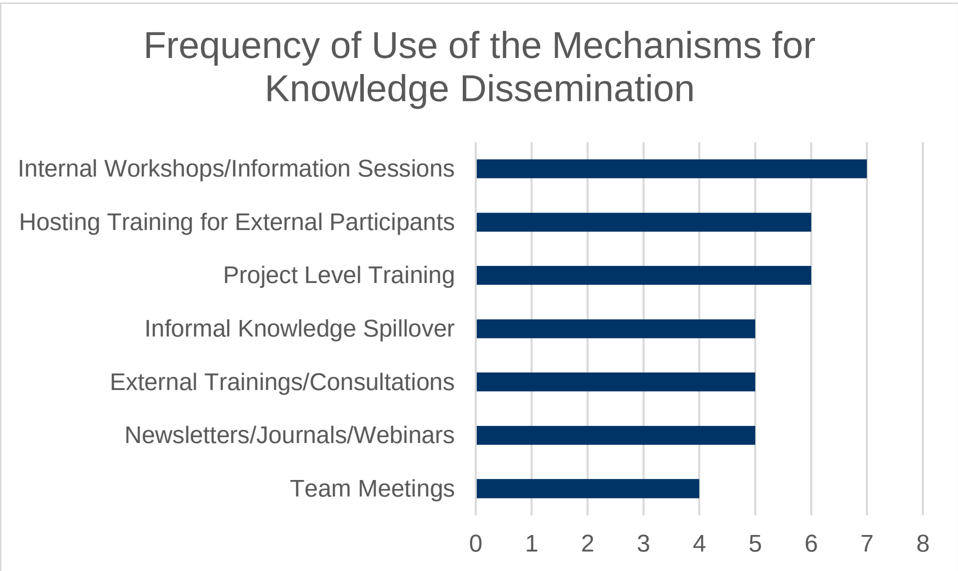


Figure 4-10: Frequency of the Mechanisms Used for Disseminating Knowledge

4.3.4 Level of Learning

This section illustrates the level or type of learning that the actors are mainly involved in, whether they are in the stages of adopting existing technologies and using them locally, or if there is incremental improvement to the technologies before their local application, or whether they're at an advanced stage of developing and using their own technologies.

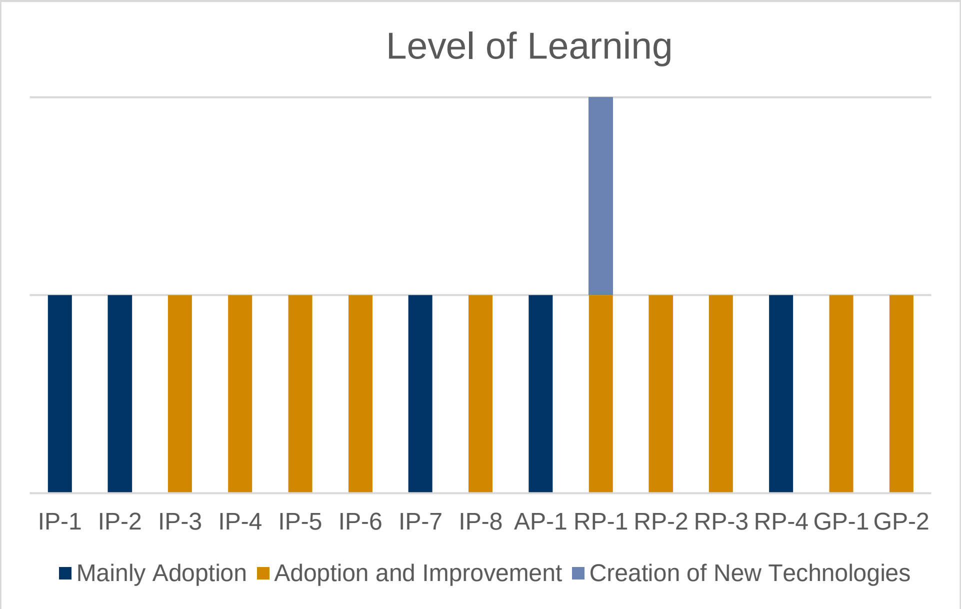


Figure 4-11: Level of Learning by the Actors

The data gathered from the participating actors and presented in Figure 4-11 above, show that the majority of the participating actors are at the stage where they're learning from the existing technologies and then applying incremental improvements to the products/processes in order to be able to make use of the adopted technology for local operations. Industry participant IP-2 indicated that although their organisation relies on technologies from the more industrialised economies, their goal is to be fast-followers as the technology becomes available. Research participant RP-1 has the capabilities to not only apply incremental improvement to existing technologies but to also develop new technologies for their clients during collaborative efforts for addressing a particular problem.

- RP-1: *We have expertise to also develop something ourselves where we see specific opportunity and then we will develop the technology*.

The diagram below (Figure 4-12) illustrates the types of learning as a proportion of the entire population and shows that adopting existing technologies and then applying incremental improvement to them are the main activities being undertaken by the participating actors for the purposes of learning and upgrading domestic capabilities in the energy sector.

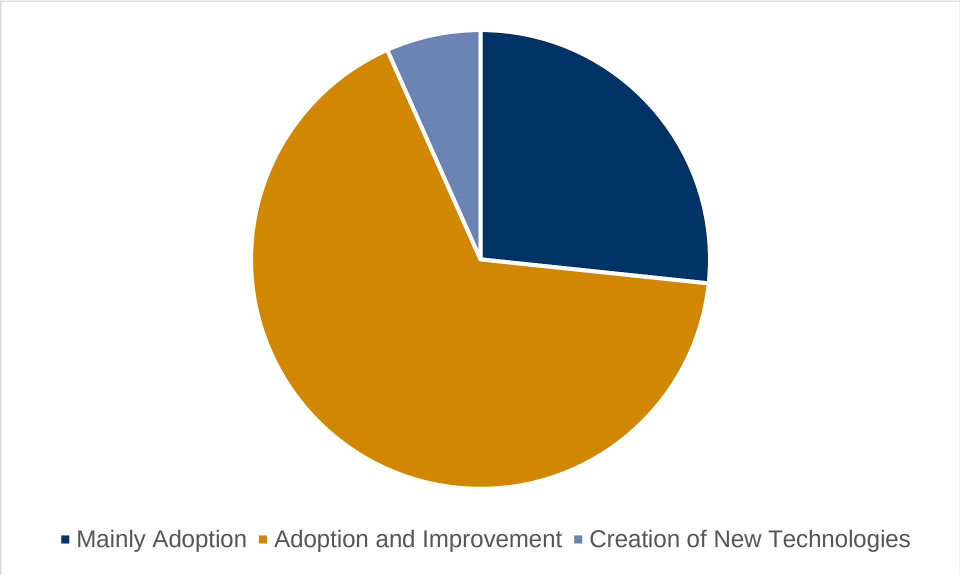


Figure 4-12: Categories and Proportions for Level of Learning by the Actors

4.3.5 Expectations on Technological Capability Building from a Policy Perspective

The participating actors were asked their perspective on how technological capability building might be influenced by the current policy environment pertaining the increase in power generators and the actors also commented on what other emerging factors might influence their rate of accumulating technological capabilities in the foreseeable future.

Impact of the Independent Power Producer (IPP) Policy on the Actors

The participating actors were engaged on their expectations of the government's efforts to break up the utility in response to ESKOM's limited capacity to meet the electricity demands currently in South Africa. The participants offered their responses on how they perceive the increased opportunity for independent power generators and whether they expect it to affect their organisations from a technological capability perspective. Some of the participating actors (IP-2, IP-3, IP-8 and RP-1) seem to believe that the introduction of more independent power generators in the grid will be favourable for technological capability building as organisations will be able to generate and gain internal expertise in the renewable energy industry, and also, the increased competition is likely to increase the appetite for organisations to improve their technological capability.

- RP-1: *Our strategy is to support where we see the market needs and the growth opportunities. (We ask) "What are the needs of South Africa to support that transition?" To ensure that we are technologically competent and can provide those services to the country*.
- AP-1: *With the new research that comes up from the different players, we could lobby for the adoption of the new technologies that are being developed*.
- IP-2: *Technological capabilities are increased since the IPP policy produces competition, although competition is not a strategic intent for state-owned entities*.
- IP-3: *The adopted policy by government makes it much, much easier to have independent power generation going, and that's one of the legs of our energy strategies to see how far we can produce*.

Participants IP-5 and AP-1 raised the point that although the increase in independent power generators has the potential to spur technological capabilities, this effect is dependent on other factors such as regulatory support and effective education on the renewable energy sector as a whole.

- IP-5: *It has a lot to do with a knock on effect of that filtering through from the utility scale projects to commercial, industrial and every sector projects and the opening up of regulation and customer appetite and education on these types of technologies*.
- AP-1: *The process of developing a project so that's the type of support where there isn't a mechanism yet that has been established, particularly for these small businesses within the sector*.

A number of the participating actors were not convinced that the IPP policy is likely to lead to conducive conditions for technological capability building. Part of the reason behind the hesitation for some of the participants having high hopes that the IPP policy will lead to increased technological capabilities is due to the IPP being more favourable for wind and solar generation mainly, and subsequently marginalising other means of power generation due to their capacity constraints. As a result, the participants expect that alternative renewable energy sources outside of wind and solar will remain more for off-grid purposes, and that is assuming that renewables are even considered mandatory in light of desperate measures to guarantee energy security.

- IP-6: *The policy is not as useful for the biogas industry. The policy is leaned mainly towards wind and solar sources. Biogas has capacity constraints is therefore more useful for off-grid production to clients*.
- RP-3: *I want to say yes, but it's yes in theory at the moment because it depends. At the moment the policy, or let's say it's not really a policy, as it was a call for renewable energy power producers to respond with the least cost, fastest build in the energy space, because it is under strain. Yeah, and they also didn't say that it has to be renewable. They said it can be any technology so long as it's the least cost, fast build. And then, of course, there's other parameters that they need to fit in with. So for us, what we would like to see is industry developing in a clean manner within the energy space*.

Government participants, who by the virtue of their mandate, have direct influence in policy making, were also not convinced that the policy for increasing power generators would likely influence technological capability building in South Africa. Participant GP-1 mentioned that the policy could improve technological capabilities in the renewable energy space, but, given the view that South Africa stands a better chance to develop more rapidly under the nuclear energy agenda, the IPP policy is therefore not as useful in the bigger picture.

- GP-1: *We're actually for all the technologies for the purposes of energy balance or the energy mix. But if we were to be aggressive, we wouldn't only embark on renewables, we should actually go beyond renewables and big infrastructure programmes. Nuclear is one of those*.

Government participant GP-2 raised the concern that the policy highlights the need for procuring the required energy units (it is essentially sales-driven in nature) without communicating any efforts for the need to localise production, and subsequently the power producers, though increased, will make no investment towards technological capability building unless the need is effectively communicated.

- GP-2: *I think when it comes to the independent power producers we appreciate what we've achieved. But I think from a science, technology and innovation perspective we can still achieve more. I think we just need to seriously have an honest discussion and an open discussion on how localisation can be increased. The unfortunate thing is that I think at times a discussion gets distorted because the IPPs are looking for their next application rather than looking at the bigger picture. So for them it's like, "Give me 2000 megawatts guaranteed on an annual basis for the next five years then I put up in manufacturing plant." We cannot work back like that… I think we need to get into a system where we start looking at the South African manufacturing sites and see which companies can be a supported to a level that they are not only supporting their South African component of the IPP localisation, but they become part of their global value chain*.

External Shocks That Could Potentially Invigorate Technological Capability Building

The participating actors were also engaged on their expectations on the factors that could potentially lead to the rate of gaining technological capability building being realised more rapidly. The majority of the participants, particularly those in industry, commented on the challenges of competing on volume and price given their recent entrance into the industry. In order for the participants to gain some level of leverage in technological capabilities, the participants believe that it would take government intervention in the form of subsidies, funding or grants, tax rebates and other mechanisms that would protect localisation.

Although some of the participating actors also noted the need for policy improvement, they raised the point that policy already shows considerable support to specific renewable energy industries (namely wind and solar) and therefore policy improvement would not only be required for the renewable energy sector at high level, but would need to be intentional towards the support of other kinds of renewable energy sources which are currently being overlooked.

Some of the responses with regards to the factors that would impact South Africa's ability to gain technological capabilities reported that this would require some improvement to the current levels of corruption and improved political stability. Such changes would have an impact on foreign direct investments and in commercial engagements with key actors in the international platform.

Apart from the factors related to the policy and political landscapes, some of the participating actors also mentioned other external shocks that would trigger the rapid acquisition of technological competencies in the energy sector. The phasing out of coal fired plants and continued penetration of the national grid with renewables is expected by a participating actor in the government sector to induce the need for nuclear energy as this situation would create an imbalance in the grid as it requires baseload power. This belief was not supported by a research participant who referenced some parts of the world that are currently operating at very high levels of renewable energy integration and successfully so.

A participating actor who is primarily involved in the conventional energy sector responded that the rapid adoption of electric vehicles would represent a threat to the incumbent particularly from a liquid fuels perspective. The increase in electric vehicles would cause disruption to the incumbents and pressure them to invest more intentionally in capability building for new/up-coming technologies rather than settling for their existing capabilities. Another participating actor who is also involved in the conventional energy sector provided similar insights, stating that the shock of disruptive technologies would alter their business model, and therefore lead to declining revenues, which would then force the incumbent to respond.

4.4 Document Analysis

Document analysis included the search of publicly-available documents that relate to the renewable energy mandate and innovation strategies within the South African energy sector. The most recent versions of the documents published by the respective government organisations were used in order to garner an understanding of the country's current position with regards to technological capability building as well as their foreseeable strategies for the future. The aim for the document analysis was to map out the intent for technological capability building and the findings have been summaries for each of the analysed documents, as shown in the section below.

4.4.1 Department of Science and Technology (DST) Ten-Year Innovation Plan (2008-2018)

The DST's Ten-Year Innovation Plan aims to drive the country from being dependent on knowledge gained from other nations to a position where South Africa is able to domestically produce and disseminate knowledge for the purposes of building the country's knowledge base. The plan is intended at addressing issues regarding the country's inability to commercialise its own results of scientific research and the issue with a lack of local expertise for building local technological competencies. With regards to energy, the plan outlines the challenges with energy security and a need for the country to invest in clean coal technologies, nuclear energy, renewable energy, as well as the emerging hydrogen energy solutions. The plan proposes four elements that will help transform the country from a resource-based to a knowledge-based economy, namely, 1) human capital development; 2) knowledge generation and exploitation (R&D); 3) knowledge infrastructure and 4) enablers to address the innovation chasm between research results and socioeconomic outcomes.

The Ten-Year Innovation Plan shows regard for the importance of strengthening linkages within the national systems of innovation as it emphasises the need for collaboration with international partners. Working partnerships between intellectual property owners and industry are also noted as important for harvesting research outputs for commercialisation purposes. Localisation is also emphasised for reducing the country's dependence on imported technology to becoming more self-sufficient in the energy space.

The major R&D thrusts presented in the plan embraces conventional energy sources (clean coal technologies and nuclear energy) which will remain the major energy generators in the country. The plan sets clear objectives in terms of the technologies that the country will embark on developing for growing its knowledge base in the conventional energy sector, but with less clarity for the renewables (noting that a strategy for achieving a green economy is yet to be developed) and a futuristic approach for hydrogen energy.

Although not covered by the Ten-Year Innovation Plan, the plan notes the need for policy and innovation instruments to be redesigned to create a strong incentive for innovation through improved access to finance, conducive regulatory environment and a strengthened national systems of innovation. There still remains a challenge with developing procurement regulatory frameworks that will encourage localisation and the improvement of domestic capabilities.

4.4.2 Department of Science and Technology (DST) Annual Report 2017/2018

The Department of Science and Technology (DST) (currently referred to as the Department of Science and Innovation (DSI)) plays a significant role in defining the science, technology and innovation space and the White Paper on Science and Technology introduced in 1996 set a stage for this. The 2017/2018 annual report for the DST provides feedback on the developments and major projects that were undertaken during the period. Over the year, the DST provided significant funding support through offices of technology transfer (OTTs), with the goal to improve training on intellectual property and providing support to intellectual property institutions for the protection and maintenance of IP. Flagship programmes aimed at improving energy security were also funded and resulted in the support of postgraduate students, academic publications, as well as prototypes and commercial products being realised. Infrastructure for research and innovation also received a focus and was funded via national research institutions and funding schemes.

Although there were limited mentions of the direct investment in the energy sector in 2017/2018 report under the report of the accounting officer, the need for this was highlighted by the service delivery improvement plan which listed a need for providing funding to institutions to support the energy space. In terms of the strategic goals, the

DST's mandate was reported to be to create a responsive, coordinated and efficient national system of innovation, as well as a goal to maintain and increase knowledge generation. The goal for increasing knowledge generation is set to be achieved through funding access, collaborative initiatives with European expertise and use of international resources, the creation of multi and transdisciplinary research platforms, and overall investment in research infrastructure.

Under the technology innovation programme, the report highlights the need to facilitate resource investment in the energy sector through initiatives such as the Energy Grand Challenge, the renewable energy hub program for energy generation, and projects for energy storage systems to support R&D in the renewable energy sector. The Hydrogen and Energy subprogram can also provide support and policy insight into the energy sector.

Overall, the DST has expressed strong intentions to improve the energy sector through participating in programmes that will build the renewable energy expertise. The DST aims to achieve this by making funding opportunities available, improving research infrastructure, through various innovation and development programmes, as well as through strengthening linkages with the internationally renowned in the energy sector.

4.4.3 White Paper on Science, Technology and Innovation (2019)

The White Paper on Science, Technology and Innovation forms a part of the Department of Science and Technology's (DST) government policy and follows from the 1996 White Paper on Science and Technology. The paper focuses on the core themes of inclusivity, transformation and partnerships. The paper aims to address issues with policy coherence, the development of human capacities, knowledge expansion, innovation performance, as well as increased investment, with the purpose of forging agile governance that is able to respond to rapidly changing economic and technological environments.

The DST sets to improve governance of the national systems of innovation through committing public resources to priority science, technology and innovation programmes; through increasing coherence between education, skills development, social development, and the economy; as well as through improved sector coordination. The paper is intentional about strengthening links and improving coordination between research institutions and funding agents. Efforts for improving monitoring and evaluation frameworks for the national systems of innovation are also noted.

The DST aims to foster an enabling innovation environment through designing policy that supports the entire process of innovation, and not simply R&D. The department is committed to introducing mechanisms for strengthening support to business (particularly small and medium enterprises (SMEs)) for instance through increasing the uptake of locally developed technologies through government, along with supporting state-owned entities. Beyond this, government also aims to foster innovation at school level in order to instil an innovative mind-set in the nation's educational system. Post-secondary education, the government seeks to improve researcher base and grow the human resource pipeline from a tertiary institution level to vocational training. The White Paper covers plans to deepen African collaborations, as well as strengthening cross-border linkages and aligning with the SADC goals and the objectives of the Pan-African agendas.

Although the White Paper proposes policy actions towards improving the country's technological capabilities, it is not designed to provide an implementation plan. The paper states that the successive decadal plans are the documents responsible for providing details on the technology focus areas, the actions to be taken and ways in which these will be evaluated.

4.4.4 Department of Trade and Industry (DTI) Annual Report 2019/2020

The Department of Trade and Industry (DTI) Annual Report 2019/2020 refers to the Integrated Resources Plan (IRP) 2019 and their efforts to achieve the goal of supporting a diversified energy mix with continued use of coal as the main energy source. The DTI invested towards the use of Koeberg Nuclear Power Station as well as future nuclear capacity. Provision for a total of 6,000MW of new solar PV capacity and 1,4400MW of new wind power capacity was made and is planned to be commissioned by 2030.

The DTI has shown intention to improve energy security in South Africa. Their intentions are mainly through ensuring current and future nuclear capabilities, while also considering the contribution that green energy has in benefiting the economy.

4.4.5 Department of Mineral Resources and Energy (DMRE) Strategic Plan 2020-2025

The Department of Mineral Resources and Energy (DMRE) Strategic Plan 2020-2025 has been envisioned in light of the IRP 2019 as a response plan to improving energy supply and energy efficiency. The goal of the IRP (2019) is to address challenges that are faced nationally (whether short or long term) by providing policy support pertaining to matters of energy security and ensuring its affordability for all citizens.
The DMRE outlines an investment on nuclear power generation through the Nuclear New Build Programme which is targeted to bring 2 500 MW to the grid in the long run. The DMRE is also invested in the extension of the Koeberg nuclear power station through the Koeberg Life Extension Programme. Furthermore, the DMRE strategic plan 2020-2025 highlights the action to improve coal sustainability through cleaner coal technologies (such as Carbon Capture Utilisation and Storage). Gas will also form part of the venture for power supply through the conversion of diesel-fired power plants to gas. The DMRE strategic plan does feature the exploration of renewable energy sources (through state owned vehicles; hydropower through the development of the Grand Inga Hydroelectric Project in the Democratic Republic of Congo (DRC)). South Africa is looking into supporting strategic power projects emanating from other countries, although the lack of infrastructure to transmit the power and lack of trade relationships between South Africa with other countries (such as the DRC) make the plan for clean energy import less plausible.

Regarding innovation capability building, the DMRE points out that a transition to clean technologies does provide opportunity of the South African energy industry to move from being a raw export economy to a processing economy driven by the demands for manufacturing batteries and reactors for powering a greener economy. The Nuclear Energy Programme provides training, research and development opportunities which are important contributors to domestic technological capability building. A move towards producing energy from gas will also require new technologies and new modes of transportation that currently do not exist. Gas energy would also require South Africa to collaborate with neighbouring countries that are endowed with gas, thus providing opportunities for South Africa to learn. The Council for Geoscience's (CGS) Shale Gas project also provides research and development that will aid in the country's approach on shale gas exploration in the future.

4.5 Conclusion of the Document Analysis

This section looks at various documents published by the South African government in relation to the energy transition agenda and the subsequent development of expertise in this regard. In conclusion, the DMRE strategic plan for 2020-2025 pays more attention to the improvement of energy efficiency within the conventional energy production processes in order to appropriately exploit existing resources. The overarching focus seems to be on the improvement of conventional energy production through the means of improving efficiency and reducing carbon emissions generated. Although there is an aspiration towards increasing the amounts of renewable energy in the grid, the introduction of renewable energy provides both opportunities and threats to the coal industry. The DMRE strategic plan provides limited plans on how renewable energy will be achieved particularly in the short term especially since there are some challenges (i.e. infrastructure) that still need to be overcome before this goal can be effectively realised. The DMRE aims to explore technological capability building for the purposes of improving energy efficiency and transitioning towards cleaner energy production. Their strategy for achieving this is mainly through research and development via training programmes and projects conducted by research institutes, as well as through multinational collaborations.

4.6 Summary of the Research Findings

The summary of the research findings is covered using three key categories for assessing technological capability building and policy change in the South African renewable energy sector.

The categories identified based on literature review were 1) the coalitions within the South African energy sector; 2) the level of knowledge exploration by the actors, 3) the level of knowledge exploitation by the actors, and lastly, 4) the actors' view on technological capability building in light of current/emerging external changes.

Overall, the findings based on the content analysis suggest that there is a considerable number of actors who are focused on renewables and are mostly industry organisations (IP-1, IP-5, IP-6, IP-7 and IP-8). Actors varying from business organisations who have included renewables in their line of business (IP-2 and IP-3), research institutes (RP-1 and RP-2), as well as government entities (GP-1 and GP-2) seem to be involved in both the renewable and conventional energy industries. Actors who are focused on conventional energy (IP4, RP-2) remain few but have become well-established over longer periods of operation.

In the attempt to explore the actors' levels of beliefs in technological capability building, their current efforts in technological capability building, along with their levels of aspiration for competitiveness, their collaborative efforts and the resources required for achieving technological capability building were all taken into consideration. The majority of the participating actors are either not participating in technological capability building for the energy sector (IP7, RP4) or this is not the actors' current focus given that they're currently making use of technology that is pre-existing (IP-1, IP-3, IP-6, IP-8). While other actors did express longer term aspirations towards improving technological capabilities (IP1, IP-6, AP-1), some of the actors are already pursuing this (IP-5, RP-1, RP-3). With regards to the actors' levels of competitiveness, the majority of the participating actors are still seeking domestic and regional competitiveness (given their current limitations and subsequent future pursuits for technological capabilities), while the established organisations (IP-4, RP-2, GP-1, GP-2) expressed an aspiration for competitiveness internationally, particularly for the conventional energy sector.

The majority of the participating actors have established relationships with academic and/or research institutes, and RP-1 is particularly the main research institute that actors in the South African energy sector are connected to. The actors are also well connected with business partners both locally and internationally, although the incumbent actor IP-4 does so with caution due to competitor threats. Actor IP-8 also expressed their biasness towards local business partners as a result of their staunch beliefs in supporting localisation in production and procurement. Strong links exist between actors in the energy sector and government entities (including development agencies), although the actors reported their relationship with government agencies as being for the purposes of accessing funding support and/or regulatory information and not particularly for gaining support for gaining technological capabilities. However, even with there being established relationships with government entities, the actors expressed the need for improved financial access, policy support as well as strengthened links between private and public sector partnerships. Government also seems to be aware of this need and the intentions for improving linkages within the national systems of innovation were formally documented in the DST's Ten-Year Innovation Plan (2008-2018). The White Paper on Science, Technology and Innovation (2019) also recognise the need for government to play an active role in strengthening links and improving coordination between research institutions and funding agents.

With regards to the level of exploration, the activities and intentionality for building technological capability were discussed. The processes and mechanisms that enable learning were looked at in order to assess how the actors are organised with regards to knowledge acquisition. The actors are currently focused on production-oriented activities given their primary goal of improving sales. R&D activities seem to be taking place in small pockets and are limited mainly due to budget constraints, although actor IP-5 did express capabilities to undertake application-based R&D activities. Manufacturing capabilities are reportedly scarce within the South African energy sector and subsequently a single actor (IP-4) who is well-established in the sector is involved in manufacturing under their conventional line of business. In preserving knowledge and attracting new expertise, some of the actors were identified to have robust programs in place for this (IP-3, IP-5, AP-1, RP-1, RP-3, GP-1 and GP-2), while others (IP-2, IP-4, IP-7) did very little to achieve this.

For the purposes of learning and gaining new knowledge outside of their organisations in order to improve technological capabilities, the well-established actors (IP-2, IP-3 and IP-4; RP-1 and RP-2; GP-1 and GP-2) have deliberate internal programs for facilitating this, while the new entrants in the industry mainly rely on the outsourcing of expertise. Collaborative efforts and partnerships also play a significant role across all actors in inducing knowledge spill-over. The DST's Ten-Year Innovation Plan (2008-2018), the DST 2017/2018 Annual Report and the DST's White Paper (2019) all expressed strong intentions for investing on programmes and in building relationships with regional and international partners in order to facilitate knowledge acquisition in the energy sector.

In assessing how the actors are making use of the acquired knowledge in order to exploit it and build their capabilities internally, their mechanisms for knowledge sharing and their level of learning (whether at the stage of adoption, improvement or advancing to new technologies) were discussed. Various platforms for disseminating knowledge were identified for actors IP-5, IP-8 and RP-1. On the contrary, actors IP-2 and IP-4 did not display as much intention for effective knowledge sharing within their organisations when comparing this to their aggression in accumulating the knowledge. The actors generally use internal workshops, information sessions and project-level trainings as their platforms for knowledge sharing, while also making use of trainings they provide for their external stakeholders as a means of sharpening their own expertise.

With regards to the participating actors' levels/stages of learning, the majority are utilising existing technologies (adoption) and then applying incremental improvements for making them fit for purpose. Some actors in the energy space (such as IP-2) aspire to be fast-followers even if they do rely on more industrialised economies for their technologies. The research institute RP-1, which was also noted earlier as being connected to all the other actors in the sector through providing technical expertise and technology development capabilities, does have actual capabilities to create new technologies for the rest of the actors in the sector.

While engaging the actors on their perspective on how the national call for independent power generators would influence their ability to build technological capabilities, a handful of the actors (IP-2, IP-3, IP-8 and RP-1) believed that this regulation would enable technological capability building particularly in the renewables industry mainly due to increase in competition among players. Some of the actors (IP-5, AP-1) responded that, beyond allowing for more power generators, other factors (such as regulatory support, improved knowledge of the renewable energy industry) would be required in order for there to be any impact in technological capabilities for the sector. The DST's Ten-Year Innovation Plan (2008-2018) recognises the need for procurement regulatory frameworks that will encourage localisation and the improvement of domestic capabilities, but without delving into how this will be addressed. More-over, The DST's White Paper (2019) expresses commitment to introducing mechanisms for strengthening support to business (particularly small and medium enterprises (SMEs)), for instance, through increasing the uptake of locally developed technologies through government procurement programmes.

The majority of the participating actors in the renewable energy space do not believe that increasing power generators into the grid will result in any technological capabilities being acquired based on the fact that the current policy environment is not favourable for all kinds of renewable energy sources (but is biased towards wind and solar given their production capacity) and therefore, if any technological development would be to take place, it would likely be for a select kind of renewables options. Government actors also expressed a lack of correlation between enabling IPPs to join the grid and the sector gaining technological competencies on the basis that the government department (GP-1) is persuaded that nuclear power generation would spur up the nation's technological competencies more rapidly than other means of energy generation (such as renewables). This view is also evident on the document findings from the DTI Annual Report 2019/2020 and the DMRE's Strategic Plan (2020-2025). Another government actor (GP-2) raised concerns that policy is focused on improving production and consequently power producers are driven by sales as opposed to being influenced by policy and being held accountable to consider making a contribution to domestic capability building.

In light of external factors that would assist the actors in realising technological capabilities more rapidly, the majority of the participating actors believe that government support and intervention, especially towards infant industries, would play a major role in achieving this. Moreover, some of the actors expressed that this approach would need to be applied across all kinds of renewable energy sources, as opposed to a select number. Improved political stability and reduced levels of corruption was also mentioned as an ideal condition that would make the country more reputable to receive foreign direct investments and to collaborate with in business. More-over, the phasing out of coal fired plants and the rapid introduction of electric vehicles were raised as potential shocks that would provide opportunities for accelerated acquisition of technological know-how in order to facilitate catch-up for the purposes of keeping the energy sector afloat with the demands.

4.7 Conclusion

The chapter presented the key research findings of the semi- structured interviews and the content analysis. The aim of the chapter was to relate the research findings to the research questions in an attempt to provide insight to the questions that were posed by this research. The chapter that follows presents the analysis of the research findings.

5. CHAPTER FIVE: ANALYSIS OF RESEARCH FINDINGS

This chapter discusses the results presented in Chapter 4. A combination of primary data collection through research interviews with actors in the energy sector and a documentary analysis of the primary institutions that influence policy in the energy sector was used for this research. The discussion in this chapter is based on the matters covered by the interviews according to the following objectives: identifying the actors advocating for the renewable and/or conventional energy cohort, analysing the actor involvement in the upgrade of domestic technological capabilities, as well as discussing the windows of opportunity for the actors to potentially influence policy for the purposes of elevating domestic capabilities. In order to address the posed research questions, the findings were compared to the relevant literature.

5.1 Advocacy Coalitions in the South African Energy Sector

Advocacy coalitions include actors with similar beliefs who engage in a level of coordination (Sabatier & Jenkins-Smith, 1999). Weible (2006) points out a common criticism of ACF research being that the results point out the obvious, and an outsider can easily identify who is on each side of an issue with very little effort. This was also observed during the process of this research, and the process of data gathering therefore required careful consideration against bias. The results indicate that there are a number of actors who are involved in the renewable energy space either as a core business or those who are undergoing transition/ inclusion of the renewables wing within their conventional energy business.

The realisation by actors for the need to transition to cleaner energy alternatives is in line with the ACF which assumes that actors can be motivated to convert their beliefs, and eventually seek allies to form advocacy coalitions to accomplish policy change (Weible, 2006). The fewer actors in the conventional energy space were expected due to the monopolised nature of conventional energy business. However, judging from the document analysis of reports/strategy plans from the relevant government departments, their political influence cannot be disregarded and might have been further propelled by the mineral resources and energy departments being run under one roof at the Department of Mineral Resources and Energy (DMRE).

Coalition Belief Systems

The ACF allows for analysing actors at the policy subsystem level. The ACF views policy core beliefs as the most important stakeholder attribute for understanding individual behaviour (Weible, 2006). Interviews were conducted for this study in order to identify actors within the energy sector, whether pro-renewables or pro-conventional, and to understand their beliefs as they relate to technological capability building in the energy sector. The table below shows the actor affiliations which span over industry organisations, advocacy organisations, research institutes and government agencies, and the different aspects of their beliefs.

The table below shows that actors from both the renewable and conventional energy groups tend to be aligned on some aspects of technological capability building, while also differing on others. There seems to be a strong intent for achieving improved technological capabilities from both sides in the energy sector. However, the conventional energy coalition (including those actors who have grown capabilities in renewable energy over time and those in support of it through research and regulatory services) appear to have established solid processes for building technological capabilities through knowledge exploration activities. The renewable energy coalition is generally disadvantaged in this regard given their relatively new status in the industry and current pursuit to become profit-making rather than having the financial means to grow technological competencies. Subsequently the government plays a key role in either supporting or crippling the learning process in how it relates to the means, the incentives and the capability to learn (Lundvall & Johnson, 1994). The concept of infant industry protection (List, 1909) is therefore an important one, even if selective and temporary, to allow home firms within industrialising economies a chance to benefit from learning by doing and other interventions such as subsidies.

Programmes for attracting talent and preserving knowledge gained internally appear to be scarce on both sides, with the support affiliations (advocacy, research institutes, government agencies) investing more efforts in these when compared to industry actors. Likewise, both the renewable and conventional energy coalitions seem to focusing less on how the acquired knowledge gets exploited for the purposes of learning, although a few members of the renewable energy coalition were reported as being more intentional in this regard. Contrasting results were observed when comparing the stages of learning at which the coalitions are in. As anticipated, the renewable energy coalition consists of some members who, at this stage, can only adopt pre-existing technologies and do not have the resources or capabilities to apply improvements even if incremental. Conventional energy coalition members who have added capabilities for renewables, along with the support affiliations, are generally able to apply incremental improvements to technologies being applied.

In relation to the increased IPP participation, it is generally the conventional energy members who also possess a wing in renewables who seem to believe in a positive outcome for technological capability building, while the renewable energy coalition (those whose core business is in renewables) disagree with this notion and are advocating for further policy intervention and support measures to be put in place before technological capability building can be realised. This view is supported by Rennkamp and Boyd (2013) who analysed the enabling environment for low-carbon technologies and the implementation of clean technologies in South Africa and upon their findings, concluded that the government currently does not provide support for developing technological capability through its regulatory frameworks and policies.

Table 5-1: Summary of Beliefs by Organisational Affiliations

	Industry								**Advocacy Association**	**Research Institution**				**Government**	
	IP-1	IP-2	IP-3	IP-4	IP-5	IP-6	IP-7	IP-8	AP-1	RP-1	RP-2	RP-3	RP-4	GP-1	GP-2
Involvement in RE	X	X	X		X	X	X	X	X	X		X	X	X	X
Involvement in CE		X	X	X						X	X	X		X	X
Strong Intent for TCB	X			X	X	X		X	X	X	X	X		X	X
Established Processes for TCB (Knowledge Gain)		X	X	X						X	X	X		X	X
Effective Knowledge Preservation Programs			X		X				X	X		X		X	X
Strong Intent for Knowledge Sharing					X			X		X					
Level of Learning: Adoption	X	X					X		X				X		
Level of Learning: Adoption with Some Improvement			X	X	X	X		X		X	X	X		X	X
Significant Influence on TCB by Increasing IPPs		X	X					X		X					

Previous External Shocks and Policy Change

Changes in beliefs can be brought about by external shocks (Weible, 2006), and external shocks have been described as events that take place outside a policy subsystem. In applying a retrospective view to South Africa's energy sector and policy regime, it is observed that over the years the country has taken a leap and prepared policies with the aim to address the issue of climate change. The country's publicised intent for addressing this dates back to 2005 when a Member of Parliament and then Minister for Environmental Affairs and Tourism, Marthinus van Schalkwyk, revealed the ruling party (the African National Congress) and government's position on climate change and future directions for policy at both the national and international levels (Nhamo, 2011). The minister communicated a need for the country to make a global commitment and to invest in mechanisms to provide new and additional finance, capacity and technology, sourced primarily from developed countries, and to assist the affected countries and populations to cope with the consequences of climate change (Van Schalkwyk, 2005). The issues and subsequent need for finance, capacity and technology were re-affirmed four years later in President Jacob Zuma's Copenhagen Climate Summit speech (Zuma, 2009).

In 2011, South Africa hosted the 17th formal meeting of the UNFCCC (United Nations Framework Convention on Climate Change) in Durban where countries agreed to establish a universal and legally-binding climate treaty by 2015 for the post-2020 period. This was the platform that South Africa utilised to express its global commitment in response to climate change, which ultimately led to the 2015 Paris Agreement. South Africa submitted a climate pledge which was based on the "peak, plateau and decline" approach between 2020 and 2025 (as discussed in Chapter 2 under the *National Climate Change Response Policy White Paper)*. Given the country's heavy reliance on coal, the development of policies for cutting emissions and transitioning to cleaner energy alternatives became the focus which resulted in the expansion of renewables getting the required attention from government.

In light of the ACF, South Africa's nationally determined contribution for addressing the issue of climate change expressed at the UNFCCC meeting in 2011, served as an opportune moment for policy change in favour of the renewable energy sector. This notion is also supported by Rennkamp (2019) in her analysis of institutional change in the country's climate policy, and her view that the climate policy emerged between 2009 and 2012 during the early years of the Zuma administration. Programmes that emerged after this period such as the Renewable Energy Independent Power Producer Procurement Program (REIPPPP) are evident to institutional change that took place following the external shock event.

Emerging External Shocks and Opportunities for Policy Change

Currently, the nation's demands for electricity due to unreliable supply from ESKOM pose another form of external shock, which has already resulted in a policy measure being undertaken (the addition of more power generation into the national grid). This current socio-economic challenge can be viewed as a potential window of opportunity for coalitions to mobilise for the purposes of influencing policy to being more intentional about building technological capabilities in the energy sector. However, considering how the actors are currently organising themselves to seize this window of opportunity, with the renewable energy coalition not anticipating much benefit from it, it is unlikely that this external shock will result in major policy change beyond the minor policy alteration that has occurred. Major policy change, in terms of the ACF, would require a long-term alteration of a policy that is subsystem-wide (Sabatier & Jenkins-Smith, 1999), while minor policy change is a modification of a specific policy (changes in secondary aspects of the policy subsystem) (Weible, 2006).

In order for major policy change to be influenced, an introduction of other factors would need to be in place. These may include the reduced reliance on existing energy sources (for example, though the phasing out of coal powered station for power generation), and/or an increase in the adoption and manufacturing of electric vehicles in South Africa. Such conditions would sway policy to redistribute resources and put more emphasis on the need to localise skills, component manufacturing and technology development in the energy sector.

This would allow for both coalitions to consider a consensus-based approach as both the renewable and conventional energy coalitions would be concerned about gaining technological competencies and would subsequently advocate for policy change that would foster it.

5.2 Technological Capability Building in the South African Energy Sector

Learning in the South African Energy Sector

The adopted definition for learning for the purposes of this study is “the process of technical change achieved by diffusion (in the perspective of technology absorption) and incremental innovation” (Viotti, 2001). Learning in this context takes into consideration the adoption of technologies in regions where the technologies did not exist in before and the resulting modification of the technologies in order to suit the new context in which they’re being introduced to. The concept of learning is therefore relevant in South Africa as a catching-up economy with a need to procure renewable and/or energy efficient technology alternatives in order to address the rise in energy demands in a manner that is mindful of the insistent global challenges brought by climate change.

The findings show that participants in the South African renewable energy sector are currently at the stage of focusing on production-oriented activities (rather than manufacturing), which are focused on improving sales and consequently, growing their business. Although these organisations are disadvantaged in terms of resources and capabilities due to their late entrance in the industry, there is still some leverage that they can possess from this from a secondary business-model innovation perspective (Wu, Ma, & Shi, 2010). The latecomer firms can still build modest technological capabilities through information spill-overs while skipping trials and errors (Cho, Kim, and Rhee (1998) and Wu et al. (2010)), until such a time that they are able to upgrade more intentionally within the secondary innovation scheme. There also exists the opportunity for latecomer firms to learn while incrementally improving and tailor-making technologies adopted from industrialised economies to fit the local context of emerging economies, which constitutes business-model innovation (Wu et al., 2010).

In relation to the technology trajectories of secondary innovation discussed in secondary innovation literature (Wu, Ma, & Xu, 2009), the renewable energy sector can be identified as achieving standard secondary innovation which is based on acquisition I, which is the selection of mature technologies from more industrialised economies. The research results also showed that there is more room in the conventional energy sector, particularly in the nuclear energy space, for South Africa to participate in post-secondary innovation where South Africa would have leverage to select emerging technologies from developed economies (acquisition II) given that the country already possesses advanced expertise and regional competitiveness in the field.

When considering the research results and the stage of secondary innovation that South Africa is currently in with regards to the energy sector, the actors fall into the duplicative and creative imitation stages (as illustrated in Figure 5-1 below), whereby the actors are utilising existing knowledge in an imitative manner while also generally applying a level of creativity by making the adopted technologies fit-for-purpose locally. As noted above, South Africa is reported to possess capabilities for gradually moving to exploitative stages of innovation and creating knowledge particularly in the nuclear energy field. The R&D institutions also participate in exploitative innovation within the energy sector but this is reported to be occurring in isolated pockets as and when it is required by stakeholders working in partnership with the research institutes. The research results also showed strong intentions from the established industry players of being fast-followers to the developed economies in their emerging technologies (such aspirations were noted specifically for those industry players who have the resources to do this).

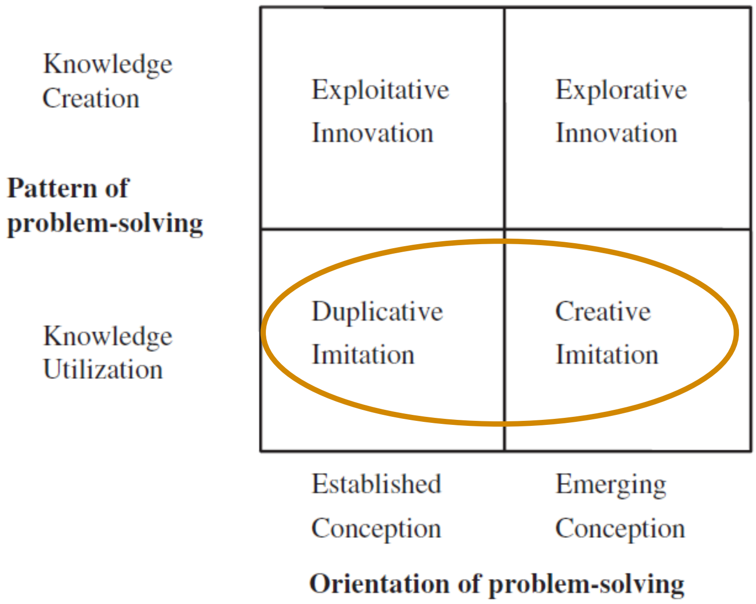


Figure 5-1: Stage of Learning for the South African Energy Sector (adapted from: Wu, Ma, Shi, et al. (2009))

Mechanisms Used for Learning by Actors in the South African Energy Sector

In order to analyse the concept of technological capability building within the South African energy sector, this research sought to identify the kinds and the levels of learning processes that the actors apply for accessing technological knowledge both internally and externally. Marcelle (2004) investigates how firms participate in technological capability building efforts within developing economies and notes that firms improve their effectiveness in learning by deploying a set of five integrated process mechanisms, namely, allocating financial resources to technological capability building efforts; implementing and supporting the technological capability building effort through appropriate management practice systems; enabling an organisational culture in which the technological capability building effort is exercised with committed and skilled leadership; accessing external technological capabilities from suppliers; and finally, through accessing technological capabilities resources from other local and external players (Marcelle, 2004).

The research results show that it is the well-established actors who are mainly involved in conventional energy production that are deploying various mechanisms for gaining new knowledge whether internally through demand-specific R&D efforts (allocating financial resources to technological capability building efforts) or through external avenues. Actors in the renewable energy sector mainly rely on outsourced expertise, while all actors in the energy sector expressed how knowledge spill-overs through partnerships with suppliers and international players (accessing external technological capabilities from suppliers and through accessing technological capabilities resources from other local and external players).

Considering the view of Figueiredo (2002) on the processes of technological capability building consisting of mechanisms for accumulating technological capabilities as well as mechanisms for knowledge accumulation by individuals within the organisation for internal use, fewer actors were identified as having robust programs to facilitate the second process of the knowledge being accumulated internally for internal exploitation when compared to their deliberate actions for gathering the knowledge. This finding alludes to the fact that the actors that do have the means (financially and in terms of human resources/ technical expertise) to access technological knowledge are putting more emphasis on the process of accumulation, and still require more focus towards processes for absorbing the knowledge to a point that they're able to significantly improve their technological competencies.

Factors Inhibiting Learning in the South African Energy Sector

The results indicate that actors in the South African energy sector generally have aspirations towards technological capability building, even if it is from a secondary innovation perspective where they may not necessarily be leaders in the technology front, but are able to position themselves in such a way that capabilities are becoming increasingly localised. Players involved in the renewables are generally intending to contribute to the upgrade of domestic capabilities but are disadvantaged by their latecomer state which is by necessity and not by choice or strategic intent. The lack of financial resources, human resources, along with the current policy environment are not conducive for the purposes of developing technological competencies. Policy's narrowed objective for procurement and achieving energy security in response to current socio-economic pressures is not beneficial in terms of building technological capabilities and improving innovation processes. Lall (1992) makes a warning that, "until host countries achieve fairly high levels of development, transnationals tend to transfer the results of their R&D rather than the innovative process itself".

5.3 Summary of Research Findings

The research identified a bigger coalition group for the renewable energy agenda which also comprises players who are traditionally from the conventional energy side but who have embarked on a transition journey towards incorporating renewable energy alternatives in their business model. The conventional energy cohort consists of a small but powerful number of players based on their historic monopoly of the energy sector, their access to financial and human resources, as well as their political influence given government's intent to continue exploiting the readily available resources for the conventional energy agenda. Both the pro-renewable and pro-conventional coalitions seem to share similar aspirations towards technological capability building although the renewables cohort is disadvantaged given their new entrant status and a current focus to generate revenue with a longer term objective for investing in gaining technological competencies.

With regards to the country's learning as understood in secondary innovation, actors in the energy sector are currently at the stage of making use of pre-existing technologies in an imitative manner and applying a level of improvement to them for the purposes of applying them under local contexts. Latecomer firms in the energy industry are disadvantaged with regards to having resources to develop their own technologies, however, information spill-overs and learning opportunities that arise during incremental improvements of adopted technologies enable a level of technological capability building to take place. Although South Africa is likely to move towards more exploitative levels of innovation, this is particularly anticipated to take place in the conventional energy sector. Government strategies such as the DST's Ten-Year Innovation Plan seem to have a clear road-map on how to improve technologies for conventional sources, whether in clean coal technologies or in the nuclear energy space.

The literature reveals that the process of technological capability building takes both the process of accumulation of technological capabilities as well as the assimilation of those capabilities to individuals within organisations in order to effectively make use of the technological capabilities internally. Although the results showed that actors in the energy sector do apply mechanisms for accessing technological know-how, whether through internal and/or external means, there still remains a gap between knowledge accumulation and the effective integration and utilisation of that knowledge internally. Moreover, the way in which policy is structured tends to prioritise the procurement of energy at low costs, does not provide support for technological capability building and leaves little to no room for creativity in how actors can improve their technological competencies and localise expertise as part of their performance indicators. Government has expressed intentions for making the policy environment more conducive for innovation and localisation, however, successive plans detailing how this will be achieved are yet to be established.

When applying a retrospective view on the policy development for the energy sector in the past two decades, South Africa’s turning point as it relates to the renewable energy agenda can be attributed to the nation’s global commitment to cutting emissions and the expansion of renewables which took place back in 2011 during President Zuma’s administration. This moment served as an external shock which brought about institutional change to the country’s energy policy environment. Although the current energy crisis with ESKOM struggling to ensure adequate electricity supply to the nation poses another potential shock to the policy subsystem, the analysis shows that this external shock might not lead to significant policy change but rather influence minor policy alteration. It is anticipated that other emerging factors in the form of disruptive innovation, which may increase the pressure on the nation to transition even faster from being coal reliant, would result in longer lasting effects on policy for the purposes of technological capability building.

5.4 Conclusion

The chapter presented a discussion of the research results. The aim of the chapter was to relate the research findings to the theoretical frameworks that were applied to this research. The chapter that follows presents the conclusion of the research, recommendations, limitations and areas for potential future research.

6. CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This research seeks to understand technological capability building and major policy change in the South African renewable energy sector. This chapter provides a summary of the research findings and the conclusions that are drawn from the literature and the data collected on the main research themes, identifying the actors within the renewable and conventional energy cohorts; assessing the actors' participation in technological capability building for the sector; as well as discussing the windows of opportunity for the actors to potentially influence policy for the purposes of technological capability building. This chapter also highlights the possible recommendations for addressing the findings with the study as well as suggesting some avenues for future research that are relevant to this study.

6.1.1 Main Research Issue

The research problem for the research as identified in Chapter 1 can be summarised to the following main research issue:

What is the relationship between policy in the South African energy sector and learning as understood in the systems of innovation and how are actors in the sector currently organised with regards to learning for the purposes of influencing policy change?

6.1.2 Research Questions

The research questions and the statement of propositions of the research are as follows:

1. Who are the key actors in the energy sector that are advocating for either the renewable or conventional methods for energy production in South Africa?

   Proposition: The main actors in the energy sector in South Africa are advocating for conventional coal-based fuel production over the renewable option.

2. Which of the actors are advocating for technological upgrade (beyond the renewable/conventional energy debate) and are participating in elevating domestic innovation capabilities?

   Proposition: actors in the renewable energy sector are advocating for technological upgrade and are participating in elevating domestic innovation capabilities more evidently than those in the conventional energy sector.

3. a) In the past two decades, how have external system events influenced policy change towards renewable energy and how much emphasis did policy place on technological learning and innovation that is necessary to support the transition?

   b) In the face of what seems to be an emerging external shock, how are the coalitions (both conventional and renewable energy) organising themselves in order to seize this window of opportunity and take advantage of influencing policy change?

   Proposition: Actors stand a better chance to influence policy change by converging for the purposes of technological capability building (as opposed to solely concentrating on the renewable or conventional energy agenda).

6.2 Research Findings

The research is based on exploring the conditions for major policy change with respect to technological capability building within the South African energy sector. This study performs a comparative case study analysis to examine major policy change, with each case consisting of the identified advocacy coalition for renewable energy and conventional energy respectively. The research then assesses the involvement of the coalitions in the improvement of domestic technological capabilities and their likelihood in influencing policy change.

Moreover, the research looks at major policy change in the energy sector and maps out previous external shock events that have led to the change and discusses emerging events that might potentially influence future policy change. The research makes use of the relevant literature review which informs the theoretical and conceptual framework that is applied for the purposes of the research. Semi-structured interviews were conducted with actors in the South African energy sector in order to gather information required to address the research questions posed in this study. Document analysis of government reports and strategy plans was also undertaken.

The research findings show that the pro-renewable coalition consists of more actors than the pro-conventional resources coalition. This is due to the fact that some of the pro-conventional actors have added renewable capabilities in their businesses and are currently exercising a transition strategy from high carbon emitting and coal-dependent energy sources to cleaner if not renewable energy production alternatives. Another contributing factor to the pro-conventional actors being less in numbers is due to the inherent nature of energy production in South Africa and how the role has been monopolised in the past, with ESKOM being the only strategic state-owned electricity utility in South Africa. It is noted in the research that even though the pro-conventional coalition consists of a limited number of actors, the coalition has a strong influence on the political front. Since South Africa still possesses significant mineral resources (as well as expertise and experience) for running with conventional energy options, it is easier for government to provide support in the tried and trusted, rather than investing in alternatives that bring new challenges that the government might be less prepared to address and that could potentially bring a level of risk in the face of serious energy demands. This is also evident in the government reports and strategic plans which pay significant attention to conventional energy and also consider mainly wind and solar in the renewables portfolio due to their mass-producing capabilities.

Beyond the renewable and conventional debate, the actors in the South African energy sector were assessed in relation to their current activities for achieving technological capability building as well as their overall aspirations for this (whether this is even a significant objective for the actors). Actors from both coalitions generally have aspirations toward improving technological competencies in the energy sector. Those who tend to not aspire towards building any technological capabilities are either not required to given their business operations or they view it as a futile exercise given that there are currently no benefits particularly from government in rewarding organisations that spend more efforts improving their technological capabilities. The high-production and low-cost approach by government invigorates a similar mind-set for those in the bidding process and provides no opportunities for creativity or a desire to achieve more than simply securing a procurement contract. Government recognises this shortfall and is currently faced with the challenge of redesigning procurement regulatory frameworks that will stimulate innovation and localisation.

Actors on both coalitions share similar values for technological capability building, but it is generally the well-established actors whose main business is conventional energy (even though some have capabilities for renewables), who are actively participating currently in processes for building technological capabilities. Although some of the well-established actors in the conventional space are deploying effective mechanisms for gathering technological information which is current and/or outside of their organisations, the actors tend to apply less efforts in ensuring that the information gets effectively disseminated and absorbed within their organisations internally in order to reap benefits and to gain some level of competitive advantage from this. The renewable energy actors are relatively new in the industry and are yet to deploy more effective mechanisms for building their knowledge base. More-over their lack of financial and human resources makes building technological competencies more difficult to achieve in their current state. Some level of technological capability building for the renewables actors, who are latecomers due to late industry entrance, occurs during incremental improvement efforts to adopted technologies which gives rise to learning opportunities and information spill-overs.

The research indicates that major policy change took place around the 2009 – 2011 period, with the government taking firm steps to respond to the issue of climate change and making a global commitment to reducing emissions and expanding cleaner renewable alternatives. This external shock event led to institutional change, with programs being developed to ensure that the nation does actually move towards the proposed and pledged approach. The research also notes that it will take more than ESKOM’s current electricity production constraints to significantly alter policy for the purposes of technological capability building in the energy sector. The increased energy demands have certainly caused a stir on the institutional front, which is evident through the increase in independent power generators in the national grid. However, this modification imposes a sales focus and cannot be considered a window of opportunity for actors advocating for technological capability building to mobilise themselves in a manner that will influence major policy change. It will possibly take a different shock or a combination of shocks which might make it more likely for the technological capability building agenda to be realised, and in the foreseeable future, emerging disruptive innovations could just achieve this.

6.3 Recommendations

The recommendations are focused on improving technological capability building in the South African energy sector and improving influence of technological capability building in the policy making process.

- Government should consider policy interventions that will shield new firms, in the case of this study, in the renewable energy industry that are relatively new in relation to firms in the established conventional energy industry. These interventions can be in a form of subsidies, more readily available access to funding or grants, tax rebates or other mechanisms that would assist fast-track and protect their localisation.
- Policy makers in developing countries who are undergoing learning as understood in innovation systems must consider formulating policies and programmes that are relevant in improving domestic technological capability.
- Drawing from the previous point, government should consider a way to include technological capability building as a prerequisite in the procurement process. The procurement process should not only be focused on securing high energy volumes at the lowest price, but should find a way to score bidders on their level of localisation of core components and an awareness for improving domestic capabilities.
- Private-public partnerships can be further strengthened in order to ensure that actors are learning from each other. This would be beneficial for encouraging knowledge spill-overs within the participating actors in the industry.
- Organisations should consider how knowledge gets disseminated and shared among their professionals who can then gain leverage from exploiting new knowledge internally. Programmes for exploring knowledge more intentionally and for ensuring that the organisation keeps abreast of incoming new knowledge can be considered and put in place by organisations.

6.4 Limitations and Areas for Further Research

6.4.1 Limitations of the Study

Limitations of the study are indicated as follows:

- The study has been limited to the energy sector in South Africa and does not include other countries or other sectors in South Africa.
- The research has been conducted based on the information that was gathered from the participants at a specific point in time, which may vary over an extended period of time.
- The number of participants was limited due to time constraints posed by the nature of the research, and is therefore not representative of the entire South African energy sector.
- The number of participants could not be improved upon, given their unavailability and communication constraints which were exacerbated by the national lockdown restrictions in 2020 and 2021 in response to the Covid-19 pandemic.
- Given that *innovation systems* constitute a complex construct that is not widely understood at this stage, misconstrued views on technological capability building might have been gathered with participants viewing it mainly from a sales / business development perspective.

6.4.2 Suggestions for Further Research

This study sought to address the relationship between policy change and learning as understood in innovation systems, however, the study was limited to the process of learning via technological capability building. Further research can be undertaken to address the topic of learning in the context of organisational and policy learning within the energy industry more intentionally.

Since the study addresses technological capability building in the context of latecomer firms within a developing economy, further research can be conducted to map out technological capability more intensely using the appropriate frameworks, such as the secondary business-model innovation, as a lens.

The study was limited to a single sector within the South African economy. Further research can be conducted on other sectors to assess the country's intentions and performance with regards to technological capability building.

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APPENDIX A – INTERVIEW PROTOCOL

The purpose of the interview is to answer research questions on the topic "Technological capability building and major policy change in the South African renewable energy industry". The special focus is your approach to building innovation capabilities within the energy sector in South Africa.

Technological capability is the ability of an organisation to make effective use of technological knowledge in efforts to assimilate, use, adapt and change existing technologies, or, the ability to create new technologies and develop new products and processes in response to changing economic environment.

Technological capability building is defined as the process of assembling or accumulating technological know-how (capability).

Interview Respondent Profile

Date of interview	
Name	
Organisation	
Position	
No. of years in position	
Nature of work/research	
Funding for work/research	
Other	

Addressing key Research Questions

1. Please indicate your organisation's involvement in the South African energy sector.
2. Can you please provide some insight on the organisation's efforts in developing or significantly improving technologies for the energy sector?
3. What are your organisation's short term and long term aspirations with respect to improving its competitiveness? Are these aspirations aimed at achieving domestic/regional/international competitiveness?

4. What are the kinds of activities that help your organisation achieve its ambition for improved competitiveness? Are these activities focused mainly on improving sales or the diffusion of technologies?
5. Would you describe the activities intended for acquiring technologies as being production-oriented, manufacturing-oriented, or are they research and development oriented?
6. Do you have designated staff who search for new knowledge and with the expertise to understand technologies that can assist the organisation to achieve its objectives? If so, how are they being utilised?
7. What programmes do you have in place for stimulating, attracting, retaining and improving talent within your organisation?
8. With respect to acquiring technological know-how, do you attempt to adopt, imitate, substitute and/or improve upon what was originally developed in more industrialised economies?
9. How do you access new knowledge outside your organisation for increasing your competitiveness (or achieving your stated goals/KPIs if your organisation is a government agency or NGO)? Do you have any platforms that help you gain access to technological know-how?
10. How do you coordinate inputs from different collaborators in order to facilitate knowledge diffusion and exploitation within your organisation?
11. Would you consider the work conducted in your organisation to be in support of developing energy technologies for renewable, conventional or energy-efficient production? Can you identify any other actors that are also involved in the domestic upgrade of either renewable or conventional energy technologies?
12. Do you collaborate with any other stakeholders (locally, regionally, or internationally) who share a similar focus on upgrading domestic technologies? If so, please share the nature of their industry (academic, business, government agencies etc.)
13. What kinds of human resources or funding does your organisation utilise to strengthen its alliances with other stakeholders who share the same goals?
14. Does the recently adopted policy of increasing the participation of independent power generators help facilitate your organisation’s aspirations to improve its technological competences? Kindly explain how in relation to your response.

15. Under what external conditions, whether gradually evolving or unexpected, might your organisation’s ability to acquire significantly improve technological capabilities be more rapidly realised?