

Professionals' perspectives on the future role of coal in South Africa's electricity supply industry

Lionel James Andrews

Student no.: 2293174

Email: 2293174@students.wits.ac.za / Tel: 072 643 8454

Supervisor: Prof Gillian Finchilescu

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ABSTRACT

Over the past few years, the South African electricity supply industry (ESI) has been subjected to intense scrutiny. Two key issues have been (1) the long delay in updating the Integrated Resource Plan (Government's main policy instrument for long-term planning in the ESI) and (2) the dismal state of affairs in which Eskom (the state-owned utility) finds itself. Central to both issues is the future role of coal. Stakeholder perspectives play an influential role in long term planning in the ESI. A systematic study was therefore conducted to explore the perspectives of select individuals from a variety of professional fields within the ESI on the future role of coal as an electricity generation option. The objectives of the research were to identify and collect as many perspectives as possible of the sampled professionals on the future role of coal as a generation option, using a Q-Methodological approach. The use of factor analysis revealed that professionals engaged in the ESI hold several distinct perspectives, though one clear area of consensus and some other distinct areas of contention emerged from the findings.

The results are discussed in the context of the future role of coal in the ESI and its impact on energy policy formation and include the following: The dominant perspective, held by a majority of the respondents sampled (Factor 1), is a strong disapproval of coal and a strong preference for a renewables-dominant supply mix, supported by a high regard to environmental issues. The next prominent perspective (Factor 2) is emphatic in its support for coal power to remain in the ESI, especially 'clean coal' technologies. This factor grouping indicated a strong rejection of the perspectives favoured by the Factor 1 participants. The third and final perspective (Factor 3) doesn't have a particular preference for either coal or renewables and shows the greatest enthusiasm for economic issues and the protection of jobs.

KEY WORDS

Coal, coal-fired power plants, 'clean coal' technologies, renewable energy, South Africa, electricity supply industry, Q-Methodology

DECLARATION

I, **Lionel James Andrews**, 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 Energy Leadership** 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: **Lionel James Andrews**

Signature:

Signed at Johannesburg on the 30th day of April 2021.

DEDICATION

This research is dedicated to my wife, Morgane Andrews, and my two children, Tommy and Elle.

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An immense gratitude goes out to the 33 participants in this study and two experts who, despite significant work pressures of their own, volunteered in providing their much needed opinions. This was especially significant considering the surveys had to be administered Online, due to the ongoing COVID-19 public health crisis. I sincerely appreciate their contributions.

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LIST OF ACRONYMS

CCS – ‘carbon capture and storage’ coal technology

CCU – ‘carbon capture and utilisation’ coal technology

CO₂ – carbon dioxide

ESI – the (South African) electricity supply industry

HELE – ‘high-efficiency, low-emissions’ coal technology

IPP – independent power producer

IRP – Integrated Resource Plan

LCOE – levelised cost of energy

MEC – minerals-energy complex

MW – megawatt

NGO – non-governmental organisation

PV – photovoltaic

CHAPTER 1. INTRODUCTION

1.1 Purpose of the study

Stakeholder perspectives play an influential role in long term planning in the South African electricity supply industry (**ESI**) and energy policy decisions. For example, just under 6 000 submissions were received by Government on the draft 2018 integrated resource plan for electricity (**IRP**) - being the main policy instrument for long-term planning in the ESI (Department of Energy, 2019, pp. 22). A systematic study was therefore conducted to explore the perspectives of a select group of individuals from a variety of professional fields within the ESI on the future role of coal as an electricity generation option. The purpose of the study is to identify the distinct perspectives on the future role of coal held by such professionals, and to endeavour to understand the various areas of consensus and contention among them. It was hoped that areas of latent synergy, as yet undiscovered, would be brought to light.

1.2 Context of the study

Over the past few years, the ESI has been subjected to intense scrutiny, frequently making headlines in the national news. The two main issues have been (i) the failure of Government to update the IRP (Department of Energy, 2011) and (ii) the dire state of affairs in which Eskom (the state-owned utility) finds itself. Central to both issues is the future role of coal in the ESI.

South Africa's economy is heavily reliant on domestic coal as a primary source of energy. Around 240 million tonnes of coal is mined annually (Bischof-Niemz & Creamer, 2018), a large portion of which is used as fuel in the country's fifteen coal-fired power plants. Thirteen of such plants are owned and operated by Eskom. Coal is responsible for roughly 70% of the total national primary energy supply (Department of Energy, 2016): over 90% of total electricity production is from coal and over 30% of total liquid fuels production is from coal (IEA, 2018). Almost half of the domestic coal mined is exported, making it the largest exported

commodity in the mining sector by value, amounting to R61 billion in 2017 (MCSA, 2018). The coal power industry employs around 130 000 people across coal mining and electricity production activities (Kings, 2019). It is evident that energy security in South Africa is inextricably linked to coal.

From an emissions perspective, electricity generated from coal is the most carbon intensive of the main fossil fuels, accounting for 30% of global energy-related carbon dioxide (CO₂) emissions (IEA, 2018). Over 80% of South Africa's carbon dioxide emissions is produced from coal-fired power plants (Yoro & Sekoai, 2016). South Africa is under significant pressure to meet its own climate change targets (Simpson *et al.*, 2019).

At the same time, the World Bank rates South Africa the most unequal society in the world (Sulla & Zikhali, 2018). A significant percentage of the population lives in abject poverty, including in and around coal mining communities.

Notwithstanding the environmental and social challenges, South Africa is a developing economy and electricity is a commodity in strong demand, yet short supply. It is assumed that any reduction in dependence on coal would negatively impact the economy in terms of jobs, energy security and export revenue (Simpson, Badenhorst, Jewitt, Berchner, & Davies, 2019). However, in the long run, sustainable growth and development will crucially depend on a shift away from a coal-intensive energy system and economy (Burton, Caetano, & McCall, 2018).

Given the aforementioned state of affairs, there are numerous divergent stakeholder groups all campaigning for their interests to be protected. It is therefore unsurprising (and perhaps understandable) that Government's attempts at implementing clear national energy policies and regulations have been protracted. The latest update to the IRP, which was Gazetted on 18 October 2019 (Department of Energy, 2019) (**IRP 2019**), took a full seven years longer to be published than required. The previous version stipulated that "*The [IRP] is a living plan that is expected to be continuously revised and updated as necessitated by changing circumstances. At the very least, it is expected that the IRP should be revised by the Department of Energy (DoE) every two years,*

resulting in a revision in 2012” (Department of Energy, 2011. pp. 7). Furthermore, Eskom continues to find itself in a downward financial freefall with no clear sign of escaping its loss-making troubles (Reuters, 2019).

The dismal state of affairs has attracted much public debate. The future role of coal in the ESI is a hotly contested subject. The IRP 2019 update was received with mixed reaction from the South African public: the renewable energy sector welcomed the plan’s inclusion of substantial solar photovoltaic (PV) and wind energy capacity allocations, while several environmental organisations have expressed sharp criticism regarding the inclusion of new coal power projects (Mabena, 2019). Greenpeace has complained that there is no reasonable basis for 1 500 MW of new coal power to have been included, considering that *“technology and costs are clearly in favour of renewables”* (Greenpeace Africa, 2019).

Prior to the release of the IRP 2019 update, the Minerals Council South Africa produced a report (Chamber of Mines of South Africa, 2018) which proudly announced that coal is the cheapest source of base-load power and that renewable energy is more expensive on a levelised cost of energy (**LCOE**) basis. The inclusion of new coal power allocations in the IRP 2019 is therefore justified, they campaigned.

The ‘coal versus renewables’ debate is also characterised by robust lobbying from Eskom and other powerful political and economic actors, who favour a future energy system dominated by coal. These stakeholders were happy with the IRP 2019’s inclusion of coal power and wish for coal to remain as an energy source in future IRP updates, for as long as possible (Burton, Caetano, & McCall, 2018).

Simpson *et al.* (2019) argue that Eskom should rather retrofit its existing coal-fired power plants to make them more efficient and flexible, allowing for the introduction of flexible renewable energy technologies into the system more easily. Their research cites similar trends in Germany and Denmark (Agora Energiewende, 2017). In addition, they argue, Government should consider lifting the restriction on the importation of hydroelectric power in order to decrease the country’s dependence on coal power.

Ultimately, coal power has been included in the IRP 2019 and therefore remains a part of the future electricity generation mix. In this regard, Government has outlined several “policy positions” relating to coal power, including:

“Policy Position 5: Retain the current annual build limits on renewables (wind and PV) pending the report on a just transition.” (pg. 41)

“Policy Position 6: South Africa should not sterilise the development of its coal resources for purposes of power generation, instead the planning framework for energy and environment must support a just transition”. (pg. 42)

Policy Position 5 (Department of Energy, 2019, pp. 41) highlights that Government has imposed annual build limits on wind and solar PV in their modelling, in order to make way for other technologies such as coal power. This appears contradictory to the findings of certain scientific research, which indicates that renewable energy provides the least-cost scenario pathway and has better environmental attributes than coal power (Bischof-Niemz & Creamer, 2018; Ireland & Burton, 2018; Oyewo, Aghahosseini, Ram, Lohrmann, & Breyer, 2019; Vivid Economics, 2016).

As a result, the coal debate continues. The challenges for those in Government who set the policies related to the ESI are undoubtedly immense. This has motivated this study.

1.3 Research problem

New coal power capacity is included in the IRP and public debate around its inclusion surges on. The plan will need to be updated again soon and, before it is, stakeholder engagements will need to be held. As highlighted above, long term planning in the ESI is a complex problem for policy makers. The policy problem is especially compounded when the voices within the discourse have conflicting knowledge claims.

It is assumed that professionals engaged in the ESI have deep knowledge of the main issues surrounding coal power. They have a subtler understanding of the

nuances than most other stakeholders, who are often motivated (and therefore campaign) by desperation to protect their interests. They also have a better sense of the political economy influencing policymakers. However, it would be naive to assume all professionals have the same level of understanding or that their perspectives on coal are aligned. There is need to understand the perspectives of these professionals in order to set the stage for better policymaking.

1.4 Research objectives

The objectives of the research were to:

- (1) identify and collect as many perspectives as possible of a sample group of professionals engaged in the ESI on the future role of coal as a generation option; and
- (2) using a Q-Methodological approach, identify clusters of opinions amongst the sample professionals,

with the hope that the results reveal alternative perspectives to the stark “coal” versus “renewables” narrative portrayed in the media.

The overall objective of this study was to better understand how professionals perceive the future role of coal in the ESI, and through analysis and interpretation, reveal their logic and put the most important issues into context.

1.5 Significance of the study

A study of this nature, which seeks to explore the perspectives of professionals engaged in the ESI using Q-Methodology, is novel. In-depth, quantitative method research has been widely conducted on the coal transitions (Burton, Caetano, & McCall, 2018), new coal plants in South Africa’s electricity future (Ireland & Burton, 2018) and on positioning South Africa’s energy supply mix internationally (by comparing, and comparative and analysing policies) (Ndlovu & Inglesi-Lotz, 2019), to name a few. Very few Q-Methodology studies at all have been completed in South Africa (Finchilescu & Muthal, 2019). Ones that have were in

the field of medicine, market research and educational psychology (Finchilescu & Cooper, 2018).

Q-Methodology has been used to good effect in other parts of the world in the field of energy and environmental policy, especially in interrogating conflicting knowledge claims with the hope that this will contribute to effective policy outcomes (Clarke, 2002; Cotton, 2015; Cuppen, Bosch-Rekvelde, Pikaar, & Mehos, 2016; Cuppen, Breukers, Hisschemoller, & Bergsma, 2010; Ellis, Barry, & Robinson, 2007; Fisher & Brown, 2009; Lombard & Ferreira, 2013, Setiawan & Cuppen, 2013).

It is well known that long-term planning policies in a societal context are inherently complex and difficult to solve (Rittel & Webber, 1973). Amongst such planning problems is undoubtedly the development and updating of the IRP. This study was chosen to investigate professionals' perspectives on the future role of coal in the ESI, using a Q-Methodological approach, with the aim of contributing to better policy making, particularly the preparation of the next update to the IRP 2019. The research approach will be explained in more detail in Chapter 3.

1.6 Delimitations of the study

The research used a Q-Methodological approach focusing on the perspectives of a select group of professionals engaged in the ESI on the future role of coal. Such perspectives were analysed and interpreted using techniques unique to Q-studies.

The focus of the study was not, nor was it intended to be, a substantive analysis on:

- (1) the benefits of any single energy source or technology option;
- (2) whether or not coal (or any other technology option) should feature in the ESI in future; or
- (3) what options are available to policymakers, or how to improve policymaking.

1.7 Definition of terms

In this report, unless the context indicates a contrary intention, the following terms have the following meanings:

“**clean coal technologies**” - means the proposed new generation of advanced coal utilisation processes designed to enhance both the efficiency and the environmental acceptability of coal extraction, preparation and use;

“**concourse**” - means the range of views that currently exist on the future role of coal in the ESI as a generation option;

“**ESI**” - means the electricity supply industry in South Africa;

“**P-set**” - means the sample of participants selected for the Q-study;

“**Q-set**” - means the list of statements reflecting the key issues of the concourse, which represent a wide range of perspectives;

“**Q-sort**” - means the completed grid once the participant has ranked all the Q-statements according to their personal opinions of the issues;

“**Q-statement**” - means a statement in the Q-set; and

“**Q-study**” – means research conducted in accordance with the established techniques unique to Q-Methodology.

1.8 Assumptions

In conducting this study, the following assumptions were made at the outset:

- (1) professionals engaged in the ESI have deep knowledge of the main issues surrounding coal power;
- (2) the P-set would apply their minds to the Q-sorting exercise diligently, thereby reflecting their true opinions on the Q-statements and therefore the concourse; and

- (3) the results of the Q-sorting exercise will reflect perspectives of professionals engaged in the ESI on the future role of coal.

In order to ensure a robust study, all reasonable care was taken in identifying appropriate participants. The Q-study was conducted completely, accurately and in accordance with Q-Methodology established techniques (as explained in Chapter 3 and 4).

The assumptions listed above are reasonable and the sensitivity of the research outcome to each assumption is considered low.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

To better appreciate the potential range of perspectives on the future role of the coal in the ESI, a literature review was conducted. In a study like this where perceptions on a topic are investigated, it is instructive to undertake a review of past and current industry expert and academic views. The literature review sought to cover a broad overview of coal as an energy source, current worldwide and local trends relating to coal, clean coal technologies, the just transition, and the main arguments put forward by industry experts and academics relating to coal power. It also canvassed similar Q-Methodology papers, which involved research into stakeholder perspectives on energy policy related topics, as well as delved into possible lines of coalitions on which various actors in the ESI might sit, as regards the clean energy transition debate.

2.2 A brief overview of coal as an energy source

Coal has been mined around the world for thousands of years (Dodson *et al*, 2014). In the early years, rudimentary extraction methods of surface (or near to the surface) coal meant that production was small scale and inefficient. Large scale coal mining using more advanced extractive methods, such as test boring and chain pumps, began to develop around the 17th century. During the Industrial Revolution of the 18th and 19th centuries, access to coal was positively correlated with economic development (Fernihou & O'Rourke, 2014). Coal production ramped up significantly between the 19th and 20th centuries due to increasing demand, as it became the new primary energy source to power steam engines, heat buildings and produce electricity. As a result of coal having a much higher energy content per mass than wood fuels, it became the favourite energy source during the Industrial Revolution. Coal extraction and production continues in current times, although its popularity is on the decline mainly due to competing new energy sources and environmental concerns, as will be discussed further below.

In South Africa, coal has traditionally been the most abundant and cheapest fuel source available. The first commercial coal mine was established near Molteno, Eastern Cape in 1870 and not long thereafter, new coal mines opened up in the Vereeniging and Witbank areas of the Highveld (Jeffrey, Henry, & McGill, 2015). Towards the end of the 19th century, when gold and diamond mines began to proliferate, coal mining became more prevalent as well, though mainly as a means of providing cheap electricity. As such, many of the earlier collieries were owned by large gold or diamond mining companies themselves, who sought to keep the costs of their operations as low as possible. (Munnik, 2010).

Since then, the coal mining sector has played a pivotal role in structuring South Africa's economy, and consequently also the country's prolific carbon emissions record (Burton, 2011). This is largely due to the development path that the economy has followed, forged by what is now known as the "minerals-energy complex" (MEC). This notion was illuminated in the seminal work of Fine and Rustomjee (1996). The MEC explains the process by which capital accumulation in South Africa was built, and was designed to be driven, by particular linkages in the economy.

The economic sectors which are predominantly responsible for the structure of the economy as we find it, and which make up the MEC, are mining, energy and several associated sub-sectors of manufacturing. To describe the 'linkages' briefly, Fine and Rustomjee (1996, pp. 79) explain how electricity generation is derived mainly from coal (being a mining activity) or nuclear energy (which uses mined uranium) and, in turn, how coal, gold and other mining and associated minerals beneficiation activities consume the bulk of electricity in the economy. Likewise, a significant amount of electricity is needed in iron and steel alloys smelters. A web of interconnections links these economic sectors, all of which are to a greater or lesser extent reliant on coal power (Burton, 2011).

The second feature of the MEC, according to Fine and Rustomjee (1996), is that it is a system of accumulation in the country, owing to many of the mining companies' significant concentration in the Johannesburg Stock Exchange and dominance in the financial and the industrial economy. They theorise that the

MEC was the “*form taken by capitalism in determining economic and social outcomes*” (Fine, 2008, pp. 3).

The importance of coal to the MEC, and *vice versa*, cannot be understated. Coal is the primary fuel source for electricity generation and industrial processes, as well as the majority of liquid fuels production in the country. This enables the mining and associated manufacturing sectors to be competitive in the export markets upon which the economy depends. Another part to the MEC that was prevalent in the past, was the exploitation by these economic sectors of ‘cheap labour’. Such exploitation provided the engine room for the MEC’s prosperity, as Eskom was able to offer some of the cheapest power in the world to these highly energy intensive mining and industrial sectors. As such, these sectors had a disproportionate influence on energy policy planning, which was repeatedly adjusted to the demands of the dominant mining companies, thereby ensuring coal’s dominance and the self-reinforcing cycle of the MEC. The cycle perpetuated as cheaper electricity created the impetus for even more energy intensive industries to sprout up.

The structure of the coal mining sector in South Africa was traditionally concentrated in a few major players operating a small number of mega mines. The major producers, accounting for 85% of the total production, included South32 (previously, BHP-Billiton), Anglo American, Glencore, Exxaro and Sasol (Burton & Winkler, 2014). Besides Sasol, which mines for its own use, the coal majors supplied approximately 90% of total feedstock to Eskom and 75% of total exports (Burton & Winkler, 2014). In line with world trends, these major mining companies are facing increasing pressure from their shareholders to take stronger action on climate change issues, including getting rid of their thermal coal assets (Dempsey & Hume, 2019).

2.3 Current worldwide and local trends relating to coal power

Internationally, coal’s dominance during the Industrial Revolution gradually gave way to crude oil as the primary source of energy, particularly in industrial and ground transportation applications (Zou, Zhao, Zhang, & Xiong, 2016). However,

in South Africa, where there remained an abundance of cheap coal and a negligible quantity of proven crude oil or natural gas, coal has not declined as much as in other parts of the world. Thanks mainly to the MEC, coal has remained the primary energy source for the economy.

Strambo, Burton, and Atteridge (2019) assert that there are a series of steady changes in the local and worldwide energy production system, which impact the role of coal in South Africa. Their research found that the ESI is embarking on structural changes due to coal-fired power plants approaching the end of their useful lives and becoming too expensive to operate. The wider trend indicates that the coal plants are and will continue to be supplemented and/or wholly replaced by renewable energy technologies, which are proving to be cost-competitive (Wright, Calitz, Bischof-Niemz, & Mushwana, 2017).

Domestic coal resources are close to being depleted in many existing mines (notably in the Central Basin reserves where most mining takes place), while new coal basins face commercial and infrastructural challenges, due mainly to limited rail connections and water supply (SACR, 2013).

In addition, new coal plants are becoming increasingly more difficult to finance. Many of the major global funds and investors (including BlackRock, JP Morgan Chase, Bank of America and CitiGroup) are beginning to shift their capital away from traditional fossil fuel investments towards investments aligned to the emerging climate change policies (Corkery, 2016; McKibben, 2020). By the end of 2020, South32 and Anglo American (two of the 'majors') had concluded deals to sell off the last of their remaining South African thermal coal assets to Seriti Coal, a large local resources group (Dempsey & Hume, 2019). Moreover, several South African banks have recently confirmed their commitment to financing 'greener' energy sources in line with the latest protocols of the Organisation for Economic Cooperation and Development. Significantly, most of the largest local commercial banks have withdrawn their commitment to financing the two proposed coal IPP projects, which feature in the IRP 2019, namely the Thabametsi and Khanyisa projects (BusinessTech, 2019).

Strambo *et al.* (2019) also found that if global coal demand declines as anticipated, South Africa's export markets would be at unprecedented risk of collapse. Exports into Europe have already tapered off dramatically due to the trend in most European countries towards decarbonising their energy systems. Most coal exports today go to the Pacific market, predominately India. Although India seems to have an insatiable demand for South African coal at present, it is deeply investing in its own domestic coal production capacity. Strambo *et al.* (2019) warn that even if only a small part of India's production expansion is achieved, this could easily displace a significant percentage of South Africa's coal exports, if not all of it. Should such a scenario materialise in the near term, it would have dire consequences for the South African coal industry. This is mainly because most South African coal mines are largely reliant on higher priced exports, which they require to supplement their comparatively lower priced domestic sales, in order to remain commercially viable. Consequently, many mines would become commercially unviable should their export sales dampen - placing them at risk of being "stranded assets".

2.4 'Clean coal' technologies

From a technological point of view, there are currently a range of 'clean coal' technology options being explored to help decarbonise thermal coal plants, including 'carbon capture and storage' technologies (commonly abbreviated to "**CCS**"), 'carbon capture and utilisation' technologies (commonly abbreviated to "**CCU**") and other so called 'high-efficiency, low-emissions' technologies (commonly abbreviated to "**HELE**"). Such 'clean coal' technologies are under special focus in many parts of the world – especially in the Americas, Asia Pacific, Europe and the Middle East and parts of Asia (Global CCS Institute, 2017; IOGP, 2019). CCS seeks to capture carbon emissions from point sources, such as coal-fired power plants and industrial processes, in order to prevent it from being released into the atmosphere (Yoro & Sekoai, 2016). Whereas CCU seeks to capture carbon emissions from point sources for feedstock in the production of chemical building blocks, synthetic fuels and building materials (IOGP, 2019).

According to the research conducted by Yoro and Sekoai (2016, pp. 11), there is a “huge potential” for the implementation of CCS technologies in South Africa, specifically in regard to capturing post-combustion CO₂ through retrofitting capture devices at coal-fired power plants using solid polymer-based adsorbents. The research unfortunately concluded that despite the efforts of the Government-mandated body, South African Centre for Carbon Capture and Storage, CCS is currently facing implementation challenges arising (*inter alia*) from financial barriers and lack of clear policy frameworks.

Quite recently, a study of ‘clean coal’ technologies for the recovery of energy from Nigerian coals was carried out by a team of researchers from South Africa and Nigeria (Oboirien, North, Obayopo, Odusote, & Sadiku, 2018). Coals from Nigeria are comparative to coals found in South Africa. The research aimed to evaluate the coal consumption rate, emission factor and total energy recovery for Supercritical-Fluidised Bed Combustion Technology (**FBC**), Ultra-Supercritical Combustion Technology (**USC**), Integrated Gasification Combined Cycle Technology (**IGCC**) and Coal bed Methane Technology (**CBM**) as compared with conventional Sub-critical Pulverised Fuel Technology (**PF**), for different Nigerian coals in ten different mines. The results established that depending on the quality of the coals, either USC or CBM was the best performing technology and in varying degrees of consumption rates, emission factor reduction and total energy recovery. It was an interesting result that with certain quality coals, conventional PF was still optimal in regard to total energy recovery, and therefore upgrading/beneficiation would be needed before the benefits of ‘clean coal’ technologies could be unlocked. The study did not go into detail on the added capital expenditure impacts of ‘clean coal’ technologies, nor their impact on the LCOE before and after the intervention of such new technologies.

Further afield, ‘clean coal’ technologies and engineering practices have been found to enable coal-fired power plants in China to achieve near-zero emissions, bringing the units below the emission limits of gas-fired power plants – and such interventions only increase the generating costs by roughly 0.01 CNY (Chinese Yuan) per kilowatt-hour (Wang, 2020).

2.5 Just transition

On the labour front, over the last 50 years over four million coal jobs have been lost around the world, due mainly to mine mechanisation, declining profitability, competing alternative fuels and technologies and the anti-climate change agenda (Halsey, Overy, Schubert, Appies, McDaid, & Kruyshaar, 2019). Coal, in the end, is a fossil fuel and as new laws are gradually being implemented to curb air pollution and environmental degradation, so jobs are being shed as a consequence of declining profitability. South African coal mine job numbers have declined by 60% since a peak of 135 000 in the 1980's (Halsey *et al.*, 2019).

Despite a few breakthroughs in 'clean coal' technologies, around the world there is still a clear trend of pulling back from coal power and new coal projects. Sartor (2018) conducted an international study on the major coal-consuming economies, focusing on pathways to implement a transition away from coal. The key findings were:

- (1) ***The transitions are already in motion.*** Thirty six nations and twenty eight corporations around the world have committed to phasing out coal from their energy systems by 2030. Even countries like China, India and South Africa are introducing policies or at least serious national dialog on the need to curtail coal usage. There seems to be a realisation that demand for coal is either peaking (as is the case in India) or in decline (China and South Africa are examples). The discussions mainly centre around when and how to manage the transition. Governments around the world appear to be implementing new initiatives, just transition programmes, coal transition commissions and public-private stakeholder consultation platforms with the aim of exploring the possibility of ending coal.
- (2) ***The transition is technically and financially viable.*** Techno-economic studies are beginning to show that there is a strong push to achieving the Paris Agreement targets (especially the sub-2 degree by 2040 to 2050 target) in at least six of the major coal reliant countries (namely, India, China, Germany, Poland, South Africa and Australia) – by aiming to

transition coal power towards new cleaner energy options such renewables and natural gas. This is because of the precipitous drop in costs and technology advancements of renewables. Sartor (2018) argues that governments can avoid stranded coal assets by preventing over-capitalisation, removing plants which have been fully amortised from service and committing to a maximum number of remaining operating years for current plants in operation.

- (3) ***It is possible to have a “just transition” for coal workers and affected communities.*** While admitting that there is no standard model or “universal blueprint”, Sartor (2018) found that there are a large number of viable policy solutions, so long as they are properly designed and involve a great deal of stakeholder participation early on. The earlier the anticipation and preparation for a transition, the better. (On this front, Strambo *et al.* (2019) point out that in Spain, coal mine closures have been accompanied by state funded transition programmes for coal mine workers of varying ages, together with environmental rehabilitation projects which prioritise jobs for former workers.)
- (4) ***Transitions away from coal support and enhance climate action together with delivering other socio-economic objectives.*** As an example, the research found that in India, by avoiding coal-fired power plants in certain water-stressed regions, this would alleviate conflicts between water and electricity access.

The last key finding is highly relevant to South Africa. Simpson *et al.* (2019) critically researched South Africa's main coal region, Mpumalanga Province, from the perspective of the water-energy-food nexus. Their research found that the strong dependence of the South African energy system on the coal-fired power plants in the province “severely impacted” the agricultural potential of the region and the quality of the water within the province's rivers. Yet, such is the dependence of the economy on coal, reducing coal production in the region would negatively impact employment, energy security, export revenues and the economy as a whole. These considerations need to be delicately balanced if the country is to follow a sustainable development path. Sartor (2018) argues that in

Africa and India, access to energy could be more affordable and effective by choosing to focus on micro-grids than new coal power stations. This would provide relief to a water stressed country such as South Africa.

Unfortunately, it appears that South Africa is not as well positioned compared to its global peers when it comes to its ability to transition to a just energy system. South Africa is currently ranking 114 out of 115 countries in the World Economic Forum's Energy 2019 Transition Index Report, which ranks countries' relevant positions in regard to their overall preparedness to transition to a secure, sustainable, affordable, and reliable energy future (World Economic Forum, 2019). This may however improve if South Africa is able to receive part of the over US\$ 100 billion per year in climate financing, as targeted by the participants of the recent COP26 UN Climate Conference (European Commission, 2021).

2.6 Viewpoints of academic and industry experts

Bischof-Niemz and Creamer (2018) advocate for a renewables-based power system where wind and solar PV energy technologies represent the bulk of the power generation options in the system, replacing coal-fired power plants as the main workhorses. In such a scenario, the peak-load capacity (being the flexible, yet more expensive power) could be delivered by gas and battery energy storage technologies – which are highly complementary to renewable energy technologies. A move away from coal, according to Bischof-Niemz and Creamer, does not involve an abandonment of the existing coal expertise or infrastructure either, much of which could be repurposed to produce liquid fuels from renewable electricity (rather than coal) - thereby positioning South Africa as a leading producer and exporter of 'power fuels'. In that regard, their research strongly indicated that South Africa has a global competitive advantage arising from its world-class solar and wind resources when it also couples such low-cost energy with its Fischer-Tropsch technology to produce low-cost, decarbonised fuel products for export.

This viewpoint is shared by Oyewo *et al.* (2019). Their research into optimal pathways towards a decarbonised and least-cost electricity system in South

Africa found that a renewables-based system, where solar PV and wind technologies are placed at the core of the system, would provide both an achievable and realistic policy option for South Africa. In their least-cost scenario pathway, their findings showed that no new coal power is required, and all current fossil fuel installations are to be removed from the system in line with the technical end of their useful lives.

Ireland and Burton (2018) conducted a study on new coal plants in South Africa's electricity future. A key finding was that in all scenarios modelled, neither coal nor new nuclear power plants are required to meet the energy demand at the lowest cost. Therefore, the assessment concluded, the two proposed coal IPP projects (Thabametsi and Khanyisa) were found to be unnecessary to meet demand and their inclusion in the long-term plan for the ESI would actually significantly increase energy costs and substantially increase greenhouse gas emissions over their lifetimes.

In contrast, opponents of renewable energy, such as Eskom, the Department of Public Enterprises and Minerals Council South Africa, support a coal dominated energy system (Morris & Martin, 2015). Their arguments include that coal is good for grid stability, it is an abundant resource forming the backbone of the mining industry and is cheaper on a LCOE basis. The Minerals Council South Africa, in particular, has argued that because renewable energy technologies deliver either a constant oversupply or constant undersupply into the grid, they need to be supplemented with 100% back-up power, which raises the LCOE above coal power (Chamber of Mines of South Africa, 2018).

These pro-coal arguments are strongly refuted by many industry experts (Bischof-Niemz & Creamer, 2018; Vivid Economics, 2016, to name a few), who contend that when comparing costs, one has to account for the 'externality costs' of electricity produced from coal as well. 'Externality costs' are the total costs and benefits which are not factored into the decision and are borne by other parties or society as a whole.

In closing for this section, it is also noted that there is surge in research and development into 'clean coal' technologies around the world, particularly coming

out of China – the world leaders in thermal coal mining. Journal articles such as Sun, Zhang & Peng (2020)'s "Development Trend and Strategic Countermeasures of Clean Coal Technology in China Toward 2035" in *Strategic Study of Chinese Academy of Engineering* is but one amongst dozens which appeared on Google Scholar after a simple search by the researcher of "clean coal research" (after setting the date range filter to '2020 onwards').

2.7 Q-Methodology papers

On the question of whether Q-Methodology is an appropriate research technique for investigating stakeholder perspectives on a given topic, the literature is clear. A plethora of studies has been conducted, focusing on several categories or sub-categories of stakeholders on a range of topics.

An empirical study conducted by Cotton (2015) based in the United Kingdom examined emergent perspectives on a range of environmental, health and socio-economic impacts associated with shale gas fracking. A study was conducted by Setiawan and Cuppen (2013) into stakeholder perspectives on CCS in Indonesia. Moreover, Cuppen *et al.* (2016) used Q-Methodology as a congruent method to anticipate unforeseen stakeholder issues and as a precursor to a participatory procedure with external stakeholders, in the context of a Dutch shale gas exploration project. Lombard and Ferreira (2013) used it to better understand certain communities' reactions to proposed wind farm projects in the West Coast Region of the Western Cape Province, South Africa. They investigated whether the reasons for their opposition or acceptance of the proposed projects were similar to those in the developed world. Similarly, the study conducted by Ellis *et al.* (2007) explored the nature of public acceptance of wind farms in Northern Ireland, by investigating the discourse of support and objection to a proposed offshore project, applying Q-Methodology.

The literature review referred to in this Chapter 2 sought to enquire whether a better understanding of stakeholder perspectives would benefit policymaking processes. Cotton (2015), Ellis *et al.* (2007), Lombard and Ferreira (2013), and Setiawan and Cuppen (2013) were all interested in analysing stakeholder

perspectives for the benefit such a review would derive for policymaking. The conclusion in each of these studies was that a better understanding of the nuanced perspectives of stakeholders helps to identify gaps in policy and helps save time, costs and effort in the stakeholder engagement part of policy formulation and adjustment. Ellis *et al.* (2007) found especially that their research helped identify a number of recommendations for policy functions, demonstrating, for example, how Q-Methodology can act as a potential bridge between positivist and post-positivist approaches to policy analysis.

Aruja (2014) conducted a Q-Methodology study on the perspectives of various professionals involved in the Canada oil sands on issues that are central to the oil conversation in that country. An important and relevant takeaway in the context of the present study was that Aruja's research focused on only one sub-set of stakeholders of the wider stakeholders affected by the Canada oil sands. The author's justification of this approach was the following: *"stakeholders of Canada's oil sands could encompass almost anyone in Canada given the scope of the industry's impacts. However, people professionally engaged in the oil sands were targeted, with depth of knowledge specified as a requirement for participants. Breadth of perspective was achieved by including a range of professions from a variety of industries in the study."* (Aruja, 2014, pp. 10-11). Accordingly, focusing on one stakeholder group (in the present case, professionals) should not be a materially limiting factor for the study.

In closing for this section, all the Q-Methodology studies reviewed validate the present research objective of seeking to understand stakeholders' perspectives through Q-Methodological technique. Furthermore, choosing only one stakeholder group amongst a range of relevant stakeholders does not necessarily limit to the study.

2.8 Coalitions within the ESI

Rennkamp, Haunss, Wongsu and Ortega (2017) investigated the political coalitions for and against policies promoting renewable energy in three middle-income countries: Mexico, Thailand and South Africa. These countries are

characterised as being semi-industrialised developing countries which have traditionally (and continue to have) a high dependence on fossil fuels. In each of these countries, the governments seem to promote renewable energy despite having access to cheaper fossil fuels and there being a relative lack of financial support from industrialised countries or international organisations.

The main findings were that they do so when coalitions of powerful political actors support the clean transition. Using network analysis techniques (specifically, hub centrality), the paper presented an analysis of the coalitions of supporters and opponents of the renewable energy transition. The research findings in respect of South Africa were that the coalition of those in support of South Africa's renewable energy policy consist largely of certain trade unions, certain government departments, international investors, renewable energy industries, certain sections of civil society and academic organisations. The coalition of opponents unites Eskom, large business associations and national and international fossil fuel industries. A further noteworthy finding of the paper was that it supported the general argument in the international climate change debates, that transitioning economic systems towards clean energy can achieve both emissions reductions and advance socio-economic development. This challenges the assumption that meeting these two objectives requires substantial trade-offs.

Morris and Martin (2015) investigated the power dimensions and struggles between various interest groups that are influencing the unfolding of South Africa's climate change policy. Their report identified the complex array of public and private sector actors and institutions, which are determining the advancement of renewable energy technologies in South Africa, including their aims, priorities and objectives. As of 2015, the coalition of actors supporting change towards renewables is comprised of various departments in the public sector including the Treasury Department; the Department of Energy; the Department of Environmental Affairs; the National Energy Regulator of South Africa; and the Department of Trade and Industry. In addition, some private sector groups, particularly larger IPPs and ancillary business professionals and owners linked to such companies, and pro-climate change NGOs support this change.

Actors such as the Energy Intensive User Group and other large industrial corporations, who are primarily interested in energy security and low prices, were found to be fairly neutral, but would likely abandon their alliance with Eskom if they had the opportunity. Other actors such as municipalities and household consumers are also fairly neutral. The core opposition to the change comprises Eskom and the Department of Public Enterprises. Eskom, because the largest share of its revenue comes from its coal-fired power plants, and the Department of Public Enterprises, because it is the shareholder representative of Eskom, appear to be opposed to the renewable energy transition. The report concludes that the coalition in favour of change is in a relatively powerful position.

2.9 Conclusion

As mentioned in Chapter 1, the premise of the research is to investigate and analyse perspectives of professionals engaged in the ESI on the future role of coal. By identifying nuanced perceptions, the expectation is that new interpretations of stakeholder viewpoints may be uncovered. However, as this research takes a Q-Methodological approach, it is exploratory in nature as it aims primarily to contribute to the understandings of stakeholder viewpoints.

To that end, its intention is not to prove or disprove any particular hypotheses or propositions – as clearly pointed out by Watts and Stenner (2005). It was noted in the beginning of this Chapter 2 that the objective of the literature review was to cover a broad overview of coal as an energy source, current worldwide and local trends relating to coal and the main arguments put forward by industry experts and academics relating to coal power. It also canvassed similar Q-Methodology papers, which involved research into stakeholder perspectives on energy policy related topics, as well as delved into possible lines of coalitions on which various stakeholders in the ESI might sit, as regards the clean energy transition debate.

While some of the discourse on the role of coal in the ESI have been canvassed by the literature review, the main objective was less concerned to confirm or to reject specific theories than to discover new interpretations of a certain

stakeholder group (in this case, professionals in the ESI). Accordingly, no basis of a theory is proffered or discussed, nor was it required.

Finally, Aruja (2014) found that seeking to investigate professionals' opinions in the oil sands industry in Canada (using Q-Methodology) was a sound exercise, which likely contributed to better policy making in that country. The focus on professionals' perspectives by Aruja, therefore somewhat justifies the approach taken in this study.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Research approach

As highlighted above, planning in the ESI is a complex policy issue. Problems of this nature have no clear boundaries, or simple solution, and need to be investigated. This was considered when selecting a particular research approach, and Q-Methodology was found to be especially fitting owing to its congruency with unstructured and complex problems (Mertens, 2015).

Q-Methodology is a ‘quali-quantological’ research procedure comprising a hybrid of qualitative and quantitative techniques (Stenner & Stainton Rogers, 2004). It enables the investigation of perspectives in an open, yet structured way (Setiawan & Cuppen, 2013). It involves the study of the viewpoints held by a sample of participants knowledgeable on the issue; in other words, it involves a “*systematic study of subjectivity*” (Brown, 1993, pp. 93). The researcher is required to apply qualitative judgement in formulating the research problem, searching for and generating the statements that are used to investigate the perspectives of the participants, and selecting the participants. It then uses inverted factor analysis to correlate the participants, which are the variables (as opposed to the traits of the participants as is usually the case in other methodologies), into groupings (‘factors’), based on shared perspectives on the issue. The researcher thereafter interprets the factors, which often leads to a more nuanced understanding of the issues at hand than could be achieved through more traditional qualitative techniques, such as questions or scales defined by the researcher (Finchilescu & Cooper, 2018).

Q-Methodology is a good research technique for studies on social phenomena involving intense debate, opposing views and contestation, as is often the case with energy and sustainability policies, where understanding conflicting perspectives assists with selecting an effective policy solution (Setiawan & Cuppen, 2013).

This research aims to interpret and draw out a more nuanced understanding of the coal debate in South Africa, through the perspectives of professionals.

Accordingly, Q-Methodology was considered an optimal research methodology for this study.

3.2 Research design

The overall Q-Methodology technique involves five basic steps, as follows (van Exel & de Graaf, 2005):

- (1) Defining the concourse and developing the Q-statements that cover all relevant aspects of the issue (the '**Q-set**').
- (2) Selecting the sample of participants (the '**P-set**').
- (3) Collecting the '**Q-sorts**', which involves the participants organising the statements on a grid according to their beliefs (typically between the ranges 'strongly disagree' to 'strongly agree').
- (4) By using inverted factor analysis techniques, analysing the Q-sorts to correlate groupings ('**factors**') within the P-set, each of which reflect shared perspectives on the issue.
- (5) Interpreting and discussing the perceptions of each of the factors and drawing conclusions.

The research process conducted for this report followed the above steps closely.

3.3 Data collection methods

The Q-Methodological technique of developing and collecting the Q-sorts is well established. The Q-set comprises as many statements from the concourse (the full range of ideas on the issue at hand) as the researcher deems appropriate. Researchers should choose enough statements to cover the breadth of the issues, but also not too many that the sorting task becomes unnecessarily cumbersome (Watts & Stenner, 2005). Around 40 to 50 statements seem to be the norm (van Exel & de Graaf, 2005).

Upon completing the sorting processing, the participants were then asked two open-ended questions:

- (1) *“Please elaborate on why you chose the ”strongly agreed” with statements”*; and
- (2) *“Please elaborate on why you chose the ”strongly disagreed” with statements”*.

The literature confirms that post-survey interviews such as this often lead to a more penetrating interpretation in Q-studies (van Exel & de Graaf, 2005). Indeed, the answers to these questions were considered most helpful for the interpretation of the results in the present study.

There is some debate in the literature about whether it is better to conduct the Q-sort collection process remotely, via Online administration (as was the case in the present study), or by means of face-to-face interviews. Authors such as Aruja (2014) and Setiawan and Cuppen (2013) preferred face-to-face interviews as they ensured good communication of instructions and a high completion rate. Finchilescu and Muthal (2019, pp. 136) point out that the face-to-face method is more resource intensive, requiring the presence of the researcher, but the researcher can at least ensure that the participant *“really engaged with the task”*. Researchers Reber, Kaufman and Cropp (2000) performed validation studies and determined that there was no apparent difference in the validity or reliability between the two methods.

Unfortunately, due to the ongoing public health crisis caused by COVID-19, conducting face-to-face interviews was not feasible in the present study, and therefore Online administration was the only option.

3.4 Population and sample (P-set)

Stakeholders in the ESI could encompass almost anyone in South Africa given the scope of the industry’s impact on the economy and importance of coal derived energy as an energy source. However, people professionally engaged in the ESI

are deemed the optimal category of stakeholders, with sufficient depth of knowledge as is required for Q-Methodology research.

The selection of the P-set in Q-Methodology is never random. Rather, the participants are carefully selected based on their specific knowledge and are expected to have a clear and distinct view on the issue at hand (Brown, 1980). Furthermore, a large P-set is not required for Q-Methodology studies. The point of Q-Methodology is to extract and analyse the main viewpoints of a select group (Watts & Stenner, 2005) and it has been established by Brown (1980) that there are only ever a limited number of distinct viewpoints on any topic.

Most importantly, as mentioned earlier, in Q-Methodology studies, the participants are the variables in the study, as opposed to their traits or the questionnaire items (Finchilescu & Cooper, 2018).

A population of 40 to 60 participants is common for Q-Methodology studies, but a lower number has been found to be acceptable (Brown, 1980; Finchilescu & Cooper, 2018). The number of participants selected for the present study totalled 33, after a snowball sampling technique was used to help source participants (as described in more detail below).

In order to ensure breadth of perspective, individuals who come from different organisational backgrounds and affiliations were selected. The participants were selected from a wide range of professional fields, including law, banking, economics, engineering, accounting, social and environmental sustainability, research and development, environmental science, project management and strategy and training.

A requirement for the inclusion of a participant in the sample was that they should either work in the ESI or possess deep knowledge of key issues related to coal power. Significantly, the average working experience of the participants in this study was just under 15 years. Table 3.1 below sets out the various categories of professions from which the participants were sampled.

Table 3.1: Profile of participants

Type of Profession	Number sampled
Lawyer	3
Banker	2
Engineer	6
Economist	1
Environmental scientist	4
Sustainability practitioner	3
Researcher	5
Project manager	3
Environmental consultant	1
Lecturer/ Trainer	3
Strategist	1
Accountant	1
TOTAL number of participants	33

A further requirement of the sample was that participants should work in a variety of organisations, including multinational corporations, local companies, professional firms, science councils, consultancies, financial institutions, state-owned enterprises, non-governmental organizations (NGO's) and academia. Table 3.2 below provides a breakdown of the organisational types of the selected participants.

Table 3.2: Organisation types represented

Type of Organisation	Number
Multinational corporation	5
Local company	5
Professional firm	3
Science council	3
Consultancy	6
Financial institution	5

State-owned enterprise	3
Non-governmental organization (NGO)	1
Academia	2
TOTAL	33

The snowball sampling technique was used to expand the sample, in terms of which each participant selected was asked to refer someone else with similar or divergent views to his/her own, who was then approached as potential candidate.

Caution was taken to ensure that only a limited number of respondents were employed in the same organisation and/or line of profession – thereby minimising potential bias in the perspectives across the sample, as much as possible.

The study does not heavily depend on having a broad range of demographic representation across the sample, such as race, gender, age, income range, religious views *etc.*, since personal traits are not critical variables with regard to the research objective. Q-Methodology is less concerned with ‘*who* said what about the issue at hand’ than ‘*what* is currently being said about the issue at hand’ (Watts & Stenner, 2005, pp. 86).

3.5 The research instrument (Q-set)

A copy of the final list of 46 statements forming the Q-set used in the present study is attached as Appendix “A” hereto. The Q-statements were drawn from the literature reviewed in Chapter 2 and from an array of other sources, including Online news providers (local, national, international), academic and industry specific publications and relevant social media feeds.

Prior to finalising the Q-set, the assistance of two industry experts was procured in order to narrow down and confirm the final list of Q-statements. This was to ensure that the Q-set remains relevant and as accurate a reflection of all the main subjective viewpoints in the concourse as possible.

A copy of the cover letter which accompanied the Q-set is attached hereto as Appendix “B”. The letter set out the purpose of the research, the respondent’s role in the data collection process and the terms and conditions of participation.

3.6 Procedure for data collection (Q-sort process)

The collection of the data in the present study involved the use of a software programme called QsortWare (as mentioned above). The participants were each emailed a link which directed them to a web-based Online platform (powered by QsortWare), at which they completed the Q-sort sorting process electronically.

After the participants completed the Q-sorting process, the completed ‘Q-sorts’ were retrieved by the software programme and stored in .csv and .txt files for later use.

3.7 Data analysis and interpretation

The .csv and .txt files were uploaded to another free software programme called Kade (version 1.2.1) (Banasick, 2019), which is specifically designed for the analysis part of Q-Methodology studies. The software organised the data by assigning numbers to each participant’s Q-sort, depending on the positioning of the Q-statements on their grid. It then factor analysed the data (with orthogonal rotation) in order to correlate clusters of participants (referred to as ‘factors’) who shared similar perspectives. The process of extraction selected was Principal Component Analysis. Another option, namely Brown’s centroid factor analysis, was available but not chosen for the present study. There is considerable debate around which method is best for the analysis (Finchilescu & Muthal, 2019), however authors Watts and Stenner (2005, pp. 80) confirmed that they have used both and found the results to be equally satisfying.

It is not necessary for this report to go into the technical mathematical equations underpinning the factor analysis of Q-data. As mentioned by Brown (1993, pp. 110), *“few statistical procedures can be more daunting than factor analysis, but in Q methodology there is little more reason to understand the mathematics involved than there is to understand the mechanics in order to drive a car.”*. To

this end, the researcher trusted that Kade facilitated the data input by automatically generating the initial by-person correlation matrix. This made the process of factor extraction, rotation and estimation part of the statistical analysis very straightforward.

It is however relevant to mention the high-level steps which were considered and taken during the present study. The theories and details of the steps below are drawn from Finchilescu and Muthal (2019 pp. 136 – 139).

(1) Step 1: Selecting the initial number of factors

After the extraction method (Principal Component Analysis) was chosen, the researcher was required to decide how many factors to specify for the further analysis by Kade. In the present study and based on the number of Q-sorts in the study (namely, 33), the number of factors chosen was six. This is line with the recommendation of Watts and Stenner (2012, pp. 197).

The extraction process produced an unrotated factor matrix which indicates the loading of each participant on the factors. The eigenvalues, as well as the variance explained, is shown for each factor in the matrix in Table 3.3 below. As Finchilescu and Muthal (2019, pp. 137) explain, the eigenvalue of a particular factor is the extent of variability explained by the factor (in mathematics, this is the sum of the square of each loading in the factor). The resulting loadings of the participants on the factors are basically the correlation coefficients, indicating the degree to which a participant exemplifies the given factor. The unrotated factor matrix produced eight factors in the present study.

Table 3.3: Table of eight unrotated factors

Unrotated factors	F1	F2	F3	F4	F5	F6	F7	F8
Eigenvalues	10,833	4,301	1,906	1,699	1,555	1,440	1,320	1,111
% Explained Variance	33	13	6	5	5	4	4	3

(2) Step 2: Selecting the number of factors to keep

In typical R factor analysis, the Kaiser-Guttman criterion is used which selects factors based on eigenvalues which exceed 1.00 and/or it uses a scree test. This criterion is also generally used by Q-methodologists, although others follow the recommendation of Brown (1980) that eigenvalues of less than 1.00 may also be meaningful. A further criterion common to Q-analysis is to only choose a factor if it contains at least two participants with significant loadings. There is yet another method for selecting a factor, known as the Humphrey's rule. The mathematics equation to determine if a factor complies with this rule is as follows: the cross-product of the two highest loadings of a factor (disregarding negative signs) must exceed twice the standard error in the study, in order to be accepted.

In the present study, five of the unrotated factors were chosen for the next step in the Q-analysis process, as the researcher preferred to stay with factors with eigenvalues that were at least over 1.500.

(3) Step 3: Rotation

Rotation involves realigning the participants' Q-sorts to ensure a clearer picture of the membership in the factors. There are two forms of rotation: oblique and orthogonal. The methods for rotation involve an objective method (such as varimax), or a theoretical (or judgmental) method - which is decided by the theoretical concerns, prior knowledge or a prior idea of the researcher for the study approach (van Exel & de Graaf, 2005, pp. 9).

In the present study, the varimax option was chosen, mainly because Watts and Stenner (2005, pp. 81) concluded it is the "*mathematically superior option*" as it "*maximizes the amount of variance explained by the extracted factors*".

(4) Step 4: Flagging Q-sorts for factor estimates and running the analysis

Following the rotation, the researcher then had to decide which participants should ideally be used as the "*best estimate of the factor*" (Finchilescu and Muthal, 2019, pp. 139). One considers the loadings in the

rotated matrix and seeks to categorise the participants into those which load significantly on one of the factors (this is called “flagging”). In Kade, the researcher was able to set the significance threshold (e.g. $p < 0.1$, or $p < 0.5$), depending on how stringent a range the researcher preferred. If a participant loads on more than one factor, this is considered a “confounded loading”, and cannot be used.

Kade has an automatic flagging function which will select all the loadings which exceed the threshold range selected. In the present study, a range of $p < 0.5$ was chosen, which elicited only three of the final five rotated factors as suitable, as the other two had only one flagging and therefore had to be rejected. In the present study, these were Factors 1, 2 and 5.

Once the flagging was completed, the final analysis was activated in Kade, which calculated a weighted average score for each of the factors based on their flagged participants.

The interpretive part of Q-Methodology follows after the above-mentioned automatic Q-analysis process has been completed. This is considered a qualitative step as it involves interpreting the factors and forming narratives. Chapter 4 sets out the interpretation process in more detail.

3.8 Reliability

Q-Methodology is unique in that a small sample is sufficient to generate required results. This, as pointed out earlier, arises from the notion that only a limited number of distinct viewpoints exist on any topic (Brown, 1980). One of the most important type of reliability tests for Q-Methodology is the replicability of the results (van Exel & de Graaf, 2005). On this note, it has been established by a number of researchers following the test-retest protocol that Q-Methodology technique is reliable - with test-retest scores ranging from 0.80 upward (Amin, 2000; Brown, 1980; Nicholas, 2011).

Base on the comments above and by ensuring a solid selection of knowledgeable professionals from a broad range of organisation types, it is reasonable to

assume that the findings achieved in this study will in fact be duly representative of the range of viewpoints that exist on the discourse, and will be considered reliable.

3.9 Ethical considerations

The risk category for the present research, according to the standards of the National Health Research Ethics Council of the Department of Health, is “minimal risk”. A copy of the signed ethics clearance certificate (protocol number: WBS/BA2293174/594, dated 4 August 2020) issued by the Ethics Committee of the Wits Graduate School of Business is attached as Appendix “C” hereto.

No individuals from any vulnerable category of society were requested to participate in the study. Only limited personal information on the participants was requested in order to ensure their viability for the research aims, such as: gender, profession, organisation and number of years’ working experience. Formal prior consent to participate was obtained from each participant prior to commencing the Q-sorting process. No personal information of any participants (including names, email addresses, contact details, job titles or the names of organisations), nor any individual responses, are identifiable in this report. No personal information, nor personal results, of any participant was disclosed to any other participant or third party.

The participants were informed that although anonymity cannot be absolutely guaranteed, no personal data, nor their specific perspectives, will be linked back to them or publicly divulged in any way. All confidential information retrieved has been and will continue to be kept strictly confidential. The raw data is stored in a password protected computer and will be destroyed two years after submission of this report for examination.

CHAPTER 4. RESULTS

4.1 Introduction

This Chapter describes the results of the research. It begins with an explanation of the Q-Methodology interpretation process, introduces the factor arrays for the three identified factors, then presents the factor score correlations, followed by the areas of consensus amongst the factors. The main results are then presented by way of a detailed summarising accounts of each factor, including the areas of contention amongst the factors. The Chapter concludes with a few conclusionary remarks on the results.

4.2 Interpretation process

The purpose of Q-Methodology is to identify the differences and similarities between the participants' perspectives on a certain topic and to explore the viewpoints in a different way (Webler, Danielson, & Tuler, 2009). Each identified factor represents the perspectives of a grouping of the sampled participants that are highly correlated with each other and uncorrelated with others.

In the present study, Kade automatically computed a 'factor score' and 'difference scores' for the three factors. The factor score is the normalised weighted average statement score of the participants included in that factor. Using Z-scores, the extent of the difference between a statement score on any two factors is determined to be statistically relevant or not.

When a statement's score of a factor differs from that of all the other Factors, this is described as a "distinguishing statement" for that factor. A statement that is ranked similarly by all the factors is called a "consensus statement".

Based on the factor scores, Kade generated a composite Q-sort for each factor which resembles the best-estimate Q-sort (or "**factor array**"). This represents how a hypothetical participant with 100% loading on that factor would have arranged the Q-sort.

Although Kade produced the results of the data using factor analytical techniques, it does not interpret these factors – which was left to the researcher. This is considered the endpoint of the statistical analysis part of the Q-study (Watts & Stenner, 2005).

The factor arrays of the factors are shown in tabular format below (Table 4.1) and each composite Q-sort is visually represented in grid format in Appendices “D” to “F” hereto. In addition to the factor arrays, the answers which the participants gave to the open-ended questions were taken into account, as many such answers served to validate the interpretations of the factor in which such participant was placed.

4.3 Factor arrays of the three factors

The factor arrays, being composite results of all the Q-sorts in each factor, were drawn from Kade and are shown in Table 4.1 below. The three distinct factors which emerged with sufficient flagging were Factors 1, 2 and 5. However, for ease of reference in this report, Factor “5” will hereinafter be referred to as Factor “3”. Table 4.1 below shows the Q-sort values of each statement as ranked by each factor.

Table 4.1: Factor arrays for the three factors

No. Statement	Factor Arrays		
	F1	F2	F3
1. New ‘clean coal’ technologies are possibly revolutionary and have the potential to sustain the value of South Africa’s significant coal reserves.	-1	5	4
2. South Africa is already a water stressed country. We cannot afford to dedicate any more water to “dirty” coal projects.	5	-1	0
3. Coal-fired power generation has a very poor ‘energy returned on energy invested’ (ERoEI).	0	0	-2
4. Government should enact protective legislation to regulate coal exports and domestic coal pricing in order to ensure security of coal supply to Eskom.	-2	2	-1

5. Coal as an energy source is actually “subsidised”, because it does not pay the full environmental cost of its use (such as climate change, land degradation, water use and contamination, etc.).	4	0	-4
6. Keeping Eskom’s older coal power stations in operation, despite their failure to meet the required Minimum Emission Standards, is justified in light of the socio-economic imperative of protecting jobs.	-1	3	-4
7. The negative externalities of coal power disproportionately affect marginalised communities living near coal mines and power stations.	3	-1	-1
8. Coal projects no longer represent a reliable, safe, investment as many, well-known large banks and financial institutions are refusing to finance coal and many commodity trading firms are withdrawing from coal.	3	-1	5
9. ‘Clean coal’ technologies are expensive, add to the enormous resource consumption of coal-fired generation, and either don’t work or make little difference to the harm done to health and the environment.	0	-3	-1
10. More funding should be targeted at long-term R&D into ‘clean coal’ technologies, as these will be essential in ensuring that South Africa continues to exploit its vast, indigenous coal deposits responsibly and sustainably.	-2	4	0
11. It is true that coal jobs are at risk in South Africa, but this is not as a result of the Renewable Energy Independent Power Producers Procurement (REIPPP) programme.	2	2	5
12. When it comes to the ‘just energy transition’, the real choice is not jobs or the environment; it is both or neither. In other words, without an environmentally sustainable solution, there will be no jobs.	5	1	-2
13. Coal is no longer a cheap and bountiful resource that can ensure security of supply for the national energy system.	0	-4	-2
14. The unintended health consequences of coal are often overlooked and is another reason why coal power should be phased out of the energy system, as quick as possible.	0	-2	1
15. Coal power requires enormous volumes of water. Considering South Africa is a water scarce country, it is not environmentally sustainable to continue depending on coal for the country’s base load power.	2	-2	3
16. Given South Africa’s world-class wind and solar resources, Government should fast track the renewable energy transition in order to position the country as a preferred investment destination for energy intensive businesses.	4	0	4
17. Social justice is more important than environmental justice.	-2	0	0

18. Most of the country's remaining coal resources lie in the Waterberg Coalfield (Limpopo Province), which faces water and rail network constraints. To develop the necessary infrastructure in this region to extract the coal for export or domestic use will lock-in coal in the energy system for a period longer than the country can afford having regard to climate change.	0	0	2
19. The declining investment appetite around the world for new coal-fired power projects is permanent and not a temporary downward shift.	3	1	1
20. The Government should allow market forces to choose the energy technologies and which energy resources to exploit.	2	1	0
21. Lending to coal companies is too risky and could ultimately prove unprofitable when stiffer environmental standards are enforced.	1	-2	3
22. Eskom should retrofit its existing fleet of coal-fired power plants to increase their efficiency and flexibility in order to facilitate the addition of fluctuating renewable energy into the system.	-1	4	1
23. Government should not intervene in the Integrated Resources Plan (IRP) technology selection process by trying to "pick winners" on "strategic" grounds.	1	0	2
24. Due to grid instability, South Africa's national electricity system will never be able to support a renewables-dominant supply mix.	-4	2	-3
25. Government and private sector collaboration on providing financial support through the investment in new 'clean coal' technologies, is a sure-way to keep the South African coal mining sector prosperous.	-3	2	0
26. There are no viable technology options to make coal environmentally sustainable.	-1	-5	-5
27. South Africa cannot and should not reduce its dependency on coal for primary (base load) energy.	-5	3	-5
28. The adverse effects of greenhouse gas emissions from coal power on our children and grandchildren is an intergenerational crime.	1	0	-2
29. South Africa will never be able to build sufficient technical capacity to compete with foreign renewable energy technology developers so we might as well focus on our strengths - coal power.	-4	-4	-4
30. The reality of climate change requires a rapid response and therefore Government cannot wait for Eskom's coal power plants to reach their end of design life before removing them from service. It is imperative that they retire them early.	-1	-5	-1
31. It is arguably far cheaper to fulfil the shortfall of primary energy requirements from renewable energy and rather seek solutions to distribute this energy in a balanced way to meet customer demand (e.g. assisted by pumped hydro storage, adjusting power-station maintenance schedules and demand side management) than investing in new base load coal.	1	1	0

32. South Africa cannot cling to coal when the rest of the world is moving away from it.	1	-1	1
33. South Africa's vast coal deposits cannot be sterilised simply because we have not exploited technological innovations to use them.	-2	1	0
34. Flexible gas-fired power stations are the key to South Africa's national electricity system being able to handle large amounts of variable renewable energy. Flexible gas and RE technologies used in tandem present a real alternative to base load coal power.	0	0	1
35. 'Clean coal' and coal conversion technologies are a long way off from commercial and environmental viability (primarily because they are still highly inefficient). Therefore, owing to the high R&D costs required, investing in such technologies will only serve to lock-in coal in the energy system for a longer than the country can afford if we hope to achieve climate change targets.	0	-3	-2
36. The argument that renewable energy independent power producers (IPPs) are destroying Eskom financially is a gross misrepresentation.	2	3	3
37. There is no reasonable basis for building new coal plants when the technology and costs are clearly in favour of renewables and flexible generation.	2	-3	-3
38. The critique that renewable power will reduce power system reliability is now debunked.	-1	-2	-1
39. Coal is the source of the most valuable commodity in the South African economy - as it provides low-cost energy.	-4	2	1
40. Since South Africa has known coal reserves, coal should remain part of the energy mix in the future.	-3	5	0
41. Given the country's high unemployment rate, there cannot be privatisation of state assets at the expense of jobs - even if it would ultimately lead to lower electricity prices.	-3	-1	2
42. South Africa needs to drastically reduce dependency on coal for primary (base load) energy.	4	-2	4
43. The economies of scale for coal technologies are very large. The opposite is true for renewable energy technologies. The latter therefore has the better prospect for true market prices.	0	-1	-3
44. National electricity supply security can only be achieved through exploitation of domestic coal.	-5	1	-1
45. The only true ethical solution for the country is to phase out coal.	1	-4	2
46. 'Clean coal' technologies are a necessary step towards a more sustainable energy system.	-2	4	2

The factor arrays show that each factor typically depicts a clear and unique perspective when compared with the others (although there are few areas of

consensus). They explain 50% of the variance across all Q-sorts collected in the study, with Factor 1 accounting for 26%, Factor 2 for 15% and Factor 3 for 9%.

Further below in this Chapter, a summarising account of each factor, which attempts to explicate the perspectives of that factor, will be set out. The interpretations are drawn primarily from the statements positioned at the extreme ends of the composite grids (representing issues which are most agreed and disagreed with), the centre column statements (which are issues considered less important) and how the composite factors relate to each other. After presenting each perspective, an analysis of the results will be discussed in Chapter 5.

As mentioned above, each factor is visually represented in grid format in Appendices “D” to “F” hereto.

4.4 Factor Score Correlations

Table 4.2 below shows how statistically correlated each factor is with the others, and suggests that each factor is unique. The higher the correlation value, the more similar the perspectives are.

Table 4.2: Factor Score Correlations

	Factor 1	Factor 2	Factor 3
Factor 1	1	-0,3343	0,3758
Factor 2	-0,3343	1	0,1819
Factor 3	0,3758	0,1819	1

4.5 Areas of Consensus

From the factor analysis performed by Kade, four statements of consensus appeared amongst the factors. The software identifies ‘consensus statements’ as statements that do not distinguish between any pair of factors, provided they are within a Z-score range of $p < 0.01$. Table 4.3 below lists the consensus statements.

Table 4.3: Consensus Statements

No. Statement	Factor Scores		
	F1	F2	F3
3. Coal-fired power generation has a very poor ‘energy returned on energy invested’ (ERoEI).	0	0	-2
29. South Africa will never be able to build sufficient technical capacity to compete with foreign renewable energy technology developers so we might as well focus on our strengths - coal power.	-4	-4	-4
31. It is arguably far cheaper to fulfil the shortfall of primary energy requirements from renewable energy and rather seek solutions to distribute this energy in a balanced way to meet customer demand (e.g. assisted by pumped hydro storage, adjusting power-station maintenance schedules and demand side management) than investing in new base load coal.	1	1	0
34. Flexible gas-fired power stations are the key to South Africa’s national electricity system being able to handle large amounts of variable renewable energy. Flexible gas and RE technologies used in tandem present a real alternative to base load coal power.	0	0	1

There is one particularly important area of consensus: all factors strongly rejected (each with a ranking of **-4**) the notion that South Africa will never be able to build sufficient technical capacity to compete with foreign renewable energy technology developers, so we might as well focus on coal power. A deeper discussion on this consensus follows in Chapter 5.

4.6 Summarising account of Factor 1

Pro-environment Anti-coalers

Factor 1 personifies “Pro-environment Anti-coalers”. It consists of twelve participants, and it explains 26% of the study variance. Five of the loading participants are women and seven are men. The average working experience of the significantly loaded participants is 13.42 years. The various organisation types represented in this Factor are: three lawyers, one environmental scientist, one environmental consultant, four engineers, one accountant and two lecturer/trainers – a diversion grouping.

Factor 1 participants clearly support the environment and oppose coal, including even ‘clean coal’ technologies. They strongly believe South Africa is already a water stressed country which cannot afford to dedicate any more water to “dirty” coal projects (2: **+5**, -1, 0)¹ and that when it comes to the ‘just energy transition’, the real choice is not jobs or the environment; it is both or neither (12: **+5**, +1, -2). South Africa should focus on its world-class wind and solar resources, and fast track the renewable energy transition in order to stimulate investment (16: **+4**, 0, +4), and drastically reduce its dependency on coal for primary (base load) energy (42: **+4**, -2, +4). Factor 1 participants agree that there is a declining investment appetite around the world for new coal-fired power projects – which they acknowledge is permanent and not a temporary downward trend (19; **+3**, +1, +1).

While both other Factors rejected the idea that the negative externalities of coal power disproportionately affect marginalised communities living near coal mines and power stations, Factor 1 participants considerably agree with it (7: **+3**, -1, -1). They agree that coal as an energy source is actually “subsidised”, because it does not pay the full environmental cost of its use (such as climate change, land degradation, water use and contamination, *etc.*) (5: **+4**, 0, -4). These two results clearly distinguish Factor 1 participants as being more environmentally conscientious than the participants in the other Factors.

Whereas Factor 2 and 3 participants support the idea that Eskom should retrofit its existing fleet of coal-fired power plants to increase their efficiency and flexibility in order to accommodate renewables) (22: **-1**; +4, +1), and that ‘clean coal’ technologies are a necessary step towards a more sustainable energy system (46: **-2**, +4, +2), Factor 1 participants rejected each of these ideas. They also outright rejected the notion that coal provides low-cost energy (39: **-4**, +2, +1), whereas the other two Factors agree with that statement.

Fundamentally in line with its persona, Factor 1’s participants were the only group who agree there is no reasonable basis for building new coal plants, as they

¹ The first number is the statement number, and the next three numbers are the Q-sort values chosen by the factors F1, F2 and F3 respectively. The Q-sort value for the factor under consideration is **bolded** for ease of reference.

believe the technology and costs are clearly in favour of renewables and flexible generation (37: **+2**, -3, -3), and they were the only factor to reject the idea that social justice is more important than environmental justice (17: **-2**, 0, 0) – indicating a slant towards the environment over social issues.

They strongly disagreed that national electricity supply security can only be achieved through exploitation of domestic coal (44: **-5**, +1, -1) and that South Africa cannot and should not reduce its dependency on coal for primary base load energy (27: **-5**, +3, -5).

One participant sums up the perspective of Factor 1 participants succinctly: *“It is clear that coal should make way for cleaner technologies that have now been proven”*.

Factor 1 participants are unique in their regard for particular statements. The table below lists the distinguishing statements for Factor 1.

Table 4.4: Distinguishing statements for Factor 1

No. Statement	Factor Scores		
	F1	F2	F3
2. South Africa is already a water stressed country. We cannot afford to dedicate any more water to “dirty” coal projects.	5	-1	0
12. When it comes to the ‘just energy transition’, the real choice is not jobs or the environment; it is both or neither. In other words, without an environmentally sustainable solution, there will be no jobs.	5	1	-2
5. Coal as an energy source is actually “subsidised”, because it does not pay the full environmental cost of its use (such as climate change, land degradation, water use and contamination, etc.).	4	0	-4
19. The declining investment appetite around the world for new coal-fired power projects is permanent and not a temporary downward shift.	3	1	1
7. The negative externalities of coal power disproportionately affect marginalised communities living near coal mines and power stations.	3	-1	-1
8. Coal projects no longer represent a reliable, safe, investment as many, well-known large banks and financial institutions are refusing to finance coal and many commodity trading firms are withdrawing from coal.	3	-1	5

37. There is no reasonable basis for building new coal plants when the technology and costs are clearly in favour of renewables and flexible generation.	2	-3	-3
21. Lending to coal companies is too risky and could ultimately prove unprofitable when stiffer environmental standards are enforced.	1	-2	3
28. The adverse effects of greenhouse gas emissions from coal power on our children and grandchildren is an intergenerational crime.	1	0	-2
35. 'Clean coal' and coal conversion technologies are a long way off from commercial and environmental viability (primarily because they are still highly inefficient). Therefore, owing to the high R&D costs required, investing in such technologies will only serve to lock-in coal in the energy system for a longer than the country can afford if we hope to achieve climate change targets.	0	-3	-2
43. The economies of scale for coal technologies are very large. The opposite is true for renewable energy technologies. The latter therefore has the better prospect for true market prices.	0	-1	-3
13. Coal is no longer a cheap and bountiful resource that can ensure security of supply for the national energy system.	0	-4	-2
26. There are no viable technology options to make coal environmentally sustainable.	-1	-5	-5
22. Eskom should retrofit its existing fleet of coal-fired power plants to increase their efficiency and flexibility in order to facilitate the addition of fluctuating renewable energy into the system.	-1	4	1
1. New 'clean coal' technologies are possibly revolutionary and have the potential to sustain the value of South Africa's significant coal reserves.	-1	5	4
6. Keeping Eskom's older coal power stations in operation, despite their failure to meet the required Minimum Emission Standards, is justified in light of the socio-economic imperative of protecting jobs.	-1	3	-4
33. South Africa's vast coal deposits cannot be sterilised simply because we have not exploited technological innovations to use them.	-2	1	0
46. 'Clean coal' technologies are a necessary step towards a more sustainable energy system.	-2	4	2
17. Social justice is more important than environmental justice.	-2	0	0
41. Given the country's high unemployment rate, there cannot be privatisation of state assets at the expense of jobs - even if it would ultimately lead to lower electricity prices.	-3	-1	2
40. Since South Africa has known coal reserves, coal should remain part of the energy mix in the future.	-3	5	0
25. Government and private sector collaboration on providing financial support through the investment in new 'clean coal' technologies, is a sure-way to keep the South African coal mining sector prosperous.	-3	2	0

39. Coal is the source of the most valuable commodity in the South African economy - as it provides low-cost energy.	-4	2	1
24. Due to grid instability, South Africa's national electricity system will never be able to support a renewables-dominant supply mix.	-4	2	-3
44. National electricity supply security can only be achieved through exploitation of domestic coal.	-5	1	-1

As seen in Table 4.4 above, in twenty two out of the twenty five distinguishing statements, Factor 1 scored on the other end of the spectrum to the other Factors. The arguments made in the preceding paragraphs demonstrated Factor 1's strong orientation against coal power, including 'clean coal' technologies in all scenarios.

In conclusion, Factor 1 participants strongly disapprove of coal and its future role in the ESI and prefer a renewables-dominant energy mix, which they believe will address environmental and economic challenges currently experienced in the ESI.

4.7 Summarising account of Factor 2

'Clean coal' Proponents

Factor 3 personifies "'Clean coal' Proponents". It is a smaller cluster and comprises six participants, one man and five women. It explains 15% of the study variance and the average working experience of the significantly loaded participants was the highest of all Factors: 23,67 years. The organisation types represented include: one banker, one sustainability practitioner and four researchers. As there were a total of five researchers in the whole P-set, the fact that four of them loaded on Factor 2 is quite interesting. More analysis on this aspect follows in Chapter 5.

Factor 2 participants clearly favour 'clean coal' technologies ahead of any other option (1: -1, **+5**, +4), and believe that investing in these technologies is essential for ensuring that South Africa continues to exploit its vast, indigenous coal deposits responsibly and sustainably (10: 0, **+4**, 0).

They are strongly in favour of Eskom retrofitting its existing fleet of coal-fired power plants to increase their efficiency and flexibility in order to facilitate the addition of fluctuating renewable energy into the system (22: -1, **+4**, -1), and that 'clean coal' technologies are a necessary step towards a more sustainable energy system (46: -2, **+4**, +2).

They are alone in their support for the statement that South Africa cannot and should not reduce its dependency on coal for primary (base load) energy (27: -5, **+4**, -5) and they clearly believe coal power remaining in the energy system equates to protecting jobs, as they agree with the statement that keeping Eskom's older coal power stations in operation (despite their failure to meet the required Minimum Emission Standards) is justified in light of the socio-economic imperative of protecting jobs (6: -1, **+3**, -4). Both other Factors rejected these ideas.

Demonstrating their support for 'clean coal' technologies, they agree the most amongst the Factors that Government and private sector should collaborate in funding investment in new 'clean coal' technologies to keep the South African coal mining sector prosperous (25: -3, **+2**, 0).

While the other two Factors wholly rejected the theory that a renewables-dominant supply mix would cause grid instability, they in fact agreed it would (24: -4, **+2**, -3). Taking the point further, they were also the only Factor in favour of the idea that National electricity supply security can only be achieved through exploitation of domestic coal (44: -5, **+1**, -1).

They strongly rejected the ideas that the only true ethical solution for the country is to phase out coal (45: +1, **-4**, +2) and that coal is no longer a cheap and bountiful resource that can ensure security of supply for the national energy system (13: 0, **-4**, -2). This is contrary to the what the other Factors believed.

They dismissed the idea (although only mildly) that the negative externalities of coal power disproportionately affect marginalised communities living near coal mines and power stations (7: +3, **-1**, -1).

The lowest ranked statements for this Factor - indicating their total rejection of the ideas - were statement no. 26 (*There are no viable technology options to make coal environmentally sustainable*) (-1, **-5**, -5) and statement no. 30 (*The reality of climate change requires a rapid response and therefore Government cannot wait for Eskom's coal power plants to reach their end of design life before removing them from service. It is imperative that they retire them early*) (-1, **-5**, -1).

In confirmation of Factor 2's orientation towards coal power, two of the Factor 2 participants commented as follows:

- *"Investment in clean coal technologies provides better environmental conditions and socio-economic benefits. 'Carbon capture and storage' work, is really progressing and has many benefits. Despite the negative environmental impacts there are so many socio-economic benefits for local communities – work, infrastructure, etc."*
- *"I have been deeply involved in clean coal technologies and that sector, in industry, and am aware of the facts and potentials for such technologies, as are most of the Asian countries including China. There is proven coal-fired technology with minimal water that produces 98% clean air now in operation! I am aware of the problems related to renewables, their short life spans, the requirements for hazardous rare earth minerals in their make-up, the considerable need for steel (which requires coal) and silica (which needs heat to form glass) and problems related to their stability to the grid, etc etc. However, I can see the benefits of limited introduction of renewables leading to mixed energy solutions in some sectors of the country but would never sanction bulk introduction."*

Factor 2 participants strongly agreed that since South Africa has known coal reserves, coal should remain part of the energy mix in the future (40: -3, **+5**, 0). This is on the other end of the spectrum to the other Factors.

The distinguishing statements in Table 4.5 below add weight to the summarising account provided in the preceding paragraphs.

Table 4.5: Distinguishing Statements for Factor 2

No. Statement	Factor Scores		
	F1	F2	F3
40. Since South Africa has known coal reserves, coal should remain part of the energy mix in the future.	-3	5	0
10. More funding should be targeted at long-term R&D into ‘clean coal’ technologies, as these will be essential in ensuring that South Africa continues to exploit its vast, indigenous coal deposits responsibly and sustainably.	-2	4	0
46. ‘Clean coal’ technologies are a necessary step towards a more sustainable energy system.	-2	4	2
22. Eskom should retrofit its existing fleet of coal-fired power plants to increase their efficiency and flexibility in order to facilitate the addition of fluctuating renewable energy into the system.	-1	4	1
27. South Africa cannot and should not reduce its dependency on coal for primary (base load) energy.	-5	3	-5
6. Keeping Eskom’s older coal power stations in operation, despite their failure to meet the required Minimum Emission Standards, is justified in light of the socio-economic imperative of protecting jobs.	-1	3	-4
39. Coal is the source of the most valuable commodity in the South African economy - as it provides low-cost energy.	-4	2	1
25. Government and private sector collaboration on providing financial support through the investment in new ‘clean coal’ technologies, is a sure-way to keep the South African coal mining sector prosperous.	-3	2	0
24. Due to grid instability, South Africa’s national electricity system will never be able to support a renewables-dominant supply mix.	-4	2	-3
4. Government should enact protective legislation to regulate coal exports and domestic coal pricing in order to ensure security of coal supply to Eskom.	-2	2	-1
12. When it comes to the ‘just energy transition’, the real choice is not jobs or the environment; it is both or neither. In other words, without an environmentally sustainable solution, there will be no jobs.	5	1	-2
44. National electricity supply security can only be achieved through exploitation of domestic coal.	-5	1	-1
23. Government should not intervene in the Integrated Resources Plan (IRP) technology selection process by trying to “pick winners” on “strategic” grounds.	1	0	2
16. Given South Africa’s world-class wind and solar resources, Government should fast track the renewable energy transition in order to position the country as a preferred investment destination for energy intensive businesses.	4	0	4

18. Most of the country's remaining coal resources lie in the Waterberg Coalfield (Limpopo Province), which faces water and rail network constraints. To develop the necessary infrastructure in this region to extract the coal for export or domestic use will lock-in coal in the energy system for a period longer than the country can afford having regard to climate change.	0	0	2
41. Given the country's high unemployment rate, there cannot be privatisation of state assets at the expense of jobs - even if it would ultimately lead to lower electricity prices.	-3	-1	2
8. Coal projects no longer represent a reliable, safe, investment as many, well-known large banks and financial institutions are refusing to finance coal and many commodity trading firms are withdrawing from coal.	3	-1	5
32. South Africa cannot cling to coal when the rest of the world is moving away from it.	1	-1	1
21. Lending to coal companies is too risky and could ultimately prove unprofitable when stiffer environmental standards are enforced.	1	-2	3
14. The unintended health consequences of coal are often overlooked and is another reason why coal power should be phased out of the energy system, as quick as possible.	0	-2	1
15. Coal power requires enormous volumes of water. Considering South Africa is a water scarce country, it is not environmentally sustainable to continue depending on coal for the country's base load power.	2	-2	3
42. South Africa needs to drastically reduce dependency on coal for primary (base load) energy.	4	-2	4
45. The only true ethical solution for the country is to phase out coal.	1	-4	2
13. Coal is no longer a cheap and bountiful resource that can ensure security of supply for the national energy system.	0	-4	-2
30. The reality of climate change requires a rapid response and therefore Government cannot wait for Eskom's coal power plants to reach their end of design life before removing them from service. It is imperative that they retire them early.	-1	-5	-1

Factor 2's distinguishing statements exemplify the participants' strong support for coal power and all things to do with 'clean coal' technologies. Thus, twenty two out of the twenty five distinguishing statements score Factor 2 on the other side of the spectrum from the other Factors.

One area of contention is of particular interest: Only Factor 2 participants support the idea that more funding should be targeted at long-term R&D into 'clean coal' technologies (10: -2, **+4**, 0). A detailed discussion of this discovery is presented in Chapter 5.

In conclusion, Factor 2 represents 'clean coal' technology proponents, as derived from their clear support for all the statements which attributed positive perspectives for 'clean coal' technologies.

4.8 Summarising account of Factor 3

Technology-agnostic Economy Enthusiasts

Factor 3 personifies "Technology-agnostic Economy Enthusiasts". It is the smallest cluster, consisting of only three participants who are all men. However, it explains 9% of the study variance, with the average working experience of the significantly loaded participants being 16,67 years (higher than the average of the P-set). The organisation types represented by the significantly loaded participants are diverse: one environmental scientist, one banker and one project manager.

The participants in this Factor seem to be enthusiastic about growing or protecting the economy and/or protecting jobs, regardless of which technology achieves this outcome.

They wholly agree that coal jobs are at risk in South Africa, but don't think it is because of the REIPPP programme (8: +3, -1, **+5**) - which indicates support for renewable energy technologies. Yet they significantly agree that new 'clean coal' technologies are possibly revolutionary and have the potential to sustain the value of South Africa's significant coal reserves (1: -1, +5, **+4**) and they also totally reject the idea that there are no viable technology options to make coal environmentally sustainable (26: -1, -5, **-5**) – indicating support for 'clean coal' technologies.

To demonstrate their concerns for the economy, Factor 3 participants strongly agreed that coal projects no longer represent a reliable, safe, investment as many, well-known large banks and financial institutions are refusing to finance coal and many commodity trading firms are withdrawing from coal (8: +3, -1, **+5**) and they believe that lending to coal companies is too risky and could ultimately

prove unprofitable when stiffer environmental standards are enforced (21: +1, -2, **+3**).

They support the idea that Government should fast track the renewable energy transition in order to position the country as a preferred investment destination for energy intensive businesses (16: +4, 0, **+4**). They however don't agree that renewable energy technologies have the better prospect for true market prices due to their relatively lower economies of scale when compared with coal technologies (43: 0, -1, **-3**), and therefore they do not show a bias towards renewable energy technologies.

To illustrate Factor 3's concern for protecting jobs, it is the only perspective which believes that there cannot be privatisation of state assets at the expense of jobs, even if it would ultimately lead to lower electricity prices (41: -3, -1, **+2**). This indicates that they are conscientious about social issues as they are impacted by technology choices.

They don't agree that Government should interfere in the IRP technology selection process by trying to "pick winners" on "strategic grounds" (23: +1, 0, **+2**), confirming their agnostic approach to technology choice in the IRP and their economic preference for following whatever is least-cost scenario pathway.

Factor 3 participants remained neutral on the idea that social justice is more important than environmental justice (17: -2, 0, **0**), which again emphasises that they aren't bias towards coal remaining in the system or renewables being adopted.

As indicated in Table 4.6 below, there are fifteen statements where Factor 3 significantly differs from the other Factors. Given that the explanation of Factor 3 provided in the preceding paragraphs indicates an enthusiasm for the economy and their technology agnostic attitude, it is unsurprising that there is no clear pattern for Factor 3 in the table of distinguishing statements. They occasionally side with Factor 1, but also occasionally side with Factor 2.

Table 4.6: Distinguishing Statements for Factor 3

No. Statement	Factor Scores		
	F1	F2	F3
11. It is true that coal jobs are at risk in South Africa, but this is not as a result of the Renewable Energy Independent Power Producers Procurement (REIPPP) programme.	2	2	5
8. Coal projects no longer represent a reliable, safe, investment as many, well-known large banks and financial institutions are refusing to finance coal and many commodity trading firms are withdrawing from coal.	3	-1	5
21. Lending to coal companies is too risky and could ultimately prove unprofitable when stiffer environmental standards are enforced.	1	-2	3
41. Given the country's high unemployment rate, there cannot be privatisation of state assets at the expense of jobs - even if it would ultimately lead to lower electricity prices.	-3	-1	2
46. 'Clean coal' technologies are a necessary step towards a more sustainable energy system.	-2	4	2
22. Eskom should retrofit its existing fleet of coal-fired power plants to increase their efficiency and flexibility in order to facilitate the addition of fluctuating renewable energy into the system.	-1	4	1
39. Coal is the source of the most valuable commodity in the South African economy - as it provides low-cost energy.	-4	2	1
25. Government and private sector collaboration on providing financial support through the investment in new 'clean coal' technologies, is a sure-way to keep the South African coal mining sector prosperous.	-3	2	0
40. Since South Africa has known coal reserves, coal should remain part of the energy mix in the future.	-3	5	0
20. The Government should allow market forces to choose the energy technologies and which energy resources to exploit.	2	1	0
44. National electricity supply security can only be achieved through exploitation of domestic coal.	-5	1	-1
13. Coal is no longer a cheap and bountiful resource that can ensure security of supply for the national energy system.	0	-4	-2
12. When it comes to the 'just energy transition', the real choice is not jobs or the environment; it is both or neither. In other words, without an environmentally sustainable solution, there will be no jobs.	5	1	-2
24. Due to grid instability, South Africa's national electricity system will never be able to support a renewables-dominant supply mix.	-4	2	-3
6. Keeping Eskom's older coal power stations in operation, despite their failure to meet the required Minimum Emission Standards, is justified in light of the socio-economic imperative of protecting jobs.	-1	3	-4

In conclusion, Factor 3 participants strongly agree that coal projects no longer represent a reliable, safe, investment, but did not totally reject its future role in the ESI, especially where 'clean coal' technologies are employed. They indicate support for the protection of jobs no matter whether renewable energy or 'clean coal' technologies are chosen, but ultimately are mostly concerned about the economy.

4.9 Conclusion

The results of the research suggest that professionals engaged in the ESI hold three distinct perspectives on the future role of coal. The dominant perspective, held by a majority of the respondents sampled (Factor 1), is a strong disapproval of coal and a strong preference for a renewables-dominant supply mix, supported by a high regard to environmental issues. The next prominent perspective (Factor 2) is emphatic in its support for coal power to remain in the ESI, especially 'clean coal' technologies. This factor grouping indicated a strong rejection of the perspectives favoured by the Factor 1 participants. The third and final perspective (Factor 3) doesn't have a particular preference for either coal or renewables and shows the greatest enthusiasm for economic issues and the protection of jobs. The next Chapter provides a discussion of the key aspects of these results.

CHAPTER 5. DISCUSSION

5.1 Introduction

This Chapter will briefly summarise the results of the research, including drawing the connection between the findings of the research and elements of the literature review conducted in Chapter 2. The key areas of consensus and contention amongst the professionals' perspectives will also be highlighted. The Chapter will then note the limitations of the present study and provide suggestions for further research.

5.2 What is the future role of coal in the ESI?

The results of the research indicate that the perspectives of professionals engaged in the ESI on the future role of coal remain polarised. The dominant perspective held by a majority of the participants is that coal should be phased out of the electricity supply mix in favour of renewables. However, a reasonably sized portion of the participants are unequivocal in their support for coal power, particularly where 'clean coal' technologies are promoted. Finally, a third and final perspective was identified which is agnostic as to coal versus renewable energy technology choice, provided economic interests are looked after, and they also care about protecting jobs.

Factor 1 participants strongly disapprove of coal and its future role in the ESI and prefer a renewables-dominant supply mix, which they believe will address environmental and economic challenges currently experienced in the ESI. Of the twenty five distinguishing statements which can be attributed to Factor 1, twenty two of them demonstrated Factor 1's strong orientation against coal power, including even 'clean coal' technologies in all scenarios. This is made obvious by the results because Factor 1 scored on the other end of the spectrum to the other Factors in the distinguishing factors Table 4.4.

The results clarified that Factor 2 participants supported all the statements which attributed positive perspectives for 'clean coal' technologies. It had twenty two out

of twenty five distinguishing statements scoring Factor 2 on the other side of the spectrum from the other Factors (see Table 4.5 above).

Factor 3 participants strongly agreed that coal projects no longer represent a reliable, safe, investment, but did not totally reject its future role in the ESI, especially where ‘clean coal’ technologies are employed. They indicate support for both renewable energy and ‘clean coal’ technologies in different contexts. Their enthusiasm for the economy is confirmed by their strong concern that coal projects no longer represent a reliable, safe, investment and their funding is drying up (8: +3, -1, **+5**) and they believe that lending to coal companies is too risky and could ultimately prove unprofitable when stiffer environmental standards are enforced (21: +1, -2, **+3**). Table 4.6 (above) demonstrated that there are fifteen statements where Factor 3 significantly differs from the other Factors, although it was unsurprising that there is no clear pattern for Factor 3 in the table of distinguishing statements.

What is the take-away from these understandings? The areas of consensus and contention in the various perspectives provide some key insights into how professionals’ position coal in the future energy supply mix.

Implications of consensus areas

The clear illuminating area of consensus amongst professionals engaged in the ESI is that they all sternly reject the idea that South Africa will not be able to build sufficient technical capacity to compete with foreign renewable energy technology developers. This is an important finding. Industry experts and academics such as Bischof-Niemz and Creamer (2018), Ireland and Burton (2018), and Oyewo *et al.* (2019) all conducted significant research into electricity generation technology issues. They each concluded that South Africa has clear competitive advantages and is ready to adopt renewable energy technologies successfully – without losing jobs or harming the economy or grid system in the process. In analagous findings, yet the other end of the technology spectrum, Yoro and Sekoai (2016) confirmed the “huge potential” in implementing CCS technology as a means of decarbonising the South Africa’s coal-fired power plants.

Accordingly, the results of the present research as well as elements of the literature review indicate consensus and potential synergistic opportunities for proponents of both renewable energy and coal technologies. This is not to be understated. The stark “coal” versus “renewables” debate may persist in the media, but it certainly appears from the research conducted in this study and elements of the academic literature that at least professionals have common ground in their perspectives that South Africa is (or can be) technically competent at competing with foreign developers.

Therefore, whether the next IRP update includes or excludes coal power, a large part of the stakeholder group should at least be aligned in their view of the country’s technical ability to follow through with the chosen technology choice. Policymakers need to take heed of this discovery.

Implications of areas of contention

- (1) The first interesting area of contention amongst the Factors was the question of whether Eskom should retrofit its existing coal-fired power plants to make them more efficient and flexible, allowing for the introduction of renewables into the system more easily (22: -1, +4, +1). This, to some extent, contradicts with the literature, as it was a suggestion of Simpson *et al.* (2019) that Eskom should in fact retrofit its plants in line with trends set in Germany and Denmark (Agora Energiewende, 2017). The results of this study therefore don’t align well with some of the literature canvassed. There is however some hope that the second most dominant grouping of participants in this study (Factor 2) strongly support the notion.
- (2) A second interesting discovery is that Factor 2 participants, who were pro-everything ‘clean coal’ and coal remaining in the ESI generally, did not actually take a stance on the statement that Government should not be allowed to intervene in the Integrated Resources Plan (IRP) technology selection process by trying to ‘pick winners’ on ‘strategic’ grounds, whilst the other Factors marginally rejected this notion (23: +1, 0, +2). As mentioned in the introductory paragraphs of this report, Government’s

Policy Position 5 (Department of Energy, 2019, pp. 41), which is confirmed in the IRP 2019, highlights that Government has imposed annual build limits on wind and solar PV in their modelling, in order to make way for other technologies such as coal power. This flies in the face of the latest scientific studies indicating that renewable energy provides the least-cost scenario pathway and has better environmental attributes than coal power (Bischof-Niemz & Creamer, 2018; Ireland & Burton, 2018; Oyewo *et al.* 2019; Vivid Economics, 2016).

The research in the present study found that this statement was a distinguishing statement for Factor 2. The interesting discovery in this regard is that, given Factor 2's strong orientation towards coal power, one would have thought that Factor 2 participants would have shown stronger support of Government's behaviour of intervening in the modelling by setting annual build limits on certain renewable energy allocations in the IRP. Yet this was not the case.

- (3) A final area of contention is that the factors did not all agree about the need for more funding targeted at long-term R&D into 'clean coal' technologies (10: -2, +4, 0). This is contrary to the current surge in academic research around the world into such technologies, especially in other coal dominated economies such as China (Sun *et al.*, 2020; Wang, 2020).

It is noted however that of the five researchers who participated in the present study, four of them significantly loaded on Factor 2. Given this realisation that most of the researchers who were surveyed fall into Factor 2, and given Factor 2's relative strong support for statement no. 10 (above), at least the majority of professional researchers sampled believe that more funding targeted at long-term R&D into 'clean coal' technologies is necessary. This aligns with the research canvassed which indicates that more R&D into 'clean coal' technologies is needed.

5.3 Limitations of the study

The research findings of the present study appeared to have illuminated only one clear area of consensus and three distinct nuanced areas of contention amongst the sampled professionals on the discourse on coal energy's inclusion in the ESI. This was possibly due to the participants not spending sufficient time in considering the Q-sorting process and/or a consequence of some of the Q-statements not having been drafted in a simple manner, which hampered the participants from forming strong and clear opinions.

5.4 Suggestion for further studies

There may therefore be a need to replicate this study in alternative samples of professionals, but with a set of simpler Q-statements and a more intensive Q-sort process. Perhaps, after the COVID-19 public health crisis eventually dissipates, such study could incorporate more face-to-face interviews in order to ensure that participants really engage with the Q-sorting task (Finchilescu & Muthal, 2019, pp. 136).

Notwithstanding the above limitations and suggestions, the findings of this report have nevertheless highlighted key areas of consensus and contention in the debate on the role of coal in the ESI in South Africa. Chapter 6 will now provide an overall conclusion for this report.

CHAPTER 6. CONCLUSIONS & RECOMMENDATIONS

6.1 General conclusions

A systematic study was conducted to explore the perspectives of select individuals from a variety of professional fields within the ESI on the future role of coal as a generation option. The objectives of the research were to: identify and collect as many perspectives as possible of a sample group of professionals engaged in the ESI on the future role of coal as a generation option; and using a Q-Methodological approach, identify clusters amongst the sample professionals, with the hope that the results reveal alternative perspectives to the stark “coal” versus “renewables” narrative portrayed in the media.

The research identified that professionals engaged in the ESI hold three distinct perspectives on the future role of coal. The dominant perspective is a strong disapproval of coal and its future role in the ESI and a strong preference for a renewables dominant energy mix, coupled with a high regard to environmental issues. The next prominent perspective strongly favours coal power and especially ‘clean coal’ technologies. A third seems to show enthusiasm for the economy and protecting jobs, and is somewhat technology-agnostic.

The results brought at least one area of consensus to light: despite their differences as to technology choice, professionals engaged in the ESI hold a common view that South Africa has (or can have) sufficient technical capacity to compete with foreign renewable energy technology developers. Three areas of contention amongst the participants were also uncovered, namely: (1) there are conflicting views whether Eskom should retrofit its existing coal-fired power plants to make them more efficient and flexible, allowing for the introduction of renewables into the system more easily – despite some of the literature reviewed indicating this is a trend abroad (Agora Energiewende, 2017; Simpson, *et al.*, 2019); (2) given Factor 2’s strong orientation towards coal power, one would have thought that Factor 2 participants would have shown stronger support of Government’s continued ability to intervene by capping renewable energy allocations in the IRP – yet this was not the case (the three Factors seemed to

be divided on this point as well); and (3) the professionals are divided in their views on whether South Africa should spend more on long-term targeted R&D investment into 'clean coal' technologies – whereas world-wide trends indicate a surge in interest in new 'clean coal' investments (Sun *et al.*, 2020; Wang, 2020). This is except four research professionals who significantly loaded on Factor 2.

These areas of consensus and contention portray alternative perspectives to the stark “coal” versus “renewables” narrative portrayed in the media. In conclusion, the costs to uncertainty in energy policy planning have significant repercussions on the economy. Future delays in updating the IRP will undoubtedly dampen investment appetite in an energy sector which is critical need of financial injections. The results showed exactly which issues in the coal debate remain contentious. But provide a silver lining for the one clear area of consensus.

Thus, understanding perspectives of those professionally engaged in the ESI and identifying specific areas of consensus and contention has been valuable.

6.2 Recommendation on policy issues

There appears to be significant interest, at least by some professionals engaged in the ESI, in further researching 'clean coal' technologies. This is supported by Yoro and Sekoai (2016, pp. 11) who found that there is a huge potential for the implementation of CCS technologies in South Africa, although they concluded that there are current implementation challenges arising (*inter alia*) from financial barriers and lack of clear policy frameworks. The fact that there is also a surge in world-wide interest in research and development in these technologies (Sun *et al.*, 2020), it is suggested that a further study, which could in some way contribute to the development of clear policy frameworks in the arena of 'clean coal' technologies, is recommended.

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APPENDICES

APPENDIX “A”: INSTRUMENT (Q-SET)

Q-SET

1. New ‘clean coal’ technologies are possibly revolutionary and have the potential to sustain the value of South Africa’s significant coal reserves.
2. South Africa is already a water stressed country. We cannot afford to dedicate any more water to “dirty” coal projects.
3. Coal-fired power generation has a very poor “energy returned on energy invested” (ERoEI).
4. Government should enact protective legislation to regulate coal exports and domestic coal pricing in order to ensure security of coal supply to Eskom.
5. Coal as an energy source is actually “subsidised”, because it does not pay the full environmental cost of its use (such as climate change, land degradation, water use and contamination, etc.).
6. Keeping Eskom’s older coal power stations in operation, despite their failure to meet the required Minimum Emission Standards, is justified in light of the socio-economic imperative of protecting jobs.
7. The negative externalities of coal power disproportionately affect marginalised communities living near coal mines and power stations.
8. Coal projects no longer represent a reliable, safe, investment as many, well-known large banks and financial institutions are refusing to finance coal and many commodity trading firms are withdrawing from coal.
9. ‘Clean coal’ technologies are expensive, add to the enormous resource consumption of coal-fired generation, and either don’t work or make little difference to the harm done to health and the environment.
10. More funding should be targeted at long-term R&D into ‘clean coal’ technologies, as these will be essential in ensuring that South Africa continues to exploit its vast, indigenous coal deposits responsibly and sustainably.
11. It is true that coal jobs are at risk in South Africa, but this is not as a result of the Renewable Energy Independent Power Producers Procurement (REIPPP) programme.
12. When it comes to the ‘just energy transition’, the real choice is not jobs or the environment; it is both or neither. In other words, without an environmentally sustainable solution, there will be no jobs.
13. Coal is no longer a cheap and bountiful resource that can ensure security of supply for the national energy system.
14. The unintended health consequences of coal are often overlooked and is another reason why coal power should be phased out of the energy system, as quick as possible.

15. Coal power requires enormous volumes of water. Considering South Africa is a water scarce country, it is not environmentally sustainable to continue depending on coal for the country's base load power.
16. Given South Africa's world-class wind and solar resources, Government should fast track the renewable energy transition in order to position the country as a preferred investment destination for energy intensive businesses.
17. Social justice is more important than environmental justice.
18. Most of the country's remaining coal resources lie in the Waterberg Coalfield (Limpopo Province), which faces water and rail network constraints. To develop the necessary infrastructure in this region to extract the coal for export or domestic use will lock-in coal in the energy system for a period longer than the country can afford having regard to climate change.
19. The declining investment appetite around the world for new coal-fired power projects is permanent and not a temporary downward shift.
20. The Government should allow market forces to choose the energy technologies and which energy resources to exploit.
21. Lending to coal companies is too risky and could ultimately prove unprofitable when stiffer environmental standards are enforced.
22. Eskom should retrofit its existing fleet of coal-fired power plants to increase their efficiency and flexibility in order to facilitate the addition of fluctuating renewable energy into the system.
23. Government should not intervene in the Integrated Resources Plan (IRP) technology selection process by trying to "pick winners" on "strategic" grounds.
24. Due to grid instability, South Africa's national electricity system will never be able to support a renewables-dominant supply mix.
25. Government and private sector collaboration on providing financial support through the investment in new 'clean coal' technologies, is a sure-way to keep the South African coal mining sector prosperous.
26. There are no viable technology options to make coal environmentally sustainable.
27. South Africa cannot and should not reduce its dependency on coal for primary (base load) energy.
28. The adverse effects of greenhouse gas emissions from coal power on our children and grandchildren is an intergenerational crime.
29. South Africa will never be able to build sufficient technical capacity to compete with foreign renewable energy technology developers so we might as well focus on our strengths - coal power.
30. The reality of climate change requires a rapid response and therefore Government cannot wait for Eskom's coal power plants to reach their end of design life before removing them from service. It is imperative that they retire them early.
31. It is arguably far cheaper to fulfil the shortfall of primary energy requirements from renewable energy and rather seek solutions to distribute this energy in a balanced way to meet customer demand (e. g. assisted by pumped hydro storage, adjusting power-station maintenance schedules and demand side management) than investing in new base load coal.

32. South Africa cannot cling to coal when the rest of the world is moving away from it.
33. South Africa's vast coal deposits cannot be sterilised simply because we have not exploited technological innovations to use them.
34. Flexible gas-fired power stations are the key to South Africa's national electricity system being able to handle large amounts of variable renewable energy. Flexible gas and RE technologies used in tandem present a real alternative to base load coal power.
35. 'Clean coal' and coal conversion technologies are a long way off from commercial and environmental viability (primarily because they are still highly inefficient). Therefore, owing to the high R&D costs required, investing in such technologies will only serve to lock-in coal in the energy system for a longer than the country can afford if we hope to achieve climate change targets.
36. The argument that renewable energy independent power producers (IPPs) are destroying Eskom financially is a gross misrepresentation.
37. There is no reasonable basis for building new coal plants when the technology and costs are clearly in favour of renewables and flexible generation.
38. The critique that renewable power will reduce power system reliability is now debunked.
39. Coal is the source of the most valuable commodity in the South African economy - as it provides low-cost energy.
40. Since South Africa has known coal reserves, coal should remain part of the energy mix in the future.
41. Given the country's high unemployment rate, there cannot be privatisation of state assets at the expense of jobs - even if it would ultimately lead to lower electricity prices.
42. South Africa needs to drastically reduce dependency on coal for primary (base load) energy.
43. The economies of scale for coal technologies are very large. The opposite is true for renewable energy technologies. The latter therefore has the better prospect for true market prices.
44. National electricity supply security can only be achieved through exploitation of domestic coal.
45. The only true ethical solution for the country is to phase out coal.
46. 'Clean coal' technologies are a necessary step towards a more sustainable energy system.

APPENDIX “B”: COVER LETTER TO RESPONDENTS

To: [NAME]

Research study conducted by L Andrews in partial fulfilment of Master’s degree

I am conducting research into professional perspectives on the future role of coal in the South African electricity supply industry, in partial fulfilment of the requirements for the degree of Master of Management in the Field of Energy Leadership at Wits Business School, under the supervision of Dr Gillian Finchilescu.

You have been selected as a respondent in my study.

The study uses Q-Methodology as a research technique, which is a ‘mixed methods’ approach to research in terms of which respondents are asked to rank a set of subjective statements on a grid according to their personal opinions of the statements (from “strongly disagree” to “strongly agree”).

The statements (called ‘Q-statements’) are meant to reflect the full range of views which currently exist on the issue of the future role of coal in the South African electricity supply industry and are subjective (i.e. not necessarily linked to objective facts). They have been sourced from an array of sources, including online news providers (local, national, international), academic and industry specific publications and relevant social media feeds. Enough statements have been chosen to cover the breadth of the issue (i.e. the possible future roles of coal in the electricity supply industry), but also not too many that the sorting task becomes unnecessarily cumbersome.

You will be asked to sort the Q-statements using an interactive electronic survey. **Kindly click on the URL link which will be sent to you undercover of a separate email**, which you may complete at a time and place of your choosing. The process should not take more than 30 to 45 minutes to complete.

Disclaimer and confidentiality

Kindly note:

- There will be no personal costs to you if you participate in this research project.
- You will also not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study.
- Certain personal information about yourself will be requested during the survey process (e.g. gender, age, job title, organisation and professional field), however all such information will be kept strictly confidential.

- Neither your personal data, name of organisation, nor individual responses will be identifiable in the research report, nor disclosed to other participants during the data collection process.
- Please note however that absolute anonymity cannot be 100% guaranteed although every effort will be used to ensure that no personal data, nor any of your specific perspectives gleaned during the interview, will be linked back to you in any way.
- The raw data collected will be stored in a password protected computer and destroyed after two years after the report is finalised and submitted for marking.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0)11 7171408, email hrec-medical.researchoffice@wits.ac.za.

I thank you in advance to agreeing to participate in my study, and greatly appreciate your time and effort in doing so.

Yours faithfully,

Lionel Andrews (Researcher)

Email: andrews.lionel@gmail.com

Dr Gillian Finchilescu (Supervisor)

Email: gillian.finchilescu@wits.ac.za

APPENDIX: "C": ETHICS COUNCIL CLEARANCE CERTIFICATE



SCHOOL OF GRADUATE SCHOOL OF BUSINESS ADMINISTRATION ETHICS COMMITTEE **CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)**

CLEARANCE CERTIFICATE

PROTOCOL NUMBER: WBS/BA2293174/594

PROJECT TITLE

Professional perspectives on the role of coal in South Africa's future electricity supply industry

INVESTIGATOR

Mr Lionel Andrews

SCHOOL/DEPARTMENT OF INVESTIGATOR

MM (Energy Leadership)

DATE CONSIDERED

20 July 2020

DECISION OF THE COMMITTEE

Approved unconditionally

RISK LEVEL

MINIMAL RISK

EXPIRY DATE

30 JUNE 2021

ISSUE DATE OF CERTIFICATE 4 August 2020

CHAIRPERSON

A handwritten signature in black ink, appearing to read "Matshabaphala".

(Dr MDJ Matshabaphala)

cc: Supervisor: Professor Emeritus Finchilescu

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

A handwritten signature in black ink, appearing to be "L. Andrews".
Signature

Date

04 / 08 / 2020

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

APPENDIX “D”: COMPOSITE Q-SORT FOR FACTOR 1

Composite Q-Sort for Factor 1

-5	-4	-3	-2	-1	0	1	2	3	4	5
44	39	41	10	38	18	21	11	19	5	2
27	24	40	33	30	34	31	20	7	16	12
	29	25	46	26	35	28	15	8	42	
			4	22	14	32	37			
			17	1	43	45	36			
				6	13	23				
					9					
					3					

Legend

- Distinguishing statement at $P < 0.05$
- Distinguishing statement at $P < 0.01$
- z-Score for the statement is higher than in all other factors
- ◄ z-Score for the statement is lower than in all other factors
- Consensus Statements

APPENDIX “E”: COMPOSITE Q-SORT FOR FACTOR 2

Composite Q-Sort for Factor 2

-5	-4	-3	-2	-1	0	1	2	3	4	5
26	29	37	21	41	34	19	39	27	10	1
30	45	9	14	2	17	20	25	6	46	40
	13	35	15	8	23	12	24	36	22	
			42	32	3	44	11			
			38	7	28	31	4			
				43	16	33				
					18					
					5					

Legend

- Distinguishing statement at $P < 0.05$
- Distinguishing statement at $P < 0.01$
- ▶ z-Score for the statement is higher than in all other factors
- ◀ z-Score for the statement is lower than in all other factors
- Consensus Statements

APPENDIX “F”: COMPOSITE Q-SORT FOR FACTOR 3

Composite Q-Sort for Factor 3

-5	-4	-3	-2	-1	0	1	2	3	4	5
27	5	43	28	38	31	19	23	36	16	11
26	29	24	13	44	33	14	41	21	42	8
	6	37	3	7	25	22	46	15	1	
			12	30	10	32	18			
			35	4	40	34	45			
				9	17	39				
					2					
					20					

Legend

- Distinguishing statement at $P < 0.05$
- Distinguishing statement at $P < 0.01$
- z-Score for the statement is higher than in all other factors
- ◄ z-Score for the statement is lower than in all other factors
- Consensus Statements