Public Opinion concerning the Feasibility of South Africa meeting its greenhouse gas emission targets

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I. Dedication

First, I am immensely grateful to my creator, Allah (*Subḥānahu wa ta'āla*) for providing me with the opportunity to continue my studies and for sustaining me throughout all my endeavours.

I would like to express my sincere gratitude to my mother, my father, my brother as well as the rest of my family and friends. Their support, prayers and guidance throughout this journey has pushed me to persevere and reach this point.

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III. List of Common Acronyms

AFOLU - Agriculture, Forestry and Other Land Use

BECCS - Biomass Energy with Carbon Capture and Storage

BAU – Business-as-usual

CB – Carbon Budget

CER - Certified Emission Reduction Credits

CT – Carbon Tax

CDM – Clean Development Mechanism

COP21 - Conference of Parties

ETUs - Emission Reduction Units

ETS - Emissions Trading System

EU ETS – European Union Emission Trading System

GCC – Global Climate Change

GHG – Greenhouse Gas Emissions

GGR - Greenhouse Gas Removal

JI – Joint Implementation

LULUCF - Land Use Change and Forestry

MBIs – Market Based Instruments

MRV - Monitoring, Reporting, and Verification

MSR - Market Stability Reserve

MtCO2e - Metric tons of Carbon Dioxide Equivalent

NDC – Nationally Determined Contribution

SET - Sector Emission Targets

tCO2e - Tonne of CO2 Equivalent

IV. Abstract

Climate change and global warming are measurable realities. Developing countries like South Africa are more vulnerable to their impacts due to the country's socio-economic background. The Paris Agreement was adopted to limit the rise of global mean temperatures to 1.5°C above pre-industrial levels. However, with current policy projections and the absence of efficacious mitigation efforts, global temperatures are expected to surpass critical thresholds required for effective climate change management. Thus, achieving lower temperatures would require more ambitious mitigation efforts. The methodology utilized in this dissertation employs a non-random survey of expert opinions on the topic of the feasibility of South Africa meeting its greenhouse gas emission targets. A snowball sampling method was utilized to identify suitable respondents to the survey. The survey reveals about 53% of participants believe that the feasibility of South Africa meeting its emission reduction target by 2030 is quite improbable due to the country's dependence on the coal industry. Participants have expressed concerns about the effectiveness of the country's current carbon tax. They believe it may not lead to the necessary level of emission reductions or foster long-term compliance, primarily due to high tax exemptions and the low level of the carbon tax. Participants argue that enhancing South Africa's mitigation policies should include several mitigation instruments to catalyse emission reduction efforts and facilitate a renewable energy transition which should be done in a just manner. The study shows that expert opinion research could be beneficial for policymakers in advancing climate action. However, achieving this would depend on cooperation and collaboration among a wide array of stakeholders.

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Introduction

Climate change and global warming are both measurable realities but the current literature highlighting the impact of global climate change (GCC) often focuses on high emitting developed countries where emission reductions are urgently needed. However, it is important to consider the effects GCC would have on developing countries as the impact would fall disproportionately on their economies with respect to their water and food security; it may result in significant impacts to their infrastructural development; their health; human settlement developments and various ecosystems (Amusan & Olutola, 2017; Intergovernmental Panel on Climate Change [IPCC], 2018).

In the run up to the 21st Conference of Parties (COP21), several countries conveyed their commitments to address climate change and decrease their greenhouse gas emissions to the United Nations United Nations Framework Convention on Climate Change (UNFCCC). Nationally Determined Contributions (NDCs) were included and outline each country's commitments, targets, and methods to reduce their level of GHG emissions within a specified timeframe. Every party could design their own mitigation strategy while considering their own economic capacities (Wang & Chen, 2019). The Paris Agreement aimed to limit the rise of global mean temperatures to 2°C and increase global efforts to limit warming to 1.5°C above pre-industrial levels (UNFCCC, 2015).

Based on current policy scenarios and the absence of efficient mitigation efforts, global warming is estimated to increase within the range of 2.4°C – 2.9°C above pre-industrial levels by the end of the 21st century (Climate Change Tracker [CAT], 2021). Moreover, current policies are projected to reduce global emissions merely by one third based on a least cost pathway (Rogelj et al., 2016). A significant gap remains between the recently announced NDC pledges by countries like Canada, China, South Africa, and Ukraine relative to their projected emission levels for 2030 (CAT, 2021). The emissions gap for 2023, concerning the achievement of the 1.5°C pathway, has decreased by 14%, equivalent to 3.9 $GtCO_2e$. However, when comparing the required reduction of 26 $GtCO_2e$ by 2030 to global long-term commitments, there remains a deficit of 23 $GtCO_2e$. This highlights a significant gap between what governments have pledged in their NDCs, and their total level of action undertaken to date (Wollenberg et al., 2016; Lima et al., 2020; CAT, 2021; Fekete et al., 2021).

Meeting the 1.5°C compatible pathway would require more ambitious reduction efforts as well as more rapid reductions leading up to 2030 and thereafter. In order to assist these efforts, this would require additional measures such as a more precise framework regarding NDC designs; increased mitigation efforts from developing countries; an updated mechanism to avoid infeasible decarbonisation rates after 2030; the overall decarbonisation of the energy sector with the use of afforestation and reforestation; implementing market-based instruments to enhance a country's GHG reduction efforts; or the implementation of greenhouse gas removal (GGR) technologies and practices (Griscom et al., 2017; Benveniste et al., 2018; Bastin et al., 2019; Zheng et al., 2019; Forster et al., 2020: 2; Burke et al., 2021).

The literature has identified several mitigation instruments that could be used to reduce a country's level of emissions. These policies include implementing renewable energy sources at scale in several sectors while simultaneously implementing market-based instruments (MBIs) such as a carbon tax (CT), an emissions trading system (ETS) or a fuel tax. Thus, to enhance GGR adoption, it has been argued that MBIs such as carbon pricing should be implemented on a larger scale and with more ambitious objectives (Borick et al., 2010; Waller et al., 2020). However, efforts to implement these policies are often complicated by the need to significantly reduce emissions relative to a country's economic capacity and to ensure that the policy-making process is done in an efficient manner.

Climate mitigation can be a complex process which involves many actors such as NGOs, politicians, government, civil society members and citizens, all with their own ideas relating to different ways to tackle GCC. Limited public support for climate mitigation policies has hindered global efforts to adopt effective approaches in a suitable timeframe which could further delay global climate action (Lu & Schuldt, 2016). Stadelmann-Steffen and Eder (2021) argue that recent research emphasises that effective climate change policies could be considered infeasible if they are implemented without a certain degree of public support.

Dong and Olsen (2017) note that under Article 6 of the UNFCCC, public participation is regarded as a key principle for effective climate governance, but this would require the presence of actors capable of ensuring that efficient policies are implemented to meet the desired outcome. Every country should be accountable for its emissions and its efforts to reduce them, regardless of its position as a main contributor or not, to avoid engaging in greenwashing

(Adamkiewicz et al., 2022).[1] Thus, mitigating GCC necessitates a multi-level approach that combines effective policies with collective action and substantial public support, specifically from developing countries. Without this cooperation, global efforts may remain entrenched in the status quo, and countries will struggle to reduce their overall level of emissions.

Out of the top 25 GHG emitting countries, South Africa is ranked as the 12th highest GHG emitter as the country has contributed towards 1.1% of total global emissions (Bekun et al., 2019: 760). A significantly large portion of South Africa's emissions is a direct consequence of the country's reliance on fossil fuel consumption (Mashishi, 2021). This is mainly due to the country's state-owned utility Eskom, which supplies more than 90% of the country's electricity. The company retains its market power as a monopoly provider of energy and it manages the country's transmission grid, thereby exercising its monopsony power by buying variable renewable energy (VER) (Hafner et al., 2019: 121; Lawrence, 2020: 64).

South Africa's method of power generation is an example of a path dependent system with vested interests in preserving the status quo and will continue to be a significant force within the South African economy which makes the renewable energy transition considerably challenging (Ting & Bryne, 2020: 6). However, Eskom has experienced substantial financial issues which led to unreliable energy shortages and inevitably led to the country's electricity supply crisis (Adenle, 2020; Ting & Bryne, 2020: 9).

Since South Africa ratified the Paris Agreement in 2015, the country has committed to reduce its emissions level within the range of 350-420 Metric tons of carbon dioxide equivalent (MtCO2e) including LULUCF for 2030 (Government of South Africa, 2021c). There is a large amount of uncertainty when analysing the adequacy of South Africa's climate mitigation policies relative to the country's energy sector (Tyler, 2020). However, the literature has highlighted that South Africa's mitigation efforts remains insufficient and the country would need to enhance its mitigation capacity to be compatible with the 1.5°C target (Amusan & Olutola, 2017; Gao et al., 2019; CAT, 2021).

This study aims to solicit expert opinions concerning the feasibility of South Africa meeting its GHG emission targets with the use of a non-random survey, utilizing a snowball sampling technique to identify expert respondents to participate in the survey. Similar to Busby and

[1] Greenwashing refers to the practice of falsely advertising environmental commitments or investing more in marketing a green image than genuinely adopting environmentally responsible practices.

Shidore (2017), we focus on the feasibility of mitigation efforts that could significantly reduce or avoid an increase to future emissions. The expert opinion survey highlights the importance of public perceptions when considering large-scale GGR thus, the survey explores certain questions pertaining to energy policy preferences and attitudes towards South Africa's climate mitigation efforts. It should be noted that special focus has been given to market-based instruments since a wide range of literature argues in favour of these methods to catalyse a country's emission reduction efforts (Fujimori et al., 2016; Rosetti et al., 2018; den Elzen et al., 2019; Chen et al., 2020; Dissanayake et al., 2020).

This study uses a mixed method approach to include both qualitative and quantitative methods. The qualitative aspect covered by the expert opinion survey and responses were analysed using thematic coding. This method is employed to reveal different categories mentioned by participants as well as construct and identify different themes within the data (Snodgrass et al., 2020). The study includes two different dependent variables based on one-time bound question and one broad question to identify participant perceptions pertaining to the country's ability to meet its emission reduction targets. Since the dependent variables are ordered categorical variables, an appropriate estimator to use is the ordered logistic regression model. The aim of this paper is to contribute to the literature by exploring South Africa's current mitigation efforts and to highlight potential instruments that could be used to enhance the country's emission reduction efforts.

The results indicate that 53% of participants perceive that it is unlikely that South Africa will meet its emission reduction targets within the desired time frame due to the country's continued reliance on the coal industry. It has been suggested that enhancing South Africa's mitigation policy should include multiple emission reduction instruments in combination with an increased capacity to reduce the country's reliance on Eskom's insufficient power supply. In addition to this, adopting multiple policies simultaneously could increase the country's efforts and boost public support for various measures aimed at addressing climate change policies.

The study shows that climate mitigation policies could utilise expert opinion research to assess the efficacy of different emission reduction instruments. We find that individuals with strong concerns about climate change have indicated that meeting the country's emission reduction target would require collaborative efforts from all interest groups. South Africa needs to invest in more innovative ways of thinking to create more opportunities and share best practices, but

this all depends on the timing of these efforts and how they might translate into efficacious long-term climate practices.

The results highlight that given the country's flawed economic system coupled with Eskom long-standing market power and its resisting efforts to limit the implementation of renewable energy, it is difficult to match a comparable momentum and introduce the latest technologies or developments relative to those observed by other countries in their efforts to reduce emissions. This points to the inadequacy of the country's political capacity as well as the inadequacy of policy requirements that are meant to drive and promote a low carbon society. The country cannot do justice to its mitigation efforts if a significant amount of investment is not increased in education and skills development which should be seen as the driver to creating an inclusive low carbon economy. It is essential that the energy transition addresses the skills mismatch to reduce the portion of the population that might fall into the missing middle because of their limited technical know-how.[2] The government should adopt a bottom-up approach to make green jobs more appealing. This can be achieved through retraining and redeploying the workforce in local areas while gradually decommissioning the coal plants to reduce the country's dependence on fossil fuels in favour of alternative energy sources.

The paper is organised as follows: Section 2 presents a background to South Africa's emission reduction targets relative to its NDC commitments; Section 3 provides an overview of the relevant literature assessing NDC efforts. An extension of the literature review assesses different climate mitigation instruments often employed to reduce GHG emissions. Section 4 provides a country analysis; Section 5 presents the methodology and outlines how the expert opinion survey was conducted, utilizing a snowball sampling technique; Section 6 presents the results; Section 7 provides a discussion of the results.

[2] Policies aimed at addressing the skills mismatch seek to develop initiatives to enhance the education and training system to align with emerging labour market needs and prevent underemployment, particularly when transitioning away from coal-intensive industries.

Background

Between 1990 and 2016, South Africa's greenhouse gas emissions increased by 39% due to the country's reliance on the coal industry (Climate Transparency, 2019). As a result, the country adopted the Integrated Resource Plan which highlights the need to shift away from coal as well as increase the adoption of renewable energy. Diversifying the country's energy composition with renewable energy technologies could encourage sustainable economic growth but this will depend on enhancing the government's political will and its ability to transition away from fossil fuel energy (Zheng et al., 2019).

In accordance with the Paris Agreement, South Africa initially committed to reducing GHG emissions relative to a peak, plateau and decline (PPD) trajectory. The country aims to reduce emissions within the range of 398-614 $MtCO_2e$ over the 2025-2030 period (South Africa, 2016: 6; Amusan & Olutola, 2017; CAT, 2019; Den Elzen et al., 2019). GHG emissions are expected to peak between 2020 to 2025 with a lower limit of 398 (Mt) CO2-eq in addition to an upper limit of 583-614 Mt CO2-eq for 2020 and 2025 respectively (DEA, 2011: 25). This amounts to a reduction of emissions by 34% below business-as-usual (BAU) by 2020 while the 2025 target aims to reduce emissions by 42% below BAU. Between 2025 and 2035, emissions are expected to plateau before its anticipated decline by 2036 thereafter. This long-term goal is to ensure emissions decline within the range of 212-428 MtCO2e including LULUCF, by 2050 and this would be consistent with the country's PPD trajectory (DEA, 2011: 25).

South Africa's pledge aims to cover all sectors economy-wide which includes Agriculture, Forestry and Other Land Use (AFOLU) and six types of GHG emissions. Based on current policies, South Africa's GHG emission level remains above the NDC target range by 50 $MtCO_2e$ annually which amounts to nearly 400 $MtCO_2e$ for the period 2022-2030 (Den Elzen et al., 2019). According to CAT (2019), the country's 2016 NDC has been rated as "highly insufficient" as this is based on the upper end of the NDC range. A "highly insufficient" rating indicates that South Africa's 2030 climate commitment is not consistent with efforts to limit global average temperatures below 2°C, nor is it in line with limiting temperatures to 1.5°C (CAT, 2019). Instead, South Africa's rating is consistent with warming reaching between 3°C and 4°C.

Figure 1: South Africa's Emissions Per Capita vs Final Energy Demand, 1990 – 2030

(CAT, 2022)

Figure 1 above shows the difference between South Africa's projected final energy demand relative to its projected emissions per capita between 1990-2030. We have selected 1990 as the starting year for emissions per capita because each country should have been aware of global climate issues caused by GHG emissions within this period. Per capita CO_2 emissions represents South Africa's historical emission level and current emission level. The figure shows a significant difference between the projected final energy demand per capita and the projected emissions per capita.

Based on the figure above, the projected outcomes for the emissions per capita between 2020 and 2025 indicate an increase to about 10.29 tCO2e and 10.37 tCO2e per capita respectively and decline slightly to 10.23 tCO2e per capita by 2023. Total CO2 emissions has reached 427.92 MtCO2e and accounts roughly 76% above 1990 levels (IEA, 2018). Conversely, the projected outcomes for the final energy demand per capita increases by a minor amount of 52.61-52.62 giga-joules (GJ) between 2020 to 2025 but increases to 53.62 GJ by 2030. This indicates that South Africa's projected emission level is inconsistent with the country's PPD for 2030.

Although various climate mitigation measures have been outlined, the country's climate mitigation contribution remains insufficient (Amusan & Olutola, 2017; CAT 2019; CAT 2022). Given South Africa's central focus on GHG reduction, complete compliance with the Paris Agreement would imply that the economy should be driven by a society that aims to reach a net-zero state. However, since the country remains reliant on consuming fossil fuels, the centrality of clean energy alternatives relative to the country's overall development means that the impact of the transition would have a snowball effect and could impose additional economic costs (Amusan & Olutola, 2017).

On the other hand, NDCs are dynamic, and countries are obligated to improve their mitigation efforts every five years. A decarbonised society could create a wide range of opportunities within the renewable energy sector that could flow into other industries. This transition would require a significant amount of financial and technical know-how since the rapid replacement of coal would require large-scale implementation of GGR technologies such as bio energy, solar innovations, CCS or afforestation as well as market-based instruments (Amusan & Olutola, 2017; Den Elzen et al., 2019). Increasing these efforts could help South Africa meet its NDC targets or help the country go beyond its 2030 commitments.

It should be noted that South Africa has recently strengthened its 2030 targets, thereby improving the country's overall rating to "insufficient" (CAT, 2022). The updated 2030 emission reduction target includes an emissions level of 350–420 MtCO2e (incl. LULUCF) with an upper range that is 31% less than the previous NDC target and a lower range that is 12% less than what has previously been committed (Government of South Africa, 2021c). While the updated NDC indicates an increase to the country's climate ambition, the target remains inconsistent with lowering temperatures between 2°C and 1.5°C. Moreover, South Africa's 2030 fair share target would require substantial improvements and additional mitigation action both in the short and long-run (den Elzen et al., 2021).

Literature Review

Climate change is currently one of the most pressing global issues as it threatens to impact decades of economic growth and development which could put the global population at considerable risk (Zheng et al., 2019). The International Energy Agency (2018) and the World Bank (2019) suggests that a significant level of emissions should be reduced to manage increasing temperatures, but the consequences of climate change and global warming are disproportionately experienced by developing countries. Despite the current causes and expected future impacts of anthropogenic global warming, public attitude as well as large scale global climate mitigation efforts have made minor improvements (Rotman et al., 2020). In order to increase global efforts and limit the increase in temperature, numerous countries have pledged different ways to reduce their overall level of emissions.

Various methods to enhance large-scale GGR have become central to the post-2020 global commitment in the efforts to limit global temperature increases however, Kornek et al. (2020) agree that current global mitigation efforts remain insufficient. Limiting global temperatures below 2°C has become the cornerstone of global policies but the likelihood of achieving GHG reduction targets and attain this goal has been questioned as it seems to be highly unattainable. Questions relating to the course of action, how to achieve these targets and what instruments would be more effective, have been debated within the literature (Forster et al., 2020; Kornek

et al., 2020; Waller et al., 2020; Xu et al., 2020). This makes prioritising a way forward and GHG emission reduction targets quite difficult both at a national scale, and internationally.

Waller et al. (2020) argue that the feasibility of large-scale GGR has often come into question as majority of the literature focuses on the physical, technical, and economic challenges of their implementation. While technological advances are crucial to achieving emission reductions and moving towards a low-carbon society, the transition cannot be achieved without considering how these instruments or policies could impact different societies. Bellamy and Healey (2018) as well as Singh et al. (2020) argue that feasibility assessments could be used as a multidimensional approach and state that they could be used to create a more systematic global climate policy. This ideology could be implemented and used to identify potential knowledge gaps and improve future climate research.

Mildenberger et al. (2016) argue that effective and durable GHG emission reduction policies would require a significant amount of public support thus, understanding expert perceptions should be a key component to climate mitigation efforts. One way to increase salience amongst the public could be with the use of expert opinion survey research. Several studies have used surveys or interviews to try to understand public perceptions relating to GGR technologies and practices (Forster et al., 2020; Waller et al., 2020; Xu et al., 2020). Lujala and Lein (2020) examine participants' personal experiences of climate-related changes and how it has influenced their perception of GCC. The study found that individual observations of environmental changes were linked to higher levels of concern relating to GCC. On the other hand, Huber et al. (2020) finds that climate scepticism or mitigation hesitation could be associated with limited policy support.

Part of the public's ability to understand and adapt to the impacts of GCC will depend on the extent in which citizens support local institutions that implement these mitigation policies (Singh et al., 2017). Busby and Shidore (2017) argue that fragmented government structures may present a challenge for collective climate action. The level of mitigation depends on each government as well as their institutional structures, and whether they are conducive towards enhancing mitigation policies. Nonetheless, whether major economies can meet their GHG emissions targets is a crucial question that poses significant challenges towards the success of the Paris Agreement and NDC commitments.

Den Elzen et al. (2019) compare projected GHG emissions from G20 economies based on their current climate policies relative to those outlined by their NDC targets. The study found that Australia, Canada, Republic of Korea, South Africa and the United States need to enhance their policies as their projected reductions fall short from meeting their NDC targets. Based on current policies, Saudi Arabia and South Africa's emission intensity per unit GDP as well as their emissions per capita are anticipated to increase by 2030 relative to 2015 levels (Den Elzen et al., 2019). Among the G20 countries, only India and South Africa explicitly outline their investment requirements for both mitigation and adaptation actions (Climate Transparency, 2018: 10). However, Den Elzen et al. (2019) argue that even if NDCs were fully implemented, the combined global impact falls short of what is required to achieve the 1.5°C goal.

Wang and Chen (2019) conclude the EU's NDC goal will be achieved if the EU's emission reduction trend continues to decline. According to the study's estimated results, the EU's level of energy-related emissions amounted to 3.48 Gt in 2017 and the expected NDC target range falls between 3.32 – 3.49 Gt. This indicates that the EU's climate mitigation actions are in line with its NDC commitments, and it may be attributed to the implementation of an emission trading system in 2005 as the instrument became a major pillar in the EU's climate mitigation policy. In addition to the carbon price of 10 € per tonne, the EU expects onshore wind power and PV power to be more efficient than coal power generation. If the carbon price increases to 30€ per tonne, then renewable energy technologies are expected to become more competitive in relation to coal power which is a prime example of how these policies could help to assist a country to reach its emission reduction targets while simultaneously lowering a country's reliance on fossil fuel consumption (Wang & Chen, 2019).

According to Gao et al. (2019), if a country's NDC reduction target falls below its required reduction effort range, the country would be rated as "insufficient" with the 2°C compatible limit. If its reduction targets are above its required reduction efforts, then the country would be rated as "sufficient", and its proposals would be considered Paris aligned. Lastly, countries that fall in the middle of their required range would be rated as "moderate" and their efforts would fall between "inadequate" or "sufficient" range (Gao et al., 2019). Based on South Africa's required reduction efforts and its reported targets, the country's climate mitigation rating remains 'insufficient' (CAT, 2019).

The lack of transparency regarding NDC targets and climate mitigation instruments may cause a barrier between government and local citizens (Dong & Olsen, 2017; Singh et al., 2017). To

combat this, Linde (2018) argues that an effective resolution to large-scale collective action problems would depend on a country's government efforts to design efficacious policies. Social acceptance of various policies could play a significant role, but this would require cross-stakeholder communication thereby increasing overall compliance with economic development and global emission reduction goals (Waisman et al., 2019; Singh et al., 2020). Hence, collective action could provide support for adequate policy formation and proper policy implementation in the context of meeting NDC commitments. Engaging with policymakers and the public should be a compulsory component when developing low emission scenarios for each country (Waisman et al., 2019).

1.1. Different policy instruments to reduce GHG emissions.

Pricing carbon pollution is widely recognised as an efficient way to reduce GHG emissions as it captures the external costs of emissions. In turn, this leads to an increase to the price of producing goods and services, causing a decline in the purchasing power of households, thus, reducing their demand (den Elzen et al., 2021). The variety of policies shows how complex global warming is and the challenges posed by the changing climate (Stadelmann-Steffen & Eder, 2021). Hence, numerous countries are considering as well as implementing a diverse mix of policies to reduce their level of GHG emissions in a more cost-effective manner. These policy options include but are not limited to:

- Reducing reliance on fossil fuels and enhancing renewable energy capacities
- Implementing a carbon market and pricing carbon emissions through a carbon tax (CT) or an emissions trading system (ETS)
- Increasing emission reduction projects through the Clean Development Mechanism (CDM)
- Earning emission reduction units (ERUs) from emission reduction projects through Joint Implementation (JI)
- Creating carbon capture and storage (CCS) or biomass energy with carbon capture and storage (BECCS)

According to Fekete et al. (2021: 14) OECD countries have implemented various climate mitigation policies that have helped to reduce their overall level of emissions. This has induced major emitting developing countries to implement similar and more aggressive policies to increase the efforts to reduce their level of GHG emissions. Even if these options are not fully employed, they could still offer many co-benefits which could motivate and support their long-term adoption. Rogelj et al. (2015) state that BECCS are crucial in reducing GHG emissions as these instruments could be used to utilise zero emission renewable energy. This would enable countries to replace their conventional energy sources while simultaneously using negative emission technologies with BECCS. Forster et al. (2020); Guo and Huang (2020) as well as Xu et al. (2020) note that large-scale afforestation and the implementation of BECCS technologies could reduce emission levels and limit the impacts of global warming.

Despite their potential with various emission scenarios, majority of GGR technologies remain in the preliminary stages of development and have not been employed at scale (Guo & Huang, 2020). Similarly, Xu et al. (2020) highlight additional obstacles in implementing CCS technology include a lack of systematic development and planning; limited regulatory systems as well as limited supervision or security and insufficient financial support due to the high costs associated with the necessary energy and equipment required during the capture and storage phases. Utilising CCS could lead to an overreliance on these technologies thereby distracting emitters from the importance of enhancing efforts to lower emissions. Thus, a considerable level of uncertainty and scepticism exists over the efficacy of these approaches when trying to mitigate GCC. However, it is important to encourage R&D within the CCS framework to promote international implementation and cooperation of CCS technology.

1.2. Joint Implementation (JI) and Clean Development Mechanism (CDM)

Joint Implementation (JI) allows countries to meet their emission reduction targets by earning emission reduction units when implementing climate mitigation projects in other countries (Harrison, 2017). In accordance with the UNFCCC, JI may only be undertaken by developed countries that are considered Annex B parties and are subject to caps on their level of GHG emissions while developing countries would not be eligible to implement a JI mechanism. Annex B parties are eligible to earn emission reduction units (ERUs) through the JI mechanism,

but these members are required to provide financial support to encourage developing countries to undertake additional emissions reduction activities (UNFCCC, 2005).

Alternatively, under Article 12 of the Kyoto Protocol, the CDM allows a country with an emission reduction or an emission limitation commitment to implement an emission reduction project (Grubb et al., 1999). The CDM may operate at the multilateral level and has a dual purpose to help developing countries achieve sustainable development goals while reducing emissions when earning certified emission reduction credits (CER) based on each tonne of CO2 equivalent (tCO2e) (UNFCCC, 2011).

One of the reasons relating to the inefficiencies found within CDM projects is a consequence of limited public participation during the policy processes (Dong & Olsen, 2017). In addition, poor stakeholder participation is exacerbated by the fact that NGOs are not as active in the public sphere. This suggests that a large amount of barriers exist which may hinder the incorporation and cooperation of effective stakeholder participation within the CDM mechanism, thereby delaying additional mitigation efforts in the future (Dong & Olsen, 2017). Thus, it is important to increase participation, transparency, and an effective decision-making process within the CDM. Conversely, Dong and Olsen (2017) argue that a significant amount of weakness exists with current CDM rules. The authors argue that a lack of good practice and guidance remains limited since global and local stakeholder regulations are often vague. New climate mitigation instruments such as CTs or ETSs have more stringent stakeholder participation in comparison to the CDM (Dong & Olsen, 2017).

1.3. What Is Carbon Pricing?

Carbon pricing puts a price on carbon pollution and is used as an economic signal to disincentivise as well as reduce the dependence on fossil fuel consumption which simultaneously promotes investments into cleaner energy alternatives (World Bank, 2014). This helps to shift the burden onto carbon emitters and encourages the reduction of carbon emissions globally. Carbon pricing also stimulates clean technology, market innovation and fuelling low-carbon drivers of economic growth (World Bank, 2014). Currently, about 22% of emissions are covered by a carbon price but to date, most carbon prices are inefficient as they are set too low to have a considerable impact on reducing emissions (United Nations, 2021).

There are two main types of carbon pricing: emission trading systems (ETS) and carbon taxes (CT). An ETS allows industries with low emissions to sell their extra allowances to larger emitters (Chen et al., 2020: 1). ETSs can operate at a national level and have transformed carbon emissions into a tradable commodity. This allows countries to sell their excess capacity within a carbon market to countries that have used up their emission targets. The process creates a demand and supply for emission allowances thereby, creating a market price for emissions (Chen et al., 2020: 3). Creating a market price for GHGs helps to ensure that emission reductions will occur thus, improving the marginal costs of carbon emissions and restricts emitters to remain within their pre-allocated carbon budget (Chen et al., 2020: 3).

A CT sets a direct price on carbon by defining a tax rate on GHGs or on the carbon content of fossil fuels (World Bank, 2014). Stiglitz (2016) argues that an efficient carbon price could reflect the social cost of carbon emissions and could increase global mitigation efforts. Furthermore, these efforts could lead to higher investments and revenues collected from a CT which could be used to alleviate other social or economic issues. The choice of the instrument depends on the national and economic circumstances of each country, but choosing a suitable and effective carbon cap or a stable trading price could pose a challenge as it should not lead to a reduction in the regulatory efficiency of the country (Fuss et al., 2018).

Rosetti et al. (2018) compare the effectiveness of market-based instruments (MBIs) relative to non-market-based policies such as command and control mechanisms. One advantage with command-and-control mechanisms is that they are simple to implement but require a significant amount of information which includes a high degree of a country's legislative capacity to monitor these efforts. Climate policies could have regressive distributional impacts that would disproportionately impose excessive costs onto vulnerable industries and low-income households (den Elzen et al., 2021). This increases the need to implement appropriate policies to compensate producers and consumers that would be affected however, carbon pricing could be used to fund these decarbonization policies which could minimise the overall costs to society (Fragkos et al., 2021a as cited in den Elzen et al., 2021; Jotzo et al., 2021).

1.4. Market Based Instruments: Emissions Trading System vs Carbon Taxes

Although these methods reduce carbon emissions, the literature highlights that an ETS is a more economically cost-effective instrument with lower information costs in comparison to a CT (Lin & Jia, 2017: 1522; Zhang et al, 2017: 1860). Based on different country experiences, the existing literature suggests that ETSs could play a significant role in controlling the level of pollution, but the instrument's efficacy depends on the system's design characteristics; the ability of government institutions to monitor the level of emissions and the level of compliance within the trading system (Chen et al., 2020). Implementing an ETS does not come without its difficulties as monitoring, reporting, and verification (MRV) would be required and imposes a certain amount of costs in addition to establishing a carbon market which requires additional infrastructure development such as a market stability reserve (MSR) (Fujimori et al., 2016; Ramstein et al., 2019: 63).[3] Moreover, MRV costs as well as distributional effects could pose as a potential challenge as some firms or sectors may benefit from carbon pricing systems while others could face certain challenges (Joltreau & Sommerfeld, 2019: 454).

At the initial stage of emission reductions, CTs can be used more easily but with the gradual increase of reduction practices, this may not guarantee a maximum level of emission reduction. Acemoglu et al. (2016) note that CTs could encourage the production and innovation of cleaner alternatives if firms are subsidised but simply relying on CTs or delaying intervention could lead to significant welfare costs. Moreover, Chen et al. (2020: 1) argue that under complete information, CTs could prevent negative externalities but if CTs are combined with subsidies, they could improve clean innovation investment.

Shinkuma and Sugeta (2016) compare ETSs with CTs to find that under low entry costs with a certain level of asymmetric information, ETSs are superior to a tax scheme, particularly if the output market is quite large. It should be noted that although ETS systems are more economically efficient, choosing a suitable emission cap or a carbon trading price could pose a potential challenge which could delay its implementation and hinder a country's climate action. Furthermore, whether this price is fixed would affect regulation efficiency (Chen et al.,

[3] An MSR is a quantity-based stabilisation policy and aims to control the volume of carbon emission allowances (EUAs) in circulation.

2020: 6). Hence, carbon trading should be recommended as an alternative climate mitigation instrument due to their overall efficiency.

1.5. Implementation of policy instruments: Developed country perspective

The first ETS was established by the European Union in 2005. The European Union Emission Trading System (EU-ETS) was implemented in 31 countries with the aim to reduce emissions by 43% by 2030 relative to 2005 levels (Shinkuma & Sugeta, 2016: 12; Carlén et al., 2019: 816). The EU ETS covers about half of the carbon emissions of its member states as well as 40% of total GHG emissions. Furthermore, the ETS covers various energy-intensive industries, large electricity and heat producers within the European Economic Area (EEA) as well as more than 13,500 factory installations (Oestreich & Tsiakas, 2015: 295; Carlén et al., 2019: 816).

The EU ETS was set up in different phases, with the initial phase beginning in 2005-2007. Phase II was implemented between 2008 and 2012 while phase III was implemented between 2013 to 2020 (Lopez et al., 2017: 95). According to Ellerman et al. (2016: 96-97) GDP and industrial output increased at an average annual rate of 0.92% and 0.55% between 2004 and 2014 respectively while CO_2 emissions declined at an average rate of 2.1% per capita. During the first two phases, carbon emission allowances (EUAs) were granted freely to European firms but if firms emitted more than what they were permitted, extra allowances had to be purchased in the open market. The penalty for non-compliance was €40 per EUA if they were not surrendered in Phase I and €100 in Phase II (Oestreich & Tsiakas, 2015: 296). Joltreau and Sommerfeld (2019: 455) note that the initial target of reducing emissions by 21% towards the end of 2020 compared to 2005 levels had already been achieved in 2012 and by the end of 2014, emissions declined by 24%. Overall, this scheme led to the emergence of the largest multinational carbon market in the world.

Oestreich and Tsiakas (2015: 294) argued that the EU ETS is the most significant multinational initiative to promote environmental protection and has led to many countries establishing their own carbon markets while others are in the process of implementing similar systems. Many countries have come under pressure when trying to transition to a low carbon economy and with the success of the EU ETS, this has led to the creation of various carbon pricing and

carbon taxing systems across the globe. Additional systems include: the New Zealand ETS, the Australian ETS, the Regional Greenhouse Gas Initiative (RGGI) and California ETS, Québec in Canada and the Republic of Korea.

The Australian two-stage regulatory policy introduced a CT scheme in 2012 and was priced at A$23/tCO2e (Zakeri et al., 2015). However, it was later increased by 5% each year to achieve an emission target 5% below the 2000 level by 2020. The carbon pricing policy contributed to a reduction in emissions between 5-8 million tonnes during 2012 to 2013 in addition to 6-9 million tonnes between 2013 and 2014. This contributed towards an overall decline between 11 and 17 million tonnes during its first two years of operation (Tran et al., 2019: 439). After a three-year fixed-pricing period, the second stage aims to transform the CT into an ETS to include a floating price to allow the market to set the carbon price.

1.6. Implementation of policy instruments: Developing country perspective

China is the second largest economy in the world, and it is the highest carbon emitter which has contributed to significant environmental degradation and has catalysed the impacts of GCC (Lin & Jia, 2017). In 2011, China made a considerable effort to combat this issue by saving energy and reducing its level of carbon emissions with the use of a carbon pricing system. A pilot ETS was implemented in seven cities which included Chongqing, Hubei, Tianjin, Guangzhou, Beijing, Shanghai, and Shenzhen. The ETS covers around 18% of the country's total population and 20% of national GHG emissions (Lin & Jia, 2017). China's efforts in constructing the pilot ETSs are remarkably efficient. Shen and Wang (2019) argue that constructing the pilot ETS took a substantial amount of support from central and provincial climate authorities that had been active with the design and implementation of each system.

In 2017, the Chinese government launched a national carbon trading market to include 31 provincial municipals as well as 7 major industries with the addition of the aviation sector (Shen & Wang 2019: 67). The national ETS would cover 4 billion tons of CO2e which roughly amounts to 50% of China's total emissions. Establishing the carbon market will double global carbon trading volumes which could make carbon trading more attractive to other developing countries (Wang et al., 2019). Lin and Jia (2017: 1512) argue that energy consumption could

decline by 12.8% which is equivalent to 602.02 million tonnes of carbon equivalent (Mtce), while coal consumption is expected to decrease to 453.54 Mtce by 2030. The authors note that coverage has less of an impact on GDP and GHG emissions but seems to have a substantial impact on social welfare, commodity prices, carbon rights, exports as well as imports.

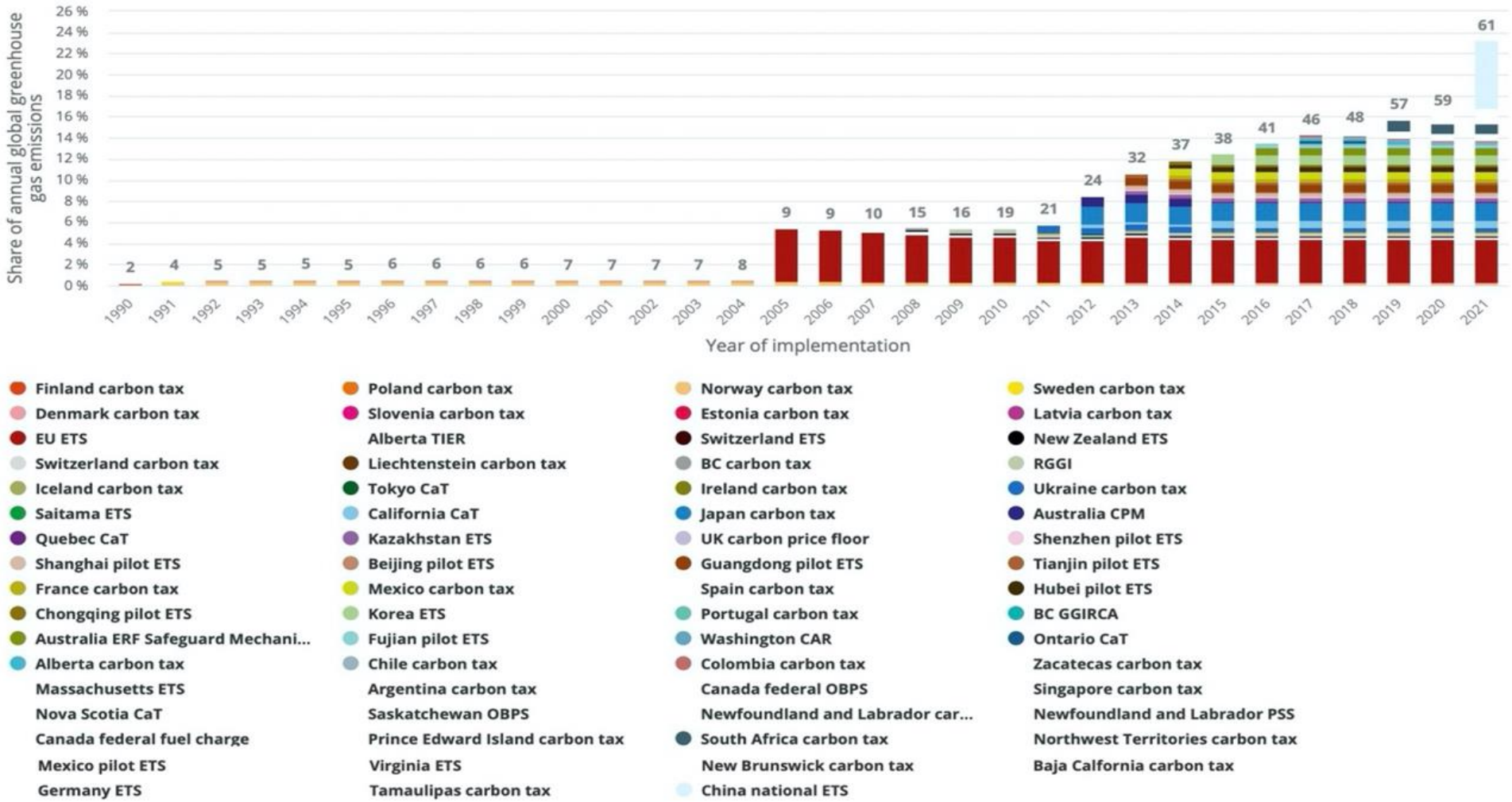
Barragán-Beaud et al. (2018) provide a comparative assessment of different carbon pricing instruments in Mexico's electricity sector. The paper assesses performance in terms of the economic impacts and political feasibility to suggest that an ETS has a higher level of efficiency, indicating that it is the more appropriate instrument for the country's power sector. Given that the government's BAU baseline is 202 $MtCO_2$, Barragán-Beaud et al. (2018: 297) recommend that the cap should be set based on a 31% abatement level relative to the baseline level. The suggested target of a 102 $MtCO_2$ decline by 2030 would lead to more cost-effective reduction potential and lower distributional effects in comparison to the \$15/tCO_2 CT alternative (Barragán-Beaud et al., 2018).

On the other hand, Dissanayake et al. (2020) compare the impacts of a CT, an ETS and a fuel tax to identify which policy instrument could reduce Indonesia's emissions. The fuel tax provided an increase in economic growth by 0.29% whilst the CT and ETS reduced economic growth by 0.11% and 0.12% respectively. The CT and ETS exhibited less of an impact on inflation, wage declines, employment losses and welfare losses in comparison to the fuel tax (Dissanayake et al., 2020). The CT and ETS are more likely to promote the implementation of renewable energy sources given the significant increase in the price of coal under the MBI scenario. Finally, Dissanayake et al. (2020) found that the CT and ETS produced the highest percentage of emission reductions from coal energy while the fuel tax displayed the highest percentage reduction for oil products. Based on these arguments, MBIs appear more attractive and cost-effective due to their revenue generating potential when emission allowances are sold at auctions, which could help compensate for potential losses. However, the amount of revenue generated may vary depending on the rules and regulations governing the system.

Figure 2 below illustrates global carbon pricing initiatives and global GHG emissions covered from 1990-2015. The figure shows global efforts to reduce emissions based on each country's carbon pricing initiatives and shows that ETSs have a larger impact of covering GHG emissions. The EU ETS seems to dominate in terms of its share of annual GHG emissions until 2020, reaching 4% of global emissions. These efforts are followed by Japan's CT in terms of

the amount of global emissions covered between 2011- 2020 but by 2021, China's national ETS contributes towards the largest share of emissions covered. However, various characteristics should be considered such as the design of each instrument; the sectors covered; the price of the CT and the policy implementation of each country as these aspects could play a significant role in each instruments successful ability to reduce GHG emissions (Chen et al., 2020).

Figure 2: Global carbon pricing initiatives and share of global greenhouse gas emissions covered.



(The World Bank, 2020)

1.7. Implementation of policy instruments: Policy mix.

Duan et al. (2018) argue that it is unlikely that China will meet its emission reduction target before 2030 without enhancing its mitigation efforts. If the CT is increased to $90 USD tCO2e, emissions will peak in 2030, 2035 and 2040 with probabilities ranging between 21.2% and 23.9% (Duan et al., 2018). However, the results show that a single carbon pricing policy or a single subsidy cannot guarantee that China will be able to achieve its emissions peak before 2030. In contrast to examples of single mitigation instruments, Cao et al. (2019) examine an ETS that covers the electricity and cement sectors aimed at reducing the carbon-GDP intensity by 60-65% by 2030. In addition to this, a CT could be included in non-ETS sectors to induce burden sharing while the simulation results indicate that a hybrid system could be a beneficial policy mechanism.

When compared to a single ETS policy, Cao et al. (2019) argue that a policy mix would be a more suitable option to help China achieve the proposed emission reduction target with lower GDP losses as well as lower permit prices. Some policy combinations may be indispensable for meeting GHG reduction targets, as suggested by Cao et al. (2019). This includes combining carbon pricing to restrain fossil fuel consumption growth alongside a subsidy to promote the development of alternative energy sources. This is demonstrated once China raises its carbon price to $60 USD and combines it with a 30% renewable energy subsidy. This increases the country's likelihood of achieving its non-fossil energy implementation target by 73.1% (Duan et al., 2018: 15). Hu et al. (2020) are in support with this by adding that a hybrid system could be implemented at a national level, but governments should customise their policy-making process when considering different sectors.

It would be easier for developing countries to follow examples of other developing and developed countries that have successfully implemented carbon pricing mechanisms to obtain mitigation and infrastructural support. This could be used in an international ETS context given the widespread adoption of carbon pricing mechanisms from several countries. As more national and regional ETSs have been established, Fujimori et al. (2016) and Zhang et al. (2017) have argued that countries should integrate their ETSs as an international effort as it could be a cost-effective method and a valuable system that could enable various countries to reach more ambitious emission reduction targets (Fujimori et al., 2016). This could create more abatement opportunities amongst different regions which could lead to the creation of a global

climate mitigation agreement. An international ETS would call for a large network of various stakeholders while simultaneously engaging with local communities (Dong & Olsen, 2017).

Country Analysis

South Africa places 12th out of the top 25 GHG emitting countries and has contributed 1.1% of total global emissions (Bekun et al., 2019: 760). A significantly large portion of its emissions is a direct consequence of the country's reliance on fossil fuel consumption and coal-based energy (Mashishi, 2021). In 2000, South Africa's carbon emission levels increased from 434 MtCO2e to 518 MtCO2e, translating to a 1.6% annual increase (DEA, 2017c). This increase is attributable to the energy sector as it has contributed towards 68% of the country's overall share of emissions in 2012. On the other hand, heavy industry contributed 13% of emissions, transport contributed 9%, agriculture, forestry and other land use contributed 6% and waste contributed about 4% towards the country's overall emissions during the same period (DEA, 2018: 10).

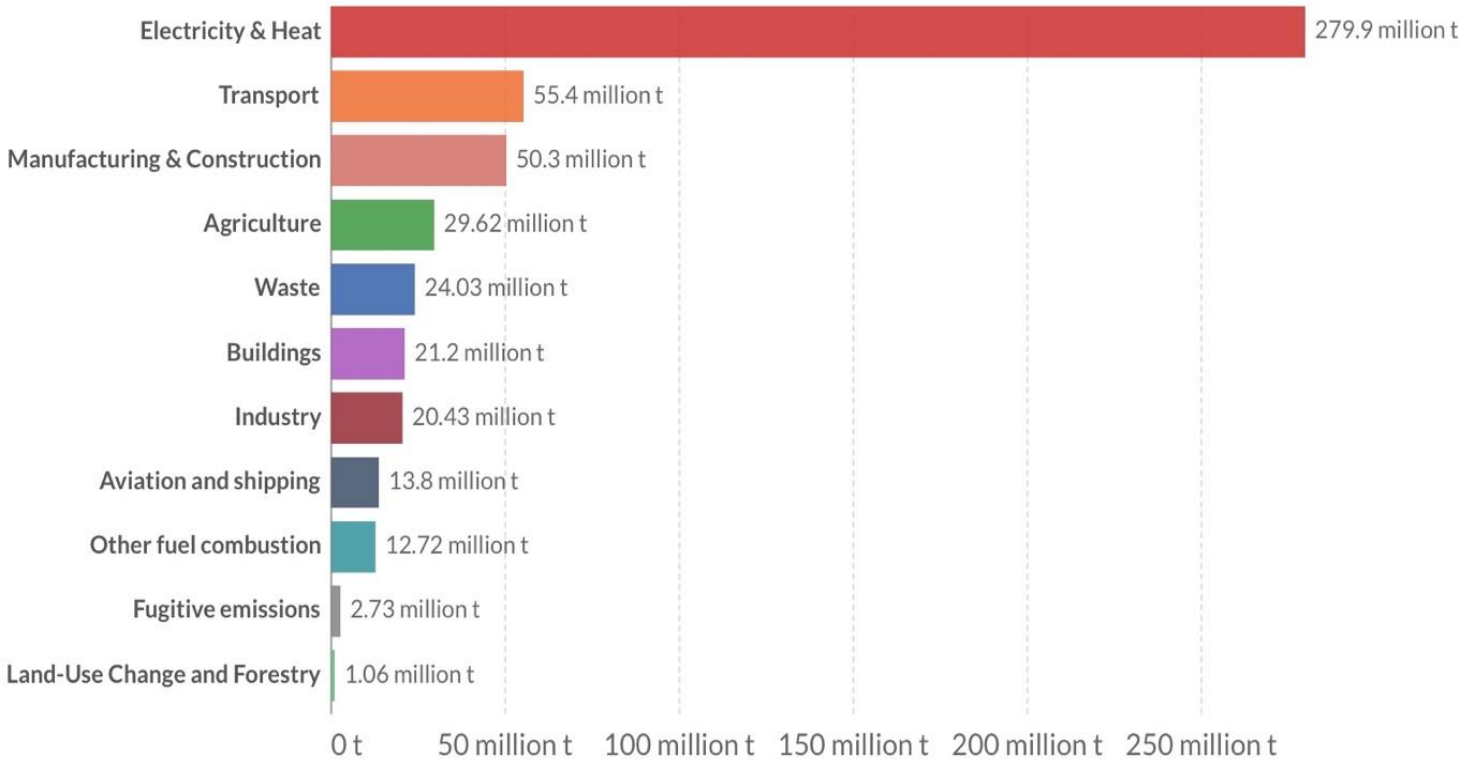
South Africa's annual rainfall has witnessed weaker trends which catalysed the 2017/2018 drought in the Western Cape while in contrast, extreme rainfall events have increased more frequently in other areas. While droughts may not be attributed to a single cause, some contributing factors include climate variability, El Niño, water management, population growth, agriculture and land use, and climate change.[4] South African agriculture faces various challenges due to the change in weather patterns, higher temperatures, and reduction in crop growth (McSweeney & Timperley, 2018). In 2018, South Africa submitted its Third National Communication report and projected that under an intermediate emissions scenario, South Africa is likely to experience an increase in temperature reaching 3-4°C by the end of the century (Department of Environmental Affairs [DEA], 2018).

Figure 3 below illustrates the country's total GHG emissions by sector, which is the sum of all GHG emissions, measured in tonnes of CO2e by sector during 2016 (CAIT Climate Data Explorer, 2016). The figure indicates that South Africa's GHG profile is dominated by

[4] The El Niño-Southern Oscillation (ENSO) is a natural climate phenomenon that can influence weather patterns worldwide which can lead to drier and warmer conditions in some regions, potentially exacerbating drought conditions.

emissions from the electricity and heat sector, followed by the transport as well as the manufacturing and construction sectors. South Africa's energy sector contributes about 80% towards the country's total GHG emissions, with half of these emissions originating from electricity generation and liquid fuel production (Gazette, 2019: 8). It is important that South Africa reduces overall emissions in all sectors, but it is imperative to focus on the electricity and heat sectors by reducing its reliance on fossil fuels as well as to encourage the phase out of coal power generation.

Figure 3: South Africa's greenhouse gas emissions by sector



(CAIT Climate Data Explorer, 2016).

The South African government recognises the urgency of reducing the country's reliance on fossil fuels and aims to move towards a carbon-neutral future. In 2011, South Africa ratified the Paris Agreement leading to the submission of its NDCs which outlined a peak, plateau and decline (PPD) trajectory for future emissions (DEA, 2018: 9). The PPD emissions range

highlights that South Africa committed to reducing GHG emissions between 398 and 614 $MtCO_2e$ over the 2025-2030 period (South Africa, 2016:6).

In 2021, the country updated its NDC targets to include an emissions level ranging between 350–420 MtCO2e for 2030 and this equates between a 3% to 23% increase above 1990 levels excluding LULUCF (Government of South Africa, 2021c). The updated NDC does not reference the PPD trajectory, but the Long-Term Strategy submitted to the UNFCCC in October 2020 refers to the PPD trajectory as a potential benchmark (Republic of South Africa, 2020). Based on current policy projections, emission levels will be 48-52 MtCO2e higher than the upper bound of the updated range by the end of 2030.

CAT (2021) indicates that a substantial gap remains between what governments have pledged and the total level of actions undertaken to date. The new NDC pledge does not include any additional policy-driven emission reductions for emission-intensive subsectors such as steel or mining production. The decade of delaying global mitigation efforts must be compensated by immediate emission reductions but this would require a substantial amount of financial, political, institutional, social support as well as overall behavioural change towards improving the country's mitigation efforts (Ou et al., 2021).

1.8. South Africa's climate mitigation strategies and policies:

Various strategies and policies have been implemented to achieve significant reductions in GHG emissions within key economic sectors. Certain policies were derived to ensure that the country could achieve its low-carbon development agenda, and these include: the Integrated Resource Plan (IRP), the Industrial Policy Action Plan (IPAP), the Green Transport Strategy (GTS), the National Waste Management Strategy (NWMS) and the Climate Change Adaptation and Mitigation Plan (CCAMP) which is specifically aimed at the Agricultural and Forestry Sectors (DEA, 2018: 11).

In 2011, the government published a National Climate Change Response Policy (NCCRP) to provide the country with a strategic approach for climate mitigation and adaption (DEA, 2018: 13). The NCCRP presents a long-term transition to create a climate resilient and internationally competitive low-carbon economy. It outlines a strategic response to climate change within the

context of South Africa's national development goals. The NCCRP emphasises and focuses on issues such as poverty alleviation; economic growth; job creation; improving public and environmental health and creating international economic competitiveness (DEA, 2018: 13).

The Climate Change Mitigation System has been implemented to determine the country's low-carbon development after 2020 (DEA, 2018: 13). The mitigation system will include several measures that have been outlined in the NCCRP. The system is currently underway and has been designed to ensure that the economy is able to meet its NDC commitments. In spite of these objectives, the Climate Change Mitigation System was introduced based on a phase-in process. The first phase was implemented between 2016-2020 which is simply on a voluntary basis (DEA, 2018: 13). The second phase will be implemented on a mandatory basis as part of the Climate Change Bill that will formally be approved by the government after 2020 (DEA, 2018: 14).

The National Climate Change Response White Paper provides the basis for the country's climate change policies, including various principles and objectives relating to South Africa's mitigation potential and its policy initiatives. The White paper includes several policy instruments and measures that could align the country's GHG emissions with the National Benchmark GHG Emissions Trajectory Range (Tyler, 2020). These instruments include an economy-wide CT; Carbon Budgets (CB) to allocate a certain amount of carbon space to individual companies; and Sector Emission Targets (SETs) for key economic sectors but this remains undefined (DEA, 2018: 14). The CB is intended to be implemented on a voluntary basis and thereafter, they would be mandatory post-2020.

The National Development Plan (NDP) aims to eliminate poverty as well as reduce unemployment and inequality by 2030 while simultaneously ensuring that South Africa becomes an environmentally sustainable society. Chapter 5 of the NDP provides a set of guidelines that demands a just transition which is ethical, sustainable as well as transformative for the South African economy (NDP, 2015: 198). The NDP advocates in favour of increasing energy security while enhancing socio-economic as well as environmentally sustainable growth (DEA, 2018: 11). The NDP proposes other climate change mitigation actions to meet the country's environmental sustainability and resilience needs.

Several support programs were implemented in response to the COVID-19 crisis which led to the release of the Economic Reconstruction and Recovery Plan at the end of October 2020

(Government of South Africa, 2021a). The plan includes a wide range of low and high carbon recovery measures with the latter aimed at procuring emergency electricity capacity and the promotion of liquefied petroleum gas (LPG) infrastructure (CAT, 2022). Low carbon measures aim to support energy efficiency and promote low-carbon urban public transport. The South African government included a recovery budget and by August 2022, only 3% of total recovery spending which amounts to $2 billion and roughly 0.69% of GDP was used to fund low carbon measures (Global Recovery Observatory, 2021). In response to the pandemic, CAT (2022) highlights that the South African government missed the opportunity to support the NDP and promote a 'green' recovery initiative.

Based on the information and policies provided above, it is evident that South Africa has implemented various strategies to mitigate climate change and increase its efforts to reduce the country's GHG emissions. According to CAT (2022); Steenkamp and Naudé (2018: 79) as well as Zheng et al. (2019), these efforts are rather vague since these policy initiatives address general sustainable economic development but barely mention climate mitigation targets. Furthermore, these initiatives do not provide definitive measures as to how the country will meet its GHG reduction targets without concrete mechanisms in place.

1.9. Efforts to diversify South Africa's energy composition.

South Africa's energy mix includes 69% of coal which dominates the primary energy supply, followed by crude oil and renewables with 14% and 11% respectively. Nuclear and natural gas both contribute about 3% to the total primary supply of energy (Department of Energy, 2019). Due to electricity constraints, South Africa continues to pursue a diversified energy mix to reduce its reliance on fossil fuels. Diversifying the energy composition would require the increased implementation and use of different renewable energy sources while increasing efforts to decommission the existing coal fleet as it has proven to be unreliable when providing the country with sufficient energy (Gazette, 2019: 11).

The African Development Bank (AfDB) has raised its concerns regarding limiting the environmental effects associated with fossil fuels. The bank has highlighted that using the most appropriate and cost-effective clean technologies is a precondition to accessing their climate funds (African Development Bank Group, 2019). By 2050, it is expected that Africa would

need more than $800 billion annually to adapt to the rising temperatures but having limited resources and a lack of access to climate finance would mean that the country would continue to depend on fossil fuels as its main energy source (Amusan & Olutola, 2017). This would merely lead to the ongoing adoption of ineffective policies and could limit climate funding.

The economic costs associated with the BAU paradigm remains a significant challenge for the country. Transitioning to large-scale renewable energy would require major transformations from all aspects of society. The timing and the manner in which the country transitions to a low carbon economy could pose as a significant issue as the transition must be socially just however, Nascimento et al. (2021) argue that a just transition plan remains underdeveloped. Low carbon investments could create substantial opportunities for value chain localisation, job creation and a significant amount of support towards the coal mining regions.

1.10. Coal

To date, coal remains a crucial source of energy to the South African economy which acts as a major driver to the country's growth and development. In the context of energy intensity, South Africa's per capita consumption is less than that of the United States, which has a per capita usage of 6.4 ktoe (IEA, 2019). However, when compared to the global average of 0.111 ktoe per capita, South Africa's energy intensity remains higher than the world average, amounting to 0.179 ktoe (in 2015 USD PPP). South Africa is the world's 4th largest coal producer, and its sizeable reserves contributes up to 34 million tonnes of coal annually which makes up 90% of the country's power generation (Bekun et al., 2019: 760; Akom et al., 2021). Apart from being the country's main source of electricity generation, in 2012 alone the coal industry contributed more than $1.1 billion in royalties and indirect taxes while employing over 83000 citizens (Amusan & Olutola, 2017). The sector employs fewer workers than it did in the past as it has become more skills intensive in recent years. A large portion of the coal mining work force is highly unskilled but with the industry becoming more technologically advanced, these workers will be left at a considerable disadvantage (Burton et al., 2018: 4). Hence, the country could expect large economic repercussions if the energy transition is not done in a just manner.

Eskom is a state-owned utility, and it is the country's national power supplier. Eskom has dual characteristics as it retains market power from being a monopoly provider of energy and it

owns as well as manages the transmission grid thereby exercising its monopsony power and performs the role of a variable renewable energy (VRE) buyer (Hafner et al., 2019: 121; Lawrence, 2020: 64). It is responsible for more than 90% of the country's electricity generation, roughly 95% of transmission and more than 50% of distribution (Ting & Bryne, 2020: 6). Several industries rely on its electricity supply and approximately 80% of Eskom's electricity consumption and revenue comes from redistributing energy to large mining companies, municipalities, and industries.

Although Eskom distributes a considerably large amount of energy to the country, nearly 14% of South Africans still lack access to sufficient and safe energy while more than a third of the population lack electricity for cooking or heating since off-grid electrification remains negligible within the country (Lawrence, 2020: 2). Hence, South Africa's method of power generation is an example of a path dependent system with vested interests in preserving the status quo making Eskom a Single Buyer Model (SBM) which ensures its continuance as the buyer of future generation capacity (Ting & Bryne, 2020: 8).

Given the nature of Eskom's vertical integration and its monopolistic power, Eskom will continue to employ resistance and remain a significant force within the South African economy (Ting & Bryne, 2020: 6). Eskom's financial issues coupled with its high maintenance costs has put the sustainability of the country's energy supply and the country's ability to transition to a low-carbon electricity system at a considerably high risk. Over the last several years, Eskom has received numerous government bailouts amounting to roughly USD 3.8 billion between 2020 and 2021 (National Treasury of South Africa, 2021) while the current level of debt has surpassed to more than USD 27 billion (Eberhard, 2021b). These financial issues have led to unreliable energy shortages which translates to a steady decline in its power capacity from 90% in 2005 to 70% in 2018 but had fallen below 60% within the first quarter of 2019 (Lawrence, 2020: 1). These energy shortages also known as 'load shedding', were implemented to curb the electricity supply to prevent a total blackout but inevitably led to the country's electricity supply crisis (Adenle, 2020; Ting & Bryne, 2020: 9).

The inability to access electricity due to the inefficient power supply and costly maintenance indicates that the vested interests surrounding Eskom's regime has led to 'cognitive lock-in' as Eskom's monopolistic power has convinced policymakers to maintain the status quo even if it is at the cost of the country's power supply (Ting & Bryne, 2020: 8). Moreover, Eskom's use of its powerful position and its attempts to influence beliefs by threatening the jobs of coal

workers or the closure of coal mines indicates how the state-owned utility has contested the rise of renewables by using the unemployment narrative and exploiting the information asymmetry to influence public policies (Ting & Bryne, 2020: 8). The inadequacy of the country's regulatory framework, along with the absence of effective mechanisms to ensure Eskom's accountability for its inefficiencies, underscores the necessity for cleaner and more cost-effective energy alternatives to fulfil the increasing energy demands of the growing population.

Currently, South Africa has 42GW of operating coal plants with 6GW new coal-fired plants under construction and an additional 3GW in the planning stage however, the existing fleet has been unreliable (McSweeney & Timperley, 2018; Steenkamp & Naudé, 2018: 81). The Medupi and Kusile power stations aim to increase the country's electricity supply with a combined generation capacity of 9,600MW of power but maintaining power plants has become costly and has resulted in time overruns (Breyer et al., 2023). Lawrence (2020: 4) argues that both plants would be responsible for an increase in emissions between 2020 and 2040, with an initial estimated annual level of emissions of 25 million tons of CO2 attributed to each plant. These increased costs, long lead times, unreliable generation capacity, energy security risks and rapidly increasing electricity prices pose major challenges to the coal sector (Steenkamp & Naudé, 2018: 81).

This led to the government releasing the Integrated Resource Plan (IRP) which sets out a least cost plan to expand the capacity of electricity up to 2030 (Kuramochi et al., 2019: 101). From 2025, the plan includes an overall cap on emissions from electricity generation and focuses on reducing its reliance on coal-based business. Consequently, the draft of the IRP intends to decommission 5.4 GW of the older plants by 2022; 10.5GW by 2030 and 35GW coal-fired capacity by 2050 but it excludes the 6GW of coal power currently under construction (IEA, 2019; Ireland & Burton, 2018; Kuramochi et al., 2019: 101). It is important to assess the cost-effectiveness of each option, including building a new plant with modern technology to ensure environmental compliance and sustainability, in comparison to maintain existing coal plants, or evaluating the costs associated with storing low-carbon alternatives. However, this will depend on different circumstances, including the availability of resources, the expected lifespan of each plant, the regulatory environment, and the long-term environmental as well as health considerations.

Burton et al. (2018) argues that the decision to proceed with the new power plants are inconsistent with goals to decarbonise the economy and would create additional economic costs. Moreover, Eskom's monopolistic power not only hinders the country's ability to enhance renewable energy capacity at scale, but it also provides potential implications for policies aimed at adapting technology, infrastructure, or those aimed at finding more sustainable alternatives (CAT, 2022). These issues paired with a lack of progress in recent years; limited political leadership as well as Eskom's unresolved operational and financial problems has led to a significant amount of uncertainty relating to the timely and successful implementation of the IRP and other flagship policies (CAT, 2022).

Relying on coal for electricity generation appears to have reached its logistical, economic, and ecological constraints, exacerbated by Eskom's inefficiencies, resulting in an inconsistent power supply throughout the country (Lawrence, 2020). Based on these reasons, Lawrence (2020: 3) argues that grid decentralisation through increasing renewable energy capacity coupled with effective control mechanisms could produce simultaneous gains for both energy justice and climate justice. By increasing access to safe, clean, and reliable energy, this could reduce energy poverty as well as enhance climate justice within the country. Additional gains through employment creation, uptake of neglected sources such as bioenergy or biogas and subsequently reducing carbon emissions are dependent on enhancing the country's climate mitigation approach.

1.11. Renewable energy

According to Ting and Bryne (2020: 8), the literature surrounding sustainability transitions highlights that change is difficult to achieve due to lock-in and resistance. Hence, increasing renewable energy within the electricity supply mix will reveal numerous challenges, specifically from Eskom and those with vested interests in fossil fuel consumption. Despite the power of coal-based interests and Eskom's efforts to resist the renewable energy transition which inevitably contributed towards the electricity-supply crisis, renewable energy-based power generation has grown in recent years and has reached up to 3.6GW of generation capacity (Ting & Byrne, 2020: 14).

Solar PV, wind and concentrating solar power (CSP) present an opportunity to allow the country to diversify its electrical power generation (Gazette, 2019: 13). South Africa has the largest potential of concentrated solar power, solar PV, and wind in Africa, amounting to 43275 TWh, 42243 TWh and 41195 TWh respectively (Adenle, 2020). Although the country has substantial renewable energy potential, at present renewable energy only contributes towards 2% of the energy mix which is largely attributable to Eskom's monopolistic power by delaying the country's ability to promote and implement alternative energy sources (Lawrence, 2020: 103; Akom et al., 2021). The IRP plans to increase capacity to include 8.4 GW solar, 11.4 GW wind and 0.6 GW concentrated solar power (CSP) which means that renewable energy sources would provide roughly 27% of installed capacity by 2030 (Department of Mineral Resources and Energy, 2018). The transition towards large scale renewable energy is accompanied by several benefits, including improvements in air quality, cheaper electricity, and less environmental effects from the extraction of fossil fuels (Burton et al., 2018).

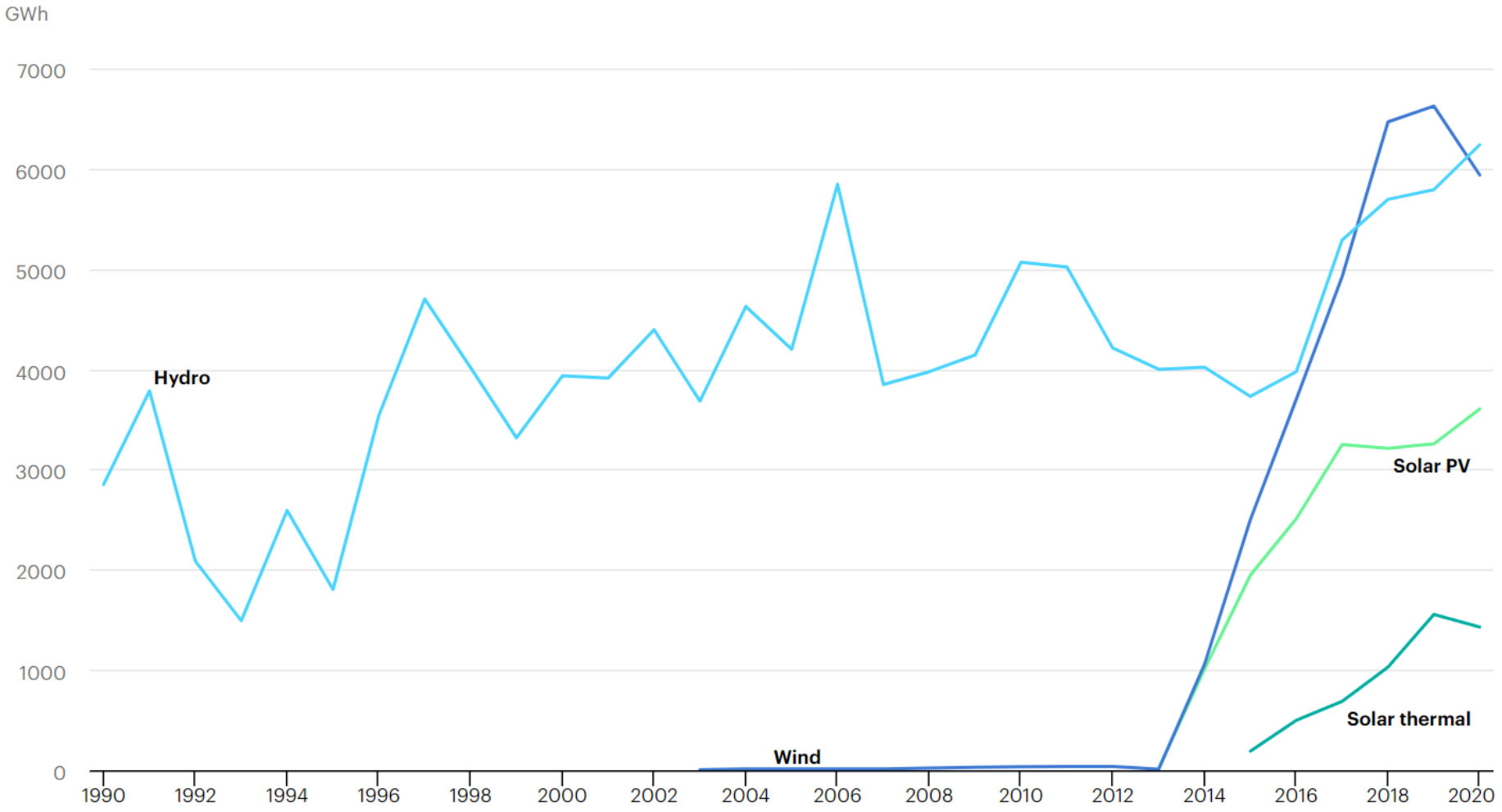
After South Africa became the first African country to install 1 GW of solar PV in 2014, installation has since declined with only 500 MW installed in 2016 and 13 MW installed in 2017. This indicates that the country's plan to install 8.4 GW of solar power by 2030 seems quite ambitious (International Renewable Energy Agency [IRENA], 2015). In addition, the lack of cooperation amongst municipalities regarding solar energy subsidies, this could suggest a substantial weakness in government policy or Eskom's abuse of market power which could delay the introduction of solar energy technologies in vulnerable communities (Adenle, 2020; Bookbinder, 2021; den Elzen et al., 2021).

Figure 4 below shows South Africa's renewable electricity generation by source (non-combustible) between 1990-2020. Hydro power seems to dominate in terms of the amount of electricity it could generate, reaching nearly 5.6 giga watt hours (GWh) (IEA, 2019). According to IRENA (2022), at the end of 2021, installed renewable energy capacity amounted to 10.2 GW. However, this quantity will prove inadequate to fulfil the country's energy requirements after the scheduled decommissioning of coal power stations by 2040, primarily because of the intermittency associated with wind and solar energy. Hence, these renewable energy sources would require adequate storage and generation capacity to ensure a consistent and reliable energy supply. The share of renewable energy would also need to increase by a minimum of 45% by the end of 2030, up to 85% by 2040 and over 90% by 2050 to be compatible with the Paris Agreement and the country's electricity demand (CAT, 2019; 2021).

Burton et al. (2018: 7) note that it is possible for the country to meet its NDC through decarbonising electricity and liquid fuels whilst increasing economic growth. This will depend on rolling out renewable energy on a much larger scale which could promote positive spin-offs in the country. In turn, this could lead to a net positive impact on employment levels, specifically within the energy sector (Ross & Winkler, 2021). Investments in renewable energy coupled with CCS technologies could present a cost-optimal opportunity and reliable energy supply choice for the country (Roff et al., 2020; Wright & Calitz, 2020).

At COP26, South Africa announced the Just Energy Transition Partnership (JETP) which aims to create $8.5 billion of grants from donor countries over the next three to five years to finance the retirement of coal plants, repurpose mining sites while specifically focusing on retraining and supporting coal workers, accelerate the deployment of renewable energy, and support green hydrogen as well as low-carbon transport technologies (Burton, 2022). This partnership would create transformational shifts and create a framework that informs policy making at the nexus of climate action and sustainable development. However, if this is done without collective action and extensive stakeholder consultations; proper government support that encourages stakeholder participation which simultaneously lowers the reliance on Eskom's monopolistic power supply, implementing large scale renewable energy technology would continue to pose significant challenge for the country (CAT, 2022).

Figure 4: South Africa's renewable electricity generation by source, 1990-2020



(IEA, 2020).

1.12. Clean Development Mechanism (CDM)

Over time, South Africa has implemented several CDM projects. Since 2004, South Africa has submitted 360 CDM projects to the Designated National Authorities (DNA) of which, 220 are Project Idea Notes (PINs) and 140 are Project Design Documents (PDDs). Of the 140 PDDs, 90 have been registered as CDM projects by the CDM Executive Board and 15 have been issued with CERs (Department of Mineral Resources and Energy, 2017). The types of projects that have been submitted to the DNA consists of bio-fuels installation, energy efficiency, waste management, co-generation, fuel switching and hydro-power projects (Department of Mineral Resources and Energy, 2017). These projects have been implemented in high emitting sectors such as manufacturing, mining, agriculture, energy, waste management, housing, transport and residential areas.

Figure 5 and 6 (see Appendix A) shows the consolidated number of CDM projects per sector at the PDD and PIN stages. Based on the figures, CDM projects seem to focus on renewable energy initiatives which accounts towards 43-45% of projects followed by energy efficiency initiatives which accounts towards 20% of both PPDs and PINs (Department of Mineral Resources and Energy, 2017). A significantly sparse number of projects are registered, and new projects have not been presented since 2017 hence, it could be argued that these efforts could be used in a more efficient manner. Furthermore, Adenle (2020) notes that despite the efforts to implement CDM projects in Africa, only South Africa, Morocco and Egypt have participated in its implementation, and this may be because of limited institutional capacity as well as the costs associated with administrative and monitoring efforts.

1.13. South Africa's Carbon Tax (CT) and Carbon Offsets

Following international examples, the South African government proposed the implementation of a carbon tax of R120/tCO_2e (US$7/t$CO_2$e) and it is expected to be implemented based on a phase-in scheme (Santikarn et al., 2020). According to the World bank (2015) the CT should be used as a fuel input tax which is based on the carbon content of the amount of fuel used but it would also be used to cover direct GHG emissions from non-energy industrial processed emissions and fuel combustion. The design of an intervention such as CT is not expected to

compromise economic competitiveness as it should minimise the potential negative impact that could be imposed on households. In March 2015, the Partnership for Market Readiness (PMR) governing body allocated a $5 million grant to design and implement South Africa's carbon tax (World bank, 2015).

Opponents of the tax include the steel, construction, transport, and mining industries as these industries would be affected directly by its implementation. It has been argued that this instrument would not be affordable in the long-run and could lead to a lack of compliance over time (Steenkamp & Naudé, 2018: 77). Since it was proposed in 2013, there have been several delays with its implementation due to vested interests and investments in fossil fuels. The South African government proposed the implementation of the tax from the 1st of January 2019, but this was later postponed to 1 June 2019, making South Africa the first African nation to launch a CT.[5] The first phase of the CT will proceed until the 31st of December 2022 while the second phase is expected to be implemented from 2023 (Ramstein et al., 2019: 40).

Currently, South Africa's carbon tax rate has increased to R144/tCO2e (US$9/tCO2e), and it is expected to increase annually by 2% until 2022 but only inflationary adjustments are envisioned after 2022 (Santikarn et al., 2020). While the carbon tax rate has been adjusted, Steenkamp (2022) notes that the first phase of the tax roll-out will be postponed until 2025. Moreover, during the first phase, the CT will only apply to scope one emitters, but a cost-effective transition and 60-95% of tax-free allowances may be applied (Nong, 2020: 2). This initial rate was set relatively low to provide current emitters enough time to transition to cleaner technologies and invest in renewables or energy efficient low carbon alternatives. Furthermore, the CT will be accompanied by revenue recycling measures to minimise the impact within energy intensive sectors as well as the price of electricity during its first phase (Department of Energy, 2019).

The tax is scheduled to provide up to 80% of sectoral coverage and cover emissions that includes: fossil fuel combustion; product use emissions; industrial processes and fugitive emissions from mining (Nong, 2020: 2). The basic tax-free allowance of 60% applies to all taxpayers and companies could receive an additional tax-free allowance of 10% if they outperform their industry's specific GHG emission intensity benchmarks. However, based on

[5] With regards to other African nations, Zimbabwe implemented a fuel levy in the early 2000s, but this is not classified as a market-based instrument. It is a straightforward tax that generates revenue for the government.

CAT (2021) recent analysis, the immediate impact of the CT is likely to be quite limited given the fact that up to 95% of emissions could be exempt during the first phase of the CT's implementation. A significant amount of uncertainty remains relating to the efficacy of this measure to reduce the country's overall level of GHG emissions.

Carbon offsets could be used as a cost-effective method to reduce a company's tax liability as they would be eligible for an offset allowance between 5 to 10% of their emissions or they may be used as a flexibility mechanism to increase tax-free allowances (IEA, 2020). Offsets could also incentivise investment in least-cost mitigation that could deliver emission reductions at a lower cost than the carbon tax. Investing in these mechanisms could help to reduce carbon emissions and contribute towards the national climate mitigation target. Additionally, these mechanisms could encourage the implementation of cleaner energy technologies, energy-efficiency measures and promote research and development into low-carbon solutions (Department of Nation Treasury, 2020). However, according to Szabo (2021), the current carbon tax does not effectively contribute to the country's emission reduction efforts due to the combination of the low levy relative to other international carbon prices as well as generous basic allowances and other available exemptions which includes carbon offset credits.

Methodology

1.14. Conducting an Expert Opinion Survey

The paper uses a non-random expert opinion-based cross-sectional survey. The power of the non-random survey and the use of open-ended questions allows us to obtain expert opinions from stakeholder participation to solicit different views relating to various mitigation instruments that could assist the country in meeting its emission reduction targets. Snowball sampling was implemented to include a wider representation of interests by recruiting additional participants with the assistance of current participants (Ghaljaie et al., 2017; Snodgrass et al., 2020). Snowball sampling helps to minimise the potential impact of researcher bias during the selection process and helps to recruit a well-informed sample regarding climate change issues.

The main objective is to understand public perceptions relating to a variety of climate mitigation instruments and energy related issues that could enhance the country's emission reduction efforts without hindering its economic, environmental or social equity objectives. The survey results will enable us to identify areas for improvement in the country's mitigation efforts based on well-informed opinions. This can help guide our investments in enhancing these efforts by incorporating alternative mitigation instruments and resources before significant expenditures are made (Fujimori et al., 2016).

1.15. Data collection

This survey was administered via email to the sample of participants, utilizing a snowball sampling technique to identify expert opinions on the topic. The survey was conducted using an online questionnaire, consisting of 22 questions, of which 18 questions were based on a Likert scale and 4 were open-ended questions which were recoded and included as multiple mention variables (the full questionnaire may be found in Appendix B). The survey was conducted between October 2020 - January 2021. The introduction of the study was shown on the first page of the questionnaire and participants could either choose to continue, thereby accepting the invitation to participate in the survey, or they could opt out. A reminder was sent every two weeks until the end of the data collection phase as a follow up.

Two separate but similar questions were asked to identify participant perceptions regarding the country's ability to meet its emission reduction targets. The general question does not include a time factor while the other is more specific and is time bound to the future. The reason why the first question is time bound, is to capture specific impacts that could arise when considering the country's emission reduction efforts. The alternative question is more general and does not include a specific time frame which has been included to reveal participant's optimistic or pessimistic views relating to the country's emission reduction efforts. Policy evaluation is a complex issue and the cognitive task of reviewing various policies may be difficult due to various factors that might be affected by timing issues hence, the inclusion of two dependent variables as they both help to explain what potential reasons could prevent the country from meeting these targets now or in the future. These questions relate to question 3 and question 7 from the full questionnaire (this may be found in appendix B).

Specific and time bound to the future: *"How do you assess the likelihood that South Africa will be able to reduce its greenhouse gas emissions within the range of 398-614 MtCO2e between 2030-2050 relative to the business-as-usual (BAU) emissions trajectory?"*

General question: *"Do you think South Africa can achieve its emission reduction targets?"*

Question 3, which is specific, and time bound, relates to the overall GHG emission achievements that have been outlined by South Africa's NDC targets which considers the time factor. On the other hand, question 7 is a broad question which deals with the current GHG emission achievements but does not include a specific time frame attached to it, but this would allow participants to interpret it subjectively and should help to identify what could potentially prevent the country from meeting these targets now. By including these two dependent variables, this will help to make sense of the different outcomes as the results will depend on which choice each participant has made and what they might consider more urgent with regards to meeting these emission reduction targets. Hence, the paper uses question 3 as the main dependent variable but includes question 7 as an alternative analysis.

1.16. Ethical Considerations

Each participant was given a consent form to ensure the anonymity of all responses (see Appendix C for the ethics clearance and Appendix D for the consent form). Upon its introduction, the survey included questions designed to capture basic demographic data such as age, gender, and ethnicity while any personal information obtained was kept confidential and results were reported anonymously. Participating in the study was completely voluntary and any participant could opt out at any time. However, completing the questionnaire implied consent to participate in the study.

1.17. Participants and Stakeholder Groups

During the sampling process, we chose a group of stakeholders from essential sectors who possess expertise in the various climate mitigation tools and techniques presently available. The sample is based on individuals that were identified through a similar process implemented

by Hamilton and Namaganda (2018), using a combination of internet searches, document reviews or nominated by other participants through the snowball sampling method. Incorporating different stakeholders is essential for policymaking as each group interacts at different levels, both on a regional and a global scale which could enhance mitigation efforts (Waller et al., 2020). This collective group could guide and help change the narrative relating to alternative ways in which the country could either enhance or change its climate action efforts in order to make a considerable impact on the country's overall level of emissions in the most efficient manner.

With the use of snowball sampling, participants could include 5 different contact details of additional individuals to include in the survey. It should be noted that the size of the sample increased significantly once additional participants were recommended through the snowball sampling mechanism. During the survey period, 468 survey invitations were sent and at the end of the data collection period, a total of (n=251, 53.6%) responses were collected which makes up the total sample size for the study, while the non-response rate is (n=217, 46.4%).

1.18. Data Analysis

This paper uses a mixed method approach which combines qualitative and quantitative methods. Various opinion-based surveys use Likert scales for their variables therefore, an appropriate estimator to use for analysis is a discrete choice model. The qualitative information obtained from the open-ended questions were analysed during the post coding process to condense and structure the information for analysis purposes (Laumann, 2020). Thematic analysis creates a framework to structure the qualitative data by generating a coding system where codes are grouped into recurrent themes (Arnets et al., 2020; Parameswaran et al., 2020). Structuring the data in this manner helps to create context out of the raw data to enhance the analysis.

In terms of the quantitative aspect of the study, we use the data from the total sample which includes 251 participants. The ordered logistic regression model is a suitable discrete choice model to analyse Likert scale outcomes, and it is this model that we fit to the data. Rating systems are often used in opinion-based surveys where individuals are asked about a certain statement, with response options which are provided based on a Likert scale. The dependent

variable is a single latent variable *y** that is unobservable, which we can only identify once it crosses different response thresholds (Williams, 2016). This means that we do not observe how an individual feels about a statement and we only observe the different categories that are available based on their ranking. Lastly, the threshold values are the ancillary parameters that define the changes amongst different categories of the dependent variable (Williams, 2016).

Specific and time bound to the future: *How do you assess the likelihood that South Africa will be able to reduce its greenhouse gas emissions within the range of 398-614 MtCO2e between 2030-2050 relative to the business-as-usual (BAU) emissions trajectory?*

General Question: *Do you think South Africa can achieve its emission reduction targets?"*

Using a five-point scale, response options for the original dependent variable were coded as extremely likely [1]; somewhat likely [2]; neither likely nor unlikely [3]; somewhat unlikely [4]; and extremely unlikely [5]. The alternative dependent variable has been coded as strongly agree [1]; somewhat agree [2]; neither likely nor unlikely [3]; somewhat disagree [4]; and strongly disagree [5]. Both dependent variables were coded as 1,2,3,4,5 but the mean values do not provide significant values since it is a categorical variable thus, modal categories have been provided for ease of interpretation (see descriptive statistics in table 2).

1.19. Theme Development and Post Coding

We asked a series of questions identifying several mitigation policies, including the promotion of clean energy and which potential policy instruments could help to ensure that the country could achieve its emission reduction targets (see appendix B for the full questionnaire). Some questions were based on each stakeholder's level of knowledge regarding different mitigation instruments. These questions enabled individuals to express their comprehension levels and participants also had the option to suggest additional methods not covered in the survey.

Open-ended questions were analysed during the post coding process which allowed us to observe the information in a thematic manner. Certain sub-themes relate to political capacity, the country's policy mix, policy inconsistencies or low carbon alternatives are similar to those found by Adenle (2020), den Elzen et al. (2021) as well as Lujala and Lein, (2020), and the list

of these responses may be found in tables 4, 6, 7 and 8 in the results section (see appendix E for additional information).

Results

All variable descriptions may be found in table 1 below (see appendix B for the full questionnaire). Table 2 provides the independent variables which summarises the descriptive statistics and includes the number of observations, the modal categories, the standard errors, the minimum, and the maximum observation for each variable. Variables included in table 2 are based on the three-category Likert scale variables that have been collapsed from the original five-category Likert scale variables. Hence the three-category Likert scale variables are used in the regression models. These variables differ from the full questionnaire response options in appendix B. Lastly, table 3 describes the sample demographics of the survey. The sample consists of individuals from academia, consultancy and other services, government, industry, and NGO's. Based on the survey results and the use of snowball sampling, 28.3% of participants were academics (n = 71), just over half of whom were female (n=129, 51.4%), while approximately 58.2% of participants were younger than 30 years of age.

Table 1: Key Variables

Variable	Question asked:
1. Age	*Which age group do you below to? (Range given: 20-29, 30-39, 40-49, 50-59, 60 or older)*
2. Gender	*What gender do identify as? (Given: female, male, I prefer not to answer, other: please specify)*
3. Race	*What is your race? (Given: Asian, Black, Coloured, Indian, White, I prefer not to answer, other: please specify)*
4. Interest Group	*Which group do you belong to? If you belong to several, choose the one to which you are closest?*
5. Effective Efforts	*How effective do you consider South Africa's climate change mitigation efforts?*
6. Increase Mitigation Efforts	*Do you agree that South Africa should try to increase its efforts to reduce its GHG emissions?*
7. NDC Likelihood	*How do you assess the likelihood that South Africa will be able to reduce its greenhouse gas emissions within the range of 398-614 MtCO2e between 2030-2050 relative to the BAU trajectory*
8. GHG Reduction	*Do you think South Africa can achieve its emission reduction targets?*
9. LCS Exist	*Does a low carbon strategy exist in your firm/sector?*
10. LCS Adoption	*How likely is it that your firm will adopt a reduced carbon strategy?*
11. Carbon Market	*How would you assess your understanding of carbon markets?*
12. CT Impact	*Do you think that the carbon tax has had a material impact on your firm/industry?*
13. CT Compliance	*Do you think that the carbon tax could promote overall climate mitigation compliance in the long run?*
14. Reduction Efforts	*How do you think South Africa could achieve its emission reduction targets?*
15. Trade-offs	*What are the potential economic costs or trade-offs of trying to meet GHG targets?*
16. Obstacles	*Overall, what would you say is the biggest obstacle to reducing GHG emissions in South Africa?*
17. Alternative Methods	*In your view, what is the best way that South Africa could meet its COP21 targets?*

Table 2: Descriptive Statistics

Variable	Observations	Mean/ Mode	Std. Dev.	Min	Max
Demographic Variables		**Modal categories**			
1. Age (20-29 years = 0)	251	20-29 years	1.0	0	3
2. Gender (Female = 0)	251	Female	0.6	0	2
3. Race (Coloured = 0)	251	Coloured	1.3	0	5
4. Interest Group (Academics = 0)	251	Academics	1.5	0	4
Likert Scale Variables					
5. Effective Efforts	251	Slightly Effective	0.5	1	3
6. Increase Mitigation Efforts	251	Agree	0.7	1	3
7. NDC Likelihood	251	Unlikely	0.8	1	3
8. GHG Reduction	251	Disagree	0.9	1	3
9. LCS Adoption	251	Likely	0.7	1	3
10. Carbon Market	251	Moderately knowledgeable	0.8	1	3
11. CT Impact	251	Neither agree nor disagree	0.7	1	3
12. CT Compliance	251	Agree	0.9	1	3
Multiple mention Variables					
13. Reduction Efforts	251	Diversify the energy composition	0.8	1	3
14. Trade-offs	251	Increase costs or prices	1.3	1	3
15. Obstacles	251	Political will	1.3	1	3
16. Alternative Methods	251	Change the energy policy mix	1.2	1	3

Table 3: Sample Demographics

Age	**Total: 251**
20-29	146
30-39	56
40-49	29
50 or older	20
Gender	**Total: 251**
Female	129
Male	116
I prefer not to answer	6
Race	**Total: 251**
Asian	10
Black	31
Coloured	88
Indian	51
White	46
I prefer not to answer	25
Interest Group	**Total: 251**
Academia	71
Consultancy or other services	52
Government	27
Industry	67
NGO	34

1.20. Analysis of participant opinions

This section aims to highlight the importance of understanding perceptions of expert opinion surveys that could be used to promote as well as enhance certain mitigation policies. Since participants were able to include a comment after each question, the most common answers were provided in this explanation to understand the basic results of the survey.

Since the dependent variable relates to Question 3 and Question 7, analysing these questions is important to understand the rest of the results first as these variables are the major outcome of interest from the paper. Question 3 indicates that about 52.9% of individuals have a negative outlook of the country's ability to meet its emission reduction targets relative to the 22.7% of individuals that have provided a neutral response. Lastly, the remaining 24.4% of individuals

have a more ambitious outlook to the possibility that South Arica could achieve its NDC commitments. These results reveal an underlying sense of scepticism that exists in relation to the country's ability to meet its emission reduction targets which should be an important outcome to note.

Question 7 asked participants how they would assess the likelihood that South Africa will be able to reduce its greenhouse gas emissions within the range of 398-614 MtCO2e between 2030-2050 relative to the business-as-usual (BAU) emissions trajectory. Overall, nearly 40% do not believe that the country will be able to achieve these targets in comparison to the 38% that have indicated that this could be a possibility while the remaining 22.7% remained indifferent. These questions highlight that majority of participants do not believe that South Africa could reach its emission reduction targets. The deficiency in South Africa's climate action, along with participants' lack of confidence in the country's capacity to decrease its greenhouse gas emissions, underscores the urgency of intensifying the nation's climate mitigation endeavours. Both questions seem to show a significant amount of climate scepticism.

Based on the results of question 1, about 4.8% of participants believe that South Africa's climate mitigation efforts are very effective while 37.5% of participants believe that the country's efforts are moderately effective. About 37% of participants believe that these efforts are slightly effective while 20.7% of participants have indicated that these efforts are ineffective. Beliefs are evenly spread however, none of the participants stated that they believe that the country's mitigation efforts are extremely effective. This indicates that there is significant room for improvement with regards to South Africa's climate mitigation policies.

After analysing the results of question 2, about 70% of participants strongly agreed that South Africa should increase its efforts to reduce its GHG emissions. About 14% of participants strongly disagree that the country should increase its mitigation efforts while 16% noted that they neither agree nor disagree. According to question 4, about 29.8% agreed that increasing these efforts would not compromise real GDP; roughly 40.7% disagreed while 29.5% remain indifferent. This is an important finding and enhances the previous outcomes from question 3 and question 7 as these results indicate that majority of participants are sceptical regarding the country's ability to reach its emission reduction targets. This is in line with to Huber et al.'s

(2020) findings, which suggest that climate scepticism or reluctance towards climate mitigation could potentially impact or impede public support for a country's mitigation initiatives.

According to question 5, about 53.4% responded yes when asked whether a low carbon strategy exists within their firm or industry while the remaining 46.6% responded no. This indicates that nearly half of the participants have stated that their firm or industries are not actively trying to reduce GHG emissions or do not have any climate compliant strategies in place. It is important to note that the selected sample consists of individuals who are knowledgeable about carbon markets, emission reduction methods and/or climate mitigation efforts, given their specific backgrounds, and occupations. Hence, one would expect that a larger number of participants would have selected yes in this case as one would expect these individuals or the companies that they are associated with, to have a low carbon strategy currently in place.

Question 6 asked what is the likelihood that a participant's firm or industry would adopt a low carbon strategy and 72.2% indicated that they would. About 18.3% remained indifferent while 9.5% of participants stated that it is unlikely that their firm or industry would adopt a low carbon strategy. This significant result can be attributed to the participants' collective understanding of the vital necessity for the South African economy to shift towards low-carbon alternatives, particularly in sectors where a significant portion of economic activities involves processes that release substantial carbon emissions. Although many participants have indicated that they would implement a low carbon strategy, this may pose as a challenge given that fossil fuels remain a substantial part of the country's economic system. This makes it difficult to shift from the status quo and may raise concerns if it is an unjust energy transition.

Certain questions like question 8 were aimed at identifying how participants viewed different mitigation efforts and each respondent could suggest various ways in which South Africa could achieve its emission reduction targets. As this was an open-ended question, participants could elaborate and provide their own opinions which were later post-coded into different themes. These themes are comparable to those found by Barragán-Beaud, et al. (2018); Dissanayake et al. (2020) and Waller et al. (2020) as these suggestions incorporate different social, political and environmental aspects which could be affected given South Africa's economic context. A list of responses has been compiled in table 4 below.

Based on the responses below, 23% of the sample indicated that South Africa should adopt effective mitigation targets while 37% indicated that the country should diversify its energy composition to reduce its reliance on fossil fuels. Only 10% stated that the country should increase compliance with regards to its climate mitigation policies. This is based on its legislative compliance to ensure the success of the country's climate mitigation efforts. On the other hand, 13% stated that South Africa should increase education and skills development to increase an overall culture of climate awareness. The remaining 16% indicated that sector integration and collaboration should be emphasised to enhance this goal.

Table 4: List of responses from an open-ended question

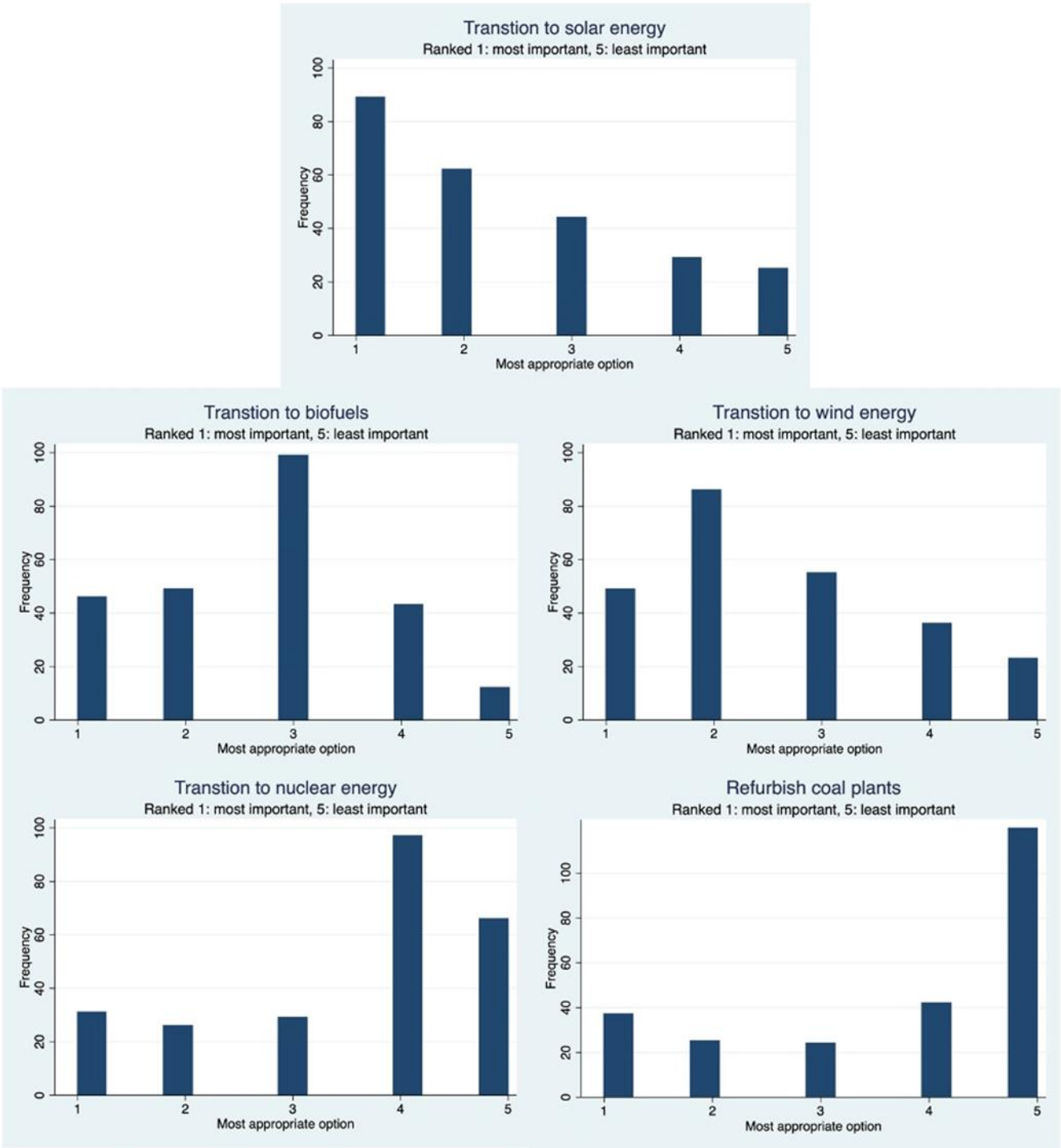
Theme	Total	Overall %
Reduction Efforts		
Adopt and incentivise effective mitigation targets	57	23
Diversify the energy composition	97	37
Increase compliance	24	10
Increase education and skills development	33	13
Sector integration and collaboration	40	16
		100

The survey included various questions that asked participants to rank different policy instruments in terms of their utility. These types of questions were included to assess each instrument's ability to promote and increase the country's emission reduction capacity. Based on a five-point scale, question 12 asked participants to rank energy alternatives that could increase the country's mitigation efforts within the energy sector. These alternatives include efforts to enhance the implementation of biofuel, wind, solar as well as nuclear energy or refurbish the current power plants. Figure 7 below illustrates different variations of individual preferences as chosen by each participant.

The results indicate that many participants are in favour of solar energy, but some respondents have ranked refurbishing the existing coal power stations as the least important. Based on the previous comments outlined within the analysis of participant preferences, many argued that the existing power stations would be able to supply certain sectors with enough energy, but

renewable energy could assist and minimise the load on the current system which could lower the frequency of load shedding.[6] Completely replacing coal with renewable energy would lead to various transition costs.

Figure 7: Energy Ranking



[6] Load shedding was implemented by the country's national electricity company, to curb the electricity supply through planned rolling blackouts based on a rotating schedule.

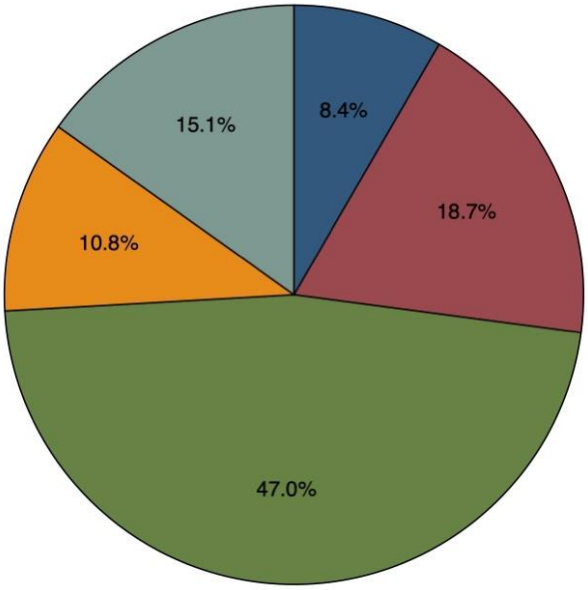
This creates a path of dependency for Eskom, the state-owned power utility, necessitating the ongoing maintenance of the existing fleet to ensure their viability. Due to the high costs associated with maintaining an aging power station coupled with Eskom's financial issues which led to the country's energy shortage, this could pose as a significant issue. Moreover, the contrast between the country's current path dependence on coal energy and the fact that respondents view solar energy as the most appropriate trajectory moving forward could lead to dissonance, which could hinder consumer support in favour of Eskom. However, from a power supply point of view, it may be cheaper and might be more plausible to continue to service the existing coal power stations.

In order to assess public perceptions regarding different market-based instruments, the survey included questions that tried to identify each participant's level of knowledge pertaining to carbon markets and different market-based instruments. Based on question 13, about 41% of participants are moderately knowledgeable while those that are extremely knowledgeable only accounts for 7% of the sample which is considerably low. However, it should be noted that roughly 69% of participants fall within the extremely to moderately knowledgeable range which is higher than the remaining 31% that are not familiar with the intricacies of this type of policy mechanism.

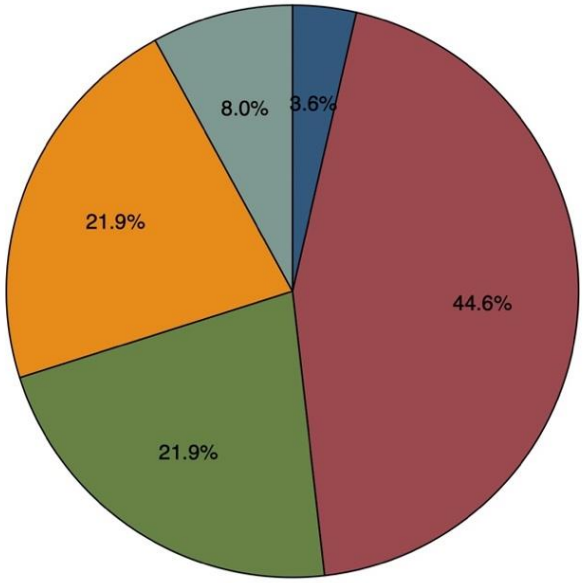
Question 14 asked participants to identify which design characteristic they considered would be more appropriate for a carbon market. Based on the results, 20.3% chose carbon offsets as an appropriate design characteristic while 8.8% chose a carbon price floor and 7.2% chose a price ceiling. In terms of a relative cap on emissions, 18.3% chose this option as their preferred design characteristic and 21.9% of participants opted for an absolute cap on carbon emissions. On the other hand, 12.4% of participants indicated that they did not know which option would be more appropriate while the remaining 11,1% of participants indicated that a combination of characteristics could be appropriate for a carbon market. More specifically, 2% indicated that carbon offsets coupled with an absolute cap on emissions could be implemented while the remaining 2,4% and 6,7% chose between the combination of carbon offsets and a carbon price ceiling or indicated that carbon offsets with a relative cap on emissions could be useful. Based on these results, it is imperative to identify which design characteristic, or the combination thereof would be considered feasible when considering South Africa's economic and environmental situation.

Figure 8: Carbon Tax Assessment

(a) Perceptions of the CT



(b) Perceptions on CT compliance

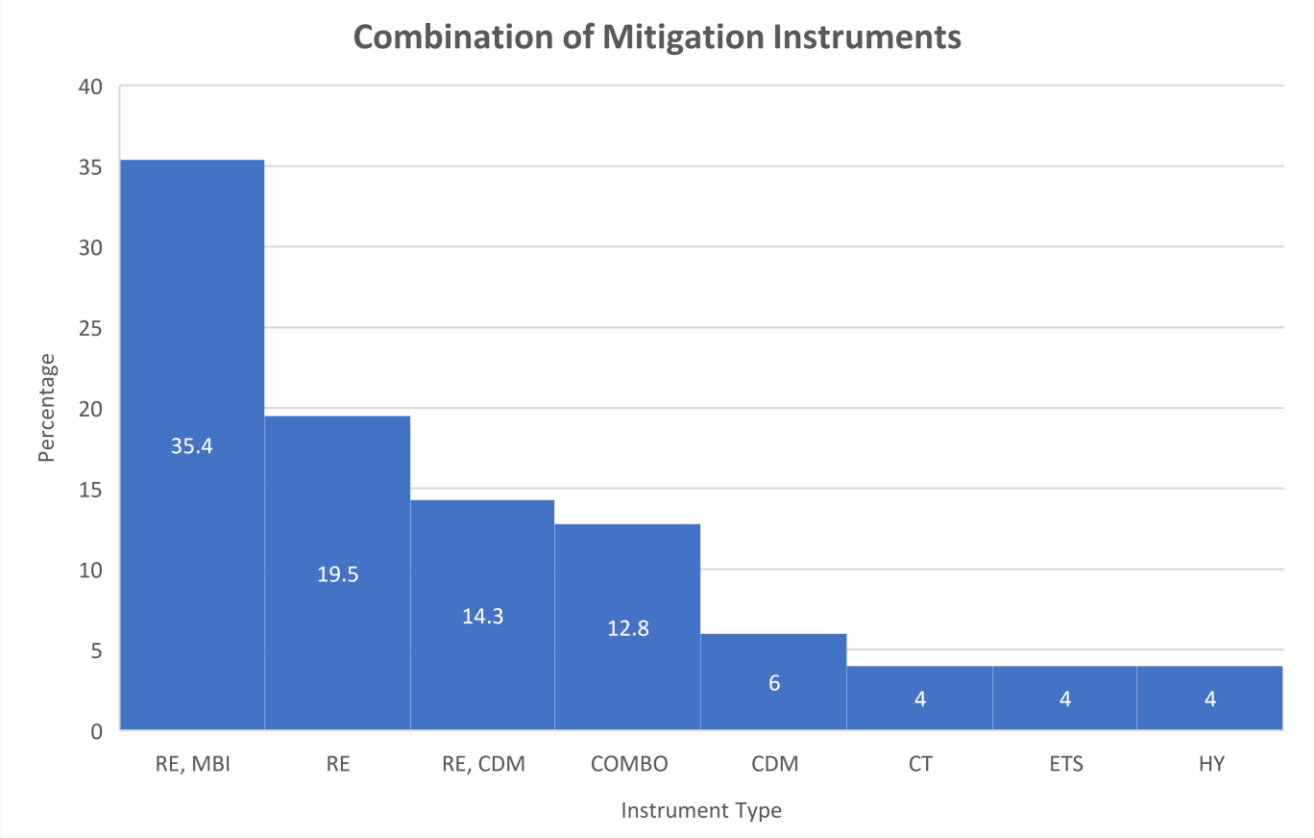


With specific reference to the carbon tax, the survey included questions to identify whether participants believe that the carbon tax is likely to reduce South Africa's GHG emissions and these results are found in figure 8 above. Question 15 asked if participants believed that the carbon tax has had a material impact within their firm or industry and these types of questions are useful to include when trying to identify the feasibility of certain policy instruments. About 47% of participants stated that they neither agree nor disagree while only 27% indicated that they agree to the statement. This result shows that only 27% of participants indicated that the carbon tax has had some impact within their firm or industries while the remaining 26% of participants indicated that their firm or industry has not been impacted by the tax. This result does not provide us with a definitive outcome since majority of participants remain indifferent to this policy choice.

Question 16 asked whether participants believed that the current carbon tax could promote long term compliance. A combination of about 29.9% of participants somewhat and strongly disagreed with the question. On the other hand, when combining strongly agree and somewhat agree, about 48.2% agreed to this statement which indicates that roughly half of the population disagree or remain indifferent while the other half of the population believe that the carbon tax could lead to long-term compliance. Similar to the previous finding, this outcome does not provide us with an overwhelming support in favour of this policy instrument which seems to indicate that there is room for improvement in terms of policy support amongst the general public.

Figure 9 below relates to question 17 pertaining to perceptions surrounding the possibility of implementing a policy mix. All participants were given the opportunity to choose a single policy or multiple policies consisting of renewable energy (RE), clean development mechanism (CDM), (MBI) market-based instruments, hybrid (HY) which consists of an emissions trading system and a carbon tax, or (COMBO) which includes all the instruments provided. In terms of single policies, 19.5% of participants chose renewable energy relative to the CT, ETS, HY or the CDM. Alternatively, renewable energy in combination with an MBI has the highest outcome in terms of a combination of instruments. Based on the overall results, 62.5% of participants stated that a combination of policies may be deemed as the more appropriate option based on the South African context in comparison to a single policy which only accounts towards 37.5% of the overall responses. If considered, this blend combined with additional efforts could help enhance the country's mitigation efforts. This is reinforced by Xu et al. (2020) advocating in favour of a multi-energy complementary system for China's power system. This would include different renewable energy sources such as wind, solar hydro, coal, natural gas, and storage to support and improve the country's power supply, market trading as well as its pricing mechanism through this large-scale integrated approach.

Figure 9: Combination of Mitigation Instruments



Leach et al. (2018) have suggested that climate action projects should address climate risk, poverty, and inequality. The authors argue that countries could combat climate change while simultaneously addressing the alleviation of poverty and inequality. However, the literature often focuses on the economic impacts without considering any social implications or alternative approaches which are often discounted in this regard. Therefore, it was important to include a question relating to the possibility of simultaneously linking these emission reduction efforts with the efforts to reduce poverty and inequality. Thus, based on question 18, about 82% stated that this could be possible while the remaining 18% indicated that this may not be the case for South Africa.

Some participants argued that the government does not have the political capacity to enforce policies that would be able to address these issues simultaneously while others argued that the government would continue to exempt large emitting companies which would minimise the country's mitigation efforts. Jewell and Cherp (2020) have highlighted that it is imperative that governments are transparent in their abilities to act independently from vested interests,

specifically within fossil fuel sectors which could hinder a just energy transition. This may be difficult since the country's national power supplier continues to abuse its market power both as a monopoly energy provider as well as a monopsony renewable energy buyer. This transition would require major reform to the government's political will, Eskom's market power and the country's renewable energy program to ensure that this leads to a just energy transition both from an energy supply perspective as well as an employment perspective. However, Waller et al. (2020) acknowledge the importance of appealing to economic interests of key stakeholders to secure long-term investments in GGR instruments. Thus, it is vital to ensure that key stakeholders could promote clean energy alternatives to reduce the country's reliance on fossil fuel energy.

Leach et al. (2018) argue that progressive revenue recycling from a carbon tax could help to alleviate poverty while avoiding disastrous outcomes of climate change. Hence, reducing energy poverty would be of great importance to the country. This point has been argued by Winkler (2017) as well as Amusan and Olutola (2017), stating that the revenues collected from the carbon tax could be used to fund different programmes that aim to minimise energy poverty within the country. However, South Africa's prohibition of 'ring-fencing' tax receipts may give rise to several challenges, among them the restriction of flexibility in allocating tax revenue (Bayale et al., 2023). Furthermore, this prohibition could lead to decreased transparency in resource allocation and hinder the establishment of specific environmental or social initiatives.[7] Moreover, Ross and Winkler (2021) note that tax revenues could result in a net positive outcome on employment when key climate mitigation policies are implemented simultaneously. Therefore, South Africa's dual challenge to combat development and climate change could be addressed in this manner.

Question 19 asked participants about the potential trade-offs that could arise when trying to reduce GHG emissions and the results may be viewed in table 5 below. About 42% suggested that reducing GHG emissions would result in an increase in costs which could be disproportionately impact low-income earners who currently cannot afford an increase in prices. About 19% stated if this is done without a just transition, this would increase unemployment in coal intensive industries while 15% noted that the overall efforts to reduce

[7] Ring-fencing involves the segregation of tax revenues for a designated purpose, thereby preventing it revenue from being utilized for other government expenditures.

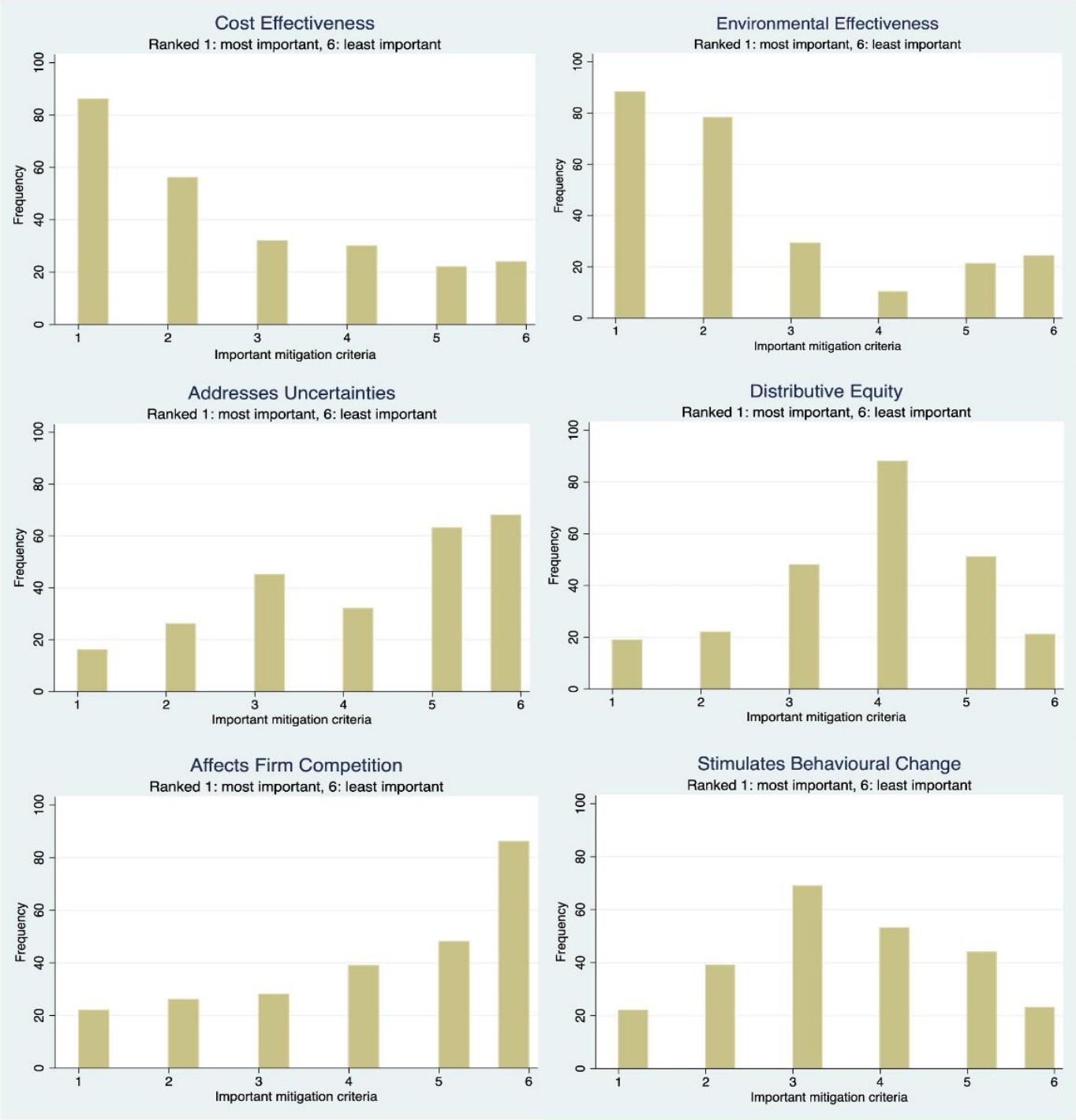
GHG emissions would lead to a lack of compliance due to inadequate monitoring of these policies. Around 14% indicated that this could create conflict between various stakeholders since the creation of a homogenous framework regarding the level of GHG reduction could pose as a challenge. Finally, 10% argued that this would result in the redirection of funds which could lead to additional distribution issues, thereby exacerbating the country's level of poverty and inequality.

Table 5: List of responses from an open-ended question

Trade-offs	**Total**	**Overall %**
Increase in costs/prices	105	42
Lack of compliance	38	15
Redirection of funds	25	10
Conflict between stakeholders	36	14
Increase job loss in coal intensive industries	47	19
		100

Question 20 asked participants to rank mitigation criteria in terms of their level of importance when choosing emission reduction instruments. Mitigation criteria is measured against a six-point scale asking participants to rate each aspect in terms of its level of importance. Figure 10 below indicates variations of individual preferences. Cost effectiveness and environmental effectiveness are ranked reasonably high, but an interesting result shows that participants have ranked 'addresses uncertainty' relatively low. However, the literature has highlighted that a large amount of uncertainty exists when analysing the adequacy of South Africa's climate mitigation policies (Tyler, 2020; Xu et al., 2020). Discounting the level of uncertainty could limit the country's mitigation policies further.

Figure 10: Mitigation Criteria



With regards to Question 21, participants were asked what potential obstacles could arise when trying to reduce emissions and the results may be viewed in table 6 below. About 22% of participants noted that the inconsistency within policy implementation could hinder long term compliance and the efficiency of these efforts. It could be argued that this is true in relation to

the constant delays regarding climate action policies such as the recent delay regarding the implementation of the carbon tax. Similar to Kornek et al. (2020) and Szabo (2021), our participants noted that opposition from vested interests could pose a major obstacle when trying to transition away from fossil fuels. This translated to 19% of participants stating that South Africa's dependence on coal creates a complex scenario and contradicts its climate mitigation efforts (Burton et al., 2018). Furthermore, this could increase resistance when trying to transition towards renewable energy alternatives.

Table 6: List of responses from an open-ended question

Obstacles	Total	Overall %
Coal Dependence	48	19
High transaction costs	37	15
Lack of knowledge regarding mitigation options	43	17
Political will	67	27
Inconsistency within policy implementation	56	22
		100

It should be highlighted that about 17% of participants stated that with regards to the general population, there is a significant lack of knowledge pertaining to different mitigation options. This could create a major issue as it prevents businesses from taking initiative due to the asymmetry of information. About 27% noted that the lack of political will could hinder the country's ability to increase its efforts further. However, these issues could be remedied with the advice taken from the African Development Bank when previously stating that a country could gain access to financial assistance if the most appropriate and cost-effective clean technologies are implemented. Despite this, the African Development Bank's financial support would depend on the government's efforts to increase its political will to transition away from fossil fuel consumption.

Lastly, Question 22 allowed participants to outline the most efficient way that South Africa could achieve its emission reduction targets. Based on table 7 below, roughly 36% acknowledge that the country should change its energy policy mix. However, this outcome

would require a significant amount of structural change and political will. Winkler (2017) highlights that in order to combat energy poverty, it is essential for the country to address its institutional constraints. Capacity building and skills transfer account7% of responses which is important to emphasise given the concern relating to the just transition. Increasing education and training could induce capacity building and skills transfer to communities that would be adversely affected during the renewable energy transition. This could create significant job opportunities within green sectors which could catalyse the decarbonisation of the economy while simultaneously improving public and environmental health. This could create a climate resilient as well as an internationally competitive low-carbon economy which would be in accordance with the country's NCCRP policy (DEA, 2018: 13).

Table 7: List of responses from an open-ended question

Alternative Methods	**Total**	**Overall %**
Capacity building and skills transfer	18	7
Change the energy policy mix	113	45
Improve administrative and monitoring efforts	23	9
Alternative and Responsible investment	54	22
Structural and governmental change	43	17
		100

On the other hand, 17% highlighted that this would require structural and governmental change. Moreover, 45% stated that South Africa should increase and promote investment through alternative and responsible investment opportunities or initiatives while the remaining 9% noted that it is important to improve the country's administrative and monitoring efforts. Ross and Winkler (2021) note that there is significant room for improvement when it comes to reporting socio-economic outcomes, collecting data, and changing national climate mitigation policies. However, to enhance these efforts, all of these suggestions require structural and governmental change. Without good governance and an increase in political will, South Africa's mitigation efforts will not improve. This is supported by Waller et al. (2020) arguing that good governance is one of the main focuses encompassing discussions relating to the efficiency of provisions made for climate policy instruments or the combinations thereof.

Regression Model Results

Our aim is to determine whether there is an association between the likelihood that South Africa will be able to reach its greenhouse gas emission targets relative to some socio-demographic variables as well as other explanatory variables identified in the survey instrument. Since the dependent variables are categorical, an ordinal logistic regression may be run.[8] However, the ordered logistic regression requires the *proportional odds* or *parallel lines* assumption to be met with the use of a *Brant* test. The Brant test is an approximate likelihood-ratio test of proportionality that tries to identify whether the slope is the same for all categories of the response variable and a significant test statistic provides evidence that the parallel lines assumption has been violated (Väisänen, 2022). If this is the case, the ordered logistic regression model is not an appropriate estimator and a multinomial logistic regression model should be used.[9]

The Brant test shows an insignificant result (Prob > chi2 = 0.228). In addition to this, a maximum-likelihood ordered logit estimation was run to test whether the coefficients are equal across categories. The insignificant result (Prob > chi2 = 0. 0742) reinforces the argument in favour of the ordered logit being the correct estimator. Hence, the proportional odds assumption has not been violated and we fail to reject the null hypothesis. This justifies the model choice, and we conclude that we may use the ordinal logistic model.

Once the regressions were run, the results using the five-point Likert scale variables did not have large enough subsample sizes and failed to achieve statistical significance. Hence, all the response options below and above the neutral response from all the five-point Likert scale variables were collapsed into a three-point Likert scale variables to provide us with more robust results. The dependent and independent variables were recoded, and all categories were recoded to likely [1]; neither likely nor unlikely [2] and unlikely [3] for the original dependent variable and all the categories from the alternative dependent variable were recoded as agree [1]; neither agree nor disagree [2]; and disagree [5].[10]

[8] For an alternative interpretation, marginal effects have been included to present the results as differences in their probabilities (see appendix F)
[9] For robustness purposes, a multinomial logistic model was run on both dependent variables (see appendix G)
[10] Each Likert scale variable from the questionnaire is numbered for ease of reference (see appendix B)

Collapsing each category into a three-point scale reduces the dimension of the outcome variable which leads to two effects: (1) it could increase the statistical significance across the explanatory variables as we now have a sufficient sample size; but (2) it could reduce the variation in the response options of the survey from five to three, providing less nuance to the results. However, one limitation with the second effect making this change means that a larger sample size would be required to prevent this effect from having an impact on the results.

To evaluate the effect of the variables with the most parsimonious specification, three ordered logistic regressions were run to show any significant findings which may be viewed in table 8 below. The first model specification is simple as it only includes demographic variables, the second includes demographic variables and all the Likert scale variables and the final model specification is more complex as it includes demographic, Likert scale as well as multiple mention variables which were formed based on the open-ended questions. It should be noted that the first two models would lead to omitted variable bias whereas the final model should lower the omitted variable bias and provide more consistent results.

The output below displays the odds ratio results from the ordered logistic regression with robust standard errors in brackets to correct for heteroskedasticity. All variables were tested based on their level of significance with the use of a Likelihood-ratio (LR) test. The LR test indicates that the model containing the full set of predictions represents a significant improvement in fit relative to a null model [LR $X^2(42) = 70.50$, $p<.001$]. In terms of McFadden's pseudo-R-square, this shows that the full model containing our predictors represents 17% improvement in fit relative to the null model. We have assigned 'neither likely nor unlikely' to be the base category, coded as 2 on the dependent variable; 'likely' is coded as 1 (collapsing "somewhat likely" and "extremely likely" in the questionnaire – see Appendix B); while unlikely is coded as 3 (collapsing "somewhat unlikely" and "extremely unlikely" in the questionnaire).

After testing the correlation between the two dependent variables which relates to question 3 (NDC Likelihood) and question 7 (GHG reduction), the correlation result of 0.621 is reasonably high. Hence, two different regressions were run using both dependent variables which provides us with similar results. Both set of results are plausible, but they change the interpretation as each regression provides us with a different outlook when considered the general dependent variable relative to the time bound dependent variable.

Table 8: Ordered logistic Regression predicting the likelihood that South Africa will be able to reach its greenhouse gas emission targets by 2050.

Likelihood of meeting the Nationally Determined Contributions		Demographic Variables		Demographic and Likert Variables		Demographic, Likert and Multiple mention Variables
Demographic Variables	Coeff.	Std.Error	Coeff.	Std.Error	Coeff.	Std.Error
Age (20-29)						
30-39	1.700	(0.561)	1.355	(0.511)	1.323	(0.565)
40-49	0.668	(0.306)	0.522	(0.266)	0.660	(0.373)
50 or older	1.190	(0.616)	0.776	(0.481)	1.011	(0.664)
Race (Coloured)						
Asian	0.721	(0.405)	0.588	(0.336)	0.605	(0.391)
Black	2.046	(1.063)	1.875	(1.102)	1.651	(1.012)
Indian	0.668	(0.223)	0.485	(0.180)	0.401	(0.164) *
White	1.007	(0.447)	1.074	(0.521)	0.827	(0.403)
I prefer not to answer	1.081	(0.475)	0.781	(0.364)	0.776	(0.429)
Gender (Female)						
Male	2.505	(0.731) **	2.009	(0.709) *	1.592	(0.596)
I prefer not to answer	0.323	(0.261)	0.357	(0.363)	0.354	(0.444)
Interest Group (Academia)						
Consultancy or other services	0.821	(0.314)	0.917	(0.379)	0.977	(0.440)
Government	2.331	(1.127)	2.107	(1.039)	2.564	(1.281)
Industry	1.140	(0.401)	1.288	(0.505)	1.023	(0.445)
NGO	2.626	(1.293) *	3.333	(1.812) *	3.447	(2.135) *
Likert Scale Variables						
Increase Mitigation Efforts (Neither agree nor disagree)						
Agree			1.985	(0.837)	2.391	(1.280)
Disagree			4.323	(2.397) **	4.761	(2.966) *
Effective Efforts (Slightly effective)						
Effective			0.703	(0.456)	1.048	(0.825)
Ineffective			1.677	(0.684)	1.801	(0.801)
Carbon Market (Moderately knowledgeable)						
Not knowledgeable at all			1.139	(0.371)	1.165	(0.436)
Knowledgeable			0.705	(0.244)	0.860	(0.313)
CT Impact (Neither agree nor disagree)						
Agree			0.913	(0.301)	0.961	(0.342)
Disagree			1.819	(0.751)	1.910	(0.860)

CT Compliance (Neither agree nor disagree)						
Agree			1.166	(0.382)	1.043	(0.348)
Disagree			2.919	(1.265) *	2.389	(1.128)
LCS Adoption (Neither likely nor unlikely)						
Likely			0.978	(0.340)	0.846	(0.348)
Unlikely			1.606	(0.890)	1.612	(0.939)
Multiple mention Variables						
Reduction Efforts (Increase education and skills development)						
Adopt and incentivise effective mitigation targets					3.882	(2.009) **
Diversify the energy composition					2.015	(0.847)
Increase compliance					2.289	(1.466)
Sector integration and collaboration					2.370	(1.146)
Trade-offs (Conflict between stakeholders)						
Increase in costs/prices					0.620	(0.315)
Lack of compliance					0.362	(0.197)
Redirection of funds					0.289	(0.178) *
Increase job loss in coal intensive industries					0.360	(0.194)
Obstacles (Lack of knowledge)						
Coal Dependence					1.109	(0.573)
High transaction costs					0.757	(0.371)
Inconsistency within policy implementation					1.604	(0.867)
Political will					1.005	(0.452)
Alternative Methods (Structural and governmental change)						
Capacity building and skills transfer					0.570	(0.305)
Change the energy policy mix					0.751	(0.319)
Improve administrative and monitoring efforts					1.489	(0.871)
Alternative and responsible investment					0.736	(0.322)
Threshold 1	-0.616	(0.306) *	0.267	(0.694)	0.051	(1.108)
Threshold 2	0.527	(0.305)	1.512	(0.679) *	1.406	(1.094)

- *Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively*
- *N=251, Log pseudolikelihood = -212.93905 , pseudo R-squared = 0.1658. Robust standard errors are provided in the table above.*
- *Likert scale reference categories: Age = 0 (20-29 years of age), Race = 0 (Coloured), Gender = 0 (Female), Interest Group = 0 (Academia), Increase Mitigation Efforts= 1 (Neither agree nor disagree), Effective Efforts = 1 (Slightly effective), LCS Adoption = 1 (Neither likely nor unlikely), Carbon Market = 1 (Moderately knowledgeable), CT Impact = 1 (Neither agree nor disagree), CT Compliance = 1 (Neither agree nor disagree)*
- *Multiple mention reference categories: Reduction Efforts = 1 (Increase education and skills development), Trade-offs= 5 (Conflict between stakeholders), Obstacles = 5 (Lack of knowledge), Alternative Methods = 5 (Structural and governmental change).*
- *Threshold values define the changes amongst different categories of the response variable. Threshold 1 indicates the estimated cut-point on the latent variable used to differentiate likely from the neither likely and unlikely **NDC Likelihood** hence, the odds of participants stating that it is likely that South Africa will reach its GHG targets when compared to those who think it is neither likely nor unlikely. Threshold 2 indicates the estimated cut-point on the latent variable used to differentiate likely and neither likely from unlikely **NDC Likelihood,** hence the odds of participants stating that it is unlikely that South Africa will reach its GHG targets when compared to those who think it is neither likely nor unlikely.*

Specification 1: Demographic Variables

With regards to the simple regression model, the main outcome indicates that no age or race group is significantly different from the others, given that all the other variables are held constant. On the other hand, one gender predictor is statistically significant at the 5% level which indicates that males are twice as likely to state that South Africa's chances of reaching its GHG emission reduction targets are likely relative to those who think it is neither likely nor unlikely, when compared to females. Similarly, NGO members are twice as likely to state that South Africa's chances of reaching its GHG emission reduction targets are likely relative to those who think it is neither likely nor unlikely, when compared to academics.[11]

Specification 2: Demographic and Likert Variables

Similar to the first specification, no age group is significantly different from each other. However, one gender predictor and one interest group variable is statistically significant at the 10% level thereby indicating that males are twice as likely to state that South Africa's chances of reaching its GHG emission reduction targets are likely relative to those who think it is neither likely nor unlikely, when compared to females. Moreover, NGO members are three times as likely to state that South Africa's chances of reaching its GHG emission reduction targets are likely relative to those who think it is neither likely nor unlikely, when compared to academics.

In terms of the Increase Mitigation Efforts variable, one predictor is statistically significant at the 5% level. A surprising result indicates that the odds are 4 times higher for participants that have disagreed with regards to the idea of increasing the country's emission reduction efforts when stating that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think it is neither likely nor unlikely. Given the backgrounds of the selected sample, one would expect that participants would have a higher inclination to agree to the idea that the country should increase its emission reduction efforts. One reason that some might disagree to increasing the country's mitigation efforts may be attributed to the fact that it could raise concerns relating to the redirection of funds or wasteful expenditure when trying

[11] Caveat: The demographic variables highlight variations in perception between gender and occupation. From a policy perspective, this could indicate that NGO members are more optimistic relative to academics but the proximity of these individuals to climate mitigation policies could influence their decisions.

something new or innovative. However, Acemoglu et al. (2016) as well as Wang and Chen (2019) note that delaying climate action could lead to significant welfare costs or could increase mitigation costs in the future.

One predictor is statistically significant at the 10% level for the Carbon Tax Compliance variable. The odds are nearly three times higher for participants that have disagreed that the carbon tax could promote long term compliance when stating that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think it is neither likely nor unlikely. This outcome indicates that respondents perceive that the country's current mitigation policies may not promote long term compliance which. This may be a result of the large tax exemptions and the low rate of the carbon tax level which could minimise the overall impact of reducing emissions. This suggests that the country's current climate mitigation instrument may not produce the desired outcome that is required to reach the country's NDC commitments.

Specification 3a: Demographic, Likert and Multiple Mention Variables

The outcomes from the full regression model includes all the variables therefore, these results should take precedence. The main outcome indicates that no age or gender group is significantly different from each other however, one race predictor is statistically significant at the 10% level. This indicates that the associated odds is 40% lower for Indian participants relative to Coloured participants when stating that South Africa's chances of reaching its GHG emission reduction targets are likely, compared to those who think it is neither likely nor unlikely. Lastly, one interest group predictor is statistically significant at the 10% level. Hence, the odds are 3.4 times greater for NGO members relative to academics when stating that South Africa's chances of reaching its GHG emission reduction targets are likely, compared to those who think it is neither likely nor unlikely.

One predictor is statistically significant at the 10% level for the Increase Mitigation Efforts variable. Similar to specification 2, the odds are 4.7 times higher for participants that have disagreed with regards to the idea of increasing the country's emission reduction efforts when stating that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think it is neither likely nor unlikely.

In terms of the multiple mention variables, one Reduction Efforts predictor is statistically significant at the 5% level. The outcome suggests that the odds are nearly 4 times higher for participants that have chosen to adopt and incentivise effective mitigation targets relative to increasing education and skills development when stating that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think it is neither likely nor unlikely.

One Trade-off predictor is statistically significant at the 10% level. The associated odds are 28% lower for participants that have chosen a redirection of funds relative to the potential rise in conflict between stakeholders when stating that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think it is neither likely nor unlikely. One could argue that this negative outcome could be a potential deterrent due the potential uncertainties that are associated with alternative methods and whether redirecting funds to enhance the country's mitigation efforts could have an impact on other sectors.

With regards to all three outcomes, the gender, interest group and Reduction Efforts variable from the multiple mentions list all seem to increase the probability of participants stating that South Africa will reach its emission reduction targets. Consequently, the outcome on the Likert scale variable relating to the idea of increasing the country's mitigation efforts seems to have the largest influence for the second and third model specification. However, the results seem to indicate that there is a negative association as the variable decreases the probability of participants stating that South Africa will reach its emission reduction targets. The results from both models are statistically significant but this provides us with contradictory outcomes as participants have stated that they disagree to the idea of increasing the country's emission reduction efforts. One could argue that factors such as the potential trade-offs that could arise may be a significant deterrent due the uncertainties associated with any alternative policy recommendation.

Lastly, the race, trade-offs and CT compliance variables seem to decrease the probability of participants stating that South Africa will reach it emission reduction targets. These are surprising outcomes as one would expect these variables would provide positive results based on the snowball set of respondents who are more likely to advocate for the adoption of low carbon strategies and different ways to enhance the country's mitigation efforts. Based on majority of the results, it seems that participants are unaware of how efficacious some of the

policy instruments that have been mentioned in this survey are with respect to achieving emission reduction targets. It may be essential to enhance the level of skills and education surrounding alternative climate mitigation instruments as well as within the renewable energy sphere as this would be crucial during the country's energy transition.

The output below displays the odds ratio results from the ordered logistic regression with robust standard errors in brackets to correct for heteroskedasticity. All variables were tested based on their level of significance with the use of a Likelihood-ratio (LR) test. Based on the LR test, this indicates that the model containing the full set of predictions represents a significant improvement in fit relative to a null model [LR $X^2(42) = 82.38$, $p<.002$]. In terms of McFadden's pseudo-R-square, this shows that the full model containing our predictors represents 19% improvement in fit relative to the null model. We have assigned 'neither agree nor disagree' to be the base category, coded as 2 on the dependent variable; 'agree' is coded as 1 (collapsing "somewhat agree" and "extremely agree" in the questionnaire – see Appendix B); while disagree is coded as 3 (collapsing "somewhat disagree" and "extremely disagree" in the questionnaire).

Table 9: Ordered Logistic Regression predicting South Africa's ability to achieve its greenhouse gas emission targets.

Do you think South Africa can achieve its emission reduction targets?	**Demographic, Likert and Multiple mention Variables**	
Demographic Variables	Coeff.	Std.Error
Age (20-29)		
30-39	0.773	(0.306)
40-49	0.600	(0.334)
50 or older	0.899	(0.651)
Race (Coloured)		
Asian	0.295	(0.226)
Black	2.192	(1.238)
Indian	0.586	(0.234)
White	0.791	(0.374)
I prefer not to answer	0.623	(0.344)
Gender (Female)		
Male	1.634	(0.609)
I prefer not to answer	0.134	(0.190)
Interest Group (Academia)		
Consultancy or other services	0.837	(0.339)
Government	1.677	(0.999)
Industry	0.760	(0.318)
NGO	1.262	(0.709)
Likert Scale Variables		

Increase Mitigation Efforts (Neither agree nor disagree)		
Agree	0.901	(0.473)
Disagree	2.022	(1.201)
Effective Efforts (Slightly effective)		
Effective	0.507	(0.469)
Ineffective	1.653	(0.609)
Carbon Market (Moderately knowledgeable)		
Not knowledgeable at all	0.872	(0.308)
Knowledgeable	0.721	(0.288)
CT Impact (Neither agree nor disagree)		
Agree	0.587	(0.244)
Disagree	1.371	(0.568)
CT Compliance (Neither agree nor disagree)		
Agree	0.393	(0.144) *
Disagree	1.606	(0.704)
LCS Adoption (Neither likely nor unlikely)		
Likely	0.586	(0.242)
Unlikely	1.127	(0.690)
Multiple mention Variables		
Reduction Efforts (Increase education and skills development)		
Adopt and incentivise effective mitigation targets	3.358	(1.765) *
Diversify the energy composition	2.073	(0.994)
Increase compliance	2.117	(1.402)
Sector integration and collaboration	1.622	(0.923)
Trade-offs (Conflict between stakeholders)		
Increase in costs/prices	1.368	(0.636)
Lack of compliance	0.748	(0.379)
Redirection of funds	0.428	(0.235)
Increase job loss in coal intensive industries	0.501	(0.295)
Obstacles (Lack of knowledge)		
Coal Dependence	0.269	(0.129) **
High transaction costs	0.449	(0.238)
Inconsistency within policy implementation	0.702	(0.371)
Political will	0.216	(0.093) ***
Alternative Methods (Structural and governmental change)		
Capacity building and skills transfer	1.939	(1.167)
Change the energy policy mix	1.016	(0.469)
Improve administrative and monitoring efforts	1.554	(1.012)
Alternative and responsible investment	1.283	(0.574)
Threshold 1	-1.754	(1.071)
Threshold 2	-0.431	(1.043)

- *Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively*
- *N=251, Log pseudolikelihood = -215.41826, pseudo R-squared = 0.1989. Robust standard errors are provided in the table above.*
- *Likert scale reference categories: Age = 0 (20-29 years of age), Race = 0 (Coloured), Gender = 0 (Female), Interest Group = 0 (Academia), Increase Mitigation Efforts= 1 (Neither agree nor disagree), Effective Efforts = 1 (Slightly effective), LCS Adoption = 1 (Neither likely nor unlikely), Carbon Market = 1 (Moderately knowledgeable), CT Impact = 1 (Neither agree nor disagree), CT Compliance = 1 (Neither agree nor disagree)*
- *Multiple mention reference categories: Reduction Efforts = 1 (Increase education and skills development), Trade-offs= 5 (Conflict between stakeholders), Obstacles = 5 (Lack of knowledge), Alternative Methods = 5 (Structural and governmental change).*
- *Threshold values define the changes amongst different categories of the response variable. Threshold 1 indicates the odds of participants stating that they agree that South Africa could reach its GHG targets when compared to those who think it is neither likely nor unlikely. Threshold 2 indicates the odds of participants stating that they disagree that South Africa could reach its GHG targets when compared to those who think it is neither likely nor unlikely*

Specification 3b: Demographic, Likert and Multiple Mention Variables

Since the alternative dependent variable relates to a general question that is not time bound, majority of these results are insignificant which reveals that most respondents have a pessimistic view when asked if South Africa could achieve its emission reduction targets. The main outcome indicates that no demographic variable is significantly different from the others, given that all other variables in the model are held constant.

Only one Likert scale variable has a statistically significant predictor at the 10% level. This outcome suggests that participants that have agreed to the fact that the carbon tax could promote long term compliance which contradicts the results from the previous specification. Although this provides us with two contradictory results, this outcome could help to explain the variation between perceptions of these two response variables. In the previous outcome, the response variable was time dependent, but this outcome is more general which seems to indicate that participants are more optimistic in this regard when looking at the immediate impacts of the carbon tax and its associated level of compliance. On the other hand, the previous response considers the time factor which specifically outlines the desired level of GHG emission reduction required to meet the country's NDC commitments. The difference between these two outcomes indicates that incorporating the time factor may lead to a more pessimistic outcome but this result could be more reliable as it considers the severity of the climate crisis which is time dependent.

With regards to the multiple mention variables, three predictors are statistically significant at the 10%, 5% and 1% respectively. With regards to Reduction Efforts, participants that have chosen to adopt and incentivise effective mitigation targets, these participants have an associated odds that is 3.4 times higher than those that have chosen to increase education and skills development. Hence, these participants are more likely to agree that South Africa could reach its GHG emission reduction targets, compared to those who neither agree nor disagree. In terms of the potential obstacles that could arise when trying to reduce emissions, participants that have stated that South Africa's dependence on the coal industry has an associated odds that are 27% less likely to agree that South Africa could reach its GHG emission reduction targets, compared to those who neither agree nor disagree.

Lastly, participants that have stated that the country's political will may be a potential obstacle relative to a lack of knowledge indicates that these participants are 22% less likely to agree that South Africa could reach its GHG emission reduction targets, compared to those who neither agree nor disagree. This is an interesting result which is different from what was found with the time bound dependent variable as it highlights how participants perceive that the country's level of political will could prove to be a significant limitation to adequate policy implementation, long term compliance and the suitable enforcement of efficacious climate action. Hence, if the country enhances its level of political will, South African government officials could implement more stringent policies to hold Eskom accountable for its insufficient energy capacity. Without more stringent policies, vested interests in fossil fuel consumption coupled with cognitive lock-in attributed to Eskom's monopolistic influence will continue to delay the energy transition which could further delay South Africa's climate mitigation efforts.

Discussion

These results highlight how essential public perceptions are and how useful they could be during the policy making process. The results have shown that several inefficiencies exist within the current system and what the South African government has pledged relative to the country's actual mitigation efforts. These outcomes, coupled with a snowball set of respondents who are meant to be well informed with regards to environmental policy instruments in comparison to the average South African, indicates that the overall level of knowledge relating to environmental policies remains considerably low in South Africa.

The ordered logistic model results allowed us to identify which variables have any influence on increasing or decreasing the probability of participants stating that South Africa will reach its emission reduction targets. With regards to the original dependent variable, the outcomes from the gender, interest group, two Likert scale and two multiple mention variables seem to increase the probability of participants stating that South Africa will reach its emission reduction targets for the likely category. On the other hand, majority of the Likert scale and multiple mention variables seem to decrease the probability.

Although majority of these results are insignificant, this indicates that most respondents do not know how efficacious these policy instruments could be with respect to meeting the country's NDC commitments or the impact these instruments could create towards ensuring long term emission reduction compliance. However, alternative policies such as promoting the energy transition could lead to public backlash if the transition is done in an unjust manner. Hence, to prevent severely negative outcomes that could arise from public hesitation or climate scepticism towards alternative policies, this calls for an increase in education campaigns to ensure that the public understands the relative merits of each policy instrument.

If capacity building, skills transfer, and specific educational programs were implemented, this could lead to employment opportunities in various green sectors and the implementation of more efficacious mitigation instruments. This could enhance the opportunity to create a net economic positive outcome in the long run and could ensure that affected communities are able to adjust and adopt to new skills that are relevant to the changing economic environment. This will help to avoid the possibility of a skills mismatch and lower the chances of increasing the portion of the population that might fall into the missing middle which remains a prevalent issue within the country.

On the other hand, structural and governmental change should be enhanced to improve the country's political capacity and political will to implement as well as reinforce these policy changes. This could improve the country's regulatory framework and create sufficient mechanisms to hold Eskom accountable for its inefficiencies while simultaneously implementing policies to increase the implementation of renewable energy. It is important to ensure that the country's political will and future climate mitigation policies align with future emission reduction targets. For this to work, this would require engaging with citizens and uplifting local communities to encourage a change in their behaviour which could make a substantial contribution towards a just energy transition.

It is vital that the country's policies not only focus on improving its emission reduction levels, but these policies should simultaneously help to mitigate energy poverty; increase public awareness relating to efficient energy usage; encourage collective action as well as create proactive interactions amongst all stakeholders. Creating and increasing climate awareness could increase local participation and create mutually beneficial relationships between institutions, civil society, and community members to ensure that the South African

government is able to make sound and well-informed policy choices. This is supported by Dong and Olsen (2017) that have noted that public participation is regarded as a key principle for effective climate governance, but this would require stakeholders that are able to ensure that efficient policies are implemented to meet the desired outcome.

The differences between the results of the two dependent variables helps to reveal an important discussion around environmental compliance and public dissonance surrounding the efficacy of the county's level of climate action. There are some similarities with each outcome however, the differences help to identify which policies each participant believes could have a considerable impact on the country's ability to reduce emissions now or in the future. This highlights the fact that considering the time factor allows participants to outline the potential ramifications that could arise if we do not meet our emission reduction targets relative to those that have considered the current analysis and how certain policies could have immediate economic or social consequences.

A significant outcome reveals that participants believe that enhancing the government's level of political will should be considered as any alternative policy choice would depend on who is in power. With regards to the time factor, policy evolution is complex and the cognitive task of considering certain policies over another could make the burden more difficult which could lead to additional issues or exacerbate current issues. Hence, South Africa will only reach its emission reduction targets if the country makes a considerable effort to transition towards renewable energy at scale. However, the path dependency issue which is a direct result from vested interests in fossil fuel consumption and cognitive lock-in from Eskom's monopolistic market power has convinced -policymakers to maintain the status quo which could hinder or delay the country's level of climate action.

Based on the results from both dependent variables, the overall response seems to indicate that participants have a pessimistic view regarding South Africa's ability to reach its emission reduction targets due to the various mitigation policies that the country has in place. Participants have argued that the country's current policies remain counter-intuitive as the impacts of the carbon tax are minimised by the country's large tax exemptions and should be set at a more efficacious level for this policy instrument to work.

Lastly, the results have shown that carbon markets could provide a valuable contribution towards creating South Africa's low carbon future however, it is also evident that these policy

instruments should not be used in isolation as they would not be able to solve the climate crisis alone. Simply reducing emissions will not reduce global temperatures therefore, a combination of climate practices could help galvanize emission reductions which could lock governments into low carbon trajectories.

Conclusion

It is evident that the ability to achieve emission reduction targets between major regions may vary substantially. Despite the success from some NDC commitments, the overall trend from several countries remains insufficient which makes the 1.5°C target seem less likely to occur within the desired timeframe. The level of reduction necessary to meet this target may only be realised if all parties enhance their commitments as soon as possible.

Previously, the literature has outlined the economic, the political and the technological aspects of a feasibility analysis when assessing various mitigation pathways but it often overlooks social and behavioural aspects. There are a wide range of arguments that acknowledge the fact that climate mitigation policies require a certain degree of public support. Hence, the study finds that a link exists between domestic policy and individual policy preferences, highlighting that these are crucial factors to investigate. This study has argued that stakeholder perceptions and incorporating the social aspect are integral within a feasibility analysis to create a more comprehensive and transparent approach as this will help to facilitate learning across several disciplines. However, finding a homogenous mitigating framework that considers efficiency, social equity and cost-effectiveness could pose as a significant challenge.

This study offers unique insights to enhance our understanding concerning the feasibility of South Africa meeting its emission reduction targets with the use of various mitigation instruments. Despite an array of climate policies, South Africa still faces numerous challenges in its efforts to reduce its greenhouse gas emissions as its climate policies are not robust enough to make a considerable contribution towards reducing its overall level of emissions. South Africa's continuous reliance on coal powered energy has created a complex scenario which contradicts the country's climate mitigation campaign.

Considering the substantial impact of fossil fuel consumption and the market power abuses by Eskom, climate action may present potential challenges due to the significant trade-offs involved in transitioning to cleaner energy sources. However, mitigating these challenges could enable the country to access a range of opportunities in an inclusive manner and alleviate potential constraints that could arise during the energy transition. Moreover, the expert opinion survey finds that South Africa's insufficient level of climate action is attributed to limited resource management; weak institutional capacity; inefficient coordination and monitoring; ineffective policy implementation; institutional fragmentation; limited financial capacity; lack of compliance; and cognitive lock-in from Eskom's monopolistic market power.

To ensure proper public service delivery, the government should enhance its policies to attain the desired objectives and prevent further delays. These policies range from implementing bans on new coal-fired power plants while phasing out older power stations; pricing carbon emissions; enhancing large scale renewable energy implementation; subsidising public transport as well as implementing and improving green educational programs. Learning-by-doing and sharing technical know-how are both essential to ensuring the success of these collective efforts and based on international experiences, these efforts could assist during the policy making process. While we acknowledge that the wider adoption of these approaches will be challenging since they not only question the paradigms of the country's climate action, but they also question its mitigation capabilities and the government's political will to enforce sufficient climate mitigation legislation.

The paper contributes to opinion-based literature as the study includes an informed sample of topic experts that introduces these issues ex post, enabling us to rationalize these outcomes. The results highlight that various challenges could arise when trying to enhance environmental compliance within the developing country context both in a general sense as well as from a forward-looking perspective with the use of the time bound analysis. Specific reference regarding the just transition, the complexity as well as the diversity of different mitigation instruments and financial constraints have been raised as potential economic detractors. However, the study also includes how alternative measures could be incorporated without hindering various industries or employment opportunities within the country. Hence, the paper has shown that that NDC commitments, climate mitigation efforts and public policy should be used to engage and promote stakeholder participation.

A prominent theme throughout the results has shown that majority of participants doubt the country's ability to reach its emission reduction targets. This stems from hesitation towards the country's mitigation efforts as several participants noted that a considerable amount of policy uncertainty exists regarding the country's mitigation strategies. To create trust and transparency, the South African government needs to supervise the proper implementation of more efficacious climate policies but there needs to be a high level of policy certainty to ensure that all stakeholders understand the country's climate action trajectory. Without policy certainty, the reluctance to invest in more efficacious policies will continue to delay South Africa's climate mitigation capabilities.

Although it has been argued that the carbon tax is a step in the right direction, many have argued that it is not an appropriate instrument to be used as the primary driver for climate mitigation in South Africa. A significant finding indicates that a blend of policies that includes renewable energy and implementing a hybrid system to include an emissions trading system with the potential addition of carbon sequestration, could be more appropriate in comparison to the carbon tax given the inclusion of large tax exemptions which could hinder long term compliance. Nevertheless, it would be easier for developing countries to follow examples of successful carbon pricing mechanisms from other developed and developing countries as well as gain an understanding on how to obtain sufficient climate action and infrastructural support. However, this would call for a large network of stakeholders while simultaneously engaging with local communities.

While the South African government has set a new target range for 2030, successfully enhancing or implementing domestic policies would require an additional boost. Despite the updated targets, both the literature and responses from the expert opinion survey have highlighted that South Africa's new targets are not compatible with the Paris Agreement and improving its overall ranking would require more ambitious efforts. This may only be possible if transformational change is encouraged across all sectors and actors in society. Stakeholders should be informed and involved during the decision-making process and should be able to critically question the feasibility of various climate mitigation instruments for the South African economy.

The paper shows how snowball sampling may be incorporated to provide the reader with more precise results as it minimises the potential impact of researcher bias. However, in combination

with the specific nature of the research, this limits the overall number of participants that could participate in the study. The five-point Likert scale did not provide significant results due to the small subsample size. Hence, collapsing the five-point scale into a three-point scale reduced the dimension of the outcome variable which increased the statistical significance of the explanatory variables. However, this could reduce the variation in the response options of the survey from five to three thereby, creating an additional limitation but increasing the sample size could correct this issue.

In terms of future research, significant efforts need to be made to increase the availability of high-quality expert opinion-based data which could be used to guide climate mitigation policies. Additionally, the data collection phase could be extended to include more participants and increase the overall sample size. Future work could be improved by incorporating questions that directly evaluate participant's perceptions relating the country's climate action, specific climate mitigation policies, and the respondents' knowledge levels. A significant outcome from the paper suggests that mitigating global warming will require coordinated action by a wide range of stakeholders.

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Appendices:

Appendix A: South Africa's CDM Portfolios

Figure 5: South Africa's Clean Development Mechanism Project Portfolio per sector (PPD's Only)

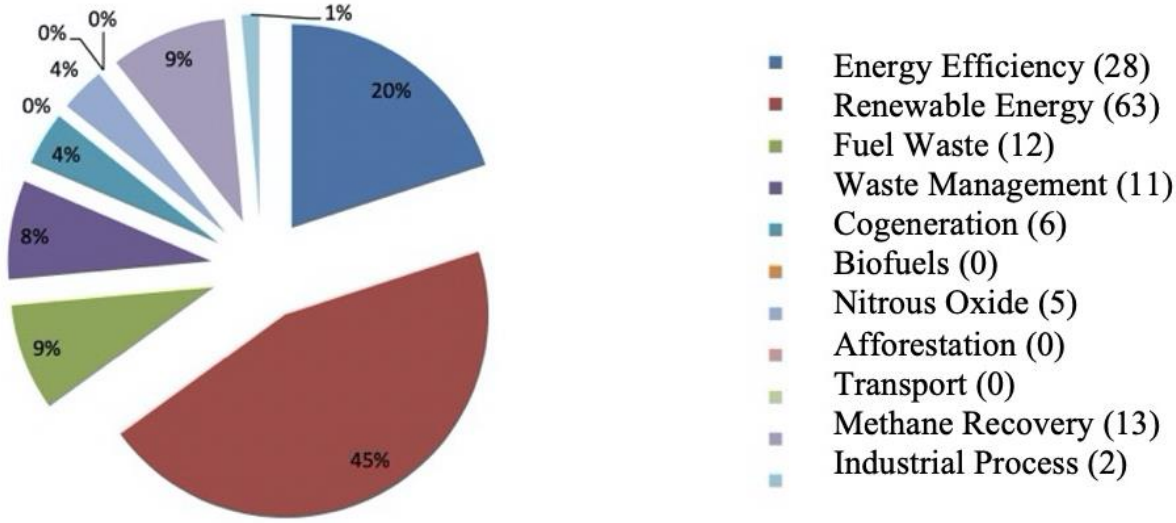
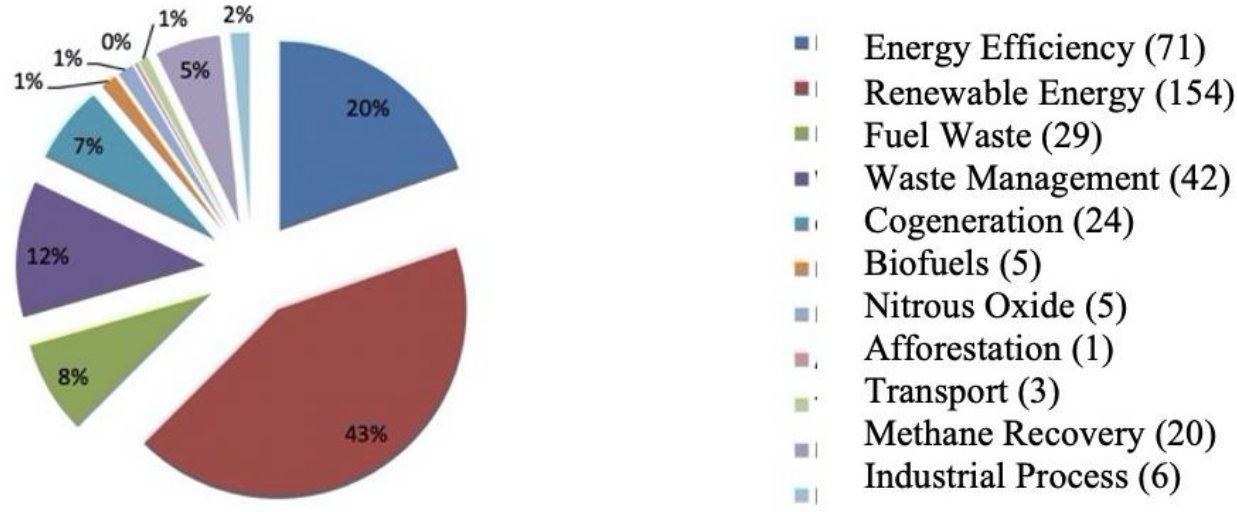


Figure 6: South Africa's Clean Development Mechanism Project Portfolio per sector (PIN's Only)



(Department of Mineral Resources and Energy, 2017)

The readability statistic score based on the Flesch Reading Ease test and the Flesch-Kincaid Grade Level test was used to understand the complexity of the language and the potential limits that the questionnaire could impose. The outcome of the score was 56,7 which is just below the normal average of 60. This indicates that the questionnaire is not as easy to read while the grade level for most people with at least a grade 9-10 (9.7) level of education. Therefore, the questionnaire used an iterated process of question development and required some editing to consolidate the language used.

Appendix B: Survey Questionnaire

Investigating the Feasibility of South Africa meeting its greenhouse gas emissions targets

Dear Sir/ Madam

You have been selected to participate in an anonymous questionnaire and your participation in this research is completely voluntary. Your participation is incredibly important in order to get a representative sample for this study. To ensure the anonymity of all responses, no identifiable information will be recorded or published in the research project. By choosing to participate in this questionnaire, you are giving consent to allow the researcher to analyse your answers.

The objective of the survey is to understand the feasibility of South Africa meeting its greenhouse gas emissions targets. Multiple choice questions only require a single answer unless stated otherwise. Certain questions relate to your understanding of different policy instruments and some questions require your personal opinion with regards to the viability of the policy instrument chosen. The questionnaire consists of 22 questions and it should take 15-20 minutes to complete.

Please provide your contact details below before answering the questionnaire. Note that all of your personal information is confidential and will not be made public.

- Name _____
- Email address _____
- Name of your organization _____

Which group do you belong to? If you belong to several, choose the one to which you are closest:

1. NGO
2. Industry
3. Academia
4. Government
5. Consultancy or other services

What is your occupation?

1. Self-employed
2. Managers
3. Professionals
4. Clerical support workers
5. Armed forces occupations
6. Technicians and associate professionals
7. Skilled agricultural, forestry and fishery
8. Plant and machine operators
9. Other (please specify below)

   _____

In which economic sector are you employed?

1. Agriculture, fishing forestry
2. Manufacturing
3. Construction
4. Electricity, gas, water
5. Transport, storage and communication
6. Finance, real estate and business services
7. Community social and personal services
8. Other (please specify below)

   _____

Survey Introduction

Information Based on the current level of greenhouse gases (GHGs) and the minimal efforts to reduce carbon dioxide emissions, climate change will have irreversible impacts that could lead to an increase of the earth's temperature to 4°C by the end of this century. Developing countries are more vulnerable to the impacts of global climate change and delaying intervention could exacerbate the effects and increase welfare losses. Therefore, implementing effective and inclusive adaptation methods should be seen as a collective effort.

South Africa's annual GHG emissions has increased by 2.3% per year in comparison to the world average of 1.8% per year (SARS, 2020). However, South Africa made a political

commitment by submitting its Nationally Determined Contribution (NDC) and will implement mitigation actions that will result in a 34%, 42% and a 45% reduction of emissions below the business-as-usual (BAU) emissions trajectory by 2020, 2025 and 2030 respectively (South Africa's Intended Nationally Determined Contribution [INDC], 2015). The country's climate change response is an economy-wide effort which includes all sectors and six GHGs with the addition of implementing a carbon pricing instrument. Carbon pricing is a way to address the market failure by putting a price on carbon in order to incentivise reductions either by imposing a cost on emissions or by rewarding the level of reduction.

The Carbon Tax Act No 15 came into effect on the 1st of June 2019 and will be administered as well as collected by SARS (SARS, 2020). The carbon tax is imposed on South African entities that operate emissions generation facilities and emit emissions that are equal to or above the carbon tax threshold. The tax ensures that firms and consumers are responsible for their level of emissions by considering the adverse costs associated with future production, consumption as well as investment decisions (International Energy Agency [IEA], 2020). The carbon tax is calculated at a rate of R120 per tonnes of carbon dioxide equivalent (tCO2e) but the tax will be phased in to avoid potential economic disruptions. The first phase will be implemented from the 1st of June 2019 up to the 31st of December 2022, and the second phase will be implemented from 2023 to 2030.

The tax will apply to energy combustion emissions, fugitive emissions as well as industrial processes (SARS, 2020). The carbon tax is designed to provide tax-free emission allowances that range between 60% to 95% within the first phase which amounts to R6 to R48 per tCO2e. However, with the introduction of the tax, this will have a substantial impact on the price of electricity during the first phase of its implementation as it could increase fuel prices by more than 20% per litre (Ramstein et al., 2019; Nong, 2020:2). This is relatively modest carbon tax rate per tCO2e emitted that will provide current emitters time to transition and invest in energy efficient and low carbon technology.

In light of the information presented above and what you know, please answer the questions below.

Q1: *How effective do you consider South Africa's climate change mitigation efforts?*

1. Extremely effective
2. Very effective
3. Moderately effective
4. Slightly effective
5. Not effective at all

Q1a *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q2: *Do you agree that South Africa should try to increase its efforts to reduce its greenhouse gas (GHG) emissions?*

1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Q2a *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q3: *How do you assess the likelihood that South Africa will be able to reduce its greenhouse gas emissions within the range of 398-614 MtCO2e between 2030-2050 relative to the business-as-usual (BAU) emissions trajectory?*

1. Extremely likely
2. Somewhat likely
3. Neither likely nor unlikely
4. Somewhat unlikely
5. Extremely unlikely

Q3a *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q4: *Based on your answer above, do you think this could be done without compromising real GDP growth?*

1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Q4a *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q5: *Does a low carbon strategy exist in your firm/sector?*

1. Yes
2. No

Q6: *How likely is it that your firm will adopt a reduced carbon strategy?*

1. Extremely likely
2. Somewhat likely
3. Neither likely nor unlikely
4. Somewhat unlikely
5. Extremely unlikely

Q7: *Do you think South Africa can achieve its emission reduction targets?*

1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Q8: *How do you think South Africa could achieve its emission reduction targets?*

_____

Q9: *The supply of energy is coal intensive, and the biggest emitter of carbon emissions is the energy sector. Do you agree that South Africa should transition away from its coal based energy sector?*

1. Yes
2. No

Q9a *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q10: *Do you think South Africa should replace its dependence on coal with nuclear energy?*

1. Yes
2. No

Q10a: *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q11: *Do you think South Africa should replace its dependence on coal with renewable energy?*

1. Yes
2. No

Q11a: *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q12: *What would be the most appropriate option to ensure that South Africa could meet its GHG targets? Order them by their level of importance, 1: most important, 6: least important.*

1. Transition to biofuels
2. Transition to wind energy
3. Transition to solar energy
4. Transition to nuclear energy
5. Refurbish its current coal plants

Q12a: *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q13: *How would you assess your understanding of carbon markets?*

1. Extremely knowledgeable
2. Very knowledgeable
3. Moderately knowledgeable
4. Slightly knowledgeable
5. Not knowledgeable at all

Q14: *Which design characteristic would be more appropriate for a carbon market?*

You may select more than one answer

1. Carbon Offsets
2. Carbon Price Floor
3. Carbon Price Ceiling
4. Relative Cap on carbon emissions
5. Absolute Cap on carbon emissions

Q14a: *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q15: *Do you think that the carbon tax has had a material impact on your firm/industry?*

1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Q16: *Do you think that the current carbon tax could promote overall climate mitigation compliance in the long-run?*

1. Strongly agree
2. Somewhat agree
3. Neither agree nor disagree
4. Somewhat disagree
5. Strongly disagree

Q16a: *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q17: *Considering the common policy instruments that are available to reduce emissions, what policy mix c*ould allow *South Africa to reach its Conference of Parties (COP 21) targets*?

You may select more than one answer. * *For additional information, see the point below.*

1. Change to renewable energy
2. Increase the carbon tax (CT)
3. Implement an emissions trading system (ETS)
4. Implement a hybrid system (CT and an ETS)
5. Implement a clean development mechanism (CDM)
6. Other (please specify below)

_____

_____

Note * Additional carbon pricing instruments include:

- Carbon Tax
- Clean Development Mechanism (CDM)
- Emissions Trading Systems (ETS)

The CDM operates at the multilateral level. The CDM may operate at a multilateral level and has a dual purpose to help developing countries achieve sustainable development goals and to meet their emission reduction targets by earning certified emission reduction credits (CER) based on each tonne of CO2 equivalent (tCO2e). ETSs can operate at a national level and have transformed carbon emissions into a tradable commodity by allowing countries to sell their excess capacity within the carbon market to countries that have used up their emission targets. This process creates a demand and supply for emission allowances and creates a market price for emissions (Chen et al., 2020: 3). South Africa's national carbon tax was initially aimed at R120 per tonne of CO2 equivalent (tCO2e) but during its first phase, the tax will range from R6 to R48 per tCO2e emitted. (Note: the current exchange rate is R16.45 to the Dollar. As a reference, the value of the tax in different countries is: Australia $10/tCO2e, Mexico $15/tCO2, Indonesia $35/tCO2, Britain $25/tCO2, USA $15/tCO2).

Q18: *Do you think that it is possible to simultaneously link the efforts to reduce carbon emissions with the efforts to reduce poverty in South Africa?*

1. Yes
2. No

Q18a: *Feel free to comment below and provide an explanation to your answer above (optional)*

_____

_____

Q19: *What are the potential economic costs or trade-offs of trying to meet GHG targets?*

_____

Q20: *How important are the following criteria when evaluating climate change mitigation instruments? Order them by their level of importance, 1: most important, 6: least important.*

1. Cost-effectiveness
2. Environmental effectiveness
3. Addresses uncertainties
4. Distributive equity
5. Stimulates behavioural change
6. Affects firm/ industry competitiveness

Q21: *Overall, what would you say is the biggest obstacle to reducing GHG emissions in South Africa?*

_____

_____

Q22: *In your view, what is the best way that South Africa could meet its COP21 targets?*

_____

_____

End

Thank you for completing the questionnaire. We would like to obtain some basic demographic information from you. Please remember that all of this information is confidential, and your personal information will not be made public.
Please indicate your age, race and gender below.

Age

1. 20-29
2. 30-39
3. 40-49
4. 50-59
5. 60 or older

Gender

1. Female
2. Male
3. I prefer not to answer
4. Other (please specify below)

_____

Ethnicity

1. Asian
2. Black
3. Coloured
4. Indian
5. White
6. I prefer not to answer
7. Other (please specify below)

_____

Thank you for participating in this questionnaire.

Could you recommend 5 additional respondents that could contribute towards this study?

Please remember that all of this information is confidential, and your recommendations will not be made public.

- 1. _____
- 2. _____
- 3. _____
- 4. _____
- 5. _____

Appendix C: Ethics Approval

Faculty of Commerce
Private Bag X3, Rondebosch, 7701
2.26 Leslie Commerce Building, Upper Campus
Tel: +27 (0) 21 650 4375/ 5748 Fax: +27 (0) 21 650 4369
E-mail: jacques.rousseau@uct.ac.za
Internet: www.uct.ac.za
@Commerce UCT **UCT Commerce Faculty Office**

16/10/2020

Zah'Raa Davids

School of Economics

University of Cape Town

REF: REC 2020/10/007

Investigating the Feasibility of South Africa meeting its greenhouse gas emissions targets

We are pleased to inform you that your ethics application has been approved. Unless otherwise specified this ethical clearance is valid until 31-Oct-2021 .

Your clearance may be renewed upon application.

Please be aware that you need to notify the Ethics Committee immediately should any aspect of your study regarding the engagement with participants as approved in this application, change. This may include aspects such as changes to the research design, questionnaires, or choice of participants.

The ongoing ethical conduct throughout the duration of the study remains the responsibility of the principal investigator.

We wish you well for your research.

2020.10.16
14:26:17 +02'00'

Jacques Rousseau
Commerce Research Ethics Chair
University of Cape Town
Commerce Faculty Office
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Appendix D: Cover letter

School of Economics
Middle Campus, UCT, Rondebosch
Private Bag – Rondebosch 7701
Tel: (021) 650. 5751 Fax: (021) 650 2854
Internet: https://www.commerce.uct.ac.za/Economics/

October 2020

Request to conduct research and interview participation consent form

Dear Sir/Madam,

In terms of the requirements for completing a Masters of Commerce Degree in Development Economics at the University of Cape Town a research study is required.

The researcher, in this case Zah'Raa Davids, has chosen to conduct a case study entitled "Investigating the Feasibility of South Africa meeting its greenhouse gas emissions targets". The objective of the research is to gain a better understanding on how South Africa can reach its emission targets in accordance with the Paris Agreement. This survey is a non-random survey to solicit the views of different stakeholders about various GHG mitigation methods. You have been selected to participate in the survey and your responses to the questionnaire will be anonymised. Your participation in this research is completely voluntary. All information will be treated confidentially and used exclusively for the purpose of this study. This research has been approved by the Commerce Ethics in Research Committee and the reference number is REC 2020/10/007.

As a stakeholder that has chosen to participate in this questionnaire, you are subsequently giving consent for the researcher to analyse your answers. If you choose to not participate, there will not be any negative consequences and you may withdraw at any time. However, your participation would be highly beneficial and I would be grateful if you would assist me by answering the survey questionnaire.

The data collection method will be an online questionnaire. The findings of this research will be compiled into a Masters Dissertation and presented to the University of Cape Town for academic purposes. The questionnaire will be conducted online via email and will last 15-20 minutes. If you are willing to participate in this study, kindly click on the survey link provided.

Your participation in this study would be greatly appreciated, but is entirely voluntary. Should you have any questions regarding this research or would require electronic copies of the paper, please feel free to contact me on 0832512090 or email: DVDZAH003@myuct.ac.za

Sincerely,

Zah'Raa Davids
Researcher/ M.com Student, (UCT)
Department: School of Economics
University of Cape Town
Email: DVDZAH003@myuct.ac.za

Associate Professor Reza Daniels
Research Supervisor
Department: School of Economics
University of Cape Town
Email: reza.daniels@uct.ac.za

Appendix E: Participant Comments

1. **How effective do you consider South Africa's climate change mitigation efforts?**

Carbon tax in South Africa is as farcical as Eskom which is by far the biggest producer of greenhouse gasses and will receive an exemption in phase one, until 2023, Given the parlous state of Eskom's finances and the probable inability to increase tariffs at least temporarily, it is likely that the ruling party will simply vote in favour of another extension.

Government cannot be decisive due to economic risks and political outfall from certain labour sectors. People will still buy electricity because they have no other option. South Africa should not focus on increasing the electricity price and pay taxes but rather find other solutions of sustainable energy sources. There are many ways South Africa can harness solar, wind and water energies. Such strategies have been implemented and proven successful in other countries. It is still early days on this front but the political support toward a greener economy is gaining traction in the policy arena.

We are still a coal-reliant economy and among the highest per capita emissions in the world, so reconfiguring the energy mix will require significant reforms by the energy department.

As a developing nation, we are faced with the conflict of addressing high unemployment rates and social upheaval especially in key impact sectors such as mining, oil, and gas. The labour concerns typically take priority for asset owners and management companies. I believe the effectiveness depends entirely on whether we see increased use of RE and resources as a result. Simply increasing cost and yielding taxes does not equate to climate change mitigation.

I am not sure if industries or companies would be self-reporting emissions, or it is something that will be externally audited. And how strict enforcement will be. These things often require political will rather than merely legislation and the current carbon tax at R120/tCO2 is far too low.

2. **How do you assess the likelihood that South Africa will be able to reach the goals stated in the Intended Nationally Determined Contribution (INDC) to reduce GHG emissions by 45% by 2030**?

South Africa was struggling to meet the targets before the pandemic and with the significant recession and unemployment coming out of that, there is a strong focus on economic growth and building job creation. Although there are several opportunities to use this drive to create a low carbon economy, it will probably end up being the same, because of concerns about wasteful expenditure when trying something new or innovative. However, there is a lot of work being done by other spheres of government, including at the local level, which shows that things can be done, while still promoting economic development and job creation. I think that there will be pockets of the country, where we will come close to our emissions targets, but

unless we make dramatic changes to our energy supply, there is not much that can be done to meet our required emission reduction targets.

Drastic action will need to take place and important infrastructures will need to be implemented and consistently traced to stay on top of this.

I believe it is somewhat likely as we need reliable forces to lead this. Pursuant to the South African government's current service delivery efforts it is, something that needs serious dedication and effort to pull off.

There is simply zero chance as the country has no political will and a rising debt to GDP figure. Covid-19 could have a negative effect on growth, which will decrease emissions, but come at a cost of overall welfare and employment.

Given the current trajectory, it seems the response has been too slow to reach this target. I feel it is quite unlikely unless immense efforts are pushed forward from all stakeholders. With analysts predicting the South African economy's potential combustion within the next 5-10 years. `the current global pandemic, and on-going political and corruption issues, I do not see how South Africa will be able to cut GHG emissions by nearly half within 10-years particularly with the over-reliance on Eskom's coal-based energy production.

South Africa being a developing country will cause it to put greater emphasis on economic growth and environmental targets will likely fall by the wayside. We do not know whether the proposed measures will be effective. Companies may simply pass off the additional tax cost to the consumer and continue operating as per normal. We need to urgently address the issues at Eskom and the high commercial emitters such as Sasol, African Rainbow & Accelor Mittal

Especially after the year we have had this country is more focused on staying afloat. Based on the trends observed in other countries, the efforts to mitigate climate change have not received the necessary commitment required to reach desired goals. For instance, developed countries like the U.S. have lately been rescinding their commitment to fight climate change. This is an indicator that even South Africa will likely be unable to meet its target.

South Africa has recently been experiencing recessions and the country is more likely to focus on boosting productivity rather than worrying about emissions. This is because the power utility mainly runs on coal to generate electricity. Adopting new greener technology would come at a considerable cost. Given Eskom is already highly indebted this is unlikely to occur.

Implementation from government and governance structure will hamper our efforts to reach the goal. It would have made it a money-making inflow for revenue services, like plastic bags they are now an income stream for major retailers and plastic pollution on the rise South Africa lacks investment in alternative energy sources and relies mainly on coal regardless of ease of access to other sources and the proven unreliability of coal.

Corruption causes funds to be mismanaged and tenders for green solutions are often fraudulently awarded, thereby producing no results. Reaching that goal of 45% meaning almost half of its GHG emissions would take a huge amount of effort and investment in a short period. South African is not ready and there is not enough awareness, but there is not sufficient training

at the local level hence, we are not equipped enough to handle such a humongous shift in technology. I think this is more a political promise than a ground achievable goal in such short time.

Most of South Africa's energy production is focused on coal. The coal mining industry is a massive employer. A shift from coal-based power to alternative "green" energy could severely impact unemployment rates. I believe that the government would be hesitant to make this change so abruptly. There are still too many barriers in place for private small companies to generate electricity independently. Education related skills in South Africa are scarce. There is a lot of uncertainty, and all projects seem to drag, visions are hardly met historically. Moreover, covid has disrupted many national development efforts. It is probably an ambitious target to reach in only 10 years. The measures are being phased into 2030 which makes this target seem unlikely.

Government interpretation of South Africa's mitigation commitment results is a very low ambition - as demonstrated in a variety on international and local analysis that rates the commitment as highly insufficient.

Given that the PPD has not been updated, the current goal is inadequate to begin with and whether South Africa achieves it or not will not compensate for its inability to increase its ambition. The goal is 45% below a business-as-usual trajectory, and the BAU articulated is higher than any likely outcome. As such, the goal can be achieved with only moderate changes in energy emissions, and the economic attractiveness of renewable energy will make this goal relatively easy to achieve. However, this ambition is insufficient for the country. South Africa's current tax system is ineffective, currently there are many people who evade taxes – there is a very unlikely chance that the same will not happen with a GHG tax. Additionally, South Africa has a history of bribery - this habit can very easily impact the effectiveness of compliance officers who will be employed to ensure GHG laws are being followed.

South Africa has not met any of the developmental goals. We are past the deadlines and are still trying to reach up. At the rate the country is going now it will be burned out by the next 10-15 years. South Africans only adhere to realities like these once it is too late or if their livelihoods are at stake.

The recent drought showed that limitations had to be placed on the public before they started to save water. It will depend on our policy option for energy generation. The PPD and NDC trajectory is so broadly stated. South Africa has already complied simply by virtue of the economic downturn due to covid and previously due to load shedding. The question would be better framed around whether the NDC is appropriate. As much as the notion itself is noble and realistic at face value, countries like South Africa prioritize social and economic issues above environmental ones.

Since our BAU has changed a lot - due to several factors, including anemic economic growth for quite a few years, very rapid decreases in costs of wind and solar, etc, the target is quite reachable. But we will never know what BAU would have been as it is a counter factual. For reductions from a precisely stated target, I would say very likely South Africa can get there.

3. **Based on your answer above, do you think this could be done without compromising real GDP growth?**

No, South Africa's GDP will be significantly impacted. From consumer goods to industry production output, South Africa does not have the necessary infrastructure and expertise to transition efficiently enough. Real GDP growth would be affected. It is an expensive effort, and alternative energy sources are expensive. A large portion of our economy relies on processes that emit large amounts of GHG and reducing these emissions will affect the real GDP.

There are areas in the country where things are happening and where economic growth and low carbon futures are successfully being implemented, but if you look at the country, this may be a challenge. The current economic system and structures are so ingrained, that it may be difficult to implement the substantial shifts that are required to see a difference particularly in a country that is trying to get out of a recession.

I think it could go either way, however I do feel that the drastic action could lend itself to compromising GDP growth overall. If done gradually and in a non-disruptive manner and implemented efficiently.

The South African economy is already fragile and biased, so unless strict policies are upheld and put in place on those who bear the onus, there is a chance that it will not affect the GDP growth tremendously. Transition to a significant portion of RE in the electricity sector is a least-cost option, potentially freeing more fiscal investment in other non-energy sectors to grow the economy. In addition, the relative cheapness of renewable electricity compared to fossil fuels could create an economic stimulus. However, this is predicated on effective economic planning in the post-Covid recovery, which is not yet evidenced in publicly facing documents.

As a developing country, we have a lot of priorities. The impact will depend on the involvement and commitment of the advocacy groups and big business to the cause. While some sectors would decline, e.g., coal mining, others would grow, e.g., PGM mining or RE industry. Much more can be done than has been embraced by South Africa, which could have positive GDP impact- not a good measure of adding value. Mitigation at scale required by goals of the Paris Agreement could have a negative or a positive effect on expansion of economic activity, depending on the means of implementation. Mitigation can be fully compatible with economic growth, including in short-term. Short term could affect GDP negatively, but long term could have positive effect. For there to be higher GDP and lowered carbon emissions, there will have to be a greener alternative for energy production. Since there is not, the bill will negativity affect GDP.

The question is more of how the benefits and negative impacts are distributed spatially as these are likely to be quite local in character. At an aggregate level these will likely be some growth, but this could "hide a lot of pain". Fossil fuels are cheaper and effective in providing energy to power industries in comparison to RE. GDP growth is minimal now anyway. In the long term, I would say it should be beneficial. In the short run decarbonization will compromise GDP growth, but in the long run not being decarbonized will lead to GDP shortfalls, especially if

developing country markets decarbonize significantly and thus reduce access to exports from carbon intensive economies. We need to invest in R&D to make sure we can get where we need to get to before implementing.

The impact of the Covid crisis and the spiral of a faltering economy on account of Eskom will have far detrimental impact on the real GDP growth than any effort to reduce GHG emissions. If South Africa was to give a decisive signal about its willingness to transition away from fossil fuels, then it would bring itself on the radars of funds which are starting to divest from coal. Unfortunately, that is not the case right now.

Any change to lower or to change to greener practices will be costly for companies initially as it is a change from the status quo. Disastrous management and cost overruns of new coal build at Medupi and Kusile, not to mention load shedding risks that have stemmed from that, give the best possible illustration of how staying with "business as usual" will have much worse outcomes for GDP growth, and other socioeconomic indicators, compared with a just transition to a green economy.

Impossible because up to now the country is already battling with meeting its current energy demand while it is still heavily relying on fossil fuel that has a better or higher heating value than other energy source. Reducing the GHG would mean focusing more on renewable source such as Solar, Wind and Biogas. These sources alone cannot maintain the country's GDP. It will all depend on the economic strategies that government would enact. Poor decision making and corruption could prove detrimental to any forward-thinking suggestions that could help South Africa navigate this socio-economic change. By expediting IPP contracts, providing grant funding for private solar and wind installation and by allowing small scale embedded generators to sell excess power to city grids, we could reduce carbon emissions and the load placed on the national power utility significantly.

There is potential for it to go both ways, but I believe that this could also lead to a new industry of companies developing new and exciting technologies to help reduce emissions. There will need to be well thought out and planned transitions in certain sectors. For instance, in power and electricity, people need to be educated and trained (up skilled) in working with renewable energy sources to move away from fossil fuels and to be successful in jobs in renewable sources. It could be done however, proper planning, monitoring and implementation needs to be put in place. I think there are opportunities to increase GDP growth off the back of a low-carbon transition.

I do not think it is possible to not sacrifice GDP growth unless some of the burdens relating to carbon emission taxes, particularly those affecting poorer groups are subsidized by the government. There will be an impact on consumers disposable income as the increased tax cost needs to be passed onto someone - a reduction in disposable income will reduce already constrained consumer spending and investment. Unless government expenditure and net exports increase to match these decreases, real GDP will decline. Naturally it will hamper the GDP as prices will increase and consumer spending will be less. I do not see how mitigation measures would not affect people's livelihoods and income streams.

9. The supply of energy is coal intensive, and the biggest emitter of carbon emissions is the energy sector. Do you agree that South Africa should transition away from its coal-based energy sector?

This has been Energy Policy since 1998 to diversify the energy supply. A planned coal phase-out is essential for an affordable and just energy transition, starting with electricity generation, which should be coal-free by 2040. Yes, they should but as we have recently spent billions on the new plants that do not work, going into a new field will not solve this issue. Again, implementation and governance will not be done correctly and corruption and miss management will occur. They must approach private wind and solar warms to provide electricity to Eskom for a premium also encourage development of affordable solar products for household consumption.

It could however influence GDP as well as the unemployment rate taking into consideration the amount of people in the coal industry. Coal is unsustainable and emissions are bad for the environment. We have enough wind and solar energy in this country. Even ocean energy is feasible with the use of our strong ocean currents, it is already being used in the western and eastern cape on a small scale. The sooner South Africa signals a shift away from coal, the better it would be for attracting international finance.

South Africa is facing a significant and real risk of getting stuck with stranded assets if it does not start moving away from coal on a priority basis. This is the only way that we are going to make a significant dent to our emission profile. Coal for electricity generation as well as industrial purposes make up the bulk of our emissions and without shifts to cleaner and lower emission options, the rest of the changes that can be made will have very little impact. Not only will this have a great impact on the environment, but it will also assist in the sustenance of electrical service delivery and break down the monopoly of energy supply thus creating jobs and developing the economy in the long run.

It would require a lot of investment, innovation, and commitment to follow through and South Africa has a lot of deep issues that take preference over solving current problems. Moving from coal to RE is critical for South Africa's low-carbon transition. This will however leave the country in an energy deficit given the lack of other viable options and the indebtedness of Eskom.

10. Do you think South Africa should replace its dependence on coal with nuclear energy?

Nuclear is expensive, technologically difficult (not a huge job creator) and sticking to the model of large base load power stations. There is also the serious question of waste management, which has not yet been adequately addressed. The energy solution in South Africa should be focused on smaller, localized, or decentralized energy options, including

renewables and possibly natural gas as a transition fuel. It is historically one of the most corrupt industries due to veil of secrecy of nuclear, given (often spurious) claims of national security.

The period where we could have considered nuclear has passed. It no longer fits into a least-cost scenario. RE and utility scale batteries & gas & pumped hydro with steady decommission of coal is cheaper and can be delivered quicker. Ideally, we should be using a wide array of energy sources, thus not being overly reliant on any one source.

No because nuclear is energy has proved ruinously expensive elsewhere and it takes longer to build. South Africa does not have the financial capacity to replace coal with such an expensive source which is more dangerous and powerful which will further compromise the country's fiscus and debt levels. We are not equipped in terms of skill for such an undertaking.

Energy output from nuclear powerplants is typically much greater than other alternative forms of energy production and it has the potential to augment SA's current energy output in orders of magnitude. Additionally, if managed correctly, it can be even more environmentally friendly than hydroelectric power or geothermal energy.

I think nuclear is better than coal. I do not think it should be the end goal though. While nuclear is cleaner in terms of carbon, one is effectively swapping one form of environmental management issue for another. We do not have the infrastructure to dispose of it correctly. I think we should switch both out and rely on renewable energy sources like wind and solar energy.

Nuclear is carbon free and makes sense if you are trying to decarbonize to reduce emissions. If emissions are the immediate concern, then nuclear is the answer despite cost. There are other ways of providing clean energy. There will always be some give and take but ultimately there are methods way safer and more sustainable than coal or nuclear.

2. **Do you think South Africa should replace its dependence on coal with renewable energy?**

There is strong evidence for the role that renewable energy can play in the South African energy mix. We have strong wind and solar resources, we have the expertise locally as well as the manufacturing capability, there are job creation opportunities at all levels and opportunities for local economic development which are not found in large scale coal and nuclear power options.

It is a necessary transition but not replace it as this would not be feasible and would cause various transition issues and costs. South Africa should, however, include more RE into the energy mix

Look at Germany, Denmark, Norway etc all using trash to generate their energy. Landfills is also a major problem in South Africa is going unnoticed. Renewable energy prices are coming down rapidly and are already lower over the lifecycle of the generation plant. An energy mix that is not dominated by one type of energy is what South Africa needs for a resilient economy.

This is more sustainable for a population that is constantly growing and is reliant on cheaper sources of energy in the long run.

Renewables are the least cost option as already identified in the IRP, 2019. Investor sentiment is significantly favoring an increase in Renewables. In addition, as climate vulnerability increases, renewables build in flexibility in the energy system due to dispersion of energy generation. This also requires substantial storage and should also be applied to liquid fuels - Hydrogen from RE to replace fossil feedstocks.

Very high upfront costs in the face of very high cheaper RE potential thus do not replace it entirely on renewable. There should be a balance. Nuclear energy has many risks attached to it. We cannot replace one destructive energy source with another.

RE coupled with various energy storage technologies can fill energy needs faster and cheaper. Nuclear may play a role in the long term, but there is little benefit investing in it now, when bigger gains can be obtained elsewhere. It makes more sense to wait for developed nations to undertake investment and research in cheaper nuclear technology and effective disposal mechanisms for nuclear waste.

Big power projects tend to foster corruption. Additionally, the risks associated with nuclear energy are too large to be left without questioning. The cost to install solar and wind has come down significantly. South Africa's IRP also identifies renewables as least cost option and can generate much more jobs than Nuclear.

Replace, definitely not. But mix it coal with renewable, yes. I think we can all agree that it would be more cost benefit and efficient for South Africa to have a smooth energy transition than a fast one. This would allow the country to adapt but also master the new technology and improve on it.

3. **What would be the most appropriate option to ensure that South Africa could meet its GHG targets?**

Consider carbon sequestration as another important step to meeting GHG reductions. This can include carbon capture and storage technology. Upgrade the grid and allow for split of transmission and distribution and supply. Create tradeable energy market and market for ancillary services, increase solar and storage at scale. Sustainable aviation fuels, electrification of the transport sector, including both private vehicles and commercial fleet.

Fracking natural gas and tidal power generation, energy storage technologies (batteries, hydro power, gravity storage, molten salt storage) coupled with RE. "Biofuels" has a limited potential in South Africa but coupling RE with SASOL and PetroSA's Fischer-Tropsch artificial fuel technology provides an opportunity to manufacture e-fuels that will be essential for transition aviation and shipping to zero-emissions pathways and presents an opportunity for South Africa to lead the world in this technology.

14. Which design characteristic would be more appropriate for a carbon market?

Caps will catalyze advancement of clean technology. The cap should be different for different organizations and incentives provided if lower targets are met. A blend but it depends on how it interacts with other instruments.

By providing a cap on emissions for a country relative to a metric such as GDP or perhaps population growth, this will allow for manageable carbon emissions controls. Setting such standards will allow for organic economic growth without curtailing or limiting the means of production.

Carbon offsets should only be used for essential sectors that are unable to transition to zero-emissions technologies (such as steel and cement) and as an interim measure. Furthermore, by limiting the sectors that can generate carbon offsets, rent seeking can be reduced. An emissions cap that is gradually reduced will incentivise innovation in these sectors and a reduction in overall emissions. Hence, it is essential to regulate carbon prices to enhance real pricing externalities while simultaneously enhancing the rate of the energy transition.

Regulating carbon prices ensures real pricing of externalities and enhances the rate of transition. I think the cap on emissions is the most important starting point for a carbon market. If the cap is ambitious and in line with the 2-degree target, then the market is already off to a good start. Next would be to set a price floor that is equal or close to a carbon price required to meet the target.

16. Do you think that the current carbon tax could promote overall climate mitigation compliance in the long run?

Greater awareness must be generated about carbon emissions, but the government does not have the political strength to enforce it and will continue to give biggest emitters a free pass. Exemptions phased out to make more of a difference, but the efficacy of the tax would depend on the real carbon price which reflects true cost of carbon emissions. It is very weak to make any material impact on mitigation compliance.

A carbon tax is an important component of environmental fiscal reform but is not appropriate as primary driver of mitigation in South Africa - rather an instrument complementary to the mitigation system put forward in the CC Bill. With specific regard to compliance - assuming that binding limits or targets are legislated at some time - penalties are necessary for enforcement, additional to a tax (this is particularly the case for countries like SA with high inequality).

Depends on the level but not at current price. Hence, it could assist subject to increase in pricing and removal of tax-free allowances. The price should align with a real social cost of carbon and be at least $100/tonne by 2030 to have any material impact on mitigation compliance.

Carbon taxes have shown to be effective in other countries, but it is really about the costs of the tax - it needs to show companies and industries that it will be more affordable to invest in

emission reduction options than to pay the tax. This is currently not the case, with the number of exemptions that have been put in place. The enforcement or lack thereof, is also a concern.

To enterprise, potentially but to small-medium companies, I think compliance may be more difficult. Carbon taxes only makes the price of energy more expensive and does not deter its use. It is a step in the right direction in terms of introducing responsible corporate behaviour and enforcing a strategic approach to business operations from an eco-perspective. Essentially laying the foundations for a paradigm shift in energy.

17. Considering the common policy instruments that are available to reduce emissions, what policy mix could allow South Africa to reach its Conference of Parties (COP 21) targets?

Specific national investments should be included to reduce Agriculture, Forestry and Other Land Use (AFOLU) emissions and increase sequestration. The government should increase incentives for energy efficiency; create a transition within the transport sector to mass transit and rail goods as well as the electrification of transport that could be linked to the large-scale rollout of renewable energy.

The best policy mix is having carbon budgets and sectoral targets operate in parallel and there is no fungibility between carbon budget allocations and the carbon tax, with emissions crediting and trading confined to off-setting carbon tax liabilities.

The offset system will play an important role but the current CDM mechanism is problematic. Carbon sequestration policy is critical in this instance and reducing fossil fuel subsidies is also important. An instrument like the carbon tax could generate revenues which could be allocated and used to reduce levels of poverty and inequality.

Job creation in the renewable energy sector could create significant employment opportunities for the country. On the other hand, economic costs of climate change are likely to be borne by poorer households but there are opportunities to reduce poverty by creating economic as well as job opportunities while trying to reduce emissions. This would require a just transition which could provide pathways out of poverty by replacing the exploitative character of the current 'extract and burn' approach. This could be done by shifting to a more localised system and implementing principles of a just transition.

18. Do you think that it is possible to simultaneously link the efforts to reduce carbon emissions with the efforts to reduce poverty in South Africa?

By shifting to a more localized system and implementing principles of a just transition, there are opportunities to reduce poverty and create economic and job opportunities while simultaneously reducing carbon emissions.

The economic cost of climate change is likely to be borne by poorer households. A just transition properly implemented could provide pathways out of poverty by replacing the exploitative character of the current "extract and burn" approach.

Appendix F: Marginal Effects

Table 10 below provides the marginal effects from the ordered logistic regression for each categorical outcome of the dependent variable (Probability = 1 Likely) and (Probability = 3 Unlikely). The output shows the results with robust standard errors in brackets to correct for heteroskedasticity.

Table 10: Marginal Effects estimating the likelihood that South Africa will be able to reach its greenhouse gas emission targets by 2050.

Likelihood of meeting the Nationally Determined Contributions	**Margin = 1 (Likely)**		**Margin = 1 (Unlikely)**	
Demographic Variables	Coeff.	Std.Error	Coeff.	Std.Error
Age (20-29)				
30-39	-0.038	(0.057)	0.052	(0.079)
40-49	0.064	(0.090)	-0.077	(0.104)
50 or older	-0.002	(0.094)	0.002	(0.122)
Race (Coloured)				
Asian	0.074	(0.101)	-0.095	(0.121)
Black	-0.060	(0.068)	0.091	(0.110)
Indian	0.143	(0.067) *	-0.171	(0.074) *
White	0.026	(0.069)	-0.036	(0.092)
I prefer not to answer	0.036	(0.080)	-0.048	(0.104)
Gender (Female)				
Male	-0.066	(0.054)	0.089	(0.073)
I prefer not to answer	0.182	(0.237)	-0.190	(0.210)
Interest Group (Academia)				
Consultancy or other services	0.004	(0.071)	-0.004	(0.086)
Government	-0.124	(0.062)	0.174	(0.090)
Industry	-0.004	(0.068)	0.004	(0.083)
NGO	-0.153	(0.067) *	0.224	(0.104) *
Likert Scale Variables				
Increase Mitigation Efforts (Neither agree nor disagree)				
Agree	-0.139	(0.090)	0.160	(0.093)
Disagree	-0.223	(0.088) *	0.283	(0.109) *
Effective Efforts (Slightly effective)				
Effective	-0.007	(0.116)	0.009	(0.147)
Ineffective	-0.079	(0.055)	0.108	(0.080)
Carbon Market (Moderately knowledgeable)				

Not knowledgeable at all	-0.021	(0.052)	0.028	(0.068)
Knowledgeable	0.022	(0.054)	-0.028	(0.068)
CT Impact (Neither agree nor disagree)				
Agree	0.006	(0.054)	-0.008	(0.067)
Disagree	-0.087	(0.056)	0.120	(0.082)
CT Compliance (Neither agree nor disagree)				
Agree	-0.007	(0.053)	0.008	(0.064)
Disagree	-0.117	(0.061)	0.164	(0.088)
LCS Adoption (Neither likely nor unlikely)				
Likely	0.024	(0.058)	-0.031	(0.075)
Unlikely	-0.061	(0.072)	0.086	(0.104)
Multiple mention Variables				
Reduction Efforts (Increase education and skills development)				
Adopt and incentivise effective mitigation targets	-0.194	(0.072) **	0.250	(0.089) **
Diversify the energy composition	-0.100	(0.060)	0.129	(0.077)
Increase compliance	-0.118	(0.091)	0.153	(0.118)
Sector integration and collaboration	-0.123	(0.068)	0.159	(0.088)
Trade-offs (Conflict between stakeholders)				
Increase in costs/prices	0.068	(0.072)	-0.088	(0.092)
Lack of compliance	0.145	(0.076)	-0.187	(0.096)
Redirection of funds	0.177	(0.085) *	-0.228	(0.107) *
Increase job loss in coal intensive industries	0.146	(0.075)	-0.188	(0.096)
Obstacles (Lack of knowledge)				
Coal Dependence	-0.015	(0.074)	0.019	(0.095)
High transaction costs	0.040	(0.070)	-0.051	(0.090)
Inconsistency within policy implementation	-0.068	(0.077)	0.087	(0.099)
Political will	-0.001	(0.064)	0.001	(0.083)
Alternative Methods (Structural and governmental change)				
Capacity building and skills transfer	0.080	(0.076)	-0.104	(0.099)
Change the energy policy mix	0.041	(0.061)	-0.053	(0.078)
Improve administrative and monitoring efforts	-0.057	(0.083)	0.073	(0.107)
Alternative and responsible investment	0.044	(0.063)	-0.056	(0.081)

- *Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively*
- *N=251. Robust standard errors are provided in the table above.*
- *Likert scale reference categories: Age = 0 (20-29 years of age), Race = 0 (Coloured), Gender = 0 (Female), Interest Group = 0 (Academia), Increase Mitigation Efforts= 1 (Neither agree nor disagree), Effective Efforts = 1 (Slightly effective), LCS Adoption = 1 (Neither likely nor unlikely), Carbon Market = 1 (Moderately knowledgeable), CT Impact = 1 (Neither agree nor disagree), CT Compliance = 1 (Neither agree nor disagree)*
- *Multiple mention reference categories: Reduction Efforts = 1 (Increase education and skills development), Trade-offs= 5 (Conflict between stakeholders), Obstacles = 5 (Lack of knowledge), Alternative Methods = 5 (Structural and governmental change).*

Likely relative to neither likely nor unlikely

The main outcome from the results of the age and gender variables seems to indicate that no age or gender group is significantly different from each other, given that all other variables in the model are held constant. One race predictor is statistically significant at the 10% level. This result suggests that the probability increases by 14% for Indian participants relative to Coloured participants when stating that South Africa's chances of reaching its GHG emission reduction targets are likely, relative to those who think it is neither likely nor unlikely. On the other hand,

the probability decreases by 15% for NGO members relative to academics when stating that South Africa's chances of reaching its GHG emission reduction targets are likely, compared to those who think it is neither likely nor unlikely.

In terms of the Likert scale variables, only one predictor is statistically significant at the 10% level for the Increase Mitigation Efforts variable. A surprising result indicates that the probability decreases by 22% for participants that have disagreed to the idea of increasing the country's emission reduction efforts when stating that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think it is neither likely nor unlikely. Although this result is negative, it is similar to the outcome found with the ordered logistic regression. This contradictory result provides additional evidence in favour of increasing the country's mitigation efforts since further delays to implementing or enhancing efficacious climate action could lead to significant welfare costs or could increase mitigation costs in the future (Acemoglu et al., 2016; Wang & Chen, 2019)

Several of the multiple mention variables are statistically significant at the 5% and 10% levels respectively. These five options are linked to question 13 and shows that one predictor of the Reduction Efforts variable is statistically significant at the 10% level. This outcome suggests that the probability decreases by 19% for participants that have chosen to adopt and incentivise effective mitigation targets when stating that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think it is neither likely nor unlikely.

Lastly, one predictor is statistically significant at the 5% level and these options are linked to question 14 and relates to the multiple mention variable coded as Trade-offs. The outcome indicates that the probability increases by 18% for participants that have chosen a redirection of funds relative to conflict between stakeholders when stating that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think that it is neither likely nor unlikely.

Unlikely relative neither likely nor unlikely

The results of the age and gender variables shows that no age or gender group is significantly different from each other. However, one race predictor is statistically significant at the 10%

level. This indicates that the probability decreases by a 17% for Indian people relative to coloured people when stating that South Africa's chances of reaching its GHG emission reduction targets are unlikely, relative to those who think that it is neither likely nor likely. On the other hand, the probability increases by 22% for NGO members relative to academics when stating that South Africa's chances of reaching its GHG emission reduction targets are unlikely, relative to those who think that it is neither likely nor likely.

The only Likert scale variable that is statistically significant is for the Increase Mitigation Efforts variable. A surprising result indicates that the probability increases by 28% for participants that have disagreed to increasing the country's emission reduction efforts when stating that South Africa's chances of reaching its GHG emission targets are unlikely, relative to those who think it is neither likely nor unlikely. In terms of the multiple mention variables, Reduction Efforts which relates to question 13 and Trade-offs which relates to question 14, both have predictors that are statistically significant at the 5% and 10% levels respectively. With regards to Reduction efforts, the probability increases by 25% for participants that have chosen to adopt and incentivise effective mitigation targets when stating that South Africa's chances of reaching its GHG emission targets are unlikely, relative to those who think that it is neither likely nor unlikely.

With regards to the potential trade-offs that could arise when trying to reduce emissions, the probability decreases by 23% for participants that have chosen a redirection of funds relative to those that have chosen that conflict could arise between stakeholders when stating that South Africa's chances of reaching its GHG emission targets are unlikely, relative to those who think it is neither likely nor unlikely.

Table 11 below provides the marginal effects from the ordered logistic regression for each categorical outcome of the dependent variable (Probability = 1 Agree) and (Probability = 3 Disagree). The output shows the results with robust standard errors in brackets to correct for heteroskedasticity.

Table 11: Marginal Effects estimating South Africa's ability to achieve its greenhouse gas emission targets.

Do you think South Africa can achieve its emission reduction targets?		**Margin = 1 (Agree)**		**Margin = 1 (Disagree)**
Demographic Variables	Coeff.	Std.Error	Coeff.	Std.Error
Age (20-29)				
30-39	0.043	(0.066)	-0.042	(0.064)
40-49	0.087	(0.096)	-0.082	(0.087)
50 or older	0.018	(0.121)	-0.018	(0.119)
Race (Coloured)				
Asian	0.212	(0.130)	-0.189	(0.103)
Black	-0.118	(0.080)	0.138	(0.100)
Indian	0.091	(0.068)	-0.089	(0.065)
White	0.039	(0.080)	-0.040	(0.080)
I prefer not to answer	0.081	(0.095)	-0.079	(0.089)
Gender (Female)				
Male	-0.083	(0.063)	0.084	(0.066)
I prefer not to answer	0.336	(0.198)	-0.250	(0.119)
Interest Group (Academia)				
Consultancy or other services	0.031	(0.070)	-0.030	(0.068)
Government	-0.083	(0.093)	0.090	(0.105)
Industry	0.048	(0.072)	-0.045	(0.069)
NGO	-0.039	(0.093)	0.040	(0.097)
Likert Scale Variables				
Increase Mitigation Efforts (Neither agree nor disagree)				
Agree	0.018	(0.089)	-0.017	(0.087)
Disagree	-0.112	(0.095)	0.122	(0.103)
Effective Efforts (Slightly effective)				
Effective	0.120	(0.164)	-0.106	(0.133)
Ineffective	-0.083	(0.059)	0.087	(0.065)
Carbon Market (Moderately knowledgeable)				
Not knowledgeable at all	0.023	(0.059)	-0.023	(0.059)
Knowledgeable	0.055	0.067)	-0.054	(0.065)
CT Impact (Neither agree nor disagree)				
Agree	0.093	(0.073)	-0.086	(0.067)
Disagree	-0.052	(0.067)	0.054	(0.072)
CT Compliance (Neither agree nor disagree)				
Agree	0.170	(0.063) *	-0.165	(0.064) *
Disagree	-0.073	(0.067)	0.090	(0.084)
LCS Adoption (Neither likely nor unlikely)				
Likely	0.088	(0.066)	-0.090	(0.071)
Unlikely	-0.018	(0.094)	0.021	(0.107)
Multiple mention Variables				
Reduction Efforts (Increase education and skills development)				
Adopt and incentivise effective mitigation targets	-0.204	(0.085) *	0.201	(0.083) *
Diversify the energy composition	-0.123	(0.080)	0.121	(0.079)
Increase compliance	-0.126	(0.111)	0.124	(0.110)
Sector integration and collaboration	-0.081	(0.095)	0.080	(0.093)
Trade-offs (Conflict between stakeholders)				
Increase in costs/prices	-0.053	(0.078)	0.052	(0.077)
Lack of compliance	0.049	(0.085)	-0.048	(0.083)
Redirection of funds	0.142	(0.090)	-0.140	(0.089)
Increase job loss in coal intensive industries	0.116	(0.098)	-0.115	(0.097)
Obstacles (Lack of knowledge)				

Coal Dependence	0.221	(0.079) **	-0.217	(0.077) **
High transaction costs	0.134	(0.087)	-0.132	(0.085)
Inconsistency within policy implementation	0.059	(0.089)	-0.059	(0.087)
Political will	0.257	(0.066)***	-0.253	(0.065) ***
Alternative Methods (Structural and governmental change)				
Capacity building and skills transfer	-0.111	(0.101)	0.110	(0.099)
Change the energy policy mix	-0.003	(0.078)	0.003	(0.077)
Improve administrative and monitoring efforts	-0.074	(0.109)	0.073	(0.107)
Alternative and responsible investment	-0.042	(0.075)	0.041	(0.074)

- *Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively*
- *N=251. Robust standard errors are provided in the table above.*
- *Likert scale reference categories: Age = 0 (20-29 years of age), Race = 0 (Coloured), Gender = 0 (Female), Interest Group = 0 (Academia), Increase Mitigation Efforts= 1 (Neither agree nor disagree), Effective Efforts = 1 (Slightly effective), LCS Adoption = 1 (Neither likely nor unlikely), Carbon Market = 1 (Moderately knowledgeable), CT Impact = 1 (Neither agree nor disagree), CT Compliance = 1 (Neither agree nor disagree)*
- *Multiple mention reference categories: Reduction Efforts = 1 (Increase education and skills development), Trade-offs= 5 (Conflict between stakeholders), Obstacles = 5 (Lack of knowledge), Alternative Methods = 5 (Structural and governmental change).*

Agree relative to neither agree nor disagree

The main outcome from the results indicates that no demographic variable is statistically different from each other and only one Likert scale variable is statistically significant at the 10% level. This indicates that the probability increases by 17% for participants that have agreed that the carbon tax could promote long term compliance when stating that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree.

A few of the multiple mention variables are statistically significant at the 10%, 5% and 1% levels respectively. In terms of Reduction Efforts, the five predictors are linked to question 13 but only one predictor is statistically significant at the 10% level. The result indicates that the probability decreases by 20% for participants that have chosen to adopt and incentivise effective mitigation targets when stating that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree.

With regards to the potential obstacles that could arise when trying to reduce emissions, the probability increases by 22% for those that have stated that South Africa's coal dependence could be regarded as a potential obstacle when stating that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree. Lastly, the probability increases by 26% for participants that believe that the country's political will may create a potential obstacle when stating that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree.

Disagree relative to neither agree nor disagree

The main outcome from the results indicates that no demographic variable is statistically different from each other and only one Likert scale variable is statistically significant at the 10% level. This indicates that the probability decreases by 17% for participants that have agreed that the carbon tax could promote long term compliance when stating that South Africa may not achieve its emission reduction targets relative to those that neither agree nor disagree.

In terms of the Reduction Efforts, the five predictors are linked to question 13 but only one predictor is statistically significant at the 10% level. The result indicates that the probability increases by 20% for participants that have chosen to adopt and incentivise effective mitigation targets when stating that South Africa may not achieve its emission reduction targets relative to those that neither agree nor disagree.

With regards to the potential obstacles that could arise when trying to reduce emissions, the probability decreases by 22% for those that believe South Africa's coal dependence could be regarded as a potential obstacle when stating that South Africa may not achieve its emission reduction targets relative to those that neither agree nor disagree. Lastly, the probability decreases by 25% for participants that believe that the country's political will may create a potential obstacle when stating that South Africa may not achieve its emission reduction targets relative to those that neither agree nor disagree.

Appendix G: Multinomial Logistic Regression.

For robustness purposes, a multinomial logistic model was run on each dependent variable, and the output in table 12 and 13 displays the risk ratio results of the multinomial regression coefficients with robust standard errors in brackets.

Irrelevant alternatives Assumption

The multinomial logistic regressions have an independence assumption among the dependent variable choices which states that the choice of one category is unrelated to the choice of another category of the dependent variable (Kwak & Clayton-Matthews, 2002: 1). The

independence of irrelevant alternatives (IIA) assumption can be tested with the Hausman-McFadden test which is used as a robustness check on the estimator. Significant values of the Hausman and McFadden test will indicate that the IIA assumption has been violated (Cheng & Long, 2007: 589).

Dependent Variable: NDC Likelihood

Ho: Odds are independent of other alternatives

NDC Likelihood	Chi2	df	P>chi2
Likely	-45.600	43	.
Neither likely nor unlikely	-2.631	43	.
Unlikely	56.535	43	0.081

Alternative dependent Variable: GHG reduction

Ho: Odds are independent of other alternatives

GHG Reduction	Chi2	df	P>chi2
Agree	20.715	43	0.998
Neither agree nor disagree	19.069	43	0.999
Disagree	21.427	43	0.998

Based on the results above, the chi-square values are large and negative except for the unlikely category while the p-value for the unlikely category is insignificant. The alternative dependent variable indicates that the chi-square values from all categories are both large and positive while the p-values are both highly insignificant. Hence, the odds are independent, and both models meet the asymptotic properties which means that the insignificant outcome of the independence of irrelevant alternatives assumption has not been violated. Had the unlikely category provided us with a significant result for the original dependent variable, then a multinomial logistic regression would be the correct estimator.

Since the multinomial logistic regression has only been included as a robustness check on the estimate and the Likert scale variables are ordered by definition but since the brant test is statistically insignificant, the ordered logistic regression is the more appropriate estimator for this study. Due to the ambiguity found when trying to find an appropriate regression for a

polytomous response variable, this could lead to contradictory outcomes, but this often happens within the literature.

In terms of McFaddens' pseudo-R-square, this shows that the full model containing our predictors represents 27% improvement in fit relative to the null model. We have assigned 'neither likely nor unlikely' to be the base category, coded as 2 on the dependent variable; 'likely' is coded as 1 (collapsing "somewhat likely" and "extremely likely" in the questionnaire – see Appendix B); while unlikely is coded as 3 (collapsing "somewhat unlikely" and "extremely unlikely" in the questionnaire).

Table 12: Relative Risk Ratios predicting the likelihood of South Africa achieving its emission reduction targets by 2050

Relative Risk Ratios: **Likelihood of meeting the Nationally Determined Contributions**	**Likely**		**Unlikely**	
	Coeff.	Std.Error.	Coeff.	Std.Error
Intercept	6.40	(11.48)	1.54	(2.48)
Age (20-29)				
30-39	0.89	(0.58)	1.26	(0.71)
40-49	0.44	(0.37)	0.26	(0.19)
50 or older	0.59	(0.66)	0.57	(0.55)
Race (Coloured)				
Asian	0.12	(0.17)	0.16	(0.16)
Black	2.13	(2.13)	2.47	(2.08)
Indian	0.81	(0.47)	0.27	(0.15) *
White	1.24	(0.97)	1.07	(0.73)
I prefer not to answer	0.24	(0.21)	0.22	(0.16) *
Gender (Female)				
Male	0.51	(0.31)	0.96	(0.49)
I prefer not to answer	0.66	(0.79)	0.05	(0.08)
Interest Group (Academia)				
Consultancy or other services	4.05	(2.68) *	3.21	(1.94)
Government	0.93	(0.81)	3.71	(2.84)
Industry	2.42	(1.59)	2.20	(1.26)
NGO	1.57	(1.51)	5.86	(5.01) *
Likert Scale Variables				
Increase Mitigation Efforts (Neither agree nor disagree)				
Agree	0.21	(0.18)	0.95	(0.75)
Disagree	0.26	(0.30)	2.17	(2.00)
Effective Efforts (Slightly effective)				
Very effective	0.66	(0.63)	0.60	(0.62)
Ineffective	0.89	(0.58)	1.44	(0.79)
Carbon Market (Moderately knowledgeable)				
Not knowledgeable at all	0.48	(0.28)	0.71	(0.35)
Knowledgeable	0.67	(0.38)	0.58	(0.30)
CT Impact (Neither agree nor disagree)				
Agree	3.11	(1.83)	2.15	(1.20)

Disagree	1.01	(0.66)	2.77	(1.45)
CT Compliance (Neither agree nor disagree)				
Agree	1.53	(0.88)	1.49	(0.80)
Disagree	1.53	(1.20)	5.14	(3.56) *
LCS Adoption (Neither likely nor unlikely)				
Likely	0.93	(0.61)	0.87	(0.51)
Unlikely	1.61	(1.57)	3.82	(3.41)
Multiple mention Variables				
Reduction Efforts (Increase education and skills development)				
Adopt and incentivise effective mitigation targets	0.19	(0.16) *	1.48	(1.07)
Diversify the energy composition	0.56	(0.38)	1.72	(1.15)
Increase compliance	0.36	(0.32)	1.22	(1.06)
Sector integration and collaboration	0.35	(0.32)	1.77	(1.41)
Trade-offs (Conflict between stakeholders)				
Increase in costs/prices	0.89	(0.74)	0.46	(0.30)
Lack of compliance	5.14	(4.96)	1.36	(1.15)
Redirection of funds	2.54	(2.54)	0.31	(0.26)
Increase job loss in coal intensive industries	1.07	(0.98)	0.23	(0.18)
Obstacles (Lack of knowledge)				
Coal Dependence	0.36	(0.28)	0.46	(0.31)
High transaction costs	0.22	(0.18)	0.20	(0.15)
Inconsistency within policy implementation	0.24	(0.21)	0.74	(0.53)
Political will	0.53	(0.37)	0.59	(0.37)
Alternative Methods (Structural and governmental change)				
Capacity building and skills transfer	2.98	(3.03)	0.98	(0.94)
Change the energy policy mix	3.12	(2.27)	1.54	(0.95)
Improve administrative and monitoring efforts	0.17	(0.19)	0.76	(0.57)
Alternative and responsible investment	2.39	(1.76)	1.43	(0.88)
McFadden's pseudo-R^2	0.27		0.27	
N	251		251	

- *Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively*
- *N=251, Log likelihood = -186.55573, pseudo R-squared = 0. 2691.*
- *Standard errors provided in the table above are robust.*
- *Likert scale reference categories: Age = 0 (20-29 years of age), Race = 0 (Coloured), Gender = 0 (Female), Interest Group = 0 (Academia), Increase Mitigation Efforts= 1 (Neither agree nor disagree), Effective Efforts = 1 (Slightly effective), LCS Adoption = 1 (Neither likely nor unlikely), Carbon Market = 1 (Moderately knowledgeable), CT Impact = 1 (Neither agree nor disagree), CT Compliance = 1 (Neither agree nor disagree)*
- *Multiple mention reference categories: Reduction Efforts = 1 (Increase education and skills development), Trade-offs= 5 (Conflict between stakeholders), Obstacles = 5 (Lack of knowledge), Alternative Methods = 5 (Structural and governmental change).*

Likely relative to neither likely nor unlikely

The main outcome from the results indicates that none of the demographic variables are statistically different from each other, given that all other variables in the model are held constant. However, one Interest Group predictor is statistically significant at the 10% level. This result indicates that the relative risk increases as consultants and those in other services

are four times more likely to state that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think that it is neither likely nor unlikely.

None of the Likert scale variables are statistically different from each other while only one multiple mention variable is statistically significant at the 10% level. In terms of different ways to reduce emissions, the relative risk increases for participants that have chosen to adopt and incentivise effective mitigation targets relative to those that have chosen to increase education and skills development. This outcome indicates that these participants are 18% more likely to state that South Africa's chances of reaching its GHG emission targets are likely, compared to those who think that it is neither likely nor unlikely.

Unlikely relative to neither likely nor unlikely

In terms of the demographic variables, two race predictors and one interest group predictor is statistically significant at the 10% level. These outcomes suggest that the relative risk increases by 27% for Indian participants and 22% for participants from the refusal race category when compared to coloured participants as these participants are more likely to state that South Africa's chances of reaching its GHG emission targets are unlikely, compared to those who think that it is neither likely nor unlikely. On the other hand, the relative risk increases for NGO members as they are nearly six times more likely to state that South Africa's chances of reaching its GHG emission targets are unlikely, compared to those who think that it is neither likely nor unlikely.

Lastly, only one Likert scale and one multiple mention variable are statistically significant at the 10% level. The relative risk increases for participants that have disagreed that the carbon tax could promote long term compliance as these participants are five times more likely to state that South Africa's chances of reaching its GHG emission targets are unlikely, compared to those who think that it is neither likely nor unlikely. This is an important result as it suggests that some believe that the carbon tax may not provide the country with the desired outcome when trying to meet its emission reduction targets.

Consequently, the CT Impact variable does not provide a significant outcome, it does however highlight a contradictory one. Both predictors seem to suggest that the relative risk increases

for participants that have agreed as well as disagreed that the carbon tax has had an impact on their firm or industry. The relative risk ratio is higher for those that have disagreed which is an important result as it suggests that the carbon tax should be enhanced by increasing the carbon tax level or by removing the tax exemptions to ensure that this mitigation instrument has a substantial impact. Since the outcome on the Effective Efforts variable indicates that participants believe the country's mitigation efforts are ineffective, the carbon tax should be accompanied by additional policy instruments to enhance these efforts. Overall, the results seem to indicate that majority of respondents are unaware of how efficacious low carbon strategies and carbon markets could be with respect to achieving the country's emission reduction targets.

An additional multinomial logistic model was run with the alternative dependent variable and the output below displays the risk ratio results of the multinomial regression coefficients with robust standard errors in brackets. In terms of McFaddens' pseudo-R-square, this shows that the full model containing our predictors represents 31% improvement in fit relative to the null model. We have assigned 'neither agree nor disagree' to be the base category, coded as 2 on the dependent variable; 'agree' is coded as 1 (collapsing "somewhat agree" and "extremely agree" in the questionnaire – see Appendix B); while disagree is coded as 3 (collapsing "somewhat disagree" and "extremely disagree" in the questionnaire).

Table 13: Relative Risk Ratios predicting the probability of South Africa achieving its emission reduction targets

Relative Risk Ratios: Do you think South Africa can achieve its emission reduction targets?	**Agree**		**Disagree**	
	Coeff.	Std.Error.	Coeff.	Std.Error
Intercept	1.373	(2.03)	3.85	(5.81)
Age (20-29)				
30-39	4.486	(2.61) *	3.34	(1.96)
40-49	0.728	(0.61)	0.24	(0.21)
50 or older	1.023	(1.10)	0.87	(0.72)
Race (Coloured)				
Asian	0.682	(0.61)	0.08	(0.11) *
Black	0.506	(0.49)	1.55	(1.47)
Indian	0.476	(0.30)	0.24	(0.15) *
White	1.019	(0.63)	0.85	(0.64)
I prefer not to answer	0.542	(0.39)	0.22	(0.18)
Gender (Female)				
Male	1.356	(0.74)	2.86	(1.76)
I prefer not to answer	5.426	(7.20)	0.13	(0.23)
Interest Group (Academia)				
Consultancy or other services	0.785	(0.42)	0.64	(0.40)

Government	6.783	(6.99)	13.05	(13.6) *
Industry	1.286	(0.71)	0.72	(0.44)
NGO	2.254	(1.92)	2.18	(1.90)
Likert Scale Variables				
Increase Mitigation Efforts (Neither agree nor disagree)				
Agree	0.32	(0.26)	0.37	(0.29)
Disagree	0.56	(0.50)	1.83	(1.54)
Effective Efforts (Slightly effective)				
Very effective	2.96	(3.35)	1.90	(3.26)
Ineffective	0.45	(0.26)	0.86	(0.47)
Carbon Market (Moderately knowledgeable)				
Not knowledgeable at all	1.28	(0.66)	0.90	(0.49)
Knowledgeable	1.50	(0.86)	1.04	(0.60)
CT Impact (Neither agree nor disagree)				
Agree	1.96	(0.97)	0.91	(0.57)
Disagree	2.11	(1.20)	4.32	(2.61) *
CT Compliance (Neither agree nor disagree)				
Agree	6.48	(3.86) **	1.91	(1.26)
Disagree	1.18	(0.84)	2.08	(1.48)
LCS Adoption (Neither likely nor unlikely)				
Likely	0.46	(0.32)	0.21	(0.15) *
Unlikely	1.39	(1.33)	1.59	(1.34)
Multiple mention Variables				
Reduction Efforts (Increase education and skills development)				
Adopt and incentivise effective mitigation targets	0.31	(0.25)	1.52	(1.29)
Diversify the energy composition	0.49	(0.43)	1.57	(1.40)
Increase compliance	0.25	(0.23)	0.57	(0.57)
Sector integration and collaboration	1.17	(1.03)	2.86	(2.59)
Trade-offs (Conflict between stakeholders)				
Increase in costs/prices	1.99	(1.34)	3.88	(2.90)
Lack of compliance	2.97	(2.23)	2.34	(1.91)
Redirection of funds	1.60	(1.25)	0.70	(0.58)
Increase job loss in coal intensive industries	2.73	(1.95)	0.98	(0.85)
Obstacles (Lack of knowledge)				
Coal Dependence	2.62	(1.77)	0.44	(0.31)
High transaction costs	2.84	(2.19)	1.07	(0.95)
Inconsistency within policy implementation	0.63	(0.54)	0.49	(0.39)
Political will	1.47	(0.90)	0.19	(0.13) *
Alternative Methods (Structural and governmental change)				
Capacity building and skills transfer	1.31	(1.35)	2.78	(3.02)
Change the energy policy mix	0.93	(0.67)	0.83	(0.63)
Improve administrative and monitoring efforts	0.53	(0.46)	0.78	(0.69)
Alternative and responsible investment	0.32	(0.22)	0.42	(0.31)
McFadden's pseudo-R^2	0.31		0.31	
N	251		251	

- *Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively*
- *N=251, Log likelihood = -185.25708, pseudo R-squared = 0.3111.*
- *Standard errors provided in the table above are robust.*
- *Likert scale reference categories: Age = 0 (20-29 years of age), Race = 0 (Coloured), Gender = 0 (Female), Interest Group = 0 (Academia), Increase Mitigation Efforts= 1 (Neither agree nor disagree), Effective Efforts = 1 (Slightly effective), LCS Adoption = 1 (Neither likely nor unlikely), Carbon Market = 1 (Moderately knowledgeable), CT Impact = 1 (Neither agree nor disagree), CT Compliance = 1 (Neither agree nor disagree)*
- *Multiple mention reference categories: Reduction Efforts = 1 (Increase education and skills development), Trade-offs= 5 (Conflict between stakeholders), Obstacles = 5 (Lack of knowledge), Alternative Methods = 5 (Structural and governmental change).*

Agree relative to neither agree nor disagree

The main outcome from these results indicate that no race, gender or interest group variable is significantly different from each other, given that all other variables in the model are held constant. Only one predictor from the age variable is statistically significant at the 10% level. This indicates that the relative risk increases for participants that are between 30-39 years of age as they are nearly five times more likely to agree that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree.

None of the multiple mention variables are statistically different from each other but in terms of the Likert scale variables, an interesting result indicates that the relative risk increases for participants that agree to the fact that the carbon tax could promote long term compliance. This result contradicts the previous finding when including the original dependent variable as participants have indicated that they do not believe that the carbon tax could promote long term compliance. Hence, this outcome suggests that these participants are six times more likely to agree that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree.

Including two separate dependent variables highlights the difference in the results as the original dependent variable considers the long term impacts of the country's climate mitigation instruments relative to the country's emission reduction efforts while the alternative dependent considers the short term impacts. These contradictory results indicate that including a dependent variable with a time factor helps to evaluate the long term impacts in relation to the country's goals and whether or not these efforts could help the country achieve its emission reduction targets.

Disagree relative to neither agree nor disagree.

The main outcome from these results indicate that no age or gender variable is significantly different from each other. However, the relative risk increases for Asians and Indians as these participants are 8% and 24% more likely to disagree that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree. On the other hand, government officials are 13 times more likely to disagree that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree.

A surprising result indicates that the relative risk increases for participants that have disagreed that the carbon tax has had an impact on their firm or industry. This outcome suggests that these participants are four times more likely to disagree that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree. Moreover, the relative risk increases for participants that have stated it is likely that their firm or industry would adopt a low carbon strategy as these participants are 21% more likely to disagree that South Africa could achieve its emission reduction targets relative to those that neither agree nor disagree.

Lastly, the relative risk increases for participants that have stated that the country's level of political will could create a potential obstacle when trying to reduce GHG emissions. Based on this outcome, this result suggests that participants are 19% more likely to disagree that South Africa could achieve its emission reduction targets relative to those neither agree nor disagree.

Appendix H: Post regression diagnostics

Breusch-Pagan test

In terms of the post regression diagnostics, a Breusch-Pagan test was run to test for heteroskedasticity within the model. Based on the results with a chi2(26) = 12.55 and the p = 0.988 which is below the threshold. Therefore, we fail to reject the null hypothesis of homoskedasticity and heteroskedasticity is assumed. The regression models therefore utilise robust standard errors to account for heteroskedasticity.

Omitted Variable Bias test

When testing for omitted variable bias, a Ramsey test was run and the result of F (3, 221) = 5.31 and p =0.0015 which is less than the null. Hence, we can reject the null hypothesis and conclude that the model suffers from omitted variable bias but this should be expected due to the specialist sample which would lead to sample selection bias. This outcome could also be explained by the ambiguity that could arise when trying to find an appropriate regression for a polytomous response variable but despite the wide range of questions used within the

questionnaire and the comprehensive opinions provided by the snowball sample, we acknowledge that participant opinions might be influenced by another factor or the model might be capturing something that that has not been included in the questionnaire.

Variance inflation factors

Variance inflation factors (VIF) are commonly used to check for near perfect collinearity. Based on the table below, the vif values are low with a mean VIF of 1.7 which is below the threshold of 5. This indicates that there is a low chance of collinearity and none of the predictors are a cause for concern.

Table 14: Variance inflation factors

Variable	VIF	1/VIF
Demographic Variables		
Age		
	1.4	0.7
	1.5	0.7
	1.5	0.7
	1.3	0.8
Race		
	1.3	0.8
	1.4	0.7
	1.5	0.7
	1.6	0.6
	1.4	0.7
Gender		
	1.8	0.6
	1.3	0.8
Interest Group		
	1.7	0.6
	1.5	0.7
	1.9	0.5
	1.6	0.6
Likert Scale Variables		
Increase Mitigation Efforts		
	2.7	0.4

	2.0	0.5
Effective Efforts		
	1.3	0.8
	1.3	0.8
LCS Adoption		
	1.8	0.5
	1.7	0.6
CT Impact		
	1.5	0.7
	1.4	0.7
CT Compliance		
	2.2	0.4
	2.7	0.4
Carbon Market		
	1.4	0.7
	1.5	0.7
Multiple Mention Variables		
Reduction Efforts		
	2.6	0.4
	2.8	0.4
	1.9	0.5
	2.4	0.4
Trade-offs		
	2.5	0.4
	1.9	0.5
	1.8	0.6
	2.1	0.5
Obstacles		
	1.8	0.6
	1.7	0.6
	1.8	0.6
	1.9	0.5
Alternative Methods		
	1.7	0.6
	2.7	0.4
	1.7	0.6
	2.5	0.4

Table 15: Correlation matrix coefficients of regression model

Variable	Age	Race	Gender	Interest Group	Increase Mitigation Efforts	Effective Efforts	LCS Adoption	Carbon Market	CT Impact	CT Compliance	Reduction Efforts	Trade-offs	Obstacles	Alternative Methods
Age	1.000													
Race	-0.122	1.000												
Gender	-0.121	0.001	1.000											
Interest Group	-0.156	0.081	-0.038	1.000										
Increase Mitigation Efforts	-0.196	-0.064	-0.329	-0.127	1.000									
Effective Efforts	-0.016	0.007	-0.034	-0.037	0.076	1.000								
LCS Adoption	-0.099	-0.061	0.024	0.030	0.127	-0.005	1.000							
Carbon Market	-0.063	-0.029	-0.007	-0.020	0.084	-0.017	-0.054	1.000						
CT Impact	-0.076	0.008	0.020	-0.037	-0.074	-0.132	0.017	-0.068	1.000					
CT Compliance	-0.099	-0.010	-0.043	-0.068	-0.127	-0.162	-0.144	-0.073	-0.052	1.000				
Reduction Efforts	0.076	0.040	0.035	0.065	-0.042	0.077	-0.078	-0.040	0.087	0.064	1.000			
Trade-offs	-0.035	-0.060	-0.104	0.055	0.007	0.169	-0.021	-0.020	-0.126	0.179	0.095	1.000		
Obstacles	-0.098	-0.033	0.009	-0.013	0.049	0.006	0.031	-0.075	-0.064	-0.017	-0.028	0.052	1.000	
Alternative Methods	0.140	-0.014	-0.104	-0.096	-0.032	0.018	-0.030	0.024	0.118	0.095	0.018	0.022	-0.074	1.000

Based on the table above, the low correlation indicates that there is no clear linear correlation between two variables. Hence, it is highly unlikely that the regression suffers from collinearity as none of the variables are higher than the 0.5 threshold.