Analysis of future carbon tax scenarios for South African gold mines

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ABSTRACT

The South African Carbon Tax Act came into effect in 2019, and it places a price on the emissions of greenhouse gases (GHG). The second phase of the carbon tax will be implemented in 2023. Presently, there is uncertainty regarding the changes that will be made to tax policy during this review. This is especially problematic since GHG emissions mitigation strategies are dependent on the existing tax policy design. Subsequently, carbon taxpayers, like gold mining companies, cannot plan for future carbon tax-related scenarios.

The uncertainty regarding carbon tax policy changes needs to be reduced to assist South African gold mines with future carbon tax planning. This study investigated a variety of scenarios associated with Phase 2 tax policy designs and GHG mitigation strategies. The uncertainty was reduced through the assessment of the impact of tax policy design, and emissions mitigation strategies, on a gold mining company's future carbon tax exposure.

This study developed possible carbon tax policy scenarios and emissions mitigation scenarios. An appropriate baseline scenario was identified for 2021 to 2027. The carbon tax exposure was calculated and forecasted for each scenario for the same period as the baseline. A sensitivity analysis was performed on these scenarios with reference to the baseline scenario. This was done to ascertain the sensitivity of carbon tax exposure to the scenarios themselves.

The analysis of the carbon tax policy scenarios resulted in various findings. First, phasing out the basic tax-free allowance for fossil fuel combustion emissions would expose a gold mining company to more carbon tax annually compared to the baseline. However, the extent to which this is true could not be verified.

Secondly, selecting a carbon budget based on national emissions reductions requirements, rather than a gold mining company's mitigation potential, would lead to higher annual carbon tax exposure if said budget is exceeded. Furthermore, the option for carbon budget penalty imposition by the National Treasury would result in higher annual carbon tax exposure for a gold mining company, compared to penalty imposition by the Department of Forestry, Fisheries and the Environment (DFFE).

Lastly, carbon offsetting can reduce a company's emissions in terms of carbon accounting. This may be useful in achieving net-zero carbon emissions status. However, the resulting carbon tax exposure is only reduced if the percentage of emissions offset is within the constraint presented by the offset allowance in the Carbon Tax Act.

In terms of emissions mitigation, it was found that the implementation of a renewable energy plant to substitute coal-fired electricity purchases exposes a gold mining company to less carbon tax in future, when compared to sourcing power from the renewable energy sector.

Keywords: *Carbon tax, greenhouse gas emissions, Phase 2 carbon tax policy, emissions mitigation*

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LIST OF ACRONYMS AND ABBREVIATIONS

AFOLU	Agriculture, Forestry and Other Land Use
BAU	Business as Usual
BRICS	Brazil, Russia, India, China and South Africa
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPI	Consumer Price Index
CSP	concentrated solar power
DFFE	Department of Forestry, Fisheries and the Environment
GHG	greenhouse gas
GT	gross tonnage
GWh	gigawatt hours
HEP	hydroelectric power
IEP	Integrated Energy Plan
IRP	Integrated Resource Plan
kWH	kilowatt hour
LCOE	levelized cost of electricity
LEDS	Low-Emissions Development Strategy
MW	megawatt
MWh	megawatt hours
NDP	National Development Plan
NEMAQA	National Environmental Management: Air Quality Act
NGER	National Greenhouse Gas Emissions Reporting Regulations
OECD	Organisation for Economic Co-operation and Development
p.a.	per annum
PV	photovoltaic
RE	renewable energy
tCO_2e	tonne carbon dioxide equivalent
WEP	wind electric power
ZAR	South African Rand

CHAPTER 1: INTRODUCTION

1.1 Preamble

Climate change is an issue that plagues today's society, and it is due to the increasing amount of greenhouse gas (GHG) in Earth's atmosphere [1]. The origins of these emissions are anthropogenic GHG-emitting activities on Earth's surface [2].

In South Africa, the country's extensive combustion of fossil fuels exacerbates climate change [3]. Approximately 60% of South Africa's domestic coal supply is used for electricity generation [2], while electricity generation accounts for 56% of the country's total emissions [3]. Subsequently, the country is described as fossil-fuel reliant [1].

In terms of emissions, South Africa is ranked the 13th largest GHG-emitting country globally [4]. This is evident from Table 1, which represents the top 14 GHG-emitting countries in 2018. Figure 1 compares the GHG emissions profile of South Africa and China per capita from 2010 to 2018. International emissions data was unavailable past 2018.

Table 1: Top 14 GHG-emitting countries in the world as of 2018

Rank	Country	Total CO_2e emissions [GT]
1	China	10.06
2	United States of America	5.41
3	India	2.65
4	Russian Federation	1.17
5	Japan	1.16
6	Germany	0.75
7	Islamic Republic of Iran	0.72
8	South Korea	0.65
9	Saudi Arabia	0.62
10	Indonesia	0.61
11	Canada	0.56
12	Mexico	0.47
13	South Africa	0.46
14	Brazil	0.45

UCS (2021, Jul 23), *Each Country's Share of CO_2 Emissions* [Online]. Available: https://www.ucsusa.org/resources/each-countrys-share-co2-emissions

Although China is ranked first in terms of total emissions, as seen in Table 1, South Africa exceeds China's emissions per capita, as seen in Figure 1 [2]. Per capita, it is known that South Africa emits twice the global average of GHG [2].

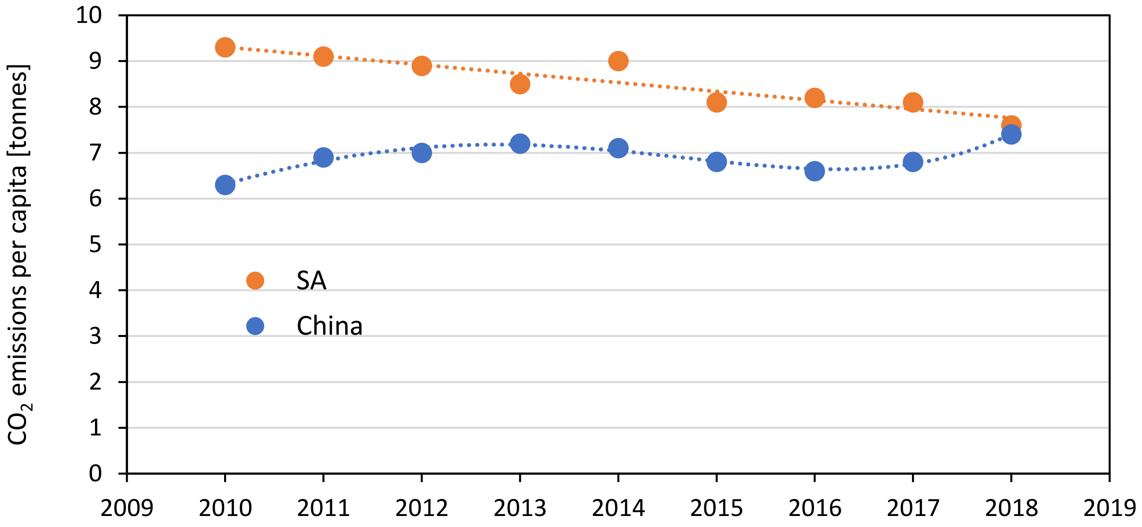


Figure 1: GHG emissions per capita for South Africa and China, 2010–2017

Adapted from The World Bank (2021, Jul 23), *CO_2 emissions (metric tons per capita) South Africa, China* [Online]. Available: https://data.worldbank.org/indicator/EN.ATM.CO2E.PC?end=2017&locations=ZA-CN&most_recent_value_desc=true&start=2010

By 2014, South Africa had generated a total of 526 million metric tonnes of GHG [3]. With emissions at this scale, the subsequent exacerbation of climate change could lead to the degradation of local ecosystems [1]. Climate change mitigation has thus become increasingly important in South Africa [3].

The country's recognition of this environmental problem has precipitated various national plans aimed at environmental sustainability [4]. One such plan is the National Development Plan (NDP) [5]. This is a long-term plan aimed at creating an environmentally sustainable energy sector that provides reliable and efficient services [5]. The NDP envisages a peak in GHG emissions by 2025, a plateau for approximately 10 years, and then a decline from 2036 [5].

South Africa also participated in various international initiatives to recognise this global problem. Examples of such initiatives are the Copenhagen Accord and the Paris Agreement [3]. Under the Copenhagen Accord, South Africa committed to an emissions reduction target of 42% from Business as Usual (BAU) by 2025. This target still governs climate change mitigation initiatives in the country [4].

In terms of the Paris Agreement, South Africa committed to minimising emissions in line with the NDP [5]. However, South African policymakers have raised concerns regarding whether South Africa will be able to meet these commitments [6]. In response, the government has introduced one of the most intricate climate governance systems seen among developing countries [7]. This system includes carbon budgeting, sectoral emissions targets, and a carbon tax [8].

1.2 Emissions classification and carbon taxation in South Africa

GHG emissions can be classified as direct or indirect [9]. Direct emissions, also described as *scope 1* emissions, are those whose source (point of origin) is owned or controlled by the taxpaying entity [9].

Indirect emissions result from a tax entity's activities that occur at sources under the ownership of or controlled by a different tax entity [9]. Indirect emissions can be classified into two groups: *scope 2* emissions and *scope 3* emissions. Scope 2 emissions are indirect emissions associated with the generation of electricity, heating or cooling. Scope 3 emissions, which are also indirect, result from upstream and downstream supply chain activities [10].

Scope 1 emissions are reported as per the regulations of the National Greenhouse Gas Emissions Reporting Regulations (NGER) [11], while scope 2 emissions are reported as per the National Energy Act [12]. No national reporting requirements exist for scope 3 emissions, as stated in the National Environmental Management: Air Quality Act (NEMAQA) [13].

A carbon tax is an environmental tax levied against GHG emissions [7]. It is calculated by multiplying a specified carbon tax base rate with the emissions for which the taxpayer is liable [7]. Carbon taxes may be divided into direct and indirect carbon taxes, which are associated with direct and indirect emissions, respectively. Carbon taxation is used in various countries around the world to reduce GHG emissions [6].

Carbon tax exposure is the total amount of carbon tax liability to which a taxpayer is exposed directly and indirectly [10]. The tax policy to which the taxpayer is bound [14] influences the taxpayer's carbon tax exposure. This definition infers that carbon taxation incentivises the reduction of both direct and indirect emissions [10]. Hence, a carbon tax is seen as a highly effective instrument for climate change mitigation [15].

Despite the definition of indirect carbon tax exposure, in South Africa, only scope 2 tax exposure is considered, not scope 3 [16]. This is because carbon taxes are only considered calculable on emissions with national reporting requirements [14].

In South Africa, the Carbon Tax Act was gazetted in 2019 [7]. This Act assigns a price to GHG emissions in South Africa [17]. Moreover, it gazettes the method of application of the carbon tax policy contained therein [7].

1.3 Carbon Tax Act of 2019

1.3.1 Background

The South African Carbon Tax Act was gazetted in 2019 and was introduced using a phased approach [7]. Phase 1 began on 1 June 2019 and will end on 31 December 2022 [17], while Phase 2 begins on 1 January 2023 and will end on 31 December 2027 [6]. Before commencing Phase 2, the tax policy described within the gazette is to be reviewed and amended. As of now, there is no certainty regarding what changes will be made [6].

In this section, the carbon tax policy is outlined, and the various policy elements of South Africa's carbon tax regime are described. These include the tax base rate, financial instruments, allowances, carbon budgeting, and border tax adjustments.

1.3.2 Carbon tax policy outline

The Carbon Tax Act of 2019 assigns a price to GHG emissions in South Africa [6] and dictates the application method of the carbon tax policy [7]. This Act gazettes the type of emissions that are liable for taxation [6]. Carbon taxes need only be levied on certain types of scope 1 emissions [7]. For Phase 1 of the carbon tax regime, these include:

- Fossil fuel combustion-related emissions [17]
- Industrial process emissions [17]
- Fugitive emissions at their source [7]

These are specifically the scope 1 emissions reported to the Department of Forestry, Fisheries and the Environment (DFFE) as part of National Greenhouse Gas Reporting [11]. The regulations and guidelines that dictate how emissions should be reported are found in the NGER, and in the *Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry* [11, 18].

It is important to note that scope 1 emissions from the Agriculture, Forestry and Other Land Use (AFOLU) sector and the Waste sector are exempt from carbon tax in Phase 1 [17]. Their exclusion is due to difficulties regarding the measurement and verification of their emissions [6].

1.3.3 Tax base rate

The Carbon Tax Act stipulates a carbon tax base rate of R120 per tonne CO_2 equivalent (tCO_2e) [17]. During Phase 1, it is stipulated that this tax base rate must increase by the Consumer Price Index (CPI), plus an additional 2%, every year [6]. After that, in Phase 2, it is evident from the gazette that the tax base rate should only increase by CPI annually [17].

Amendments to the Act in 2020 formalise a tax base rate of R127/ tCO_2e for 2020 [19]. For 2021 and 2022, the Phase 1 carbon tax base rate increase will be applicable [17]. For Phase 2, it is intended that the tax base rate considers the carbon budget policy [20].

1.3.4 Financial instruments

Financial instruments are policy instruments used to help reduce fiscal costs to taxpayers [21]. The two types of instruments used in carbon tax policy design are subsidies and incentives [21].

Subsidies can be further divided into two categories: those that result in decreased GHG emissions, and those that increase them [21]. Research and development subsidies and price supports are types of subsidies that lead to a decrease in GHG emissions [21]. Conversely, environmentally disadvantageous subsidies support the production or consumption of fossil fuels in sectors with poor energy reform [3].

The subsidisation of sectors that are a source of GHG emissions may increase emission activities and thus emissions [21]. This is because the subsidy does not incentivise a reduction in emissions [3]. Subsequently, in Organisation for Economic Co-operation and Development (OECD) countries, such subsidies have lost popularity and are slowly being phased out [22].

In terms of financial incentives, it has been noted that the most effective incentives associated with carbon tax regimes are price supports for the implementation of renewable energy (RE) plants [22]. This is because such supports aid the expansion of the RE sector, such as in OECD countries, which draws a country closer to reaching its emissions reduction targets [21].

In the South African carbon tax regime, an example of an existing financial instrument is the renewable energy premium tariff. This is awarded to taxpayers to subsidise the implementation costs of RE plants [22]. Other financial instruments include incentives awarded by the National Treasury for emissions reductions and carbon budget participation [6, 11]. Additionally, subsidies support specific sectors' emissions activities [11]. These exist in the form of allowances, which are discussed in section 1.3.5.

1.3.5 Allowances

Allowances have been included in the Carbon Tax Act [17]. These allowances function as discounts [6], and are awarded to tax entities based on their sector characterisation and the type of emissions activities under their control [6]. These allowances reduce the tax base rate to a lower rate, described as the 'effective tax rate' [17].

First, a basic tax-free allowance is described. As gazetted by the Carbon Tax Act of 2019, the basic-tax free allowance is an example of a production and consumption support subsidy [17]. It has been noted that this element of the carbon tax design will be environmentally disadvantageous if not phased out over time [3]. However, these basic tax-free allowances will remain unchanged for the duration of Phase 1 [17]. They are detailed in Table 2, together with the emissions to which these allowances are applicable.

Table 2: Basic tax-free allowances per sector as per the Carbon Tax Act of 2019 [17]

Sector	Allowance [%]	Applicable emissions
Energy/ power	60	Fossil fuel combustion emissions
Industrial	70	Industrial process emissions
Transport	75	Mobile fuel combustion emissions
Fugitive	70	Fugitive emissions

In addition to the basic tax-free allowance, other allowance mechanisms were included in the carbon tax design. These allowances function as incentivisation mechanisms, and are detailed in Table 3.

Table 3: Incentivisation allowances as per the Carbon Tax Act of 2019 [17]

Allowance name	Allowance [%]	Purpose of allowance
Carbon budget	5	Carbon budget participation incentivisation
Offset	≤ 10	Carbon offsetting incentivisation
Performance	5	Emissions reductions incentivisation
Trade exposure	≤ 10	Trade exposure compensation

Note that carbon offsetting reduces emissions to compensate for emissions made elsewhere [23]. A company that offsets its emissions can reduce its carbon tax liability by receiving a maximum offset allowance of 10% [24]. This is regardless of whether more than 10% of emissions are offset [23]. This offset allowance also acts as an incentive [17].

There is consensus that the environmental advantages of carbon taxation would be diminished if these allowances were not eventually quashed [25]. This is because applying these allowances to the tax base rate renders the effective rate too low [6]. This is problematic because the subsequent carbon tax revenue collected would be small and thus insufficient for revenue recycling purposes [6].

1.3.6 Carbon budget and carbon tax policy interaction

The Carbon Tax Act awards a 5% carbon budget allowance to any tax entity that participates in national carbon budgeting [17]. However, the Carbon Budget Design Document only considers Phase 1 of carbon budgeting, which ends in 2022 [6].

In the Carbon Budget Design Document, recognition is given to the need for consistency between national carbon budgeting and GHG reporting. By default, this includes the need for alignment between carbon budgeting and carbon tax policies [3]. It is also highlighted in the Environmental Fiscal Reform Paper that the alignment of these policies should not lead to their diminished environmental effectiveness [22].

In February 2021, the DFFE [8] held a Portfolio Committee meeting. This meeting aimed to discuss possible policy design options for a carbon tax and carbon budget alignment. Two alternatives were addressed [8], namely penalisation methods and carbon tax ramifications, and these are presented in Table 4.

For option 1, it is implied that the National Treasury would impose the penalty, as this penalty would be in response to being liable for emissions that exceed the budget [8]. However, for option 2, it is implied that the penalty would be imposed by the DFFE, as this penalty would be in response to reporting emissions that exceed the budget [8].

Table 4: Climate governance alignment options presented by the DFFE [8]

Option	Penalty for exceeding budget	Tax base rate [ZAR/tCO_2e]	Basic tax-free allowance [%]	Carbon budget allowance [%]
1	Increase in tax base rate	R120 within budget R600 over budget	60	5
2	Denial of carbon budget allowance	R120	30	35

1.3.7 Border tax adjustments

Carbon leakage is a phenomenon where an increase in emissions is observed due to moving importation from a country with stringent climate change mitigation policies to one where such policies are more lenient [26]. Countries with lenient policies are generally more carbon-intensive than those with stringent policies [26]. To eliminate carbon leakage, it has been suggested that border tax adjustments be adopted [27].

A border tax adjustment increases the cost of importation to combat carbon leakage [27]. This adjustment is proportional to the carbon leakage associated with said import, and is therefore regarded as a carbon tax [26]. Implementing border tax adjustments ensures a country's environmental integrity in terms of international relations [28].

Unfortunately, there are disadvantages associated with border tax adjustments [28]. Importers with lenient climate change policies are discouraged from importing [27], and subsequently, importing demand is diverted to countries with lenient policies, as there are fewer environmental fiscal costs associated with importation [26]. As a result, an increase in emissions is observed [27]. This defeats the intended purpose of the border tax adjustment, rendering its inclusion unfeasible in the Phase 2 carbon tax design [27].

1.3.8 Carbon tax policy elements literature review

The tax base rate, financial instruments, allowances, carbon budgeting, and border tax adjustments constitute the policy elements of the Carbon Tax Act [17]. Their application method is gazetted in the Act for the Phase 1 of the carbon tax regime [6].

The Carbon Tax Act is due for review prior to Phase 2 [7]. However, the South African government has failed to provide coherent explanations for the expected changes to the policy elements in Phase 2 [6]. It is known that this phase will be more stringent on emissions sourced from electricity generation [17], but not how the subsequent additional tax revenue will be used [6].

This has prompted various uncertainties in the lead-up to the Phase 2 policy review, as follows [6]"

- Despite the large allowances included in the Carbon Tax Act, the capacity of South African industries to absorb the financial costs incurred by carbon tax is still in question [29]. Therefore, it remains unknown how the allowances will be amended for Phase 2 [6]. As a result, it is unclear what changes will be made to the design of financial subsidisation and incentivisation in preparation for Phase 2 of carbon tax [6].
- It is yet to be determined how the carbon budget design will align with the Phase 2 carbon tax design [30]. The appropriate carbon budget methodology is still under question [30], and there is uncertainty regarding which option will be gazetted [8].
- In addition, there is uncertainty regarding how the carbon budget policy will influence the carbon tax base rate [20]. Although the tax base rate will inflate annually during Phase 2, the magnitude of the rate itself is still in question [17].
- Carbon tax policy decisions surrounding the land use and waste-related activities for Phase 2 are also unknown [6].

1.4 South Africa's emissions activities, climate change governance, and emissions mitigation developments

1.4.1 Background

The amount of carbon tax to which a taxpayer is exposed depends, first, on a company's emissions activities [14] and, second, on how the carbon tax policy is applied to said emissions [17].

The design of a country's carbon tax policy must consider the country's unique emissions activities [31], since it needs to address the environmental challenges resulting from these activities [32]. Additionally, carbon tax policy design must consider a country's emissions mitigation capacity [31].

In designing a country's carbon tax policy, the policy described in other environmental fiscal legislation is reviewed [32]. This is to ensure that the elements of carbon tax policy are not addressed in other forms of climate governance [31], as well as to ensure that the carbon tax policy includes climate governance elements that have not yet been considered or gazetted in South Africa [32].

This section describes South Africa's emissions activities and their consequences. The forms of climate governance are also explored. Finally, the country's emissions mitigation capabilities, initiatives and developments are discussed, with a specific focus on RE, biofuel substitution and carbon trading.

1.4.2 Emissions activities

South Africa is a carbon-intensive country that emits twice the global average of GHG per capita [2], and various sectors in South Africa have become economically reliant on energy-intensive operations [2]. These sectors, and their contribution to South Africa's emissions in 2016, are depicted in Figure 2. Figure 3 represents the energy mix associated with South Africa's power sector in 2016.

It is apparent from Figure 2 that the most significant source of GHG emissions is the power sector. Figure 3 indicates that 96% of these emissions result from the combustion of primary fossil fuels, namely coal, oil and natural gas. Moreover, 72% of these emissions are associated with electricity generation at coal-fired power plants. Despite a quarter of South Africa's coal supply being reserved for exportation, coal combustion still accounts for 88% of the country's net emissions [2].

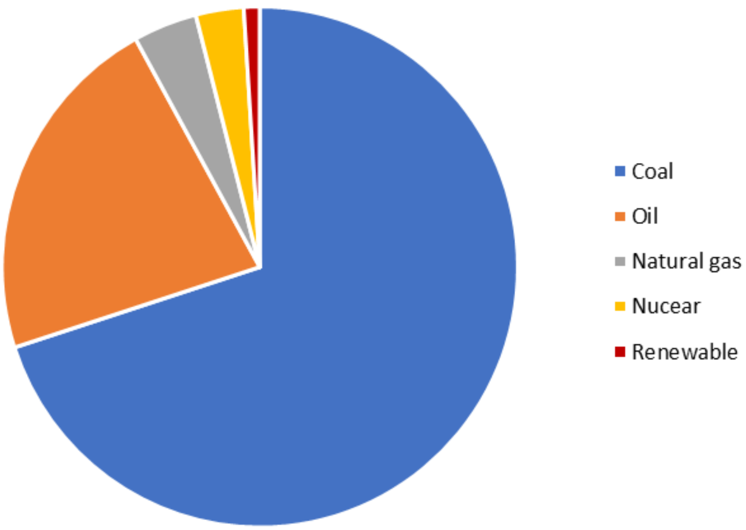


Figure 2: South African energy mix and percentage contribution to GHG emissions, 2016

Adapted from eia (2021, Aug 28), *South Africa* [Online]. Available: https://www.eia.gov/international/analysis/country/ZAF

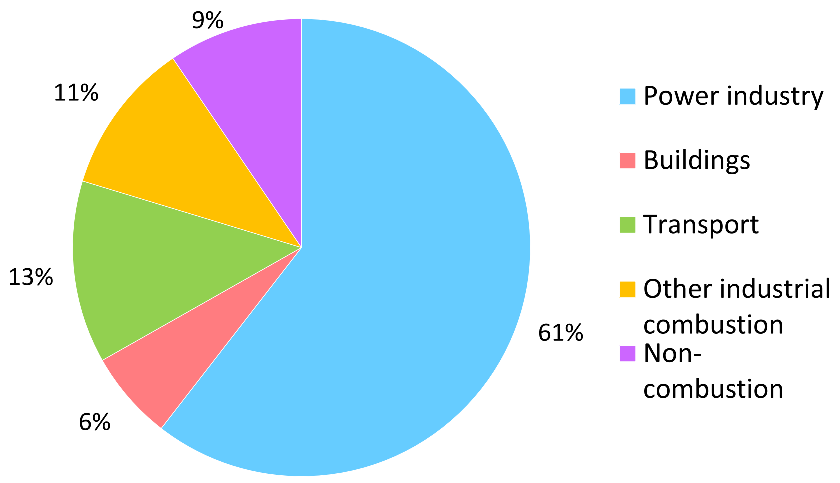


Figure 3: South African sectors' percentage contribution to GHG emissions, 2016

Adapted from Worldometer (2021, Aug 28), *South Africa CO_2 Emissions* [Online]. Available: https://www.worldometers.info/co2-emissions/south-africa-co2-emissions/

1.4.3 Climate governance

Given the energy-intensive nature of South African industrial operations, the government has targeted ambitious emission reduction [3], and significant structural transformation of the economy is required to reduce emissions under the Copenhagen Accord [6]. Subsequently, the government has initiated one of the most consultative and elaborate climate governance systems among developing countries [7].

The country has employed a Low-Emissions Development Strategy (LEDS) [33] that aims to realise the peak emissions in 2025 as per the Paris Agreement commitments [29]. The strategy aims to achieve this through two emissions mitigation measures, namely sector-specific measures and cross-cutting measures, which are characterised by their sectoral independence [33].

One such cross-cutting measure, which is part of LEDS, is the South African carbon tax regime [33]. This began in 2019 upon the passing of the Carbon Tax Act [10]. The introduction of a carbon tax in South Africa is advantageous, as environmental, economic and social benefits are associated with its implementation [6]. The obvious environmental benefit is incentivising emissions reductions and subsequent environmental protection [34].

Prior to the carbon tax regime, in 2009, the National Treasury introduced an environmental levy on electricity generation as a proxy for carbon tax [6]. This is a levy on every unit of electricity used or purchased [17]. As a result, in Phase 1 of the carbon tax regime, credits from this levy covered fossil fuel combustion emissions associated with electricity generation [6]. Subsequently, carbon tax exposure to these scope 2 emissions could be reduced [17].

The National Treasury intended to evaluate the performance of the levy in terms of emissions reductions [6]. This was to derive lessons from this levy's performance to support carbon tax policymaking decisions [6]. However, this never happened [6]. Therefore, in Phase 2 of the carbon tax regime, it is unknown whether the credits purchased through the payment of an electricity generation levy will cover the associated carbon tax liability [17]. There is no certainty regarding whether carbon tax liability will be paid in conjunction with the electricity levy [6].

Unfortunately, South Africa experiences various issues that make it difficult to ascertain how the economy will be affected by this environmental tax [15]. The economy is both inefficient and resource intensive [3]. The country's human development indices remain low, inequality and unemployment are rife, and the country continues to urbanise rapidly. Additionally, information regarding price sensitivities and technological progress is not available during policy design [25]. Subsequently, patterns regarding population growth, economic growth, and energy and resource consumption are difficult to predict [4].

1.4.4 Emissions mitigation developments

Due to its heavy dependence on coal, the harmful effects of GHG emissions in South Africa are being addressed through the encouragement of RE contributions to the country's energy mix [2]. This would also aid in reducing the unsustainability associated with the nature of electricity generation, namely coal-fired power [35].

South Africa's energy crisis combines environmental degradation (due to activities in the energy sector) with energy poverty [33]. To combat this, policy frameworks were adopted to expedite emissions mitigation initiatives [32]. These policy frameworks aim to increase the diffusion of RE technology throughout the country [34], the substitution of fossil fuels for biofuels [35], and lastly, carbon trading [36].

In sections 1.4.5, 1.4.6 and 1.4.7, the respective emissions mitigation initiatives in South Africa (described in the paragraph above) are explored. Furthermore, their policy frameworks and their alignment with the carbon tax policy are described.

1.4.5 Renewable Energy

RE technology is an emissions mitigation strategy that is growing in popularity in South Africa [34]. Various climate policy documents precipitated the formulation of national plans and strategies on the expansion of the RE sector [37]. These include the NDP, LEDS, the Integrated Resource Plan (IRP), the Integrated Energy Plan (IEP) and the National Energy Efficiency Strategy [31]. The geographical distribution of these RE initiatives in South Africa can be viewed in Figure 4.

To align carbon tax policy with the RE regulatory framework, the levelized cost of electricity (LCOE) is adjusted by a percentage, informed by Eskom, to support the RE sector [35]. Moreover, the government awards grants to taxpayers who generate RE at their facilities to reduce the amount of electricity purchased from Eskom [36]. This grant is awarded to companies that implement the types of RE power plants deemed feasible in South Africa [25], including solar, geothermal, wind, biomass, tidal wave and hydro energy [25].

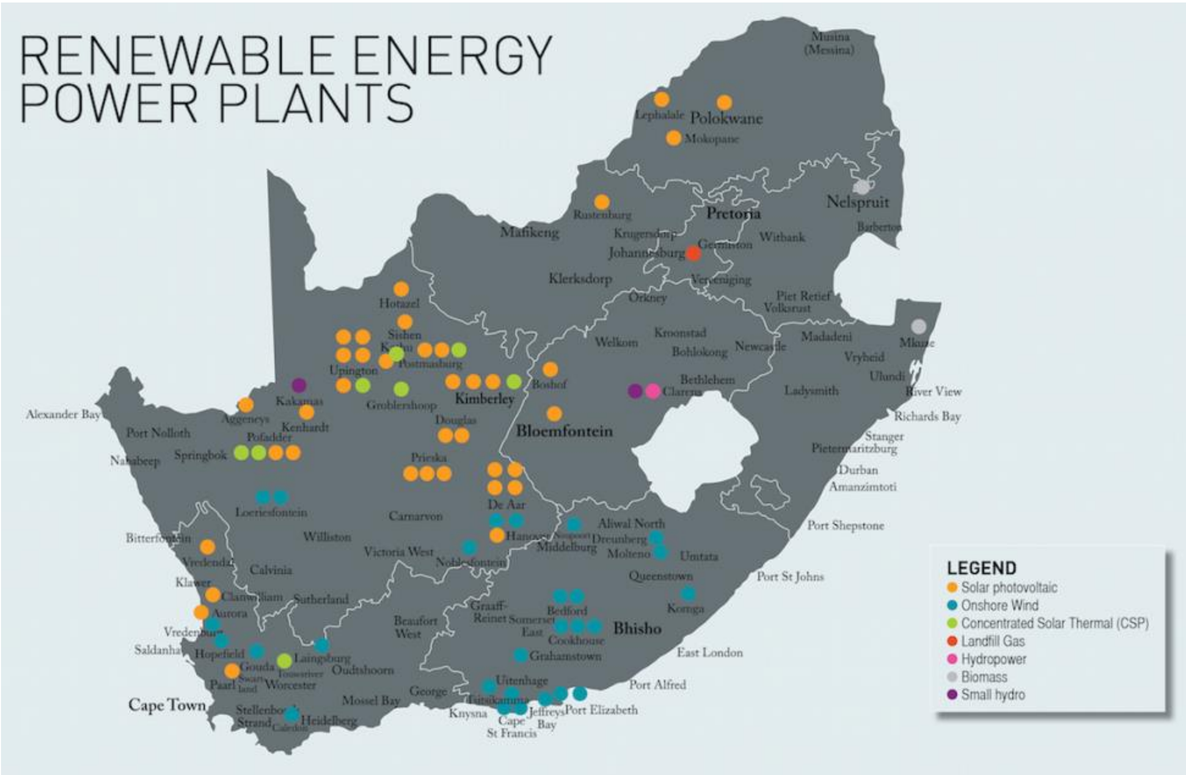


Figure 4: Geographical distribution of South African RE power plants

Sense and Sustainability (2021, Aug 7), *South Africa's REIPPP* [Online]. Available: https://www.senseandsustainability.net/2019/04/02/south-africas-reippp/

This grant takes the form of a premium tariff per unit of electricity generated renewably, and is referred to as the ‘renewable energy premium’ [25]. This grant aims to reduce the implementation costs associated with RE technologies, thus incentivising their distribution throughout the country [34].

Renewable energy for power generation is vital for emissions mitigation in South Africa [35]. This is particularly important as most of South Africa’s emissions are a consequence of electricity generation [2]. Given how RE is necessary to realise the country’s emissions reduction goals, its influence on climate change mitigation and climate governance should be considered [38].

1.4.6 Biofuel substitution

Biofuels, which are fuels of plant origin, have the potential to improve the security of a country’s energy supply [39]. Furthermore, their use can reduce GHG emissions, as biofuels are less carbon intensive than their fossil fuel counterparts. This explains their growing popularity in developing countries, especially since their governments’ policies support their use [39].

Biofuels have been proven to be practical alternatives to hydrocarbon (fossil) fuels [40]. Various biofuel industry developments have occurred in various countries, including Brazil which, along with South Africa, belongs to BRICS [40].

Developments in biofuels in Africa have been slow, primarily due to financial constraints in poor economies [41]. Furthermore, a lack of technical expertise and land availability pose hurdles to biofuel development [42]. Despite this slow pace, developments have been made in Mozambique, Malawi, Nigeria, South Africa, and a few other Sub-Saharan countries in Africa [40].

South Africa, specifically, has a large flux of biomass from the agricultural, municipal and industrial sectors [40]. Therefore, the country has a considerable potential for bioelectricity, biodiesel and bioethanol production. Accordingly, this can play a pivotal role in the diversification of the country’s energy mix [40].

Electricity could be generated using biogas as an alternative to coal [41]. This, in turn, would lead to a reduction in emissions, as biofuels are approximately 5% less carbon intensive than fossil fuels [18]. Furthermore, it would reduce the country’s reliance on coal [42].

In terms of carbon tax policy, emissions that result from the combustion of biofuels are not liable for taxation and are considered carbon neutral [17]. This implies that the substitution of fossil fuels for biofuels mitigates emissions by two means: first, biofuels are inherently less carbon intensive than fossil fuels [35]; and second, there is a biofuel combustion emissions tax exemption [17].

1.4.7 Carbon offsetting and trading

The National Climate Change Response White Paper made suggestions regarding the pivotal mitigation elements that require consideration [40]. First, the necessary instruments must be employed to support the desired emissions reduction goals [36], including the potential use of carbon offset schemes or emissions reduction trading mechanisms [23].

Carbon offsetting is a reduction in emissions to compensate for emissions made elsewhere. GHG mitigation projects generate offsets [43]. Such projects include RE, nuclear energy, geological carbon sequestration, and industrial gas abatement [24].

A company that can offset GHG emissions can reduce its carbon tax liability [24]. Carbon trading is a method used by companies liable for a carbon tax to aid the mitigation of fiscal costs [44]. This is done through the purchase of carbon credits [44].

These carbon credits are likened to carbon offsets, and allow the offsetting of emissions [44]. Carbon trading can hence be used to offset a company's emissions, thereby reducing emissions in terms of carbon accounting [44]. A company that offsets all its emissions would achieve 'net-zero status' [23].

As proposed in the National Climate Change Response White Paper, carbon trading became part of a tax-and-trade regulatory scheme in South Africa [34]. This is notably less complex than carbon trading schemes designed as stand-alone systems [44].

As part of South Africa's carbon tax regime, a maximum allowance of 10% for offsets is offered [17]. Based on a media statement made in March 2021, no changes to the size of this allowance are anticipated for Phase 2 [43].

Carbon trading is advantageous as it promotes the growth of the economy by stimulating the private sector [24]. Furthermore, carbon trading tends to be economically efficient due to limited government involvement [24].

Nevertheless, carbon trading fails to reduce emissions [23], and for this reason it cannot function as an emissions mitigation strategy [23]. However, given the tax-and-trade regulatory scheme in South Africa, the influence of carbon trading on climate governance is unavoidable [31].

1.4.8 Emissions mitigation literature review

South Africa is an energy-intensive country that is dependent on coal to support its energy-intensive industries [2]. Subsequent consequences, associated with the exacerbation of climate change, suggest ecological risks, as discussed in section 1.1 [1].

The government promulgated forms of climate governance, such as the carbon tax, to incentivise emissions reductions [3]. It has also adopted various policy frameworks to support emissions mitigation [31]. However, carbon tax in a South African context provides little environmental certainty [35], and this situation is compounded considering that the changes to the policy elements for Phase 2 of the carbon tax regime are unclear [6].

1.5 South African gold mining emissions profile and mitigation potential

South African industries face worrying cost implications due to their intensive energy usage [45]. These implications result from climate governance, namely the carbon tax regime, which has precipitated increased operating costs [45].

The mining, mineral processing, and metal production sectors are very energy intensive. In 2016, they were responsible for using 30 720 GWh of electricity [5]. Their large energy consumption is a consequence of their fixed energy consuming infrastructure, powered by coal-fired energy [46].

Various energy-intensive mining activities lead to a plethora of emissions [47]. These emissions originate from activities expected from gold mining operations [48], summarised in Table 5. This table details whether the emissions are direct or indirect.

Table 5: Gold mining emissions activities, description and type

Emissions activity	Description of emissions activity	Type of emissions
Electricity use	• Conveying of personnel • Ore, ventilation, refrigeration, air compression, ore crushing and/or pumping • Purchasing electricity from the grid	Indirect

Emissions activity	Description of emissions activity	Type of emissions
Waste related	• Incineration of hazardous waste • Landfilling of non-hazardous waste • Wastewater treatment	Direct
Blasting	• Combustion of explosives to fragment rock	Direct
Land use	• Land conversion and subsequent loss of vegetative cover, e.g. waste-rock dumping, ore stockpiling, landfilling, construction of mineral processing plants, and construction of wastewater treatment plants	Direct
Stationary combustion	• Use of fuel-fired stationary equipment, e.g. generators and boilers	Direct
Mobile combustion	• Use of fuel-fired mobile equipment, e.g. vehicles	Direct

Adapted from Van der Zee, L.F., Pelzer, R. and Bolt, G. 'Quantification of optimal electricity cost risk reduction for a South African gold mining company,' in *Proceedings of the Conference on the Industrial and Commercial Use of Energy*, ICUE 2014, pp. 1–9.

A study on Ghana's gold mining industry alluded to information regarding the contribution of these activities to overall emissions. Figure 5 depicts the different emissions activities and their mass percentage contributions.

In Phase 1 of the carbon tax regime, gold mining companies are liable for the direct carbon tax on emissions resulting from stationary combustion activities, mobile combustion activities, and blasting activities [49]. According to the Carbon Tax Act, land use and waste-related activities are tax exempt [7].

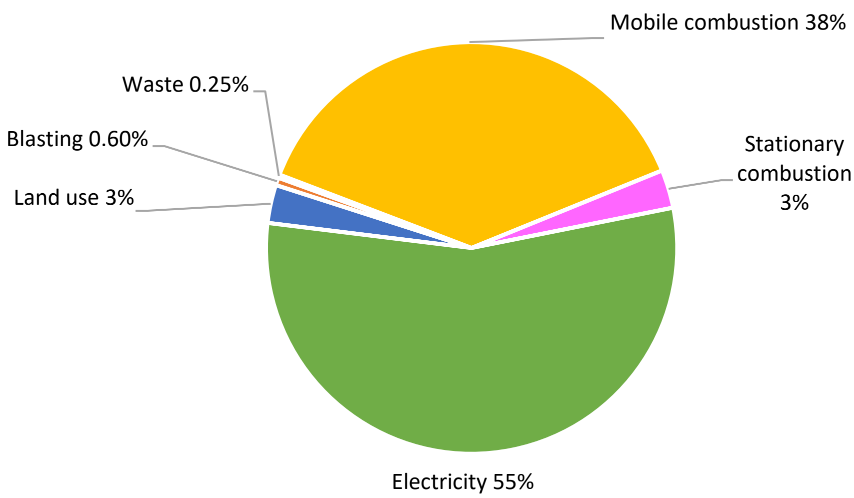


Figure 5: Mass percentage contribution of GHG emissions activities to the total emissions of a large-scale gold mining operation in Ghana [49]

In Phase 1, although indirect tax is incurred on emissions associated with electricity usage, the associated carbon tax exposure is reduced substantially due to the payment of the electricity generation levy [6]. However, in Phase 2, gold mining companies will become exposed to that indirect tax due to the anticipated carbon tax policy change [45].

In addition, the grades of metal ore have been dropping worldwide [48]. Thus, the amount of energy required for mining operations will rise [47], since extra energy will be needed to process the additional material in low-grade ore [47]. Subsequently, mine operation electricity usage is expected to increase in the future [47].

From this, it becomes apparent that the South African gold mining industry will face increased cost risks associated with carbon tax exposure related to coal-fired power use [47]. The Minerals Council South Africa fears that these additional costs will make the country unattractive to investors in this sector [50], who might then choose to invest in other gold mining countries, such as Columbia, instead [46]. The gold mining sector is thus under extra pressure to reduce its energy consumption to curb emissions [46].

Strategies to reduce emissions in the gold mining sector have been suggested [40], including initiatives and technologies that involve the addition of RE to the energy supply [36]. Developments have been made in the mining industry globally [39], involving the implementation of solar photovoltaic (PV) plants and wind energy farms to produce energy for mining operations [50].

Propositions regarding replacing fossil fuels with less carbon-intensive fuels have also been made [41]. The substitution of fossil fuels with biofuels is acquiring popularity in various African countries [48]. Studies in Australia suggest that using biodiesel instead of diesel has enormous potential to reduce emissions in the Australian mining sector [48]. Hydrogen or natural gas are proposed as fossil fuel substitutes [48]. Reductions in the amount of waste generated have been suggested to mitigate waste-related emissions [41]. Finally, suggestions regarding diverting purchases from the fossil-fuelled energy sector to the RE sector have been made [41].

Some progress towards the decarbonisation of the mining sector in South Africa has been made [38]. An example is the 1 MW solar PV plant implemented at the Thaba gold mine to meet the electricity requirements of the gold processing plants [38]. Despite this progress, the impact of these initiatives on the energy consumption of mining operations is still unclear [36]. This poses a challenge for mining companies, considering that this impact needs to be understood in order to develop emissions mitigation strategies [35]. This is especially true as emissions mitigation strategies may influence a reduction in carbon tax exposure [43].

1.6 Problem statement

The Carbon Tax Act of 2019 describes the environmental fiscal policy associated with South Africa's carbon tax regime [7]. Although Phase 1 of the carbon tax policy is understood, the details of Phase 2 have yet to be reviewed and amended [6]. The requirements of the Phase 2 policy are unknown, as no guidance from the National Treasury has yet been provided [6].

In addition, the impact of emissions mitigation strategies on the energy consumption of the South African mining sector is still unclear [35]. Therefore, the impact of emissions mitigation strategies on carbon tax exposure is difficult to ascertain [6]. This hinders gold mining companies in preparing carbon tax policy and emissions mitigation scenarios for Phase 2 of South Africa's carbon tax regime [36], and their ability to mitigate risks related to carbon tax exposure [50].

1.7 Objectives

This study aims to reduce the uncertainty surrounding Phase 2 of the South African carbon tax regime. This will be done by hypothesising a variety of plausible Phase 2 carbon tax policy and emissions mitigation scenarios as they apply to a case study.

Applying these scenarios to the emissions data of the case study will allow their impact on carbon tax exposure to be evaluated. This evaluation will take the form of a sensitivity analysis with reference to a baseline scenario. This analysis aims to ascertain the sensitivity of the case study's carbon tax exposure to the scenario itself. The observations made in this analysis will allow conclusions to be made about the scenarios.

The objectives of this study are as follows:

- Developing an appropriate baseline scenario to be used in the sensitivity analysis of other scenarios.
- Identifying potential Phase 2 carbon tax policy designs on which to base the carbon tax policy scenarios.
- Identifying various emissions mitigation strategies on which to base the emissions mitigation scenarios.

- Ascertaining and validating the sensitivity of the case study's carbon tax exposure to the carbon tax policy design in the carbon tax policy scenarios (in comparison to the baseline).
- Ascertaining and validating the sensitivity of the case study's carbon tax exposure to the emissions mitigation strategy in the emissions mitigation scenarios (in comparison to the baseline).

1.8 Scope of investigation

This study focuses on the impact of potential scenarios in Phase 2 of South Africa's carbon tax regime on gold mining operations. This includes different policy scenarios from recent literature. The purpose of including these scenarios is to evaluate their impact and feasibility.

It is important to evaluate the impact that implementing specific mitigation strategies or projects will have on a gold mine's carbon tax exposure, and to consider the potential benefits associated with such implementation. However, this study will not evaluate the feasibility of each strategy. Instead, it will assume that the requirements for implementation have already been met.

This study will indicate what to expect from the potential scenarios from the perspective of gold mining facilities. Note that these effects may differ vastly from the perspective of the South African economy. The scope of this study excludes the feasibility or economic impacts of the scenarios on the broader South African economy.

1.9 Overview of dissertation

Following this introduction in Chapter 1, Chapter 2 describes the development of the various carbon tax policies and emissions mitigation scenarios. These scenarios focus on Phase 2 of the carbon tax regime, and are developed using literature substantiation developed in Chapter 1. Chapter 2 also details the methods for generating the results required for the scenario analyses. Lastly, it outlines the methods used to verify and validate the results.

Chapter 3 presents the results of each scenario. Sensitivity analyses of the results were performed for each scenario with reference to the baseline. Observations are made regarding the carbon tax policy and emissions mitigation strategies expressed in the scenarios.

In Chapter 4, conclusions about Phase 2 carbon tax policy and emissions mitigation are made based on the observations discussed in the previous chapters. Recommendations for future studies are included.

CHAPTER 2: METHODOLOGY

2.1 Preamble

It is evident from the problem statement in section 1.6 that the uncertainty surrounding the Phase 2 carbon tax regime hinders gold mining companies from preparing for future carbon tax scenarios [6]. This uncertainty is worsened by the fact that the impact of emissions mitigation scenarios on electricity usage is unclear [35]. It therefore became necessary to investigate various carbon tax policy scenarios and emissions mitigation scenarios that are applicable to gold mining operations.

In this chapter, the methodology used in these investigations is described. First, previous investigations into South African carbon tax policy and emissions mitigation scenarios were explored, and the knowledge gaps in the literature were identified. Next, the methodology explicated how relevant carbon tax policy and emissions mitigation scenarios could be hypothesized and modelled for an appropriate case study, namely a gold mining company. The methodology underlying the hypotheses and modelling of the scenarios is detailed.

This chapter describes the data required to model the scenarios, and the data consolidation methodology. Exemplars of the expected results are illustrated. The verification and validation of these expected results are explained. Finally, an overview of the methodology is provided.

2.2 Analysis of literature scenarios

2.2.1 Carbon tax policy scenarios

Previous studies have hypothesized tax policy scenarios specific to the South African carbon tax regime. A selection is listed below.

- *Introducing carbon taxes in South Africa*, 2013 [2]
- *South Africa Carbon Tax: Rethinking Decarbonisation Incentives – Policy Case Studies*, 2018 [3]
- *Modelling the Impact on South Africa's Economy of Introducing a Carbon Tax*, 2016 [7]
- *Tax Policy to Reduce Carbon Emissions in South Africa*, 2009 [31]

In these studies, potential carbon tax policy designs were hypothesized as scenarios. The carbon tax policy designs therein were informed by policy design expectations made in the literature. The subsequent policy implications of the scenarios were viewed as the parameters to model the scenarios [2, 3, 7, 31].

These scenarios focus on the carbon tax policy elements discussed in section 1.3. The variability of the scenarios arose from the uncertainties of the policy elements therein. Carbon tax policy elements that were certain were the same for all the scenarios, and carbon tax policy elements under question in the literature varied across the scenarios.

The variance-based sensitivity analyses of these scenarios were conducted with reference to a baseline [2, 3, 7, 31]. This was to assess the variance of the alternative scenarios from the baseline, in order to make inferences about said scenarios [3]. The purpose of the sensitivity analyses was to verify that the scenario models were aligned with literature expectations [2, 3, 7, 31].

In *Modelling the Impact on South Africa's Economy of Introducing a Carbon Tax*, the scenarios were validated through external validation [7]. This entailed the revision of the baseline model, alternative scenario models, their parameters, and the repetition of the sensitivity analyses. This was done in order to make inferences about the robustness of the models using the revised alternative scenarios and baseline.

These studies aimed to identify potential carbon tax policy designs for South Africa [2, 3, 7, 31], and to decrease the uncertainty surrounding the economic impact of the carbon tax regime through their exploration [2, 3, 7, 31]. The baseline served as a reasonable counterfactual scenario to ascertain the ramifications of the alternative policy scenarios [7]. The carbon tax policy scenarios modelled in these studies were based on the information available prior to the publishing of the Carbon Tax Act in 2019. The implication is that these findings may not be relevant in the present context.

The carbon tax policy scenarios hypothesized in all these studies informed conclusions about the impact of a carbon tax on the South African economy. No industry-specific conclusions were made therein. Moreover, none of these studies focussed on carbon tax policy scenarios relating to Phase 2 of South Africa's carbon tax regime. Evidently, there is a knowledge gap regarding the current industry-specific carbon tax policy that ought to be filled.

2.2.2 Emissions mitigation scenarios

It is crucial for gold mining companies to be able to make financial decisions regarding emissions reductions [2]. However, in the gold mining industry, the impact of emissions mitigation strategies on electricity usage, and thus emissions, is unclear, which means that the feasibility of potential emissions mitigation strategies cannot be analysed [35].

However, emissions mitigation strategies reduce emissions, and thus reduce carbon tax exposure [3]. Moreover, the Carbon Tax Act incentivises emissions mitigation actions [34].

Emissions mitigation scenarios have been proposed in various national plans, including the 2019 IRP [5] and the 2020 LEDS [33]. These scenario propositions are aimed at identifying potential emissions mitigation strategies for South African industries [5].

The variability of the scenarios arose from the emissions mitigation technologies used and the strategies employed. Various emissions mitigation technologies are considered, such as biofuels and renewable energy [5, 33]. The employment strategies hypothesized therein involved the implementation of a sustainable power plant, or sourcing sustainably produced energy [5, 33].

In the LEDS, there is mention of aligning carbon tax policy with carbon budgeting after 2020, but there is no mention of Phase 2 policy design itself [33]. It is recognised in the LEDS that the emissions mitigation scenarios and measures suggested therein are short term [33]. This implies that the strategy itself may not be transformational [33].

The scenario analysis performed in Appendix D of the IRP is related to emissions mitigation in the energy sector [5]. It is explicitly stated that the certainty of the hypothesized scenarios begins to decrease after 2030 [5]. No analysis whatsoever of the carbon tax regime is included in this scenario analysis, and no industry-specific conclusions are made.

The emissions mitigation scenarios hypothesized in these national plans informed conclusions about the impact of emissions mitigation in the energy sector on the South African economy. No industry-specific conclusions were made therein. Moreover, there was no focus on the carbon tax policy relating to Phase 2. There is a knowledge gap regarding industry-specific emissions mitigation potential that considers carbon tax policy, and this knowledge gap ought to be filled.

2.3 Development of a methodology for the case study

2.3.1 Carbon tax policy scenarios

It became apparent that there is a literature gap associated with South African carbon tax policy designs relevant in a modern context. Evidently, there was a need to hypothesize scenarios that considered the uncertainties regarding the carbon tax policy elements in Phase 2. Moreover, there was a need to assess carbon taxation in an industry-specific gold mining context due to the knowledge gap. It thus became necessary to hypothesize Phase 2 carbon tax policy scenarios to ascertain their impact on the carbon tax exposure of gold mining companies.

As inferred in the other scenario studies, the hypothesis of these carbon tax policy scenarios ought to be based on the carbon tax policy elements. Policy elements that are certain should be the same for all the scenarios, while policy elements that are uncertain should vary across scenarios. The level of certainty of a policy element should be informed by literature. Lastly, the scenarios should be analysed with reference to the baseline.

The methodology for this study's carbon tax policy scenarios was developed based on the methodologies used in these other studies, and is illustrated by the flow diagram in Figure 6. First, the elements of carbon tax policy that are certain for Phase 2 needed to be identified, and thereafter, the policy elements that are uncertain. Based on these policy elements, a baseline policy and other scenarios could be hypothesized. The carbon tax policy implications (or parameters) of these scenarios then needed to be identified in order to apply them to the emissions data of the case study.

The purpose of this investigation is to hypothesize future carbon tax scenarios for gold mining companies. The carbon tax policy implications of each scenario were applied to a gold mining company case study. Thereafter, a sensitivity analysis of the case study's carbon tax exposure could be performed per scenario, to inform the conclusions of this investigation.

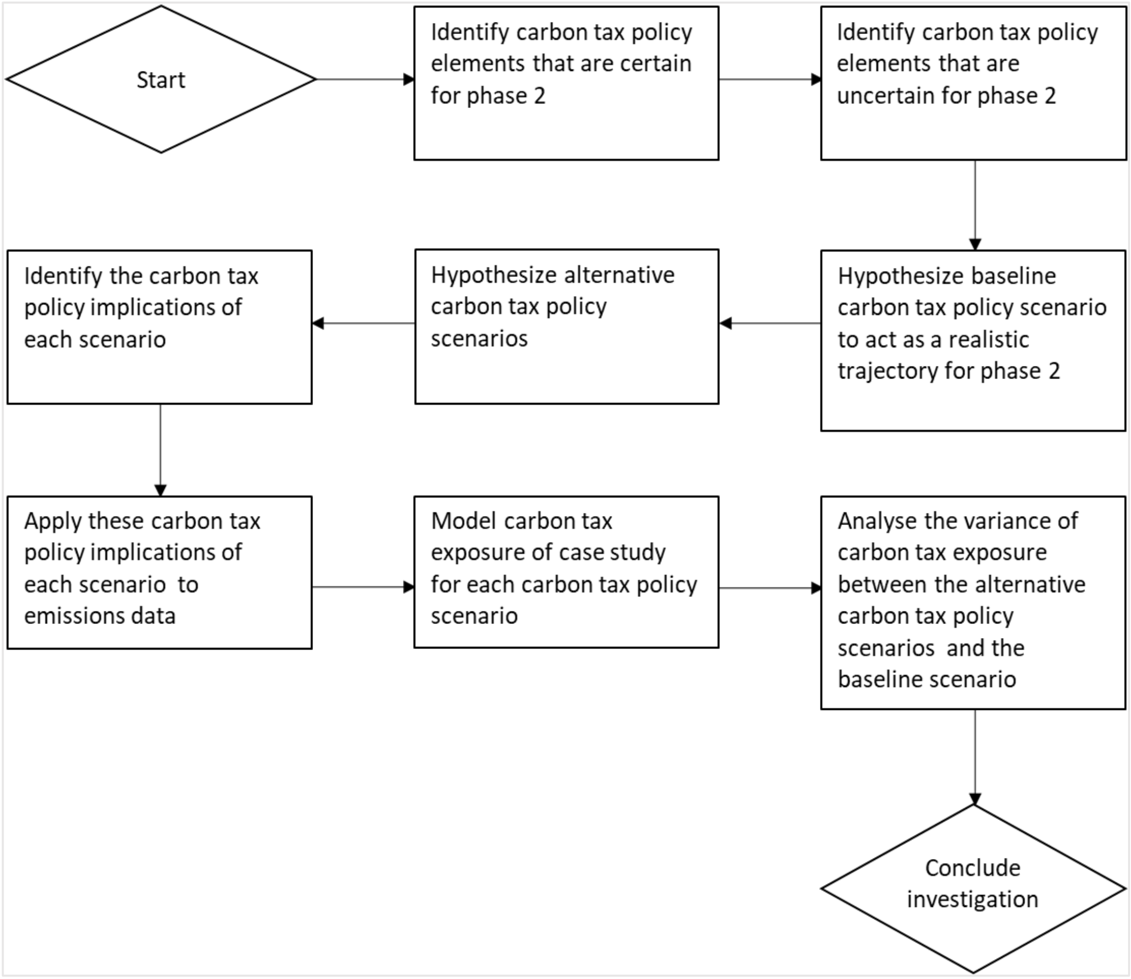


Figure 6: Methodological development of the carbon tax policy scenarios

2.3.2 Emissions mitigation scenarios

The IRP and LEDS methodology involved applying an emissions mitigation model in the energy sector instead of an economic model. There is a literature gap associated with emissions mitigation and its influence on carbon tax exposure for the various South African industries.

Hence, it became necessary to assess the carbon tax policy implications associated with the employment of emissions mitigation strategies. It was thus decided to hypothesize emissions mitigation scenarios to ascertain their impact on the carbon tax exposure of gold mining companies.

Each emissions mitigation scenario needed to be applied to a hypothesized carbon tax policy scenario for the gold mining company case study. The flow diagram in Figure 7 illustrates the methodological development of the carbon tax policy scenarios.

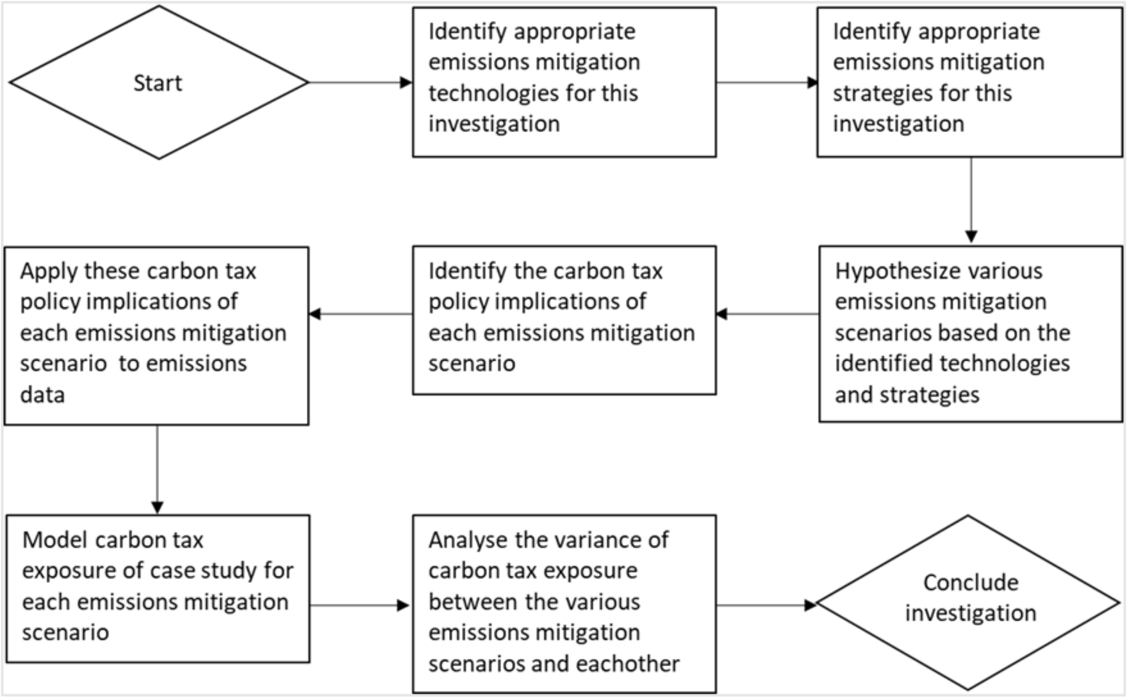


Figure 7: Methodological development of the emissions mitigation scenarios

As depicted in Figure 7, first, various emissions mitigation technologies had to be identified. Thereafter, employment strategies for these technologies needed to be identified. With technologies and strategies in mind, emissions mitigation scenarios could then be hypothesized.

Finally, the scenarios' carbon tax policy implications, or parameters, needed to be applied to the case study. For these scenarios to achieve this study's objectives, said case study would be a gold mining company. After that, a sensitivity analysis of the case study's carbon tax exposure could be performed per scenario to inform the conclusions of this investigation.

2.4 Carbon tax policy scenario hypotheses

Various carbon tax policy scenarios were hypothesized to ascertain their influence on the carbon tax exposure of a case study in comparison to a baseline scenario. In this section, the hypotheses for carbon tax policy scenarios are developed.

As discussed in section 2.3, the different carbon tax policy scenarios should have the same specific policy elements and should vary in the uncertain policy elements. The number of uncertain policy elements should thus inform the number of scenarios required for this study. This necessitates the identification of these policy elements and their certainty.

In terms of the South African carbon tax regime, the certainties can be categorised as follows:

- Phase 1 carbon tax policy elements that are unlikely to change once Phase 2 begins [6].
- Phase 1 carbon tax policy elements to which changes are expected upon the start of Phase 2 [6].

The uncertainties can be categorised as follows:

- Carbon tax policy elements that were not included in Phase 1 but may be introduced in Phase 2 [6].
- Phase 1 carbon tax policy elements that need to be re-evaluated in preparation for Phase 2 [6].

These certainties and uncertainties are tabulated in Table 6 and Table 7, together with the corresponding literature substantiations.

Three uncertainties – namely sector subsidisation, carbon budget integration, and carbon offsetting – were identified and are described in Table 7. Accordingly, three carbon tax policy scenarios were hypothesized, i.e. one per uncertainty. In addition, a baseline scenario was required. Finally, the certainties described in Table 6 must be the same for all the carbon tax policy scenarios, including the baseline scenario.

The baseline and the alternative carbon tax policy scenarios have been hypothesized in sections 2.4.1 to 2.4.4. These sections explicate how the baseline and the various counterfactual carbon tax policy scenarios were identified through carbon tax policy certainty and uncertainty.

Table 6: Certainties of future carbon tax policy elements

Type	Name of certainty	Description	Justification
1	Tax base rate annual increase	• Rate increases by inflation, with an additional 2% per annum during Phase 1 [17] • Rate increases with inflation only during Phase 2 [6]	Supported by literature [6, 17]
1	Allowance for AFOLU and waste sectors	• Remains 100% [3]	Difficulties quantifying emissions from these sectors have not been resolved since the Carbon Tax Act was gazetted in 2019 [3]

Type	Name of certainty	Description	Justification
1	Type of tax-liable emissions	• Fossil fuel combustion emissions • Industrial process emissions • Fugitive emissions	Gazetted in the Carbon Tax Act of 2019 [17]
1	Type of allowances	• Carbon budget allowance • Offset allowance • Performance allowance • Trade exposure allowance • Basic tax-free allowances	Literature suggests that it is unclear whether the type of allowances featured in the Carbon Tax Act will be re-evaluated [3]
1	Indirect tax exposure exclusion during Phase 1	• Credits from the payment of the electricity generation levy cover this indirect tax liability [6]	Gazetted in the Carbon Tax Act of 2019 [17]
2	Indirect tax exposure inclusion during Phase 2	• Credits from the payment of the electricity generation levy will no longer cover this indirect tax liability [6]	Gazetted in the Carbon Tax Act of 2019 [17]

Table 7: Uncertainties of future carbon tax policy elements

Type	Name of uncertainty	Description	Justification
B	Sector subsidisation	• Changes to basic tax-free allowances during Phase 2 [7] • Only applied to fossil fuel combustion emissions	• Subsidisation of activities in specific sectors that are a source of GHG leads to more emissions [21] • Industrial process and fugitive emissions required technological reform to be mitigated [3] • No such reform has taken place [3]
A	Carbon budget integration	• Better alignment between the carbon tax and carbon budget policy to achieve climate mitigation goals [22]	• Propositions as to how to align these forms of climate governance made by the DFFE in 2020 [8]
B	Carbon offsetting	• Maximum 10% offset allowance policy constraint as part of South Africa's tax-and-trade system for both phases [34]	• Size of allowance not altered • Offset allowances function as incentivisation [10] • Carbon offsetting does not reduce rate of emissions [29]

2.4.1 Baseline scenario

It became necessary to hypothesize a baseline scenario to provide a plausible control for the carbon tax policy scenarios [2]. This was because this investigation required a counterfactual scenario with which to ascertain the ramifications of the alternative scenarios [7]. The certainties surrounding the baseline scenario are detailed in Table 6.

It was decided that the baseline scenario would assume the exclusion of new policy design elements for Phase 2. Subsequently, the uncertainties of the baseline scenario existed as if no changes were made to the carbon tax policy prior to the start of Phase 2.

These simplifying assumptions regarding the baseline's uncertainties led to specific carbon tax policy implications for the case study. The uncertainties and the implications thereof for the baseline scenario are described in Chapter 3, and an example can be seen in Table 8.

After identifying the baseline scenario's uncertainties, it became possible to hypothesize the other carbon tax policy scenarios. The methodologies that explicate this can be found in sections 2.4.2 to 2.4.4.

Table 8: Example of baseline scenario implications for carbon tax policy

Uncertainty	Type of uncertainty	Implication of uncertainty
Sector subsidisation	Changes to carbon tax policy design associated with sector subsidisation	Implications of said changes for carbon tax policy elements
Carbon budget integration	Changes to carbon tax policy design associated with carbon budget integration	Implications of said changes for carbon tax policy elements
Carbon offsetting	Changes to carbon tax policy design associated with carbon offsetting	Implications of said changes for carbon tax policy elements
Border tax adjustments	No border tax adjustments	Implications of said changes for carbon tax policy elements

2.4.2 Sector subsidisation scenario hypothesis

The first carbon tax policy scenario, labelled Scenario 1, featured sector subsidisation uncertainty. It was stated in Chapter 1 that support subsidies, such as the basic tax-free allowances offered by the Carbon Tax Act, inadvertently cause more emissions [3]. This has been proven in OECD countries [21].

As carbon tax is part of South Africa's climate governance system, carbon tax policy should aid in realising the objectives of climate governance [25]. By not phasing out these basic tax-free allowances, the carbon tax will be rendered environmentally ineffective [7].

The basic tax-free allowances for process and fugitive emissions exist because these emissions cannot be mitigated without technological reform within their respective industries [3]. No such reform has occurred since the Carbon Tax Act was gazetted in 2019 [3]. It would be disadvantageous to phase out the basic tax-free allowances for process and fugitive emissions. Therefore, Scenario 1 featured the gradual reduction over time of the basic tax-free allowance associated with fossil fuel combustion. This uncertainty, and its implications for carbon tax policy, is detailed in Chapter 3, Table 15.

2.4.3 Carbon budget integration scenario hypothesis

The second set of carbon tax policy scenarios featured uncertainty from carbon budget integration. Thus far, no definitive policy integration of carbon tax and carbon budgeting has occurred [22], except for the carbon budget allowance offered by the Carbon Tax Act [3].

However, in 2021, the DFFE offered two variations in which carbon tax policy and carbon budgeting could be aligned [8], which were presented in Table 4. There is no certainty about which variation will be gazetted [8]. Therefore, it became necessary to develop carbon budget integration scenarios.

In addition to the alignment of these policies, consideration was given to the methodology used to choose a carbon budget [22]. A top-down or bottom-up approach should be adopted when choosing a carbon budget [30]. A top-down approach would base the budget on climate governance requirements, i.e. national emissions reduction targets [30], while a bottom-up approach would choose the budget according to a company's mitigation potential [30]. There is no certainty as to which methodology a gold mining company may use [30].

It was decided to consider both methodologies in relation to each of the carbon budget integration options, which led to the development of four different carbon budget integration scenarios. The uncertainties of these four scenarios, and the implications of their uncertainties, are detailed in Chapter 3, Table 16 and Table 17.

2.4.4 Carbon offsetting scenario hypothesis

The third set of carbon tax policy scenarios featured uncertainty due to carbon offsetting. It was evident, from section 1.4.7, that carbon offsetting does not reduce the rate of emissions [29]. However, the carbon tax regime in South Africa makes carbon offsetting part of a tax-and-trade regulatory scheme [35].

This warranted that offsetting would have implications for carbon tax exposure [34]. Therefore, this necessitated hypotheses on the implications of carbon offsetting associated with a carbon tax.

The Carbon Tax Act offers a maximum offset allowance of 10% [17], and a company's eligibility for this maximum allowance is achieved by offsetting 10% or more of its emissions [23]. The cost implications of carbon offsetting are entirely contingent on the quantity of emissions offset [44].

Carbon offsetting has implications for the accounting of GHG emissions [43]. Although offsetting does not mitigate emissions, the purchase of carbon offsets reduces the number of emissions to be accounted for [44]. Moreover, carbon offsets are cheaper than the South African carbon tax base rate [51]. As a result, carbon offsetting presents the dual opportunity to reduce carbon tax exposure or reduce the number of accounted emissions, thereby nearing a net-zero status [24].

It was evident that companies need to understand these implications for financial planning purposes [45]. Therefore, it was decided to include two carbon offsetting scenarios in this study. The first scenario assumed 10% carbon offsetting, and the second scenario assumed more than 10% carbon offsetting. The uncertainties of these two scenarios, and the implications thereof, are detailed in Chapter 3, Table 19.

2.5 Emissions mitigation scenario hypotheses

The various emissions mitigation scenarios were hypothesized to ascertain the influence of emissions mitigation strategies on the carbon tax exposure of a case study. In this section, the hypothesis for emissions mitigation scenarios is developed.

As discussed in section 2.3, the different emissions mitigation scenarios should involve the application of an emissions mitigation strategy to a carbon tax policy scenario hypothesized in section 2.4. This necessitates the identification of appropriate emissions mitigation strategies.

There are various constraints associated with the employment of emissions mitigation strategies at South African gold mining operations. Such constraints include:

- Lack of availability of emissions mitigation technology in South Africa [41].
- Lack of availability of infrastructure to support emissions mitigation technology at gold mining facilities [41].
- Lack of compatibility of infrastructure to support emissions mitigation technology at gold mining facilities [41].

- Lack of economic feasibility of strategy employment from the perspective of the gold mining company [41].

Regardless of these constraints, there is no literature regarding the impact of emissions mitigation strategies on electricity usage at gold mining operations [36]. Subsequently, for this investigation, the constraints above were assumed to be non-constraining. This meant that the following were assumed:

- Availability of emissions mitigation technology in South Africa.
- Availability of infrastructure to support emissions mitigation technology at gold mining facilities.
- Compatibility of infrastructure to support emissions mitigation technology at gold mining facilities.
- Efficiency of the technology.
- Economic feasibility of the emissions mitigation strategy from the perspective of the case study.

To reiterate, one of the objectives of this investigation is to ascertain the influence of emissions mitigation scenarios on the carbon tax exposure of gold mining companies. Therefore, it was necessary that the emissions mitigation technologies investigated in this study should have associated carbon tax benefits.

Two alternatives have been proposed in literature in terms of emissions mitigation strategies in the gold mining industry: first, implementing power plants to produce RE in order to reduce purchases of coal-fired electricity [49]; and second, substituting coal-fired electricity purchases with purchases from the RE sector [41].

To create emissions mitigation scenarios, the various possible emissions mitigation strategies and technologies needed to be applied to the carbon tax policy scenarios hypothesized in section 2.4 of this study. This section explicates how the different emissions mitigation scenarios were hypothesized. The details of the various scenarios, and their implications for carbon tax policy, can be found in Chapter 3, Table 22. An example is shown in Table 9.

.

Table 9: Example of emissions mitigation (EM) scenario details and implications for carbon tax policy and carbon tax exposure

Name of scenario	Type of EM technology	Type of strategy	Carbon tax policy scenario application	Carbon tax implications
Scenario name	EM technology type *n*	Implementation or sourcing	Carbon tax policy scenario to which EM strategy is applied to create EM scenario	Implications for carbon tax policy elements and carbon tax exposure

2.5.1 Renewable energy scenario hypothesis

Renewably generated electricity has no associated GHG emissions [35], therefore the supplementation of fossil fuel generated electricity with renewably generated electricity would lead to emissions mitigation [34]. The first set of hypothesized emissions mitigation scenarios involved using an RE strategy to substitute purchased fossil-fired electricity.

In terms of the Carbon Tax Act, a company that generates its own RE is eligible to receive the RE premium [17]. This applies to solar PV, concentrated solar power (CSP), wind electric power (WEP) and hydroelectric power (HEP) [36]. No such carbon tax benefits exist for companies that source electricity from the RE sector [41].

Based on these carbon tax policy considerations, it was decided that both strategies would be investigated. The first strategy should involve self-generation of RE, while the second should involve external sourcing of electricity from the RE sector. The details of these scenarios, and their implications for carbon tax policy, can be found in Chapter 3, Table 22.

2.5.2 Biofuel substitution scenario hypothesis

Biogas-generated electricity has fewer associated GHG emissions than coal-generated electricity [34], since biofuels are less carbon-intensive than fossil fuels [18]. The substitution of coal-fired electricity for biogas-fired electricity would lead to emissions mitigation [43]. The second set of emissions mitigation scenarios involved fuel substitution.

The Carbon Tax Act specifies that a company is not carbon tax liable for biofuel combustion emissions [17]. It was evident that environmental and fiscal benefits were associated with this substitution. It became necessary to consider the substitution of biogas-fired electricity for coal-fired electricity as an emissions mitigation scenario for gold mining companies.

To create the biofuel-substitution emissions mitigation scenarios, this strategy was applied to carbon tax policy scenarios hypothesized in section 2.4. Details of the scenarios, and their implications for carbon tax policy, are presented in Chapter 3, Table 22.

2.6 Data collection, consolidation and application

2.6.1 Background

The variance-based sensitivity analyses in the literature, mentioned in section 2.3, aimed to ascertain the sensitivity of the economically modelled scenario to its parameters, namely the carbon tax policy implications [2, 3, 7, 31]. This was done by assessing the variance between the economic models of the alternative scenarios and the baseline, in order to assess the scenarios' influence on the South African economy.

However, this investigation aims to reduce the uncertainty over future carbon tax scenarios, specifically for gold mining companies. Subsequently, in this investigation, the scenarios were hypothesized to ascertain the sensitivity of the case study's carbon tax exposure to the carbon tax policy implications of the alternative scenarios in comparison with a baseline scenario.

This necessitated the modelling of the case study's carbon tax exposure for each of the scenarios investigated in this study. This would need to be done to analyse the variance between the case study's alternative scenario and baseline scenario carbon tax exposures. This would make it possible to make inferences about how carbon tax policy or emissions mitigation may influence the case study's carbon tax exposure in the future.

The carbon tax exposure over time needed to be modelled for each scenario. This was to assess the variances with reference to the baseline. In this section, the data required and the method of data consolidation are described. Exemplars of the expected results have been given.

2.6.2 Data collection and consolidation

A company's carbon tax exposure is calculated per emissions activity. Therefore, the appropriate emissions data needed to be consolidated.

To do this, the annual historical data associated with the various mining emissions activities needed to be collected. After that, the data needed to be converted into tonnes carbon dioxide equivalent (tCO_2e).

The required data has been summarised in Table 10. Note that activities associated with the AFOLU and waste sectors are excluded, as their emissions are carbon tax exempt [17].

Table 10: Annual historical data collected per emissions activity

Emissions activity	**Annual historical data collected**	**Units**
Stationary combustion	• Total fuel usage in stationary equipment	Litres
Mobile combustion	• Total diesel usage in mobile equipment • Total petrol usage in mobile equipment	Litres
Electricity usage	• Total electricity usage of gold mining operations	MWh

Future usages do not yet exist. Therefore, it was assumed that the usage of fuel and electricity for 2021 was an average of the annual historical usage. Furthermore, it was assumed that annual fuel usage for every year after 2021 was equal to that of 2021.

These annual usage values for the various emissions activities needed to be converted to tonne carbon dioxide equivalent (tCO_2e). The methodology that details how to calculate direct emissions per direct emissions activity is described in the *Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry*. The appropriate national methodology that details how to calculate the indirect emissions associated with purchased electricity usage is described in the 2019 IRP.

With emissions data consolidated, the case study's carbon tax exposure could be modelled for each scenario investigated in this study. This required the conversion of the emissions data to carbon tax exposure. The methodology describing the application of the scenarios to this emissions data for said analyses is provided in sections 2.7.1 and 2.7.2.

2.7 Variance-based sensitivity analysis of scenarios

2.7.1 Carbon tax policy scenarios and analysis

As part of this study, a variance-based sensitivity analysis needed to be performed on each of the hypothesized carbon tax policy scenarios. These analyses used carbon tax exposure as a basis for assessment. Since a variance-based sensitivity analysis is intended, the carbon tax exposures of the various scenarios need to be estimated.

Subsequently, the annual carbon tax exposure needed to be calculated for each carbon tax policy scenario hypothesized in section 2.4. The methodology that explicates the conversion of emissions data to carbon tax exposure is described in the Carbon Tax Act of 2019. A simplified version of the methodology is illustrated in Figure 8.

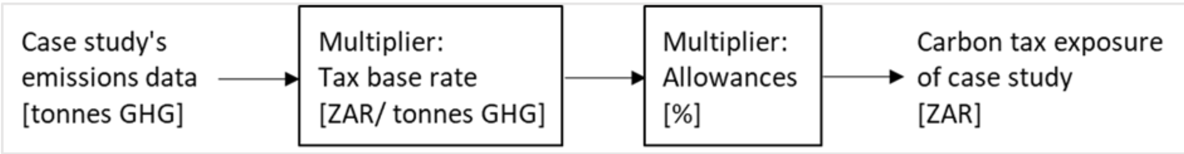


Figure 8: Calculation of carbon tax exposure from emissions data

From Figure 8, it is evident that the emissions data needs to be multiplied by the tax base rate and allowances. The tax base rate is considered a certainty, whereas allowances are uncertain. Subsequently, for modelling the carbon tax policy scenarios, the allowances and tax base rate can be regarded as the parameters.

The annual emissions data, consolidated as described in section 2.6.2, was multiplied by the appropriate allowances and the year-appropriate tax base rate associated with the scenario. This was done in order to calculate the scenario-specific annual carbon tax exposure associated with each emissions activity.

Finally, the annual carbon tax exposure associated with the different emissions activities was summated to determine the case study's total annual carbon tax exposure. The cumulative carbon tax exposure by the end of Phase 2 could be calculated by adding the annual carbon tax exposures together.

The method was repeated for the baseline and all alternative scenarios. After that, the cumulative carbon tax exposure of the various carbon tax policy scenarios could be plotted together on one bar graph. Such a graph is provided in Chapter 3.

The sensitivity analyses are performed in the above-mentioned chapter. These analyses assess the variance between the cumulative carbon tax exposure of the alternative carbon tax policy scenarios and the baseline. An example of such is provided in Figure 9. This example depicts the results of arbitrary scenario examples as a visual aid to illustrate the expected results in Chapter 3.

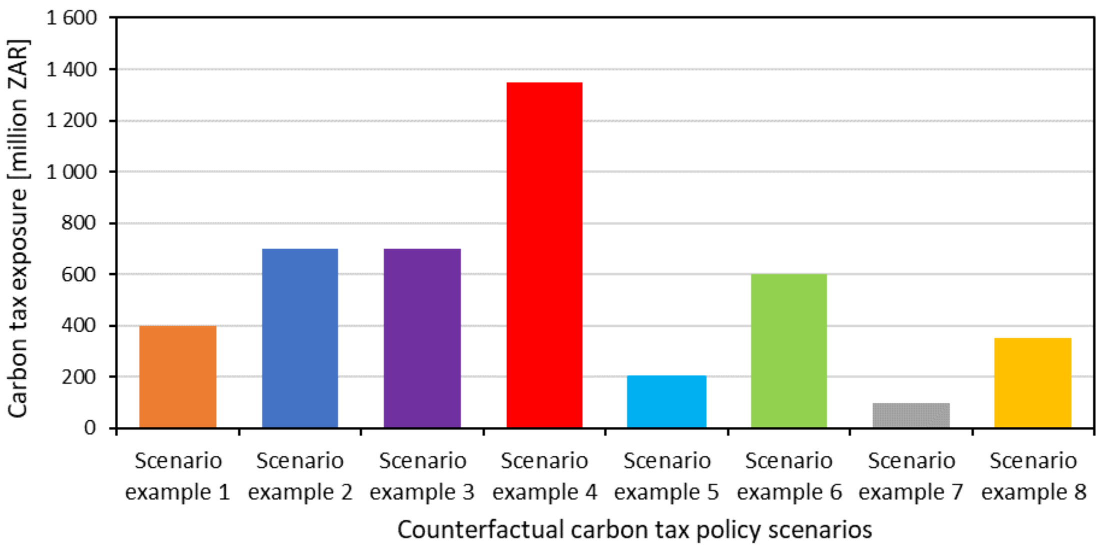


Figure 9: Cumulative carbon tax exposure associated with the carbon tax policy scenario examples

2.7.2 Emissions mitigation scenarios and analysis

In this study, a variance-based sensitivity analysis needed to be performed on each emissions mitigation scenario. These analyses used carbon tax exposure as a basis for assessment. Since a variance-based sensitivity analysis is intended, the carbon tax exposures of the various scenarios need to be modelled.

Subsequently, the annual carbon tax exposure needed to be modelled for each emissions mitigation scenario hypothesized in section 2.5. The methodology that explicates the modelling of carbon tax exposure, given the influence of emissions mitigation, is described in the Carbon Tax Act of 2019. A simplified version of this methodology has been illustrated in Figure 10.

From Figure 10, it is evident that the modelling of carbon tax exposure associated with emissions mitigation ought to involve the following:

1. Modelling the case study's annual total carbon tax exposure as per a carbon tax policy scenario.
2. Calculating the annual substituted carbon tax exposure due to emissions mitigation efforts.
3. Subtracting the annual substituted carbon tax exposure and RE premium from the total annual carbon tax exposure described in point 1.
4. Adding an adjustment to the LCOE adjustment for RE generation, from here on described as a 'green adjustment'.

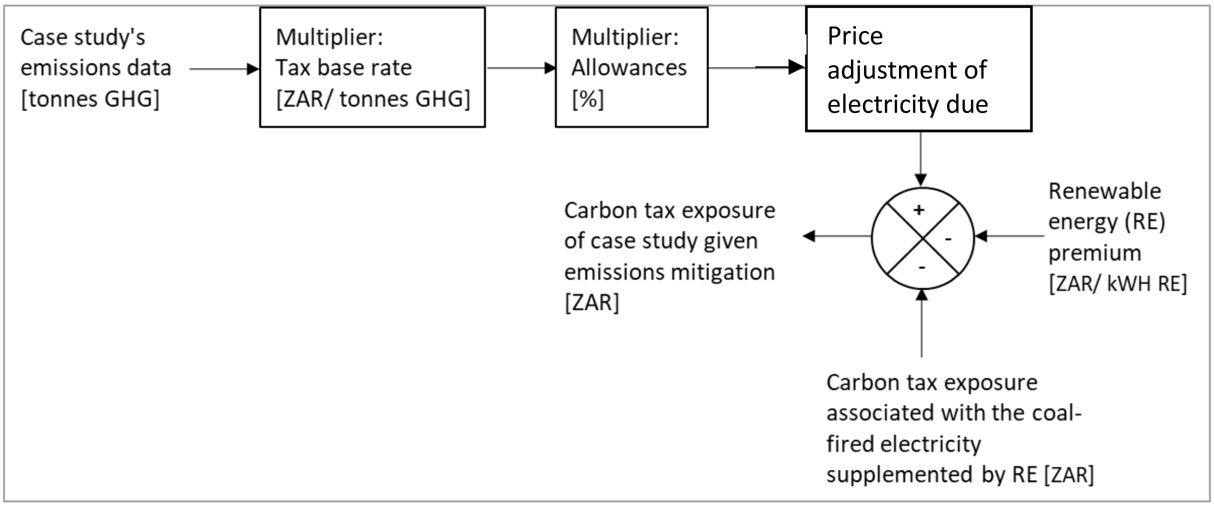


Figure 10: Calculation of carbon tax exposure from emissions data for the emissions mitigation scenarios

The methodology described above should be applied to the emissions mitigation technologies and strategies in the scenarios. As stated in section 2.5, only technologies with carbon tax benefits were to be investigated in this study. In terms of strategy, two were to be investigated.

The first strategy in this study was implementing a power plant in the case study's operations. The calculation for the scenarios using the first strategy involved subtracting the RE premium and substituted carbon tax exposure from the total associated with the relevant carbon tax policy scenario. After that, it involved the addition of the green adjustment to LCOE. This calculation was repeated for every year.

Since the RE premium acts as a grant to subsidise the cost of implementing the plant, it essentially subsidises the LCOE [35]. Therefore, it too contains a green adjustment. For the scenarios using the power plant strategy, the RE premium green adjustment needed to be subtracted from the LCOE adjustment to avoid double accounting.

The second strategy involved the purchase of electricity from the RE sector. The calculation for the scenarios using the second strategy involved subtracting the substituted carbon tax exposure from the total of the relevant carbon tax policy scenario. Thereafter, it involved the addition of the green adjustment to LCOE. Since no premium is associated with RE purchases from the RE sector, the RE premium's green adjustment need not be subtracted from the LCOE adjustment.

It is important to note that the emissions mitigation strategy and technology within the emissions mitigation scenario will have implications for the carbon tax exposure of the case study. Therefore, these can be seen as the parameters of the emissions mitigation scenarios modelled for this investigation.

With annual carbon tax exposure modelled for the case study's emissions mitigation scenarios, the cumulative carbon tax exposure by the end of Phase 2 could then be calculated. This meant summating all the annual carbon tax exposures together.

The cumulative carbon tax exposure values for the various emissions mitigation scenarios were plotted against time to construct the scenario-specific carbon tax exposure graphs of the sensitivity analysis. The scenarios represented in these graphs were categorised according to emissions mitigation strategy and carbon tax policy scenario. Their analyses focus on the sensitivity of the case study's carbon tax exposure to the emissions mitigation scenarios compared to the other emissions mitigation scenarios. Examples of the graphs in Chapter 3 are illustrated in Figure 11(1) and (2).

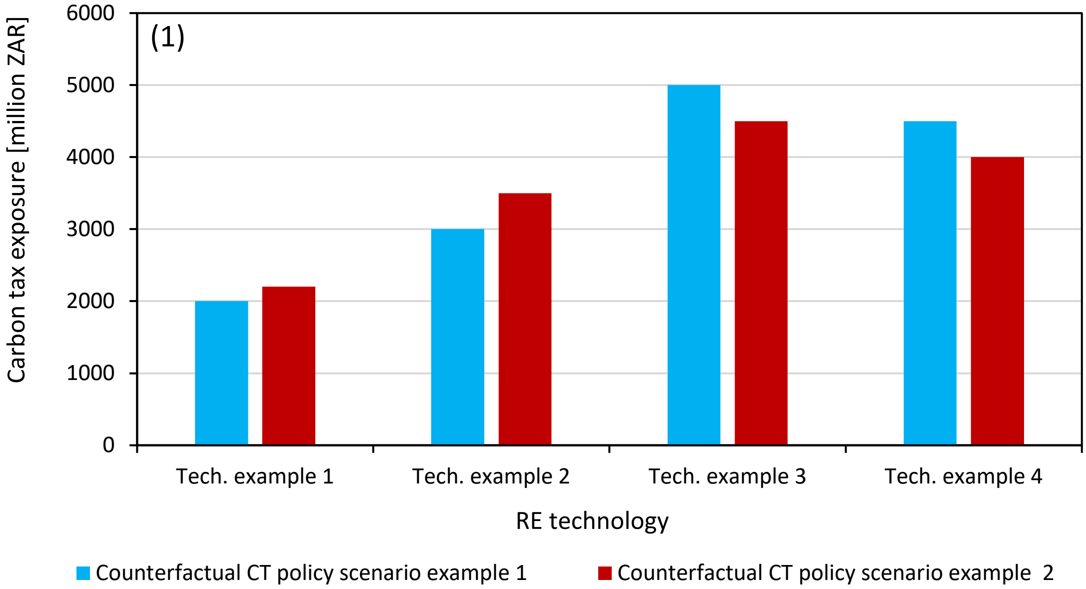
2.8 Verification and validation

2.8.1 External validation

This investigation aims to fill the knowledge gap associated with gold mining-specific analyses of future carbon tax scenarios. No literature on this topic exists, and hence the need for this study. However, external validation can be used to ensure the validity of the models, as seen in *Modelling the Impact on South Africa's Economy of Introducing a Carbon Tax* [7].

External validation of the scenarios would involve repeating the variance-based sensitivity analysis methodology with different emissions data. This would render models of a revised baseline scenario, revised alternative carbon tax policy scenarios, and revised emissions mitigation scenarios on which to perform revised variance-based sensitivity analyses. Observations made in the revised analyses will be compared to those made in the original analyses of the scenarios. Similarity between these observations will infer the validity of the scenario hypotheses themselves.

The external validation of the carbon tax policy and emissions mitigation scenarios can be found in the results and discussions in Chapter 3. The inferences made regarding the validity of the models are with reference to a figure comparing the original baseline scenario and the revised baseline scenario annual carbon tax exposure. An example of such a graph is provided in Figure 12. This example depicts the results of arbitrary, original and revised baselines as a visual aid to illustrate the expected results in Chapter 3.



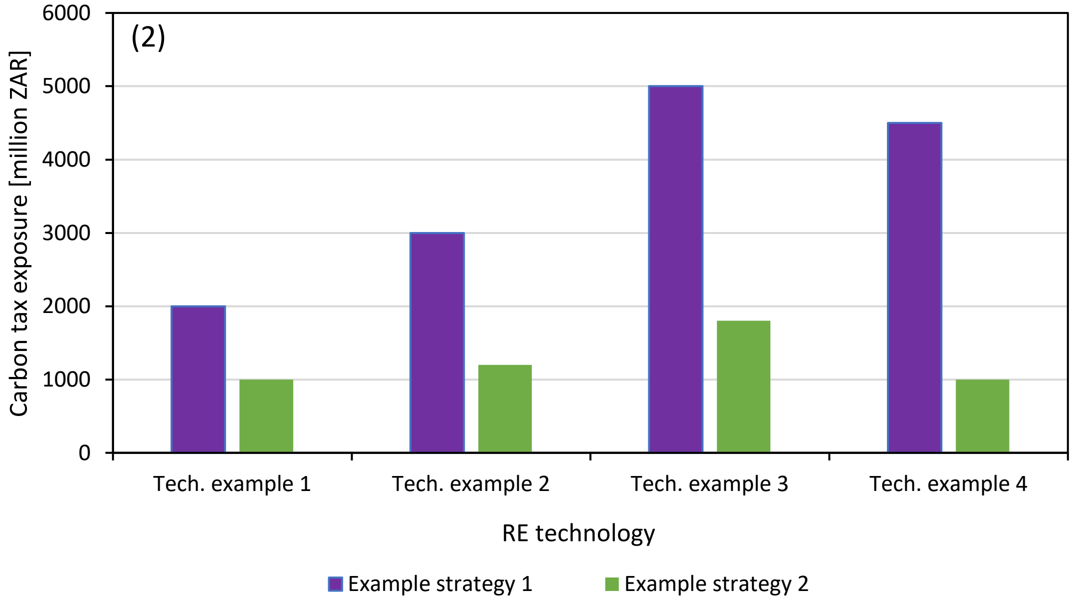


Figure 11: Cumulative carbon tax exposure of the emissions mitigation scenario examples, categorised by: (1) counterfactual carbon tax policy scenario; and (2) example emissions mitigation strategy employed

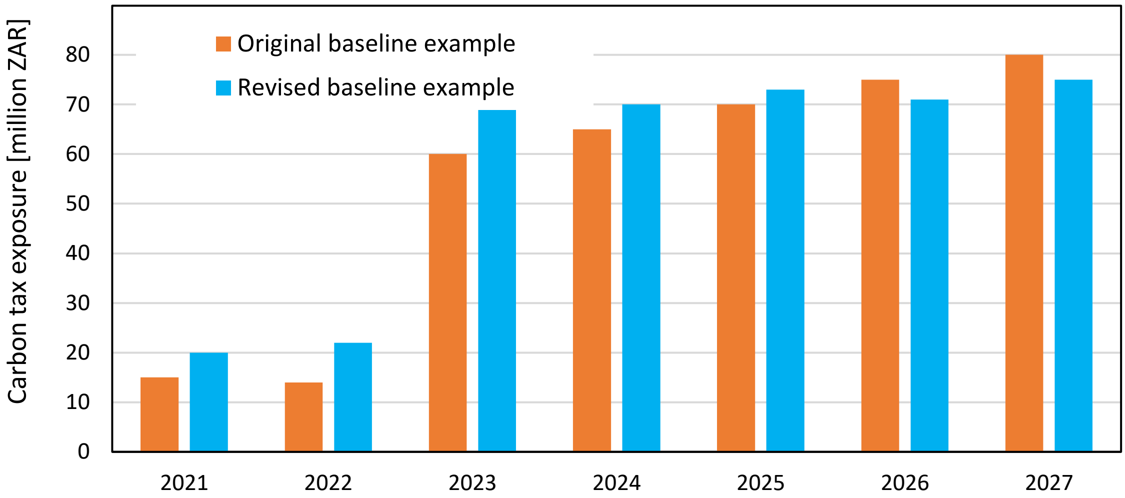


Figure 12: Example of original and revised baseline annual carbon tax exposure

2.8.2 Comparative verification

Inferences have been made regarding how carbon tax exposure would respond to a particular scenario with reference to a baseline. These were used as a basis for comparison to verify the scenarios' validity.

This comparison is summarised in Tables 11 and 12: Table 11 is for alternative carbon tax policy scenarios, and Table 12 is for emissions mitigation scenarios.

Table 11: Example of the comparative verification of the alternative carbon tax policy scenarios

Carbon tax policy scenario	Scenario number	Expectation	Observation	Verified (Y/N)	Reason
Scenario name	#	Expectations referenced from the literature	Observation from results and discussion	Y/N	Reason for not being verified, if applicable

Table 12: Example of the comparative verification of the emissions mitigation scenarios

Emissions mitigation technology	Strategy	Scenario number	Expectation	Observation	Verified (Y/N)	Reason
Technology type	Implement power plant	#	Expectations referenced from the literature	Observations made in a variance-based sensitivity analysis	Y/N	Reason for not being verified, if applicable
	Source power from RE sector	#	Expectations referenced from the literature	Observations made in a variance-based sensitivity analysis	Y/N	Reason for not being verified, if applicable

2.9 Overview of methodology

In the analyses of literature scenarios, it was apparent that there is a literature gap associated with analysing future carbon tax scenarios for gold mining companies. This was true for both carbon tax policy-based and emissions mitigation-based scenarios. Subsequently, a need for this study was realised, and a solution was developed.

The development of the methodology, described in section 2.3, suggested the hypothesis of a baseline scenario, carbon tax policy scenarios, and emissions mitigation scenarios that were applicable to a case study. The purpose was to perform a variance-based sensitivity analysis of these scenarios to ascertain the influence on the carbon tax exposure of the case study. To realise the objectives of this study, this solution was developed explicitly for a gold mining company case study.

CHAPTER 3: RESULTS AND DISCUSSION

3.1 Preamble

The methodology discussed in Chapter 2 was conducted in this section, and the results are presented and discussed.

First, the case study selection is described. This is followed by hypothesizing a baseline carbon tax policy scenario, alternative carbon tax policy scenarios, and emissions mitigation scenarios applicable to the case study.

The scenario hypotheses were used to model the scenario-specific carbon tax exposure of the case study. Finally, a sensitivity analysis of the scenario models with reference to the baseline scenario was performed. Observations made in the discussion informed the conclusions presented in Chapter 4.

3.2 Case study

For this investigation, an appropriate case study was required. In order for the case study to fulfil the objectives of this study, a gold mining company with operational control in South Africa needed to be chosen. Furthermore, it was necessary for the company to be liable for carbon taxes in the past and future.

Subsequently, an appropriate South African gold mining company was selected as the case study. This company has operational control over various mining-related activities, which are also considered emissions activities. These emissions activities and their associated emissions are detailed in Table 13.

Table 13: Emissions type, point of origin, and activity description of the chosen case study

Emissions activity	Description of emissions activity	Emission point of origin	Type of emissions
Waste-related	• Wastewater treatment • Solid waste disposal	• Wastewater treatment plants • Landfills	Direct
Blasting	• Combustion of explosives to fragment rock	• Mine shafts	Direct
Land use	• Land conversion	• Waste rock dumps • Landfills • Mineral processing plants • Wastewater treatment plants	Direct

Emissions activity	Description of emissions activity	Emission point of origin	Type of emissions
Stationary combustion	• Use of fuel-fired stationary equipment	• Poly-fuel boilers • Jet-fuel generators • Emergency diesel generators	Direct
Mobile combustion	• Use of fuel-fired mobile equipment	• Diesel-fired mobile equipment • Petrol-fired mobile equipment	Direct
Electricity usage	• Purchasing of electricity	• Eskom power plants	Indirect

3.3 Carbon tax policy scenario hypotheses

3.3.1 Baseline scenario hypothesis

The baseline scenario was hypothesized to be a reasonable counterfactual scenario with which to compare the alternative scenarios in this investigation. This baseline scenario hypothesis was associated with a realistic trajectory for the South African carbon tax regime.

The South African government has not explicitly stated the Phase 2 carbon tax policy expectations [7]. Subsequently, it was hypothesized that neither new nor adjusted carbon tax elements would be introduced in Phase 2 in the baseline scenario. This is except for the new or adjusted carbon tax policy elements already anticipated for Phase 2.

As mentioned in section 2.4, some of the carbon tax policy elements are certain for Phase 2, while others are uncertain. The uncertainty in the baseline scenario assumed that the carbon tax policy design elements remained the same as in Phase 1, except for the design elements that were gazetted to change upon the start of Phase 2.

The implications of the baseline scenario uncertainty were identified and applied to the emissions data. This comprised the baseline scenario model of the case study's carbon tax exposure. These implications are detailed in Table 14.

.

Table 14: Baseline scenario uncertainty and subsequent implications for carbon tax policy elements

Uncertainty	Type of uncertainty	Implication
Sector subsidisation	No changes to basic tax-free allowances	Basic tax-free allowances as gazetted in Carbon Tax Act of 2019:
		• 60% for fossil fuel combustion emissions
		• 70% for industrial process emissions
		• 70% for fugitive emissions
		• 75% for transport emissions
Carbon budget integration	No carbon budget participation	0% carbon budget allowance
Carbon offsetting	No carbon offsetting	0% offset allowance
Border tax adjustments	No border tax adjustments	No introduction of new policy design elements

3.3.2 Sector subsidisation scenario hypothesis

The sector subsidisation scenario was hypothesized to investigate the influence of changes to carbon tax policy elements that lead to the reduction of sector subsidisation. This scenario was hypothesized since it has been suggested that the National Treasury will be more stringent on the subsidisation of the energy sector [3].

The literature suggests that the discounts – namely allowances introduced by the Carbon Tax Act – need to be phased out to realise the objectives of South African climate governance [25]. Moreover, it has been suggested that this could be achieved by phasing out the basic tax-free allowances [7].

This scenario hypothesized phasing out the 60% basic tax-free allowance for fossil fuel combustion emissions in terms of carbon tax policy elements. This scenario's uncertainty arose from the gradual reduction in the size of this allowance by 10% per annum. This implied a basic tax-free allowance for fossil fuel combustion emissions of 0% by 2028.

In terms of uncertainty, the sector subsidisation scenario differs from the baseline scenario regarding sector subsidisation uncertainty. The uncertainty surrounding carbon budget integration, carbon offsetting, and border tax adjustments was assumed to be the same for both the baseline scenario and this sector subsidisation scenario.

From here on, this scenario will be labelled as Scenario 1. The implications of Scenario 1's uncertainty were identified. Afterwards, they were applied to the case study's emissions data to create the sector subsidisation scenario model of the case study's carbon tax exposure. These implications are detailed in Table 15.

Table 15: Scenario 1 uncertainty and subsequent implications for carbon tax policy elements

Uncertainty	Type of uncertainty	Implication
Sector subsidisation	Phasing out the basic tax-free allowance associated with fossil fuel combustion	Basic tax-free allowances:
		• 60% decreases by 10% p.a. starting from 2021 until it is zero in 2028 for fossil fuel combustion emissions
		• 70% for industrial process emissions
		• 70% for fugitive emissions
		• 75% for transport emissions
Carbon budget integration	No carbon budget participation	0% carbon budget allowance
Carbon offsetting	No carbon offsetting	0% offset allowance
Border tax adjustments	No border tax adjustments	No introduction of new policy design elements

3.3.3 Carbon budget integration scenario hypothesis

The carbon budget integration scenarios were hypothesized based on the alignment options suggested by the National Treasury, as seen in Chapter 1. In terms of carbon tax policy design elements, the uncertainty of these scenarios focused on the case study company's participation in carbon budgeting.

The uncertainties associated with sector subsidisation, carbon offsetting, and border tax adjustments were hypothesized to be the same as the baseline scenario. In terms of uncertainty, the carbon budget integration scenario differs from the baseline scenario regarding carbon budget integration uncertainty.

The carbon budgets chosen were five-year budgets for 2023 to 2027. They were based on a top-down and a bottom-up methodology, respectively. It was assumed that there would be no company participation in carbon budgeting in 2021 or 2022. Subsequently, the company did not receive the carbon budget allowance in those two years.

The top-down budget methodology was based on the national plan for emissions to peak in 2025. This peak corresponded with a 42% reduction in emissions in comparison to usual operations.

The bottom-up budget methodology was based on the case study's emissions reduction target of 7% compared to BAU. This target was published in the case study's Integrated Annual Report for 2020 [5].

Subsequently, the top-down carbon budget was chosen such that a 5% decrease in emissions per annum was realised compared to BAU operations. The bottom-up carbon budget was chosen such that a 1% decrease in emissions per annum was realised compared to BAU operations. These emissions reductions were budgeted for 2023 to 2027.

As discussed in the literature review, the DFFE presented two options to align carbon tax policy with carbon budgeting, and each option has its own carbon tax policy implications. The implications of alignment options 1 and 2 are detailed in Table 16 and Table 17, respectively.

As there were two methodologies and two policy designs to consider in this hypothesis, four different scenarios were hypothesized. The case study's carbon tax exposure for these scenarios was modelled using the same emissions data as the baseline scenario. It can therefore be anticipated that all these scenarios will feature exceeded budgets.

The labels of these scenarios, and the corresponding methodology and policy alignment option, are provided in Table 18. From here on, the scenarios will be identified by these labels.

Table 16: Uncertainty and subsequent implications for carbon tax policy elements of policy scenarios involving alignment option 1 presented by the DFFE

Uncertainty	Type of uncertainty	Implication
Sector subsidisation	No changes to basic tax-free allowances	Basic tax-free allowances as gazetted in the Carbon Tax Act of 2019
Carbon budget integration	Carbon budget participation	R600 tax base rate for emissions that are over budget
Carbon offsetting	No carbon offsetting	0% offset allowance
Border tax adjustments	No border tax adjustments	No introduction of new policy design elements

Table 17: Uncertainty and subsequent implications for carbon tax policy elements of policy scenarios involving alignment option 2 presented by the DFFE

Uncertainty	Type of uncertainty	Implication
Sector subsidisation	No changes to basic tax-free allowances	• Basic tax-free allowances as gazetted in the Carbon Tax Act of 2019
Carbon budget integration	Carbon budget participation	• Receipt of 35% carbon budget allowance on condition the budget is not exceeded • Basic tax-free allowance reduced to 30%
Carbon offsetting	No carbon offsetting	• 0% offset allowance
Border tax adjustments	No border tax adjustments	• No introduction of new policy design elements

Table 18: Carbon budget integration scenarios: Scenario label, carbon budget methodology, policy alignment option and implications

Scenario label	Methodology	Policy alignment option	Carbon tax policy implications
2.1.1	Top-down	1	See Table 16 Table 14
2.1.2	Top-down	2	See Table 17
2.2.1	Bottom-up	1	See Table 16
2.2.2	Bottom-up	2	See Table 17

3.3.4 Carbon offsetting scenario hypothesis

Carbon trading and offsetting have already been integrated into the South African tax-and-trade regulatory scheme [51]. The baseline scenario did not hypothesize the case study's participation in carbon trading or offsetting. This necessitated the carbon offsetting scenario hypothesis.

The National Treasury has not commented on changes to the existing tax-and-trade regulatory scheme [34]. Subsequently, it was hypothesized that the offset allowance would remain at a maximum of 10%. Moreover, the offset regulations for Phase 1 of the carbon tax regime would remain the same for Phase 2. The uncertainty in these scenarios arose from the case study company offsetting its emissions by purchasing carbon credits. This calculation assumed that the cost of one carbon credit was 85% of the carbon tax base rate [51].

It is important to note that the carbon offsetting scenarios' uncertainty thus differs from the baseline scenario with respect to the carbon offsetting uncertainty. The uncertainties regarding sector subsidisation, carbon budgeting, and border tax adjustments are alike for baseline and carbon offsetting scenarios.

From here on, Scenario 3.1 will describe scenarios in which only 10% of emissions are offset per annum, and Scenario 3.2 will describe scenarios in which all emissions are offset per annum. The implications of the uncertainties associated with each scenario are identified to model the scenario-specific carbon tax exposure of the case study. These implications are detailed in Table 19.

Table 19: Scenarios 3.1 and 3.2 uncertainty and subsequent implications for carbon tax policy elements

Uncertainty	Type of uncertainty	Implication
Sector subsidisation	No changes to basic tax-free allowances	• Basic tax-free allowances as gazetted in the Carbon Tax Act of 2019
Carbon budget integration	No carbon budget participation	• 0% carbon budget allowance
Carbon offsetting	Offsetting of emissions	• Receipt of maximum offset allowance of 10% • Only applicable to direct stationary combustion emissions
Border tax adjustments	No border tax adjustments	• No introduction of new policy design elements

3.4 Emissions mitigation scenario hypotheses

Following the hypotheses of the carbon tax policy scenarios, the emissions mitigation scenarios were hypothesized. The emissions mitigation scenario hypothesis was created by applying emissions mitigation technology and strategies to the carbon tax policy scenario hypotheses discussed in section 3.3. Subsequently, the emissions mitigation scenario hypotheses are based on the baseline scenario and sector subsidisation scenario hypotheses.

All the emissions mitigation scenarios hypotheses considered the substitution of 16% of the case study company's purchased coal-fired electricity with renewably generated electricity. This corresponded to the electricity demands of certain mineral processing operations specific to the case study.

The scenarios using the 'implementation of power plant' strategy assumed that these power plants would be constructed in two years, starting in 2021. The specifications of these power plants were to deliver 30 MW of power, beginning in 2023. Since the emissions mitigation scenarios were purely hypothetical, the efficiency of the power plants in these scenarios was assumed.

The RE premium acts as a grant to subsidise the cost of implementing the power plants in these scenarios. Therefore, this implementation cost, namely the difference between the green adjustments of the LCOE and RE premium, was included in the carbon tax exposure.

The RE premium, LCOE in 2016, and green adjustment per emissions mitigation technology are detailed in Table 20. The relevant CPI used to convert the LCOE from 2016 to 2021 is detailed in Table 21. Note that for HEP, an average of the LCOEs of the other technology has been used. This is because the captured LCOE for HEP was described as an underestimate [52].

The scenarios using the 'sourcing from RE sector' strategy assumed that purchased RE would substitute coal-fired electricity purchases. In these scenarios, sufficient electricity was being purchased from the RE sector such that 16% of the company's purchased coal-fired electricity was substituted.

The implications of the emissions mitigation scenarios for carbon tax policy and carbon tax exposure were identified in order to be able to model the scenario-specific carbon tax exposure of the case study. This was needed for the sensitivity analysis, which is described in section 3.6. These implications are detailed in Table 22.

Table 20: RE premium [25], LCOE [52] and green adjustment per emissions mitigation technology [53]

Emissions mitigation technology	RE premium [ZAR/kWh RE]	LCOE in 2016 [ZAR/kWh]	Green adjustment [%]
CSP	4.11	4.15	5
HEP	0.84	2.98	5
Solar PV	2.27	3.05	5
WEP	1.23	2.37	5
Biogas power	0	2.34	0

Table 21: CPIs used for carbon tax exposure calculations [54]

Year	CPI
2016	97.8
2021	115.9

Table 22: Emissions mitigation (EM) scenario details and implications for carbon tax (CT) policy and exposure

Scenario label	Type of EM technology	Type of strategy	CT policy and exposure implications
PV1B	Solar PV	Implementation of power plant	Baseline CT policy implications (see Table 12) • Reduction in CT exposure due to reduction in emissions • Solar PV RE premium considered in the calculation
PV11	Solar PV	Implementation of power plant	Scenario 1 CT policy implications (see Table 13) • Reduction in CT exposure due to reduction in emissions • Solar PV RE premium considered in the calculation
PV2B	Solar PV	Sourcing from RE sector	Baseline CT policy implications (see Table 12) • Reduction in CT exposure due to reduction in emissions • Solar PV RE premium NOT considered in the calculation
PV21	Solar PV	Sourcing from RE sector	Scenario 1 CT policy implications (see Table 13) • Reduction in CT exposure due to reduction in emissions • Solar PV RE premium NOT considered in the calculation
CSP1B	CSP	Implementation of power plant	Baseline CT policy implications (see Table 12) • Reduction in CT exposure due to reduction in emissions • CSP RE premium considered in the calculation
CSP11	CSP	Implementation of power plant	Scenario 1 CT policy implications (Table 13) • Reduction in CT exposure due to reduction in emissions • CSP RE premium considered in the calculation
CSP2B	CSP	Sourcing from RE sector	Baseline CT policy implications (Table 12) • Reduction in CT exposure due to reduction in emissions • CSP RE premium NOT considered in the calculation
CSP21	CSP	Sourcing from RE sector	Scenario 1 CT policy implications (see Table 13) • Reduction in CT exposure due to reduction in emissions • CSP RE premium NOT considered in the calculation
WEP1B	WEP	Implementation of power plant	Baseline CT policy implications (see Table 12) • Reduction in CT exposure due to reduction in emissions • WEP RE premium considered in the calculation
WEP11	WEP	Implementation of power plant	Scenario 1 CT policy implications (see Table 13) • Reduction in CT exposure due to reduction in emissions • WEP RE premium considered in the calculation
WEP2B	WEP	Sourcing from RE sector	Baseline CT policy implications (see Table 12) • Reduction in CT exposure due to reduction in emissions • WEP RE premium NOT considered in the calculation
WEP21	WEP	Sourcing from the RE sector	Scenario 1 CT policy implications (see Table 13) • Reduction in CT exposure due to reduction in emissions • WEP RE premium NOT considered in the calculation

Scenario label	Type of EM technology	Type of strategy	CT policy and exposure implications
HEP1B	HEP	Implementation of power plant	Baseline CT policy implications (see Table 12) • Reduction in CT exposure due to reduction in emissions • HEP RE premium considered in the calculation
HEP11	HEP	Implementation of power plant	Scenario 1 CT policy implications (see Table 13) • Reduction in CT exposure due to reduction in emissions • HEP RE premium considered in the calculation
HEP2B	HEP	Sourcing from RE sector	Baseline CT policy implications (see Table 12) • Reduction in CT exposure due to reduction in emissions • HEP RE premium NOT considered in the calculation
HEP21	HEP	Sourcing from the RE sector	Scenario 1 CT policy implications (see Table 13) • Reduction in CT exposure due to reduction in emissions • HEP RE premium NOT considered in the calculation
BG1B	Biogas-fired electricity	Implementation of power plant	Baseline CT policy implications (see Table 12) • Reduction in CT exposure due to reduction in emissions • Reduction in CT exposure due to zero CT liability associated with emissions resulting from the combustion of biofuels
BG11	Biogas-fired electricity	Implementation of power plant	Scenario 1 CT policy implications (see Table 13) • Reduction in CT exposure due to reduction in emissions • Reduction in CT exposure due to zero CT liability associated with emissions resulting from the combustion of biofuels

3.5 Data collection, consolidation and application

3.5.1 Data collection and consolidation

The relevant data was collected from the gold mining company's environmental officers to perform the sensitivity analysis required by this study. This historical data was explicitly associated with the emissions activities that exposed this company to the carbon tax in 2019 and 2020. These emissions activities, and the description of their corresponding data, are presented in Table 23.

A BAU trajectory was required for each emissions activity, which aimed to anticipate a constant emissions rate for each activity over time. It was assumed that the annual usage associated with 2021 was equal to an average of usage values associated with 2019 and 2020. It was assumed that the annual usage for each year beyond 2021 would be equal to that of 2021. These assumptions informed the BAU trajectory for the associated GHG emissions.

Table 23: Descriptions and year of annual, historic data collected per emissions activity of case study

Emissions activity type	Emissions activity	Associated data collected	Units
Stationary combustion activities	• Emergency generator operations • Poly-fuel boiler operations • Jet-fuel generator operations	• Annual diesel usage • Annual poly-fuel usage • Annual jet-fuel usage	Litres
Mobile combustion activities	• Diesel-fired mobile equipment operations • Petrol-fired mobile equipment operations	• Annual diesel usage • Annual petrol usage	Litres
Purchased electricity	• Purchased electricity usage	• Annual electricity usage	MWh

South Africa's 2019 IRP emphasises that there is uncertainty regarding the environmental fiscal trajectory after 2030. This is because this trajectory relies entirely on the progress made toward environmental protection up to and including 2030 [5]. Therefore, it was evident that the carbon tax calculations required for the sensitivity analysis should not exceed 2030. Since Phase 2 ends in 2027 [6] it was decided that all scenario models in this investigation would end in 2027.

The usage data associated with the various emissions activities were converted to emissions data using the methodology outlined in the *Technical Guidelines for Monitoring, Reporting and Verification of Greenhouse Gas Emissions by Industry*. This was done in preparation for the carbon tax exposure calculations required for the sensitivity analysis.

These calculations involved the application of the carbon tax equation to the data, as per the Carbon Tax Act. This was done in conjunction with the various scenarios' carbon tax policy implications. It is important to note that the influence of market volatilities, such as inflation, was excluded from these calculations. This explicates the use of a normalised tax base rate for these calculations.

The carbon tax exposure was modelled for the case study per scenario using their carbon tax policy implications. The sensitivity analysis of the carbon tax policy and emissions mitigation scenarios, with reference to the baseline scenario, is described in section 3.6. The scenarios' cumulative carbon tax has been plotted on bar graphs and used as a basis for the analysis.

3.5.2 Baseline scenario model

The case study's carbon tax exposure was modelled for the baseline scenario. This involved the application of the carbon tax equation to the consolidated emissions data. The carbon tax equation was applied to the emissions data as per the Carbon Tax Act, but using the policy implications associated with the baseline scenario. These implications were tabulated in Table 14.

This calculation was repeated for every year included in this investigation, namely the years 2021 to 2027. The results of this calculation are plotted in Figure 13, which portrays the annual carbon tax exposure anticipated by the baseline scenario for the case study.

In 2021 and 2022, the carbon tax exposure is less than ZAR 20 million per annum. However, from 2023 onwards, the carbon tax exposure increased by 228% from the previous year. Thereafter, the annual carbon tax exposure appears constant.

The drastic increase in carbon tax exposure between 2022 and 2023 is a result of the introduction of Phase 2 carbon tax policy, expected on 1 January 2023. This policy framework gazettes that carbon tax exposure associated with electricity use will no longer be reduced by paying the electricity generation levy. Subsequently, an increase in carbon tax exposure, which is proportional to that associated with the case study's electricity usage, is expected.

Although the annual carbon tax exposures for 2023 to 2027 appear constant in Figure 13, they differ slightly. This is despite having the same annual emissions trajectory based on BAU operations mentioned in section 3.5. This is a result of the 2019 IRP publishing different electricity-usage-to-emissions conversion factors for every year into the future until 2031.

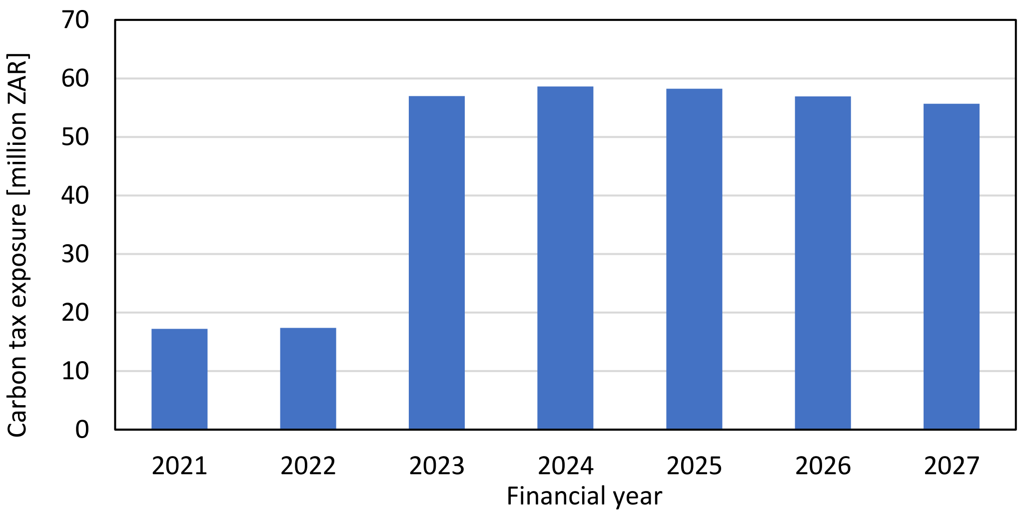


Figure 13: Annual carbon tax exposure anticipated for case study gold mining company for the baseline scenario

The cumulative carbon tax exposure associated with the baseline scenario as of 31 December 2027 is approximately ZAR 301.8 million. This was calculated by adding together the annual carbon tax exposure of the baseline scenario from 2021 to 2027.

This cumulative value is used as a basis for comparison in the sensitivity analyses of the carbon tax policy scenarios and emissions mitigation scenarios in section 3.6, respectively. Seeing that this baseline scenario intends to be a realistic trajectory for the case study's future carbon tax exposure, it was not adjusted for the emissions mitigation scenario sensitivity analyses.

3.6 Variance-based sensitivity analysis of scenario models

3.6.1 Preamble to analysis

In sections 3.6.2 to 3.6.5, the sensitivity analyses of the various carbon tax policy scenarios are discussed with reference to the baseline scenario described in 3.5.2. In section 3.6.6, the sensitivity analyses of the various emissions mitigation scenarios are presented.

3.6.2 Carbon tax policy scenario analysis

In sections 3.6.3 to 3.6.5, the sensitivity analyses of the various carbon tax policy scenarios are discussed with reference to the baseline scenario. These sensitivity analyses ascertained the influence of the alternative scenario hypotheses on the cumulative carbon tax of the case study by the end of Phase 2.

In Figure 14, the cumulative carbon tax exposure from 1 January 2021 to 31 December 2027 has been plotted for each carbon tax policy scenario, along with the baseline scenario. This figure illustrates the cumulative carbon tax to which the case study company would be exposed under policy designs that align with the scenarios given BAU operations.

The method to calculate the cumulative carbon tax exposure of the baseline scenario, as described in section 3.5.2, was repeated for the alternative carbon tax policy scenarios to plot Figure 14. This was done using the policy design implications identified for these scenarios in the following sections:

- Section 3.3.2 for the sector subsidisation scenario, namely Scenario 1.
- Section 3.3.3 for the carbon budget integration scenarios, namely Scenarios 2.1.1 to 2.2.2.
- Section 3.3.4 for the carbon offsetting scenarios, namely Sections 3.1 and 3.2.

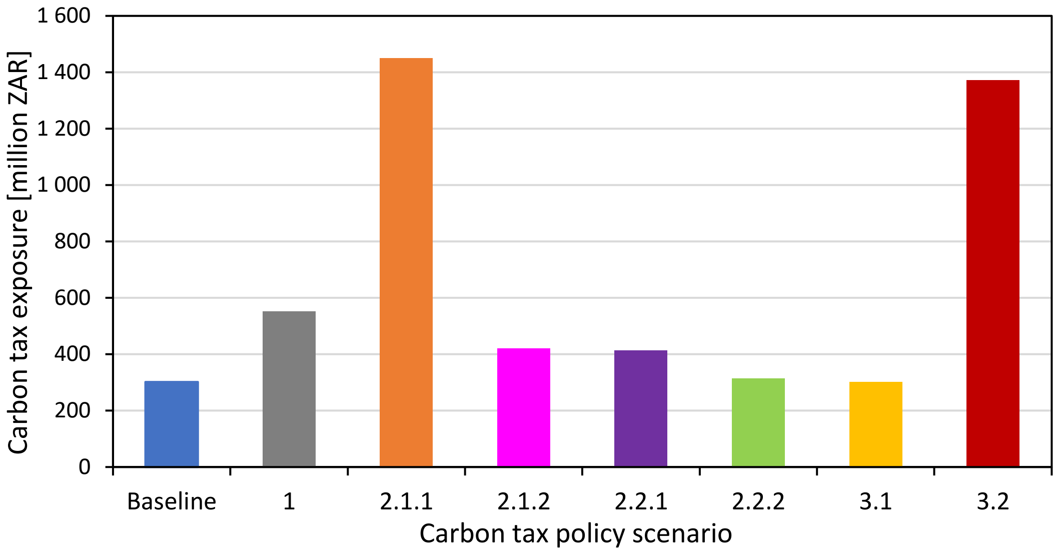


Figure 14: Cumulative carbon tax exposure associated with each of the carbon tax policy scenarios as of 31 December 2027

The significance of the cumulative carbon tax exposure associated with each of the carbon tax policy scenarios is with reference to the baseline scenario. From Figure 14, it is evident that the significance of the various carbon tax policy scenarios in ascending order is 3.1, 2.2.2, 2.2.1, 2.1.2, 1, 3.2 and 2.1.1. The most significant cumulative carbon tax exposure is associated with Scenario 2.1.1 at ZAR 1.45 billion. The least significant cumulative carbon tax exposure is associated with Scenario 3.1 at ZAR 302 million.

The analyses of the individual carbon tax policy scenarios can be found in sections 3.6.3 to 3.6.5. In these sections, inferences are made about the influence of the unique policy designs on the anticipated cumulative carbon tax exposure of the case study company as of 31 December 2027.

3.6.3 Sector subsidisation scenario analysis

The cumulative carbon tax exposure associated with Scenario 1 was calculated. This involved using the carbon tax equation as per the Carbon Tax Act of 2019. This was done considering the Scenario 1 carbon tax policy implications detailed in Table 15.

Herein is the sensitivity analysis of the sector subsidisation scenario (Scenario 1). All analyses of Scenario 1 refer to Figure 14.

It is evident from Figure 14 that the cumulative carbon tax exposure for this gold mining company would be approximately 83% greater in Scenario 1 when compared to the baseline scenario, given a BAU trajectory for the company's emissions. This is due to the decreasing basic tax-free allowance for fossil fuel combustion realised in Scenario 1.

This observation suggests that a decrease in government subsidisation would increase carbon tax exposure. If the carbon tax policy is amended in alignment with Scenario 1 for Phase 2, gold mining companies should anticipate increases in their future carbon tax exposure.

3.6.4 Carbon budget integration scenario analysis

The cumulative carbon tax exposure associated with Scenarios 2.1.1 to 2.2.2 was modelled. This involved using the carbon tax equation as per the Carbon Tax Act of 2019. This was done with consideration of the carbon tax policy implications associated with these scenarios, which are detailed in Table 18.

To reiterate, the top-down carbon budget was calculated such that a 5% decrease in emissions per annum was realised compared to BAU operations. The emissions reductions were budgeted for 2021 to 2025, as per the top-down methodology, to reach the national emissions reduction target.

For the bottom-up methodology, the carbon budget was calculated such that a 1% decrease in emissions per annum was realised compared to BAU operations. This was done to achieve the case study's 2030 emissions reduction target. The emissions reductions were thus budgeted for 2023 to 2027.

Here are presented the sensitivity analyses of the carbon budget integration scenarios (Scenarios 2.1.1 to 2.2.2). Figure 15 depicts the cumulative carbon tax exposure for Scenarios 2.1.1 to 2.2.2, the corresponding carbon budgets, and the baseline scenario.

The cumulative carbon tax exposure associated with the top-down budget and bottom-up budget is observed as ZAR 115 million and ZAR 176 million, respectively. The cumulative carbon tax exposure of the top-down budget is smaller than that of the bottom-up budget. One can thus expect larger penalties associated with exceeding a top-down budget than exceeding a bottom-up budget. This infers that a top-down budget is more stringent than a bottom-up budget.

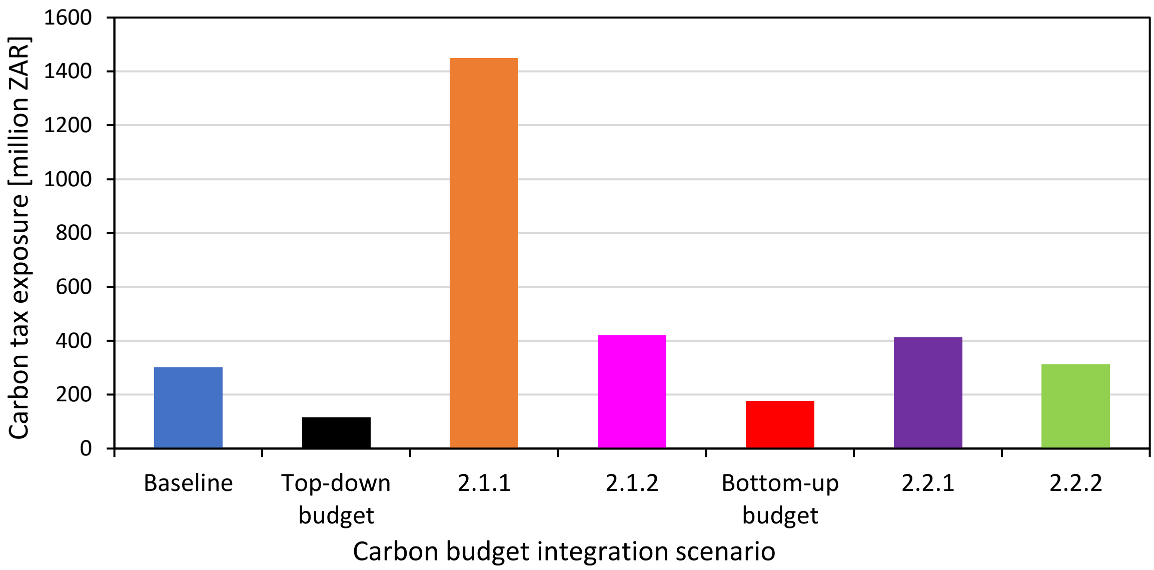


Figure 15: Cumulative carbon tax exposure associated with each of the carbon budget integration scenarios, carbon budgets and baseline scenario as of 31 December 2027

In Figure 15, it is observed that the cumulative carbon tax exposure of Scenario 2.1.1 is greater than that of 2.2.1. The same observation is made when comparing Scenario 2.1.2 with 2.2.2. Figure 15 indicates that exceeding the top-down budget leads to a larger cumulative carbon tax exposure than exceeding the bottom-up budget. This confirmed the expectation that a company should expect larger penalties when exceeding a top-down budget compared to a bottom-up budget.

Figure 15 depicts higher cumulative carbon tax exposure for Scenario 2.1.1 compared to Scenario 2.1.2. Moreover, it depicts higher cumulative carbon tax exposure for Scenario 2.2.1 when compared to Scenario 2.2.2. These observations imply that higher penalties are associated with exceeding the budget under policy design option 1 compared to option 2. These analyses infer that gold mining companies should expect higher cumulative carbon tax exposure when the carbon budget is exceeded under policy design option 1 compared to option 2. This is likely due to the method in which carbon tax and carbon budgeting have been aligned in option 1 compared to option 2. Option 1 can thus be described as more stringent than option 2.

Overall, the analyses of the carbon budget integration scenarios suggest the following: Alignment option 1, in conjunction with top-down budgeting, will lead to the most significant penalties if said budget is exceeded. The budget would have been exceeded under the most stringent policy alignment option 1 and budget.

3.6.5 Carbon offsetting scenario analysis

The cumulative carbon tax exposure associated with Scenarios 3.1 and 3.2 was modelled. This involved using the carbon tax equation as per the Carbon Tax Act of 2019. This was done with consideration of the carbon tax policy implications associated with these scenarios, which are detailed in Table 19.

Herein is the sensitivity analysis of the carbon offsetting scenarios (Scenarios 3.1 and 3.2). All these analyses refer to Figure 14.

Figure 14 makes it apparent that offsetting 10% of the case study's emissions, such as in Scenario 3.1, would result in a negligible cumulative carbon tax exposure reduction of approximately 0.02% when compared to the baseline. This is because, first, the case study company became eligible for the offset allowance in Scenario 3.1, and second, the cost of carbon credits is 15% less expensive than the carbon tax base rate. In itself, the purchase of carbon credits contributed to the reduction in carbon tax exposure associated with Scenario 3.1 specifically.

From Figure 14, it is evident that Scenario 3.2 exposed the case study company to significantly more carbon tax than Scenario 3.1. The purchase of carbon credits to offset 100% of emissions exposed the case study company to approximately 400% more carbon tax than in the baseline or Scenario 3.1. This is despite receiving the maximum offset allowance. The purchase of carbon credits resulted in increased carbon tax exposure in Scenario 3.2 specifically. However, it is important to note that a net-zero status was achieved in this scenario through the offsetting of all emissions.

Comparing these alternative carbon offsetting scenarios with the counterfactual baseline and with one another precipitated the following important observations. First, carbon offsetting can aid a gold mining company in reducing its carbon tax exposure. However, this is contingent on whether or not the extent of emissions that the company chooses to offset exceeds the fiscal constraint presented by the maximum offset allowance of 10%. Moreover, this reduction in carbon tax exposure is insignificant.

Secondly, a gold mining company can use carbon offsetting to achieve net-zero status. However, the carbon tax exposure associated with this will be extreme, as a net-zero status is an investment.

3.6.6 Variance-based sensitivity analysis of emissions mitigation scenario models

This section discusses the sensitivity analyses of all emissions mitigation scenarios that were modelled. These sensitivity analyses ascertained the influence of the various emissions mitigation scenario hypotheses on the cumulative carbon tax of the case study company by the end of Phase 2.

This section specifically analyses the emissions mitigation scenarios with reference to one another. The section compares the impacts of the different emissions mitigation hypotheses on the case study company's cumulative carbon tax exposure.

In Figure 16, the cumulative carbon tax from 1 January 2021 to 31 December 2027 is plotted for each of the emissions mitigation scenarios. The scenarios in Figure 16(1) and Figure 16(2) are categorised according to whether or not they were associated with the implementation or the sourcing strategy.

Figure 16(1) depicts significantly high cumulative carbon tax exposure for all the emissions mitigation scenarios. This is due to the investments in implementing the power plant in each scenario. These investments, in ascending order evident from Figure 16(1), are as follows: biogas power, WEP, HEP, solar PV and CSP.

All the plants in Figure 16(1) scenarios realised identical emissions reductions. This is despite the vastly different investments associated with their implementation. This inferred the cost-effectiveness associated with the RE technology type of the plant. In descending order (i.e. most to least cost-effective), the RE technology types are as follows: CSP, solar PV, WEP, HEP and biogas power.

Figure 16(1) shows the same cumulative carbon tax exposure for both solar PV scenarios, despite being applied to different carbon tax policy scenarios, namely the baseline and sector subsidisation (Scenario 1). This observation holds when comparing the cumulative carbon tax exposures of the CSP scenarios with one another. It is evident from Figure 16(1) that this is true for all RE technology types except biogas power.

Figure 16 suggests that the cumulative carbon tax exposure for an individual type of RE technology is the same despite the carbon tax policy scenario to which the implementation strategy is applied. The diminishing basic tax-free allowance for fossil fuel combustion in Scenario 1 had a negligible impact on the cumulative carbon tax exposure of the emissions mitigation scenarios involving the implementation of a solar PV, CSP, HEP or WEP plant. The reason for this is that the case study company received the RE premium, which reduced the annual carbon tax exposure from 2023 to 2027 once the plant became operational.

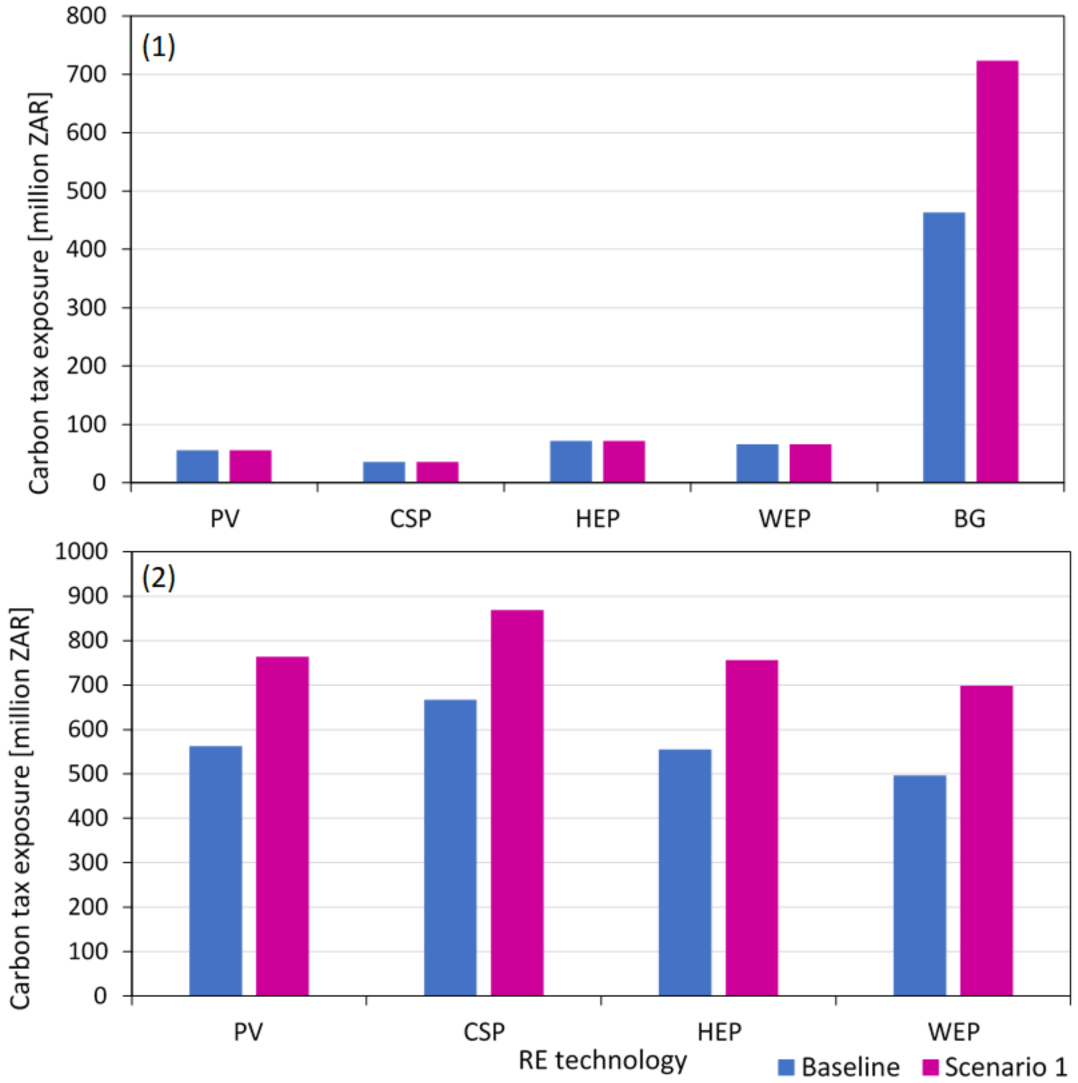


Figure 16: Cumulative carbon tax exposure as of 31 December 2027 of the emissions mitigation scenarios due to: (1) RE plant implementation; and (2) RE sourcing

It is evident from Figure 16(1), however, that the case study company's cumulative carbon tax exposure pertaining to the implementation of a biogas plant differs depending on the carbon tax policy scenario in which this strategy is applied. A larger cumulative carbon tax exposure is observed based on Scenario 1 compared to the baseline.

This suggests that the diminishing basic tax-free allowance for fossil fuel combustion in Scenario 1 would expose the case study company to more carbon tax when compared to the baseline scenario. This is likely because there is no RE premium associated with implementing a biogas-fired plant.

Figure 16(2) illustrates that the case study company's cumulative carbon tax exposure pertaining to the substitution of coal-fired electricity with purchased renewable power differs depending on the carbon tax policy scenario. A larger cumulative carbon tax exposure is associated with the employment of said emissions mitigation strategy under Scenario 1 compared to the baseline scenario. This is due to the diminishing basic tax-free allowance for fossil fuel combustion in Scenario 1, which exposes the case study company to more carbon tax when compared to the baseline scenario.

The scenarios involving substituting purchased electricity with power from the RE sector demonstrate that the carbon tax exposure is contingent on the RE technology type. This infers that the type of RE sector from which a company decides to substitute its coal-fired electricity purchases is significant.

Figure 16(2) makes it evident that electricity purchases from the CSP sector will expose the case study company to the most carbon tax, followed by solar PV, HEP and WEP.

In Figure 17, the cumulative carbon tax from 1 January 2021 to 31 December 2027 is plotted for each emissions mitigation scenario. However, the scenarios in Figure 17(1) and 17(2) have been categorised according to whether or not they are associated with the baseline scenario and Scenario 1, respectively.

Both Figure 17(1) and 17(2) make it apparent that the cumulative carbon tax exposure associated with the scenarios featuring RE plant implementation was much smaller than that of the scenarios featuring the substitution of coal-fired electricity with purchased renewable power. This strongly suggests that a scenario involving the implementation of an RE plant would lead to lower cumulative carbon tax exposure by 2027 because of the RE premium. This observation was made compared to a scenario involving substituting coal-fired electricity with power purchased from the RE sector.

Considering that both these emissions mitigation strategies aim to achieve similar emissions reductions, the strategy that involves the implementation of an RE power plant would appear to be more lucrative for all RE technology types. This is because it achieves identical emissions reductions without increasing the cumulative carbon tax exposure by 2027 as significantly as the strategy that involves sourcing electricity from the RE sector.

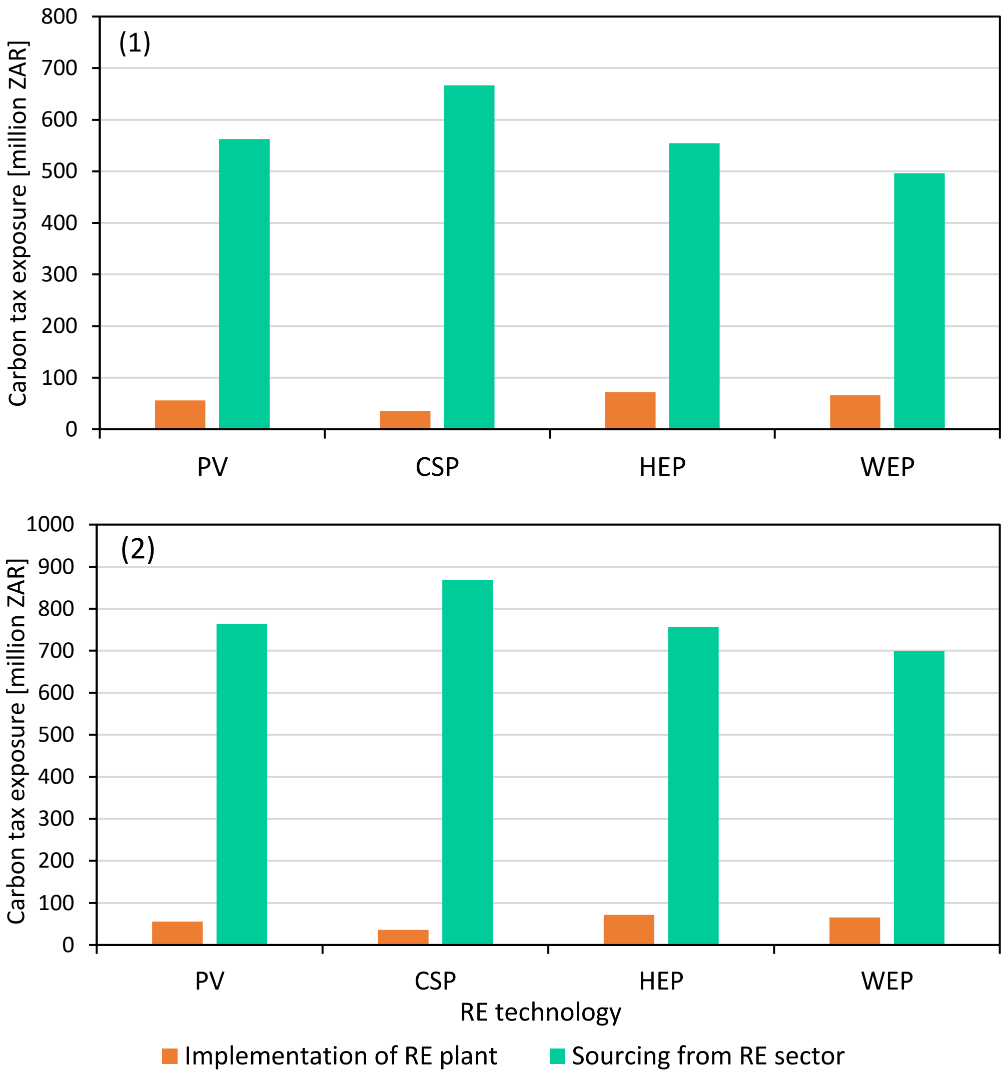


Figure 17: Cumulative carbon tax exposure as of 31 December 2027 of the emissions mitigation scenarios: (1) associated with the baseline scenario; and (2) associated with Scenario 1

3.7 Verification and validation

3.7.1 External validation

External validation of the scenarios hypothesized in this dissertation required revisions of the cumulative carbon tax exposure models discussed in the variance-based sensitivity analysis. This was done by applying the associated hypotheses to different emissions data.

Since the emissions mitigation scenario hypotheses were based on the baseline scenario and sector subsidisation scenario, the individual emissions mitigation scenarios need not be validated. Since the alternative carbon tax policy scenarios were modelled similarly to the baseline scenario, but with different parameters, it was not necessary to validate them. Subsequently, only the baseline scenario model was revised for external validation.

The emissions data used to create revised models was audited data acquired from the company contracted to verify the case study's environmental data. Note that the audited data includes explosives, but excludes poly-fuel and jet-fuel. This is unlike the data received from environmental officers, which excludes explosives. The emissions activity type, activities, and associated required data are tabulated in Table 24.

Table 24: Emissions type and activity associated with the audited data used for external validation

Emissions activity type	Emissions activity	Associated data collected	Units
Stationary combustion activities	Emergency generator operation	Annual diesel usage	Litres
Mobile combustion activities	Diesel-fired mobile equipment operations Petrol-fired mobile equipment operations	Annual diesel usage Annual petrol usage	Litres
Explosive combustion activities	Underground blasting operations	Annual explosives usage	Tonnes
Purchased electricity	Purchased electricity usage	Annual electricity usage	MWh

The methodology used to model the annual carbon tax exposure for a scenario was repeated using the audited emissions data. This rendered revised annual carbon tax exposures from 1 January 2021 until 31 December 2027 for the original baseline and revised baseline scenario. The annual carbon tax exposure for these scenarios is illustrated in Figure 18, together with their fourth-order polynomial trend lines and associated R^2 values.

From Figure 18, it is evident that the annual carbon tax exposure of the revised baseline is larger than that of the original baseline. This is likely due to the inclusion of explosives combustion activities in the revised baseline model, and their exclusion in the original baseline model. However, it can also be observed that the revised baseline scenario model has a similar trend to the original baseline model of the case study company's annual carbon tax exposure.

Moreover, their respective R^2 values of 0.913 and 0.915 are very similar. This suggests that for both the original and revised baseline models of the case study company's annual carbon tax exposure, approximately 91% of the variation in the output variable (carbon tax exposure) is explained by the input variable (emissions data). This suggests the validity of the baseline scenario hypothesis, since the R^2 value remained constant despite being applied to different emissions data. Furthermore, this suggests that the baseline scenario was robust, i.e. it can be applied to alternative data with the same observed correlation between emissions data and carbon tax exposure.

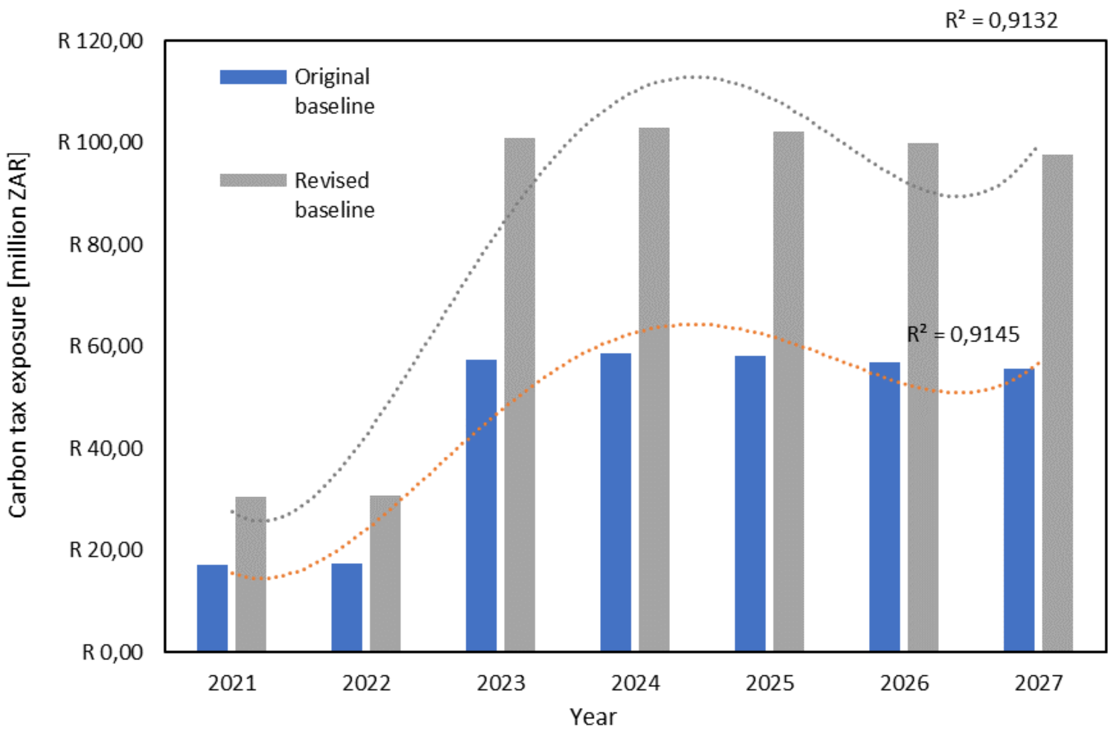


Figure 18: Annual carbon tax exposure from 2021 to 2027 associated with the original and revised baseline scenario model, for validation

3.7.2 Comparative verification

Verification of the alternative carbon tax policy scenarios and emissions mitigation scenarios was performed by comparing the scenario-specific expectations described in the literature with what was observed in the variance-based sensitivity analysis in section 3.6. The comparisons for the carbon tax policy and emissions mitigation scenarios are provided in Table 25 and 26.

As seen in Table 25, the expectations regarding the various carbon tax policy scenarios aligned with what was observed in the variance-based sensitivity analysis in section 3.6, except for the sector subsidisation scenario, Scenario 1. This is because the sector subsidisation hypothesis in this investigation does not account for revenue recycling, as seen in the literature.

It is apparent from Table 25 that all the alternative carbon tax policy scenarios were verified, except for the sector subsidisation scenario, as mentioned above.

From Table 26, both emissions mitigation scenarios that involved biogas power plant implementation could be verified. This is because the observations made thereon in the variance-based sensitivity analysis in section 3.6 align with the expectations detailed in the literature.

For the scenarios involving the implementation of RE power plants (solar PV, CSP, HEP and WEP), the corresponding literature expectations did consider the cost of implementing the power plants in these scenarios, as discussed in Table 26. Subsequently, the basis for comparison was deemed appropriate, seeing that the hypotheses in this investigation also consider implementation costs in the case study company's carbon tax exposure. The emissions mitigation scenarios involving implementing an RE power plant to substitute purchased coal-fired electricity could thus be verified.

For the scenarios involving the substitution of purchased coal-fired electricity with purchases from the RE sector, the corresponding expectations did not consider the RE sector's adjustment of LCOE to recover the capital costs to implement the plant, as discussed in Table 26.

Subsequently, the basis for comparison was false, seeing that the hypotheses in this investigation do consider this LCOE adjustment. Therefore, the emissions mitigation scenarios involving the substitution of purchased coal-fired electricity with purchases from the RE sector could not be verified.

Table 25*:* Comparative verification of the carbon tax policy scenarios

Carbon tax policy scenario	Scenario number	Expectations based on literature	Observation made in variance-based sensitivity analysis	Verified (Y/N)	Reason
Sector subsidisation	1	7% positive deviation from baseline scenario [7]	83% positive deviation from the baseline scenario	N	Expectation considers the influence of revenue recycling, while observation does not
Carbon budget integration	2.1.1 2.1.2 2.2.1 2.2.2	Penalty under top-down budget greater than bottom-up budget [8]	Penalty under top-down budget greater than bottom-up budget (observed when comparing 2.1.1 with 2.1.2, and 2.2.1 with 2.2.2)	Y	N/A
		Penalty imposed by National Treasury greater than DFFE [8]	Penalty imposed by National Treasury greater than DFFE (observed when comparing 2.1.1 with 2.2.1, and 2.1.2 with 2.2.2)	Y	N/A
Carbon offsetting	3.1	Carbon offset allowance causes a negligible reduction in carbon tax exposure seeing that offsetting does not reduce emissions themselves [29]	No reduction in carbon tax exposure was observed due to the offsetting allowance in comparison to the baseline scenario	Y	N/A
	3.2	To achieve net-zero status, purchasing offsets would increase carbon tax exposure [29]	To offset all emissions, the purchase of offsets significantly increases carbon tax exposure	Y	N/A

Table 26: Comparative verification of the emissions mitigation scenarios

Emissions mitigation technology	Strategy	Scenario number	Expectations based on literature	Observation made in variance based- sensitivity analysis	Verified (Y/N)	Reason
Solar PV power	Implementation of power plant	PVB1 PV11	Negative deviation in carbon tax exposure from baseline by 2027 due to RE premium [7]	Respective negative deviations of 81.5% and 89.9% from baseline and Scenario 1 by 2027	Y	N/A
	Source power from RE sector	PVB2 PV12	Negative deviation in carbon tax exposure proportional to the reduction in coal-fired electricity usage [17]	Respective positive deviations of 86.3% and 38.5% from baseline and Scenario 1 by 2027, including the cost of implementation	N	Expectation does not consider the RE sector's adjustment of electricity prices to recover the capital costs to implement the plant
CSP	Implementation of power plant	CSPB1 CSP11	Negative deviation in carbon tax exposure from baseline by 2027 due to RE premium [7]	Respective negative deviations of 88.2% and 93.5% from baseline and Scenario 1 by 2028	Y	N/A
	Source power from RE sector	CSPB2 CSP12	Negative deviation in carbon tax exposure proportional to the reduction in coal-fired electricity usage [17]	Respective positive deviations of 120.9% and 57.6% from baseline and Scenario 1 by 2027, including the cost of implementation	N	Expectation does not consider the RE sector's adjustment of electricity prices to recover the capital costs to implement the plant

Emissions mitigation technology	Strategy	Scenario number	Expectations based on literature	Observation made in variance based- sensitivity analysis	Verified (Y/N)	Reason
HEP	Implementation of power plant	HEPB1 HEP11	Negative deviation in carbon tax exposure from baseline by 2027 due to RE premium [7]	Respective negative deviations of 76.1% and 86.9% from baseline and Scenario 1 by 2028	Y	N/A
	Source power from RE sector	HEPB2 HEP12	Negative deviation in carbon tax exposure proportional to the reduction in coal-fired electricity usage [17]	Respective positive deviations of 83.8% and 37.3% from baseline and Scenario 1 by 2027, including the cost of implementation	N	Expectation does not consider the RE sector's adjustment of electricity prices to recover the capital costs to implement the plant
WEP	Implementation of power plant	WEPB1 WEP11	Negative deviation in carbon tax exposure from baseline by 2027 due to RE premium [7]	Respective negative deviations of 78.2% and 88.1% from baseline and Scenario 1 by 2028	Y	N/A
	Source power from RE sector	WEPB2 WEP12	Negative deviation in carbon tax exposure proportional to the reduction in coal-fired electricity usage [17]	Respective positive deviations of 64.5% and 26.7% from baseline and Scenario 1 by 2027, including the cost of implementation	N	Expectation does not consider the RE sector's adjustment of electricity prices to recover the capital costs to implement the plant
Biogas power	Implementation of power plant	BGB BG1	Negative deviation in carbon tax exposure proportional to the substitution of coal-fired power with biogas-fired power [17]	Respective positive deviations of 53.5% and 31.2% from baseline and Scenario 1 by 2027, including the cost of implementation	N	Expectation does not consider the recovery of the capital costs to implement the plant

3.8 Scenario discussion

3.8.1 Background

This section summarises the key observations made in the variance-based sensitivity analyses. These observations were regarding the influence of the scenarios' carbon tax policy implications on cumulative carbon tax exposure. The observations made herein informed the conclusions in Chapter 4.

3.8.2 Carbon tax policy scenarios

The carbon tax policy scenarios were hypothesized to model the case study company's scenario-specific cumulative carbon tax exposure. Their deviations in cumulative carbon tax exposure from the baseline scenario are tabulated in Table 27.

Table 27: Carbon tax policy scenario percentage deviation from the baseline scenario

Carbon tax policy scenario	Scenario number	% deviation from the baseline scenario
Sector subsidisation	1	83
Carbon budget integration	2.1.1	380
	2.1.2	39
	2.2.1	37
	2.2.2	3.8
Carbon offsetting	3.1	-0.03
	3.2	355

The sector subsidisation scenario features annual reductions in the basic tax-free allowance for fossil fuel combustion emissions. Table 27 makes it apparent that this scenario deviates positively from the baseline scenario by 83%.

It is deduced that such a scenario would expose a gold mining company to more carbon tax if its emissions activities remain unchanged. This suggests that if Phase 2 carbon tax policy aligns with the sector subsidisation scenario hypothesis, gold mining companies can expect significant subsequent increases in future carbon tax exposure. However, the magnitude of such increases cannot be verified, as discussed in section 3.7.

The carbon budget integration scenarios hypothesis had four variations. First, they hypothesized both budgeting methodologies, namely top-down and bottom-up. Within these scenarios, both policy alignment options presented by the DFFE were hypothesized. From Table 27, the largest positive deviation from the baseline scenario of 380% was observed for Scenario 2.1.1, while the smallest positive deviation from the baseline scenario of 3.8% was observed for Scenario 2.2.2. Two key deductions are subsequently made.

First, a gold mining company can expect larger penalties when exceeding a top-down budget instead of a bottom-up budget. Secondly, the penalty, when imposed by the National Treasury, would be larger than that imposed by the DFFE. Second, it was observed that the greatest future carbon tax exposure that a gold mining company can expect would be associated with exceeding a top-down budget with penalties imposed by the National Treasury.

Unlike the policy surrounding carbon budgeting, the policy design surrounding carbon offsetting seemed unlikely to change, based on literature. Two variations of the carbon offsetting scenarios were investigated: the first hypothesized a 10% offset of the case study company's emissions per year, and the second hypothesized a 100% offset of emissions.

As tabulated in Table 27, Scenario 3.2, it is observed that offsetting 100% of emissions would expose a gold mining company to 355% more carbon tax per year, compared to offsetting no emissions whatsoever. Nevertheless, this could still be a means of achieving net-zero status.

Conversely, Table 27, Scenario 3.1 infers that offsetting emissions in alignment with the carbon tax policy constraint of a 10% offset allowance leads to a different observation, namely that an annual offsetting of only 10% of emissions would reduce the cumulative carbon tax exposure at the end of Phase 2. However, the magnitude of this reduction is estimated as 0.03% – an insignificant contribution.

3.8.3 Emissions mitigation scenarios

The emissions mitigation scenarios were hypothesized to model the case study company's scenario-specific cumulative carbon tax exposure. Their hypotheses involved the employment of emissions mitigation strategies in conjunction with said carbon tax policy scenarios, namely the baseline scenario and Scenario 1. These strategies involved either the implementation of a particular power plant, or the sourcing of electricity from a particular RE sector. The deviation of the cumulative carbon tax exposure of the emissions mitigation scenarios from their baselines is tabulated in Table 28.

Table 28: Percentage deviation of emissions mitigation scenarios from respective baselines

RE technology	Emissions mitigation strategy	% deviation from baseline scenario	% deviation from sector subsidisation scenario
Solar PV	Implementation of plant	-83%	-90%
	Sourcing from RE sector	86%	39%
CSP	Implementation of plant	-88%	-94%
	Sourcing from RE sector	121%	58%
HEP	Implementation of plant	-76%	-87%
	Sourcing from RE sector	84%	37%
WEP	Implementation of plant	-78%	-88%
	Sourcing from RE sector	65%	27%
BG	Implementation of plant	54%	31%

It is evident that the scenarios involving the implementation of power plants deviate negatively from their baselines – except for biogas power, which deviates positively by 54% and 31% from the baseline and sector subsidisation scenarios, respectively. The anomalous positive deviation realised in implementing a biogas power plant is due to the fact that there is no RE premium to subsidise carbon tax exposure.

As seen in Table 28, the most significant negative deviation – 88% and 94% from the baseline scenario and Scenario 1, respectively – was observed for CSP. The smallest, notably negative, deviations of 76% and 87% from the baseline scenario and Scenario 1, respectively, are observed for HEP.

From Table 28, it becomes apparent that the scenarios that involve electricity purchases from the RE sector realise positive deviations in carbon tax exposure from the respective baselines. This suggests that purchasing from the RE sector exposes the case study company to much more carbon tax than the alternative strategy.

It becomes apparent from Table 28 that the largest positive deviation – 121% and 58% from the baseline scenario and Scenario 1, respectively – is observed for CSP. The smallest, notably positive, deviations of 65% and 27% from the baseline scenario and Scenario 1, respectively, are observed for WEP.

The largest range between the per cent deviations of the respective strategies was observed for the CSP technology (Table 28). One could therefore assume that CSP will be the most cost-effective technology for the case study company to implement. In addition, this also implies that CSP may be the least cost-effective RE sector from which to purchase electricity.

Conversely, the smallest range between the per cent deviations of the respective strategies is observed for WEP technology, as seen in Table 28. One could therefore assume that the WEP sector will be the most cost-effective RE sector from which to purchase electricity. This assumption is confirmed, seeing that the smallest positive deviations from the respective baselines are associated with WEP.

Moreover, this infers that one can assume that WEP will be the least cost-effective technology for the case study company to implement. However, biogas power and HEP are observed to be less cost-effective for the case study company to implement compared to WEP.

For all RE technologies, it is observed that the implementation of the power plants leads to low cumulative carbon tax exposure by the end of Phase 2. This cumulative carbon tax exposure is significantly lower than that of the corresponding sourcing scenarios. It can thus be deduced that the strategy to source electricity from a particular RE sector will expose a gold mining company to more carbon tax during Phase 2, compared to implementing a power plant using that same RE technology.

In addition, the cost to implement an RE power plant is heavily contingent on the RE technology type. It is observed that CSP will be the least expensive investment, followed by solar PV, WEP, HEP and biogas power, in ascending order. Similarly, the type of RE sector from which a company chooses to purchase electricity influences said company’s carbon tax exposure. The analyses made in this investigation suggests that CSP will expose the case study company to the most carbon tax, followed by solar PV, HEP and WEP, in descending order.

3.8.4 Overview of results and discussion

At the beginning of this chapter, an appropriate case study for this investigation was selected. After that, the data required to model the scenarios for this investigation was collected, consolidated, and converted into emissions data.

Following the hypotheses of the baseline scenario, alternative carbon tax policy scenarios, emissions mitigations scenarios, and their respective implications for carbon tax policy, were identified. These implications, along with the emissions data, were used to model the scenario-specific carbon tax exposure of the selected case study. These models were of the case study company's cumulative carbon tax by the end of Phase 2, namely 31 December 2027. After that, they were graphically presented and validated.

A sensitivity analysis of the case study company's cumulative carbon tax exposure was performed for the alternative carbon tax policy scenarios, with reference to the baseline scenario. Similarly, a sensitivity analysis of the case study company's cumulative carbon tax exposure was performed for emissions mitigation scenarios, with reference to one another.

The observations therein made inferences about the influence of these hypothetical scenarios on the case study company's carbon tax exposure. These observations informed the upcoming conclusions regarding the cost risk associated with these scenarios.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Phase 2 of South Africa's carbon tax regime will begin on 1 January 2023. A review of the carbon tax policy in the Carbon Tax Act is anticipated to occur before the second phase starts. Thus far, the South African government has not commented on the changes that are to be expected in preparation for Phase 2. The only certainty is that the electricity generation levy will no longer reduce a company's indirect carbon tax exposure as it did in Phase 1. Subsequently, South African gold mining companies expect considerable increases in carbon tax exposure associated with electricity usage.

South African gold mining companies are under pressure to reduce their GHG emissions, primarily because gold mining, as an industry, is known to be energy intensive. Strategies toward energy efficiency and emissions reductions in the gold mining industry have been made. However, the relationship between these strategies, and reductions in energy use in mining operations, is unclear.

These uncertainties make it difficult for South African gold mining companies to ascertain the future cost impact associated with carbon tax exposure and emissions mitigation. The hypotheses of future carbon tax scenarios for said companies assisted in reducing this difficulty by reducing the number of uncertainties, as seen in this dissertation.

Based on the objectives of this investigation, it was necessitated that carbon tax policy scenarios and emissions mitigation scenarios be hypothesized and modelled for a gold mining company case study. This was done using a methodological approach adapted from those seen in literature. The adaptations ensured that the methodology used in this investigation was applicable to the South African mining sector rather than the country itself. Moreover, it was adapted to be relevant in a modern context.

Regarding carbon tax policy scenarios, the hypotheses were focused on sector subsidisation, carbon budget integration, and carbon offsetting. Emissions mitigation scenario hypotheses focused on emissions mitigation strategies and technologies.

The results of modelling these scenarios could be validated, and may have useful applications for the mining industry. However, not all the scenarios could be verified, which presented a constraint to this study.

With regards to sector subsidisation, it was observed that a gradual decrease in the basic tax-free allowance for fossil fuel combustion emissions would expose a gold mining company to more carbon tax annually if its emissions activities remain unchanged. Therefore, such a scenario would pose increased exposure to carbon taxes for gold mining companies. However, the magnitude of this increase could not be verified since revenue recycling mechanisms were not considered in this investigation.

From the carbon budget integration scenarios, it could be concluded that there would be more exposure to carbon taxes for gold mining companies when exceeding a top-down budget instead of a bottom-up budget. Moreover, increases in carbon tax exposure, which would essentially be a penalty, would be larger if imposed by the National Treasury rather than the DFFE.

The carbon offsetting scenarios precipitated the following conclusions. First, offsetting 100% of emissions would expose a gold mining company to significant carbon taxes compared to offsetting no emissions. However, net-zero status could be achieved simultaneously. Secondly, offsetting only 10% of emissions would reduce annual carbon tax exposure by an insignificant amount.

The emissions mitigation scenarios involved employing emissions mitigation strategies and technologies in conjunction with said carbon tax policy designs. These strategies involved either the implementation of a particular power plant, or the sourcing of electricity from the relevant RE sector. Note that the results of the scenarios involving the latter strategy could not be verified because the RE sector's adjustment of electricity prices was not considered in this investigation to recover the capital costs to implement the plant.

For all RE technologies, first, it was concluded that the strategy to source electricity from a particular RE sector would expose a gold mining company to more cost risk than implementing a power plant using that same RE technology. Secondly, the increase in carbon tax exposure associated with the technology type is relevant in a power plant implementation scenario and a scenario involving electricity purchases from the RE sector.

4.2 Recommendations

Participation in carbon budgeting will inevitably become mandatory for all companies that are liable for carbon tax, including gold mining companies. It will become necessary for such companies to devise methods to avoid exceeding their budgets, and understand the ramifications of exceeding said budgets.

Therefore, it is recommended that a study be performed on the climate governance alignment policy scenarios in conjunction with emissions mitigation strategies. The scenarios hypothesized in this recommended study should consider alternative budget methodologies, namely top-down and bottom-up. Moreover, they ought to consider alignment options, and which government department imposes penalties.

Unlike the investigation conducted in this dissertation, this study should feature feasible emissions mitigation strategies instead of hypothetical strategies. Such a study would therefore involve the analysis of the capacity of these strategies to meet the different budgets.

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