PRESIDENTIAL CLIMATE COMMISSION
TOWARDS A JUST TRANSITION

Executive Summary Report

February 2024

ENERGY SECTOR DECARBONISATION PATHWAYS TO MEET A NATIONAL NET ZERO EMISSIONS TARGET BY 2050

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Acknowledgements

This project has been undertaken by the Council for Scientific and Industrial Research (CSIR) and the University of Cape Town's Energy Systems Research Group (ESRG) to provide research analysis and an evidence base to the Presidential Climate Commission (PCC) of South Africa, to support its objectives of facilitating conversations and building understanding of South Africa's just energy transition.

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1. Introduction

This report provides a summary of analysis undertaken by the Energy Systems Research Group (ESRG) and the Council for Scientific and Industrial Research (CSIR) that explores potential energy and sectoral mitigation pathways through which South Africa could reach net zero CO_2 emissions by mid-century[1]. The project has been undertaken to provide research analysis and an evidence base for the Presidential Climate Commission (PCC), to support its objectives of facilitating conversations and building understanding of South Africa's just energy transition.

The study has developed and characterised 40 long-term greenhouse gas (GHG) emissions pathways for South Africa to characterise those pathways which reach net zero CO_2 emissions by 2050 or 2055. The study examines the socio-economic effects of such net zero pathways and considers the additional effects of key associated measures such as the carbon tax, localisation of parts of the energy infrastructure supply chain, and energy efficiency measures. Energy supply systems, the transportation sector and industrial processes are known to have wide ranging environmental impacts for air pollution, water quality and water use. Measures that are thus taken to decarbonise these sectors have the potential to reduce these environmental impacts. Three of these decarbonisation scenarios were also to analysed in detail to determine the of potential for reduced water consumption and impacts for air quality impacts.

2. National GHG emission pathways to net zero CO2 for South Africa

Net zero CO_2 pathways form part of an integrated package of international policy measures decided by Parties to the Paris Agreement (including South Africa) in response to the IPCC's assessments highlighting the features of 1.5 degree GHG emissions pathways. The other parts of the package include a limited global CO_2 budget to 2050 and deep reductions in non-CO_2 gases to 2050, and the scaled-up provision of support to developing countries. Analysis of a net zero CO_2 target should consider both the net zero goal, and a pathway to achieve the goal which is consistent with South Africa's obligations under the UNFCCC and its Paris Agreement and subsequent decisions.

The study has been undertaken using SATIMGE, a linked energy/economics/emissions model developed and maintained by the ESRG. Figure 1 presents a set of GHG emissions pathways for South Africa, some reaching net zero CO_2 emissions in 2050, others in 2055, and in the panels on the left, without a net zero CO_2 or GHG emissions constraint. Pathways are characterised by their cumulative GHG emissions from 2021 to 2050 and have been modelled with and without a range of key long-term measures, and in two "worlds" – one with a strong multilateral regime, and one with a weak regime. Pathways were explored in detail at a sectoral level and evaluated economically.

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[1] The full report is available under the Presidential Climate Commission's technical reports publications

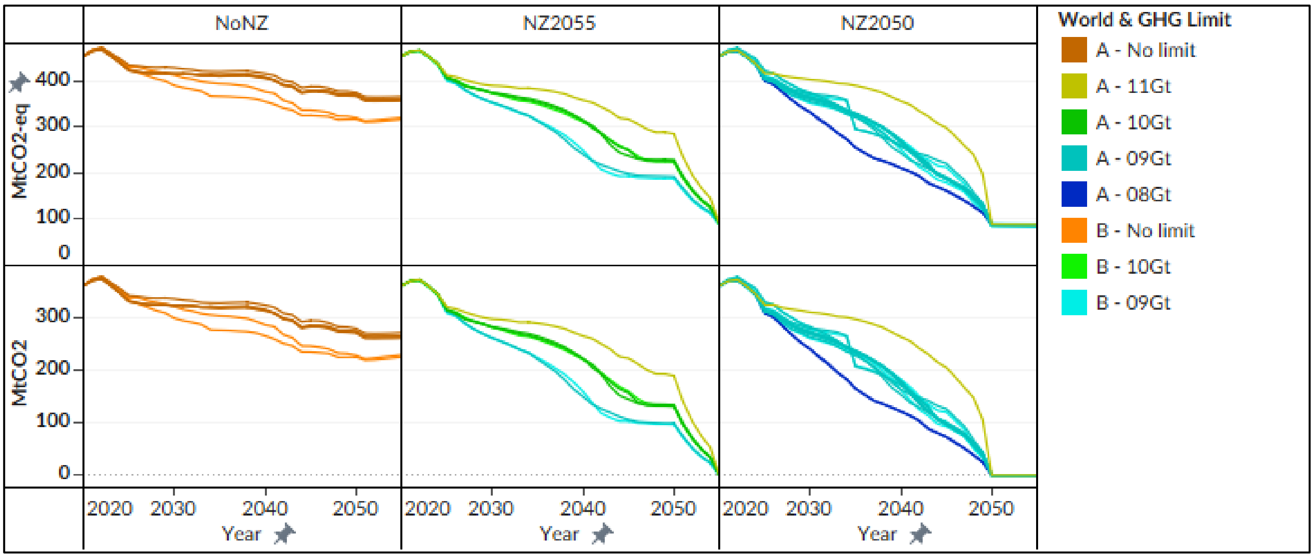

Figure 1: Net GHG (top) and CO2 (bottom) emission pathways by World, GHG limit and net zero year.

The GHG emissions pathways of three scenarios are presented in greater detail in Figure 2 to 2055, as well as the share of cumulative emissions for each sector in the same timeframe.

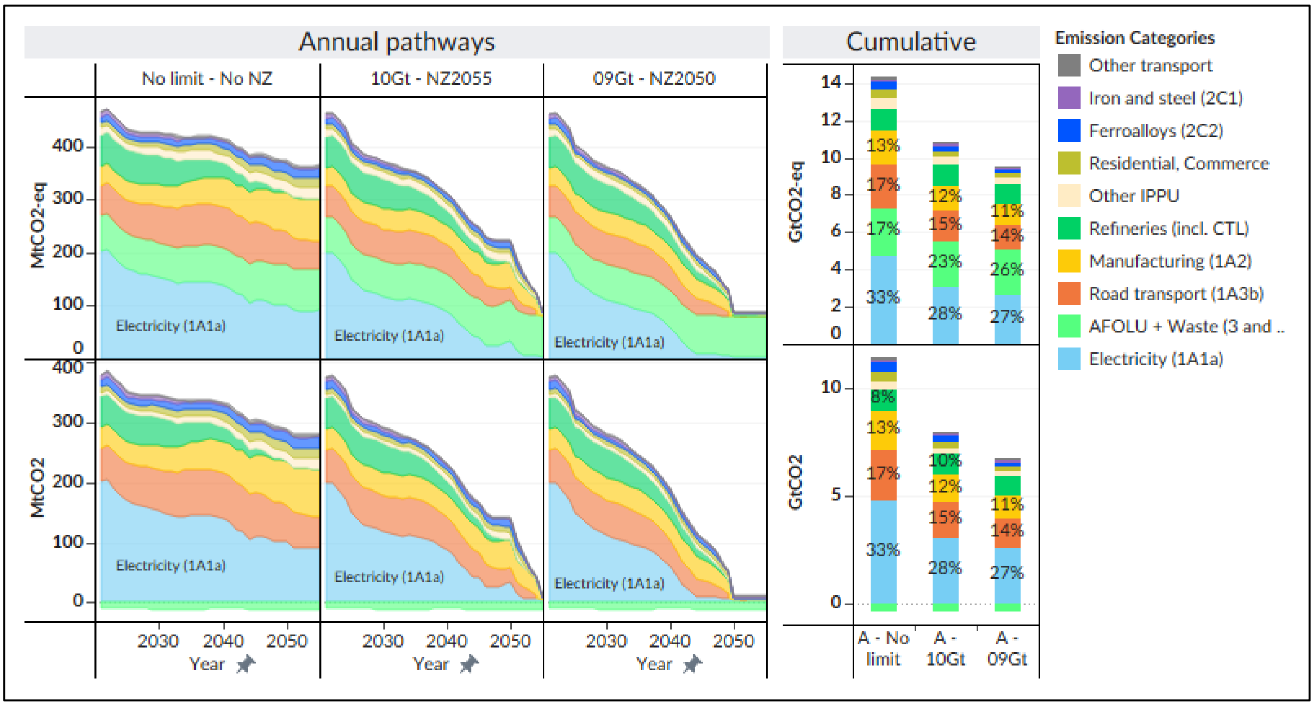

Figure 2: Annual and cumulative GHGs and CO2 by sector for an unconstrained, 10Gt (NZ2055) and 9Gt (NZ2050) scenario.

While a long-term net-zero pathway will require challenging shifts away from GHG-intensive activities in all sectors, the analysis confirms the critical importance of the electricity sector in each decade in shifting away from a CO_2-intensive economy, and ultimately reaching net zero CO_2 emissions, on account of its overall contribution to CO_2 emissions, the availability of mature low- and zero-CO_2 generation technologies, and the dependence of other sectors on zero-CO_2 electricity for their decarbonization. The energy transition away from coal is thus at the heart of all GHG emissions pathways for South Africa; at the same time, a just transition is critical, and as presented in Figure 2, coal still has a vital role to play in the transition, including in the more ambitious 9 Gt scenarios.

The effort required in the “last mile” to net zero CO_2 is immense, and rests in all scenarios on both a massive increase in investment in the electricity sector, and the extensive use of Carbon Capture and Storage technology. If CCS is not available at the required scale (30-40 Mt per annum), mitigating the remaining CO_2 emissions (primarily in the cement and ferroalloys sectors) will require the development of new technology, or finding substitutes for products from these sectors, or importing cement and exporting unprocessed ore. The massive investments required in the electricity sector and elsewhere result in a lower GDP/capita in pathways which a) reach net zero, and b) have a GHG emissions constraint of less than 10 Gt. South Africa will require support to achieve a net zero CO_2 target, both for the required level of investment in infrastructure, and in pursuing technological solutions to mitigate CO_2 in ‘hard to abate’ sectors.

Socioeconomic analysis indicates that, with the right combination of measures, a 10 Gt pathway which does not reach net zero results in the same level of GDP/capita by 2055 as a pathway without any further climate policy. Implementing measures to achieve this pathway is a no-regrets option, and higher GHG emissions have no further economic benefit.

Further analysis reveals that with the right combination of accompanying measures, it is possible to increase the GDP/capita by 120% from 2021 to 2055, reach net zero in 2050 and impose a long-term GHG budget of 8 Gt on the economy. Pathways which reach net zero in 2050 or 2055 with a 9 Gt constraint have similar outcomes. The analysis does reveal that pathways with cumulative GHG emissions below 10 Gt, and particularly for those which reach net zero in 2050 or 2055, the massive investment requirements result in a crowding-out effect which results in some GDP loss. A combination of long-term measures, especially energy efficiency measures, can offset some or most of this loss, as can concessional finance.

This analysis has been undertaken with the assumption that concessional climate finance at the required scale is NOT available. The availability of climate finance at the required scale from the international community will most likely offset GDP loss and lead to higher economic growth for ambitious mitigation pathways which reach net zero, but this possibility requires further analysis.

There are two very significant caveats to these findings. First, there is considerable risk in high-GHG emissions pathways (>10Gt) for South Africa that requires further analysis. The first risk is that of having to meet a more stringent target later, as a result of increasing international pressure in a rapidly warming world, which would require a far more rapid and costly transition. The second risk is the imposition of unilateral trade measures (border tax adjustments) on key exports.

3. Co-benefits of national GHG emission pathways to net zero CO_2 for South Africa

The projected SATIMGE reductions in GHG emissions towards a net zero also result in reductions to air pollutant emissions. The sources of air pollutants and GHG emissions are often the same.

As such decarbonisation is often associated with improvements in ambient air quality, but this is not always a given. Therefore, an analysis using an air quality modelling platform developed at CSIR (through funding from World Bank) was done in order to investigate and quantify the air quality co-benefits in taking the GHG emissions pathways into air quality emissions reductions and finally to improvements in ambient air pollutant concentrations. The model was run at a spatial resolution of 0.06° x 0.06° (~6km x 6km) for three selected years and two scenarios and a reference case. An example of analysed output for SO_2 in 2050 for the 8Gt scenario is shown in Figure 3; shown as a percentage for illustration (difference in concentrations are used in the actual analysis). This represents the reduction in risk of exposure to SO_2, however further processing is done to the spatial output to express these changes according to where people are living. This, termed Population Weighted Exposure, is then used in health impact calculations to determine a reduction in premature all-cause mortality (across all ages).

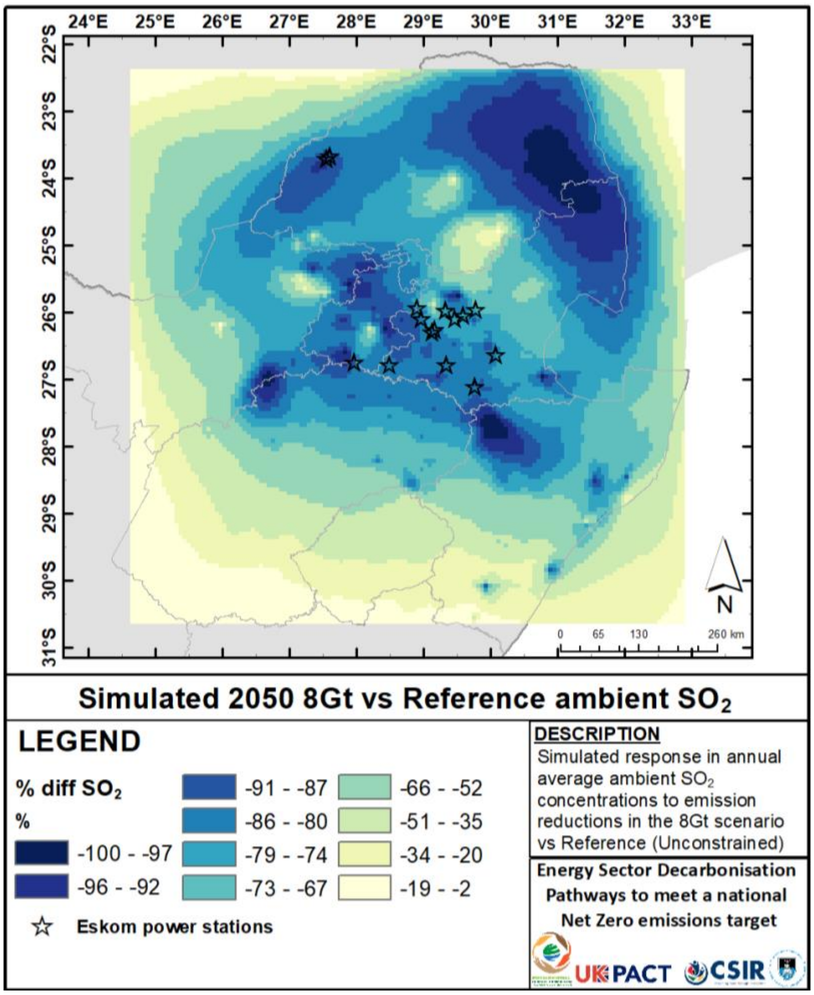

Figure 3: Percentage difference in annual average ambient SO2 concentrations for 2050 derived from comparing output from 8Gt (High reduction) scenario vs Reference (Unconstrained).

Overall, through the application of this approach, results indicate significant reductions in ambient pollutant concentrations from both a 9Gt and 8Gt pathway (up to 2050). There are however some localized increases seen due to specific industrial sub-sectors. There are large differences between the reference (unconstrained) case and the two scenarios investigated for year 2033, but less for 2023 and 2050.

Health benefits were estimated and include the reductions in premature mortality (Table 1) due to reductions in concentrations of SO_2, $PM_{2.5}$ and NO_2 over the selected three years simulated (2023, 2033 and 2050).

Table 1: Estimated reduction in premature mortality (all ages) for the three years simulated.

	Reduction (number of persons)		
Scenario	**NO_2**	**$PM_{2.5}$**	**SO_2**
High reduction (8Gt)	5821	6031	12987
Low reduction (9Gt)	5521	5500	11162

The reductions were translated into monetary terms via Value of Statistical Life metrics. Results show that in monetary terms there is only a ~11% difference between scenarios; however, the total amount includes only the three years simulated. The total monetary savings due to reduction in all-cause premature mortality across all ages brought about by the emission reductions is $30bn for the Low scenario (9Gt) and $33bn (8Gt) for the High scenario. In order to understand the potential cumulative impacts throughout the SATIMGE projection (i.e., 2023-2050), the health costing was also projected across this period. Results show a larger difference between the High ($111bn) and Low scenarios ($73bn). It was noted however that these estimates are conservative, and there is a high likelihood that monetary savings due to reduction in premature all-cause mortality from the pathways would be more in reality.

The immense cost of worsening air pollution associated with the continued use of fossil fuels is NOT fully integrated with the SATIMGE economic analysis in this study, but would possibly result in a worse GDP/capita outcome for scenarios with cumulative GHG emissions above 10 Gt. The high costs of continued air pollution are both a risk to high-carbon scenarios, and an opportunity for low-GHG emissions pathways since the co-benefits would be considerable.

In addition to air quality, there are water-related co-benefits of decarbonization of the electricity sector with the analysis in this study indicating substantial reductions in water use across all decarbonization scenarios assessed. The projected savings in water derived from transitioning away from coal imply that additional water will become available for other uses e.g., agriculture, urban, industry and meeting environmental flow requirements (especially in over-allocated water catchments).

4. Conclusion

In a context in which South Africa is required to develop a long-term mitigation response consistent with the Paris Agreement and its subsequent decisions, and with the complex and urgent development challenges that the country faces, the findings from this study comprise an essential initial evidence base and provide some key assessments of the socioeconomic implications of different pathways and the key technology shifts which this will require on a sectoral level. This study further provides quantitative evidence of the potential of different GHG pathways to reduce air pollution and its impacts on human health. Further work will be needed on a range of key issues, including incorporating the costs of air pollution and water into national economic models, the role of international climate finance in financing long-term mitigation pathways, improved spatial disaggregation, key technology choices and challenges for ‘last mile’ decarbonization, and the role of the land sector in achieving net zero targets.