ESRG

ENERGY SYSTEMS RESEARCH GROUP
University of Cape Town

South Africa's "fair share": mitigation targets in the updated first NDC in an international context.

Harald Winkler, Andrew Marquard, Guy Cunliffe, Anthony Dane

November 2020, updated May 2021

Acknowledgements

Support for this technical analysis was provided to South Africa by the NDC Partnership, through the Climate Action Enhancement Package.

Citation

Cite as: UCT 2021. South Africa's "fair share": mitigation targets in the updated first NDC in an international context. Energy Systems Research Group, University of Cape Town 2021, Cape Town.

Executive Summary

This report considers the 2020/21 update of South Africa's mitigation NDC from the point of view of South Africa's obligations under the Paris Agreement and associated decisions, to develop a framework for determining what constitutes a "fair contribution" to the global mitigation effort.

Parties to the Paris Agreement are to communicate "nationally determined contributions" (NDCs) towards the achievement of the goals of the Paris Agreement, to keep temperature well below 2 °C and pursue efforts to 1.5 °C, a long-term goal on mitigation, a global goal for adaptation and long-term goal on finance. Equity is enshrined in Article 2.2 and is thus fundamental to the effective achievement of the Paris goals. In communicating their NDCs, Parties are expected to provide information on how they consider their contributions are "fair and ambitious" (UNFCCC 2014) (UNFCCC 2015) (UNFCCC 2018a) and how these contribute to the global goals of the Paris Agreement.

The concept of "fairness", in the context of common but differentiated responsibilities and respective capabilities in the light of different national circumstances, is an important link between individual countries' contributions and the overall temperature goal of the Paris Agreement, and to its other goals. In other words, within the framework of the UNFCCC and Paris Agreement, the magnitude of each individual country's contribution must be "fair and ambitious" in the light of these principles. Fairness in this context is thus a key consideration in determining what each country's contribution should be, including in the setting of NDC targets. Understanding the context for "fairness and ambition" also rests on an understanding of technical analyses of required global pathways for achieving these long-term goals, as well as technical analyses of the costs and benefits of national GHG emissions pathways (UCT 2021)

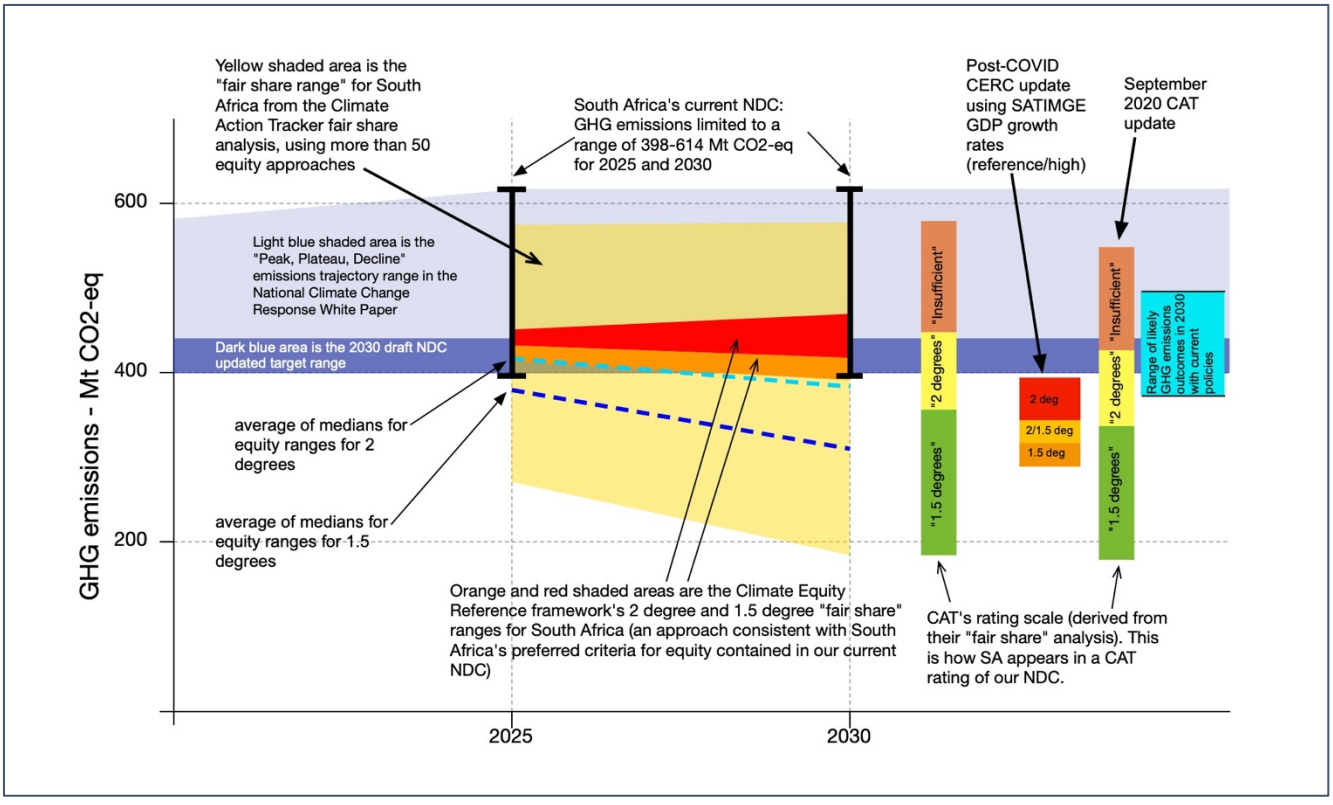

Figure 1 - South Africa's "fair share" equity lens for South Africa's NDC update, 2025 and 2030, with added updated "fair share" ranges for CAT (post September 2020) and CERC (May 2021). The May 2021 CERC range here is derived from a sensitivity analysis using SATIMGE growth rates as described above. The single bar (with 2, 2/1.5 and 1.5 divisions) combines the reference and high growth rate sensitivity analyses presented in Figure 14 and described above. The 2/1.5 block is where the two ranges overlap. The bar on the right indicates a range of likely GHG outcomes in 2030 with different growth rates and degrees of policy implementation, of the implementation of currently planned policies as modelled with SATIMGE.

The fair share framework we present here includes all these aspects of nationally determined contributions. The framework proposes a fair share "lens" through which South Africa's mitigation targets for 2025 and 2030 can be considered and whether these can credibly be presented as a fair contribution to the global mitigation effort. The "lens" set out in this section operationalises equity through quantification of key equity parameters. The independent *Climate Equity Reference Calculator* (CERC) is chosen as the primary tool to perform analysis of South Africa's fair share emissions level in 2025 and 2030, taking into account responsibility and capability, as well as the right to promote sustainable development and the need to prioritise development for those living in poverty. CERC is the preferred tool for this analysis owing to its transparency and ease of access and usability, as well as its good alignment with the equity principles South Africa values and prioritises.

We augment the CERC analysis with reference to the fair share 'ranges' determined from the aggregation of multiple current and historic effort-sharing studies that have been compiled by, and directly inform, the Climate Action Tracker (CAT). Whilst we identified certain *caveats* with CAT's methodology, such that we would not base our fair share framework solely on their analysis, their comprehensive coverage of the effort-sharing literature provides a robust and credible range of equity 'perspectives' – which translate into a wide range of emissions levels in NDC target years – that provide an extra dimension to the fair share 'lens' we are proposing here, illustrates how South Africa's NDC will be seen by other countries, and takes into account the many other possible approaches to burden-sharing, which may have different outcomes for South Africa.

The results of this analysis are shown in Figure 1. The analysis was initially undertaken in 2020, before both CERC and CAT updated their assessments (in September 2020 and May 2021 respectively). Figure 1 shows both the initial assessment, which was used to consider an appropriate target range for the NDC update, and the updated assessment[1]. The proposed target range for 2030, as well as the likely outcome of planned mitigation policies, have been included in the figure. The following observations can be made on the fairness of South Africa's contribution:

- South Africa's draft updated NDC mitigation target range is well within the overall CAT "fair share" range.
- The upper end of the proposed target range is within the CAT and CERC "2 degree" ranges (pre-update)
- The upper end of the proposed target range is not within either "2 degree" range as updated by CERC and CAT.
- While the lower end of the range remains within CAT's "2 degree" range, it would need to be lowered considerably to meet this criterion for the updated CERC range.
- Consideration of a GHG emissions outcome below the proposed ranges, would probably require more ambitious mitigation policies for South Africa than those currently planned.

We conclude in section 4 with recommendations of how the lens could be applied in technical analysis for South Africa's updated mitigation NDC, and provide insight into how this analysis links with the support component of the NDC.

[1] Another assessment was undertaken using CERC by the Climate Equity Reference Project in May 2021, which was submitted as an attachment to the Centre For Environmental Rights' submission on the draft updated NDC. This assessment is discussed below in section 5.4 and a detailed comparison is presented in Figure 15.

List of Acronyms

AR5 – IPCC Fifth Assessment Report

BAU – Business-as-usual

CAT – Climate Action Tracker

CERC – Climate Equity Reference Calculator

CMA – Conference of the Parties Serving as the Meeting of the Parties to the Paris Agreement

COP – Conference of the Parties to the UNFCCC

CSO – Civil Society Organisations

DEA – (former) Department of Environmental Affairs

DEFF – Department of Environment, Forestry and Fisheries

DoE – (former) Department of Energy

GCB – Global carbon budget

GST – Global stocktake

GW – GigaWatt (unit of power)

ICTU – Information for clarity, transparency and understanding

INDC – Intended nationally determined contribution

IPCC – Intergovernmental Panel on Climate Change

IRP – Integrated Resource Plan

LED – Low Energy Demand

LULUCF – Land use, land-use change, and forestry

NDC – Nationally determined contribution

NPC – National Planning Commission

RCI – CERC Responsibility-Capability Index

SR 1.5 – IPCC Special Report on Global Warming of 1.5 °C

UNEP – United Nations Environment Programme

UNFCCC – United Nations Framework Convention on Climate Change

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Background

This report forms part of a larger body of technical work to support the update of South Africa's mitigation NDC in 2020, and is aimed at providing guidance on a) what the legal requirements are for South Africa's NDC update in terms of the Paris Agreement and its associated decisions, and b) guidance on South Africa's fair contribution to the global effort to mitigate climate change, in terms of the Paris Agreement and its associated decisions, and the South African National Climate Change Response White Paper.

In the lead-up to the 2015 United Nations Climate Change Conference in Paris (COP21), the Lima Call for Climate Action (UNFCCC 2014) invited all Parties to the UNFCCC to communicate their intended nationally determined contributions (INDCs), which could include information on how the Party considers its INDC is fair and ambitious (para 14). The same information to accompany nationally determined contributions (NDCs) was included in the Paris decision adopted at COP21 in 2015 (1/CP.21, para 27) (UNFCCC 2015) , and was also further elaborated in decision 4/CMA.1 in Katowice in 2018.

Equity is a foundational principle of the UNFCCC and is enshrined in Article 2 of the Paris Agreement as fundamental to its implementation. Climate change is considered a "global commons problem" (IPCC 2014) that "will not be solved without a robust systems of coordination and solidarity" (CSO Equity Review 2016). Experience shows that parties will work together cooperatively and symbiotically towards a common goal if they perceive the costs and benefits are distributed fairly among them (Klinsky et al. 2017); put more directly in the context of a global response to climate change, "..countries will only join agreements, remain party to them, and increase their own ambition, if they consider the contributions of their peers to be fair.." (Winkler et al. 2018). In turn, high degrees of international cooperation were found to be a precondition to resolving the global climate crisis by the IPCC's Special Report on 1.5^{o}C:

> "The large majority of modelling studies could not construct pathways characterized by lack of international cooperation, inequality and poverty that were able to limit global warming to 1.5°C" (IPCC 2018a)

In addition, the architecture of the Paris Agreement, which is dependent on "nationally determined contributions", leaves it up to individual countries to identify the appropriate size of their contributions to all the goals of the Paris Agreement, and Parties to the Agreement are expected to take fairness considerations in terms of the principles of the Agreement and the UNFCC into account when determining the size of their contributions.

South Africa has always recognised its role in responding to the threat of climate change, which is "global in scope" and to which "global solutions must be found" (NPC 2011), both as a contributor and as a country that is particularly and acutely vulnerable to its effects. Since the dawn of democracy South Africa has grappled, and continues to grapple, with fundamental and persistent challenges of inequality, poverty and high unemployment (challenges which have been greatly exacerbated even further by COVID-19). South Africa is committed to multilateralism as a matter of foreign policy and acts as a responsible global citizen on climate change. South Africa's action or inaction on climate change thus has a global impact, not only directly in terms of GHG emissions, but also in terms of strengthening or weakening global cooperation on climate change, and it is strongly in the interests of South Africa to contribute to a strong international response to climate change. We have thus always balanced our solidarity to a collective response to climate change with our national development priorities, and have sought a transition to a society that is "environmentally sustainable, climate-change resilient, low-carbon economy and just" (NPC 2011). Furthermore, as a prominent member of important negotiating blocs in UN climate negotiations (notably the African Group of Negotiators, G77&China and the BASIC group of countries), it is assumed that South Africa will continue its principled and committed approach to finding an equitable solution to the global challenge, as in the past, as stated clearly in the National Climate Change Response White Paper, which lists a "fair contribution" as one of the two key objectives:

> "Make a fair contribution to the global effort to stabilise greenhouse gas (GHG) concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner." (South Africa 2011)

South Africa submitted its "intended nationally determined contribution" (INDC) prior to Paris in 2015, which became its first NDC following the entry into force of the Paris Agreement and its ratification by South Africa in late 2016. Analysis performed at the time demonstrated that, applying Convention principles of responsibility, capability and access to equitable sustainable development, the cumulative carbon budget implied by South Africa's NDC, relative to what might be considered an 'equitable' carbon budget in light of national circumstances, represented a fair and ambitious contribution . The assessment of the South African NDC target range is complicated by the fact that it is a range, which leads to uncertainty about the actual emissions outcome envisaged by the NDC, and thus to a certain extent separates the NDC target from a corresponding series of national mitigation policies and measures. This has been interpreted by others in various ways. CAT and others, including many South African stakeholders, have disregarded the range and assessed the NDC to imply only the upper end of the range, or regard the lower end of the NDC target range as an additional target which is conditional on support. The 2015/16 NDC does not provide any further elaboration on the meaning of the range, and under what conditions South Africa may consider achieving a specific point within it.

Much has changed since 2015. The Paris Agreement formalised a new global temperature goal in 2015, aimed at:

> "Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change" (UNFCCC 2015)(Paris Agreement, Article 2.1 a)

South Africa's INDC was communicated on the basis of a 2 °C global goal. Globally, science has articulated the potential difference in scale of impacts between a global temperature increase of 1.5 °C and 2 °C, through the 2018 IPCC Special Report on 1.5 degrees (IPCC 2018b). Further studies have pointed to the increasing urgency of action to limit warming to well below 2 °C (more so 1.5 °C) and the significant gap that remains between mitigation contributions required to meet these contributions and what countries have collectively pledged across NDCs so far (UNEP 2019, 2017). Meanwhile, renewable energy prices have fallen dramatically, and other zero-carbon technologies have become significantly cheaper; an increasing number of countries set goals for emissions to reach zero CO_2 or GHG emissions around 2050, some earlier, some in legislation and others as policy statements. An increasing number of financial institutions have indicated that they will no longer invest in coal, or align their lending policies with long-term net zero targets[2]. Internationally, the global momentum towards more ambitious climate action (on mitigation) has been considerably strengthened by the newly-elected Biden Administration's rejoining of the Paris Agreement, and submission of a significantly more ambitious USA NDC (United States of America 2021). The impact of the IPCC's Special Report on 1.5°C on the debate on mitigation ambition internationally cannot be overstressed. Not only has it strengthened the importance of the 1.5°C limit in the long-term Paris Agreement temperature goal, but also delineated a clear quantitative pathway to this goal, and stressed the urgency of the next decade for decisive climate action, and the importance of reducing global CO_2 emissions to zero by 2050.

South Africa's national circumstances have also changed considerably since 2015. Our emissions trajectory over the last decade has been far lower than was anticipated, and recent studies show emissions will continue to be lower into the future than was expected back in 2015. Factors attributed to this are persistent low economic growth, structural shifts in the economy reducing net emissions intensity, and the policy direction implied in the Integrated Resource Plan (IRP) for South Africa's electricity supply published in 2019. Perhaps most notably, the cost of procuring renewable energy technologies, such as solar PV and wind, have fallen

[2] The latest is the Glasgow Financial Alliance for Net Zero (GFANZ), chaired by Mark Carney, UN Special Envoy on Climate Action and Finance, consisting of 16 finance actors with assets of over US70 trillion – see https://www.un.org/en/climatechange/biggest-financial-players-back-net-zero#:~:text=The%20new%20Glasgow%20Financial%20Alliance,by%202050%20at%20the%20latest.

dramatically relative to coal and other thermal generation. The IRP 2019 envisages the installation of 15.7 GW of wind power and 7.1 GW of solar PV, and also envisages the retirement of 11 GW of coal plant capacity.

Recent modelling analysis reflects these changes (see Figure 3), showing that South Africa's "Business as Usual"[3] emissions trajectory to 2050 is likely to be an order of magnitude lower than what was originally modelled in the foundational *Long-Term Mitigation Scenario* analysis (Scenario Building Team 2007), which informed the official 'peak, plateau and decline' national target trajectory codified in the National Climate Change Response Policy of 2011 (South Africa 2011) and central to the mitigation component of the first NDC (RSA 2015).

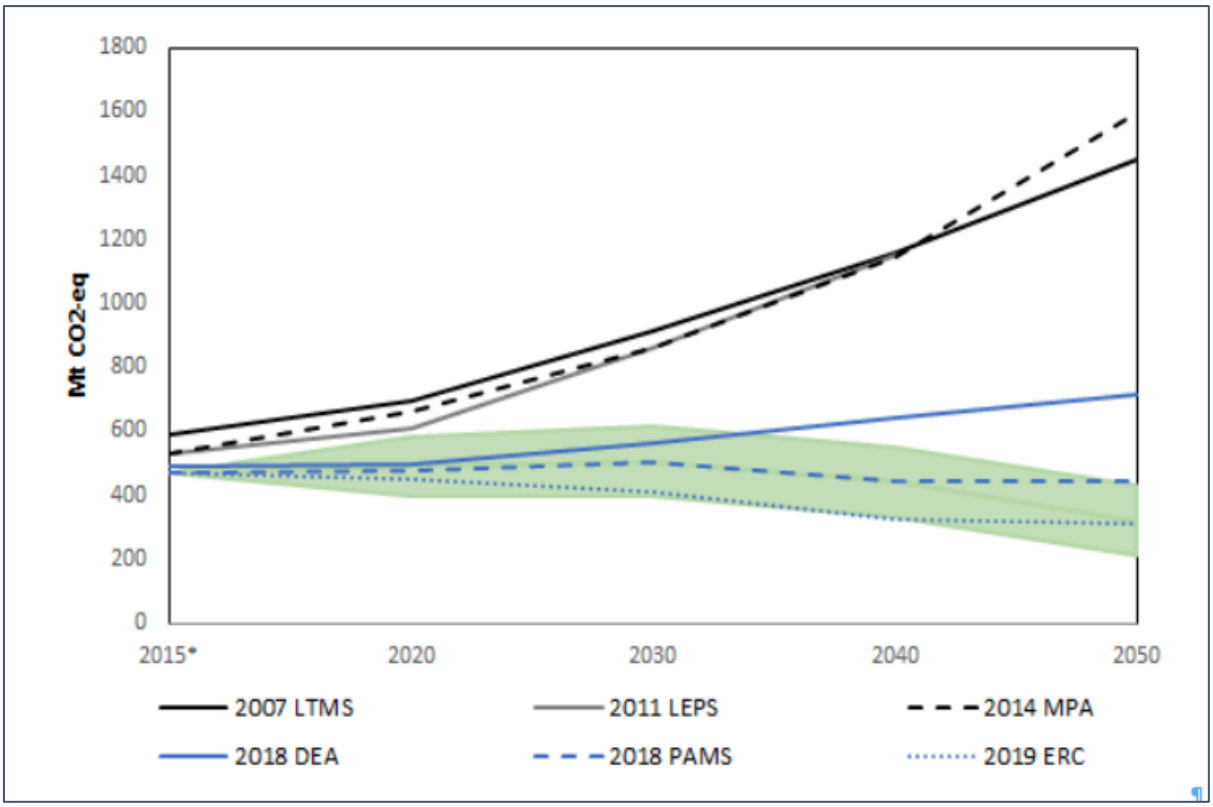

Figure 2 – Comparison of GHG emissions baselines for South Africa, various years and sources (analysis by Faaiqa Hartley)

The very dramatic change in BAU trajectories for South Africa indicated in Figure 3 does not only have significance for future South African mitigation policy and its likely outcomes, but also for equity – many of the approaches to allocating the global mitigation burden (each country's "fair share") use BAU trajectories as their starting point, since shifts in BAU have an impact on the relative mitigation efforts different countries face. As a result of all these changes, in international expectations, and the underlying economics of mitigation, South Africa's "fair share" is also likely to have changed significantly since 2015.

1.2 What are "fair shares"?

The science of climate change is very clear on the cause of anthropogenic climate change – a rise in the concentration of GHGs in the atmosphere, leading to a rise in average global temperature. Rising concentrations of GHGs in the atmosphere, particularly of carbon dioxide, are caused by anthropogenic emissions of GHGs. The basis for climate change mitigation is therefore to limit, reduce and ultimately

[3] "Business as Usual" GHG emissions trajectories are variously defined, but in general and here equated with "With Existing Measures" emissions trajectories (in other words, future emissions without the implementation of any further climate mitigation policies other than those currently being implemented).

eliminate global anthropogenic emissions of GHGs to the extent possible, globally, which requires global co-operation. This is the subject of the UNFCCC and its Paris Agreement.

Globally, climate change science can tell us how what quantity of GHGs can be emitted in the long term, to prevent dangerous anthropogenic climate change. This is illustrated in Figure 2 below (from the IPCC's Special Report on 1.5 Degrees). This is the *global* GHG emissions space which is available to all countries if we are to remain below a specific temperature threshold. Dividing this global GHG emissions space fairly amongst countries has however been one of the most difficult issues to resolve in the international climate change negotiations. Limiting and/or reducing GHG emissions is potentially very costly for individual countries, depending on the available technology, the timeframe, how much high-emitting infrastructure each country has, and other national circumstances, including the availability of natural resources such as wind and sunshine, and particularly other competing priorities such as national development needs, including poverty alleviation. In addition there are other fairness considerations in addition to these, such as the provision of support for climate action to developing countries, and considerations related to the distribution of the burden of climate impacts.

The UNFCCC outlined key principles for "fair shares" in Articles 3.1 and 3.4, as follows:

> "The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof." (UNFCCC 1992)
>
> "The Parties have a right to, and should, promote sustainable development. Policies and measures to protect the climate system against human-induced change should be appropriate for the specific conditions of each Party and should be integrated with national development programmes, taking into account that economic development is essential for adopting measures to address climate change." (UNFCCC 1992)

These are also reflected in the Paris Agreement by reference, and directly:

> "In pursuit of the objective of the Convention, and being guided by its principles, including the principle of equity and common but differentiated responsibilities and respective capabilities, in the light of different national circumstances.." (UNFCCC 2015)

This formulation is repeated in Article 2.2 and so applied to the Agreement's purpose and its whole, to NDCs in Art 4.3 and 4.4, and long-term low emissions development strategies in Art 4.19. Moreover, in terms of the Paris Agreement, Parties are obliged to explain how their contributions to the realisation of the Paris Agreement's temperature goal is "fair and ambitious" – there is a clear requirement in Annex I to decision 4/CMA.1 for Parties to provide information on:

> "How the Party considers that its nationally determined contribution is fair and ambitious in the light of its national circumstances;"

Within the broader context of legal provisions of the Paris Agreement and subsequent substantive decisions, and international and domestic developments, South Africa therefore has to consider what would constitute a "fair" contribution to the global response. In terms of mitigation, the question of how to determine a country's fair share is not a trivial one, and is bedevilled by complex normative and strategic concerns which in many instances relate to countries' national circumstances. In particular there are wide divisions between developed and developing countries on, for instance, what role historical responsibility should play in allocating mitigation burdens. This and other issues is reflected in the wide variance of approaches and indicators included by Parties as information to show how their first NDCs were considered fair and ambitious, in the absence of more detailed guidance in either of the Lima (1/CP.20) or Paris (1/CP.21) decisions. (Winkler et al. 2018) this is even more the case for adaptation, where metrics and approaches to equity are not as well understood (Cunliffe et al. 2019).

Across studies and literature aiming to resolve the question of determining fair mitigation contributions, two common approaches have generally emerged. The first is a top-down "burden-sharing" approach, the method

of which typically begins by determining an estimate(s) of the "mitigation gap" between a long-term emission trajectory consistent with a desirable temperature outcome (e.g. 66% probability ("well below") of staying within 2 °C by 2100) and a global baseline trajectory based on the *status quo* of countries' policies, NDCs and longer-term pledges[4]. The global mitigation gap, i.e. aggregate emissions that need to be abated to reach the "goal" pathway, is then divided up amongst countries according to a wide and varying array of methodologies and assumptions that operationalise equity principles (or other accounting criteria) in vastly different ways. Numerous studies appear in literature that have used this approach (e.g. Baer et al. 2008; Holz et al. 2018; Höhne et al. 2014; Müller et al. 2009), and indeed the framework proposed in this work is based on two of the most prominent effort-sharing analyses that focus specifically on NDCs – primarily the *Climate Equity Reference Calculator* (Holz et al. 2019) and also *Climate Action Tracker* (Climate Action Tracker 2019). This approach was also used by South African experts (Winkler et al. 2013) in work which was cited in South Africa's first NDC. The second is a "carbon budget" sharing approach, under which countries are allocated a share of an estimated global carbon budget consistent with a temperature outcome of varying probability determined by science. The same methodology was also applied by Indian and Chinese BASIC Experts (CASS / DRC Joint Project Team 2011; Jayaraman et al. 2011).

The use of both approaches is dependent on understanding countries' long-term goals for GHG emissions reduction, since shorter-term goals for 2025 or 2030 do not indicate very much about future emissions trajectories to 2050 or beyond, which are necessary to understand the overall impact on global temperature rise of countries' commitments. Different approaches have used different methods to extrapolate shorter term targets into longer-term emissions pathways – and the advent of more certain longer-term goals (for instance, net zero emissions by 2050) potentially removes the need for making such assumptions. A long-term perspective on GHG emissions can provides a very useful perspective on near-term targets (Waisman et al. 2019), with indicating a commitment "ultimately moving towards a goal of net zero carbon emissions by 2050" but still identifying pathways – and a just transition as the process to deliver such a pathway in the political economy.Nevertheless much uncertainty remains. Countries' contributions should therefore be properly understood on the basis of longer-term intentions, which ideally should form part of a country's explanation of the fairness of its contribution. This, however, is not an obligation under the Paris Agreement.

Equally important are the implications for adaptation. In simple terms, the less mitigation there is, the greater the impacts and the need for adaptation. The Paris Agreement states this more formally:

> "Parties recognize that the current need for adaptation is significant and that greater levels of mitigation can reduce the need for additional adaptation efforts, and that greater adaptation needs can involve greater adaptation costs" (UNFCCC 2015).

In this context, South Africa maintains the view that its adaptation component represents an equitable contribution to the global effort in the context of the adaptation global goal. A further equity question centres on climate finance and support – the question of "who pays" for mitigation (and adaptation).

The provision of support for both individual countries and for the overall multilateral climate regime is also an important element in fairness, to which not nearly as much attention has been given as to mitigation. Some approaches to equity take this into account, and others do not.

1.3 Overview of the Fair Share Framework

The "fair share" assessment is a component of the overall work supporting the SA NDC updating process, to be considered with the other technical work on the GHG outcome of planned policies, and other factors in identifying updated NDC target ranges.

We begin with a review of the legal context, stemming primarily from the Paris Agreement, which established the mechanism of NDCs over a 5-year cycle, and the Katowice Climate Package agreed at COP24, which substantiated implementation of and communication under the terms of the Paris Agreement, to establish

[4] The trajectories are often informed by scenarios found in the IPCC AR5 database, while underlying datasets can vary widely based on a combination of national GHG inventories, collated data from sources such as IEA, PRIMAP or WRI-CAIT, and economic drivers and assumptions.

South Africa's obligations in terms of what to report in the updated NDC, and what information could be included on how we consider the NDC to be fair and ambitious. We also review developments in the international climate context, including the latest science around 1.5 °C, that have transpired since the first NDC was communicated in 2015.

Thereafter, we unpack the burden-sharing frameworks we have reviewed and applied in this analysis, which can be used to determine a fair share "lens" through which to consider South Africa's emissions levels in 2025 and 2030. The lens methodology is designed to indicate fair share 'ranges' for South Africa's emissions level, based on varying underlying assumptions, value positions and socio-economic trade-offs of ambitious mitigation, bearing in mind factors of countries' responsibility, capability, and right to promote sustainable development.

We provide a benchmarking analysis by applying the same burden-sharing analysis to a few other countries, to demonstrate how the framework interprets the mitigation responsibilities of countries with widely varying national circumstances, and to provide a reference point of comparison with which to reflect on our own mitigation targets. We conclude with recommendations of how the lens could be applied in technical analysis for South Africa's updated mitigation NDC, and provide insight into how this analysis links with the support component of the NDC.

This information is intended for government to consider to what extent the enhanced NDC is "fair and ambitious". The information may also be useful in consultations with stakeholders. Some may ask directly how equity and science are integrated. Other stakeholders may raise concerns that other countries (e.g. trading partners) are not doing their fair share and the literature review is intended to address the latter concern. In all these considerations, principles of equity will be interpreted in a manner appropriate to SA's national circumstances, notably its development priorities and the triple challenge of poverty, inequality and unemployment.

Following consideration of the above, elements of the fair share section may be included in the draft NDC, specifically in a) a row in the table in ICTU in the NDC on fairness and ambition, 2) equity in the adaptation component; 3) equity in the mitigation component; 4) equity in the support component; and 5) the section on equitable access to sustainable development.

2 Review of the international context and legal framework

The Paris Agreement provides a detailed legal framework for the periodic submission of NDCs, the content of these, and associated obligations flowing from NDCs. These are elaborated further in subsequent decisions, especially 4/CMA.1, decided at COP 24 in Katowice in 2018, which specifies the "information to facilitate clarity, transparency and understanding" (ICTU) which Parties must include in their NDCs, and 18/CMA.1, which establishes modalities, procedures and guidelines for reporting on progress and achievement of NDCs.

2.1 Process and content of NDCs in the Paris Agreement and 1/CP.21

2.1.1 General provisions on NDCs

NDCs are a central feature of the architecture of the Paris Agreement, contained in its Article 3. These are "contributions to the global response to climate change", and all Parties are "..to undertake and communicate ambitious efforts as defined in Articles 4, 7, 9, 10, 11 and 13 with the view to achieving the purpose of this Agreement as set out in Article 2". Article 2 contains two critical provisions: the first is a set of three global goals, including the global temperature goal, which is defined as:

> "Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;" (Article 2.1.a, Paris Agreement)

The second is a stipulation that:

> "This Agreement will be implemented to reflect equity and the principle of common but differentiated responsibilities and respective capabilities, in the light of different national circumstances." (Article 2.2, Paris Agreement)

The second paragraph is a central part of the Paris Agreement's architecture, and provides the basis of the relationship between national contributions and the global goals of the Agreement.

The obligations and expectations of Parties regarding mitigation are contained in Article 4 of the Agreement, which contains specifications for both collective efforts (which Parties are required to contribute to, according to the principles contained in Article 2.2), and individual contributions in the form of NDCs. Article 4.1 states that:

> "In order to achieve the long-term temperature goal set out in Article 2, Parties aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter in accordance with best available science, so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty." (Article 4.1, Paris Agreement)

The three key elements contained in this opening paragraph of Article 4 are i) the necessity to reach global peaking of GHGs as soon as possible, which means the emissions of individual countries peaking as soon as possible; and that ii) globally, it is necessary to reach net zero emissions ("a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases") sometime between 2050-2100; and iii) that individual countries will achieve this bearing in mind their different development challenges. Taking into consideration the last point, this does place an obligation on ALL countries to contribute to this goal by peaking their emissions as soon as possible and to undertake "rapid reductions" thereafter, to reach net zero. The difference between developed and developing countries in this context is a matter of timing[5]. The last significant element in this paragraph is the reference to the "best available science". This provides a clear and direct context for the consideration of the IPCC's Assessment Reports, and in this context (in 2020), the IPCC's Special Report on I.5 Degrees, which was mandated by the COP decision accompanying the Paris Agreement. When considering the collective mitigation effort required, countries should therefore attach central significance to the IPCC's findings.

Article 4.1 frames the long-term mitigation context within which NDCs are situated, and Parties are expected in terms of Article 4.19,

> "to formulate and communicate long-term low greenhouse gas emission development strategies, mindful of Article 2 taking into account their common but differentiated responsibilities and respective capabilities, in the light of different national circumstances." (Article 4.19, Paris Agreement)

Para 35 of 1/CP.21 requests Parties to develop these and submit these to the UNFCCC by 2020[6]. From Para 2 on, specific obligations and expectations are outlined, including the regular communication of NDCs (every five years – Article 4.9) that Parties "intend to achieve", and an obligation to "pursue domestic mitigation measures" to achieve their NDCs. There is no legal obligation to *achieve* NDC targets, but there is an obligation *to implement measures which are aimed at achieving* NDCs. Other key conditions for NDCs specified in Article 4 are:

- Each NDC will be a progression (in ambition, coverage, form etc.) on previous NDCs (4.3)
- NDCs will reflect countries' "highest possible ambition", taking into account "common but differentiated responsibilities and respective capabilities, in the light of different national circumstances" (4.3)

[5] It is implicit in the Paris Agreement that support will be provided to developing countries to achieve this.

[6] South Africa is in the process of finalizing its long-term strategy, and is expected to submit it to the UNFCCC later this year.

- Support will be provided to developing countries for implementation (4.5)
- Parties should account for their NDCs (see ICTU for information to be provided on this)

In addition to these, Parties are also required to take into account in their NDCs the findings of the global stocktake (GST) (Article 14.3), specified in Article 14. The GST is a key feature of the Paris Agreement – to be held every five years, the GST will "take stock" of the implementation of the Paris Agreement "to assess the collective progress towards achieving the purpose of this Agreement and its long-term goals" (Article 14.1, Paris Agreement). What this means is that if "collective progress" is not on track to achieve the long-term goals of the agreement, including the temperature goal, Parties will respond by considering increasing the ambition of their NDCs.

2.1.2 Provisions regarding the update of NDCs in 2020

Article 4.9 stipulates that Parties must communicate NDCs every five years, and the accompanying decision is clear that Parties should communicate their first NDCs on ratification. Most Parties communicated their INDCs in 2015 before the Paris Agreement was negotiated, and it is not clear that 4.9 implies that Parties are obliged to communicate NDCs in 2020. However, in order to remove ambiguity re the submissions cycle of NDC, paragraphs 23 and 24 of 1/CP.21 "request" Parties who submitted NDCs up to 2025, to submit a new NDC in 2020 (with an implied timeframe up to 2030, but not stated) (para 23) and Parties who submitted NDCs "to communicate or update by 2020 these contributions" (para 24). Para 25 specifies that Parties should communicate their NDCs "at least 9 to 12 months in advance of the relevant session of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement" to facilitate "clarity, transparency and understanding", and the compilation of a synthesis report of NDCs by the Secretariat.

The other context for updating NDCs in 2020 is contained in para 20, in which it was decided

> "..to take stock of the collective efforts of Parties in relation to progress towards the long-term goal referred to in Article 4, paragraph 1, of the Agreement and to inform the preparation of nationally determined contributions pursuant to Article 4, paragraph 8, of the Agreement" (para 20, decision 1/CP.21).

This paragraph is closely linked to the next paragraph which mandated the IPCC to "provide a special report in 2018 on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways" (para 21, decision 1/CP.21).

The majority of countries have decided on this basis to update/enhance their NDCs in 2020, while a few countries have announced that they will not be updating their NDCs.

2.1.3 Provisions for ICTU to be included in NDCs in terms of 4/CMA.1

Annex 1 to decision 4/CMA.1 specifies the information to be included by Parties in their NDCs, from their second NDCs on. Parties are "strongly encouraged" to provide this information for their existing NDCs. Indications so far are that most Parties who are updating their NDCs will elect to provide ICTU as specified in the Annex. The Annex requires the provision of the following information (numbered by the relevant paras in the Annex):

- Quantifiable information on the reference point. Many countries' NDCs contain reference points in terms of which their targets are defined. For instance, the EU's NDC is defined as a reduction of 40% from 1990 GHG emissions levels, and Indonesia's NDC is defined as a 29% reduction against a Business As Usual (BAU) GHG emissions projection. Section 1 requires that countries provide detailed information on the reference point. South Africa's NDC consists of an absolute emissions target range (between 614 and 398 Mt CO_2-eq), and so does not have a reference point, and therefore this section is not applicable to South Africa (unless government chooses to change the target type).
- Time frames and/or periods of implementation. The "time frame" is the period between NDC targets. Some countries have opted for ten years (for instance, the EU), and others (such as South Africa) have opted for five years. The "period of implementation" is synonymous with the timeframe, but defined

specifically as the period during which the NDC is being implemented. During the "period of implementation", Parties are required to report on progress in implementing their NDC in their Biennial Transparency Reports. This section requires Parties to report precisely on their periods of implementation; in South Africa's case, this would be two 5-year periods, and the precise periods of implementation would be 1 January 2021-31 December 2025, and 1 January 2026-31 December 2030.

- Scope and coverage. Parties are required to describe in detail how much of their GHG emissions their NDC covers, i.e. which gases, sectors and sources, and to ensure that previously covered gases, sectors and sources are still covered.
- Planning process. Parties are required to include in their NDCs information on the planning process involved in developing their NDCs. Specific information requirements include:
    - Information on domestic institutional arrangements, stakeholder consultations (including indigenous peoples, local communities and the extent to which planning and consultation was held in a gender-responsive manner).
    - Relevant national circumstances, and experiences gained in developing their NDC.
    - How the Party has taken the outcome of the GST into account in developing their NDC.
- Assumptions and methodological approaches. Detailed information on accounting for GHG emissions and removals, and specific and detailed information on accounting for the land sector, information on any methodologies underlying reference points (for instance methodologies for developing BAU projections), and information on a Party's intention to use Article 6 to meet its target.
- "How the Party considers that its nationally determined contribution is fair and ambitious in the light of its national circumstances". Parties are required to provide information on how they consider their contributions to be "fair and ambitious", "including reflecting on equity"; how its NDC is a progression beyond previous NDCs, and how the NDC reflects its "highest possible ambition".
- "How the nationally determined contribution contributes towards achieving the objective of the Convention as set out in its Article 2". The UNFCCC's Article 2 contains the long-term goal of stabilizing GHG concentrations in the atmosphere at a level that will avoid dangerous anthropogenic climate change. The provisions also requires Parties to include information on how the NDC contributes to the long-term temperature goal of the Paris Agreement, and to Article 4.1, as referred to above (GHG emissions peaking as soon as possible, declining rapidly thereafter, and reaching net zero in the second half of the century).

2.1.4 A note on NDC mitigation targets and compliance under the Paris Agreement

Unlike in the case of the Kyoto Protocol, in which mitigation targets are legally binding (in which countries which have targets specified in Annex B of the Kyoto Protocol are legally obliged to meet these targets), the Paris Agreement obliges Parties to a) submit NDCs regularly as specified, and b) to "..pursue domestic mitigation measures with the aim of achieving the objectives of such contributions" (UNFCCC 2015). In other words, Parties to the Paris Agreement are legally required to regularly set NDC targets, and to take action to achieve these targets (and to report regularly on implementation and achievement of targets), but there are no *legal* consequences that follow from not achieving NDC targets. Compliance processes under the Paris Agreement are limited to the non-submission of either NDCs or biennial transparency reports (UNFCCC 2018b).

There may be other non-legal consequences for countries of not meeting NDC targets, such as reputational damage. While the setting of NDC targets should be undertaken with the seriousness which the global effort to address climate change requires and deserves, the legal contrast between the Paris Agreement and the Kyoto Protocol changes the balance of risks countries face between on the one hand caution in specifying a mitigation target which can be realistically met (or in respect of which the risk of NOT meeting the target is sufficiently low), and on the other hand the reputational and political risk stemming from specifying an NDC target which is not sufficiently ambitious.

3 The global temperature goal of the Paris Agreement and the latest science

As mentioned above, Article 2 of the Paris Agreement articulates its aim to strengthen the global response, in the context of sustainable development and efforts to eradicate poverty, including by;

> "Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change". (UNFCCC 2015)

It is important to emphasise that this is one of THREE long-term goals of the Paris Agreement, the other two relating to adaptation and finance (Article 2.a (b) and (c) respectively). This goal is referred to as the "global temperature goal", which consists of two "textually linked elements" (Rajamani and Werksman 2018) Rajmani and Werksman describe the goal in 2.1 (a) of the Paris Agreement as;

> "..a single goal consisting of two textually linked elements - the 1.5°C goal and the 'well below 2°C' goal. Arguably the 'well below 2°C' goal has the stronger normative force. It is given more prominence, in its order and language. While Article 2.1 describes the Agreement's purpose as 'holding' the temperature increase to 'well below 2°C', it uses the more aspirational language of 'pursuing efforts to limit' the temperature increase to 1.5°C. But for the most part, our legal and operational analysis of the two temperature limits is the same." (Rajamani and Werksman 2018)

The global temperature goal thus contains *two* global temperature limits. The inclusion of the 1.5 degree limit was strongly supported by the African Group and other especially vulnerable countries, on the basis that climate impacts that would result from a global average of 1.5 degrees of warming are potentially very severe for many countries. The definition of "well below 2 degrees" and the difference between the two temperature goals is not clearly explained in the Paris Agreement (being above 1.5 degrees and below 2 degrees). The definition of "well below 2 degrees" we will draw on here is proposed by Glen Peters:

> "..emission scenarios with a 66% or higher probability of staying below 2°C will be consistent with the Paris Agreement's "well below 2°C"; a 66% probability of keeping temperature below 2 °C is roughly consistent with a 50% probability of 1.6 °C (Peters 2017).

Legally within the Paris Agreement architecture, countries are required in terms of Article 4.1, "in order to achieve the long-term temperature goal" to "reach global peaking of greenhouse gas emissions as soon as possible, recognizing that this will take longer for developing countries", to reduce emissions rapidly thereafter "in accordance with best available science", so as to reach net zero emissions "in the second half of this century". The two global temperature limits have different implications both for the pathways which global GHG emissions will need to follow during the 21st century, and for the impact of different levels of climate change, and the associated adaptation requirements of countries. The application of Article 4 of the Paris Agreement, in relation to the long-term temperature goal contained in Article 2.1(a), requires countries to consider the relationship between their NDCs and *both* global temperature limits. In practice, this means considering how countries' NDCs relate to the global GHG emissions pathways which are necessary to limit temperature rise to the global temperature limits described above.

In order to further inform countries' implementation of Article 4, a decisions was also taken in 2015 to request the IPCC to "..provide a special report in 2018 on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways" (UNFCCC 2015) to understand better what insights "best available science" could provide on what would be necessary to keep temperature rise to 1.5°C, and in particular the different requirements for 1.5° pathways and 2° pathways, and what the difference in climate impacts and adaptation requirements would be.

The IPCC's Special Report on 1.5°C, published in late 2018, contained results of a multitude of modelled scenarios for both 1.5°C (a 50% chance) and scenarios with a 66% chance of keeping global temperature below 2°C. Figure 4 shows global emission pathways to limit global warming, with four illustrative pathways (P1-4) within the range. It compares these 1.5° pathways with pathways limiting global warming to 2°C with at least 66% probability. Note that the SPM focuses on 1.5° scenarios with limited or no overshoot, which are shaded

in blue below and have a 50-66% probability that warming temporarily ends up above 1.5°C before returning to 1.5°C later on in the century; this implies a best estimate (median) of at maximum a 0.1°C exceedance of the 1.5°C temperature limit (further details in Table 2.1 in the main report (IPCC 2018b)).

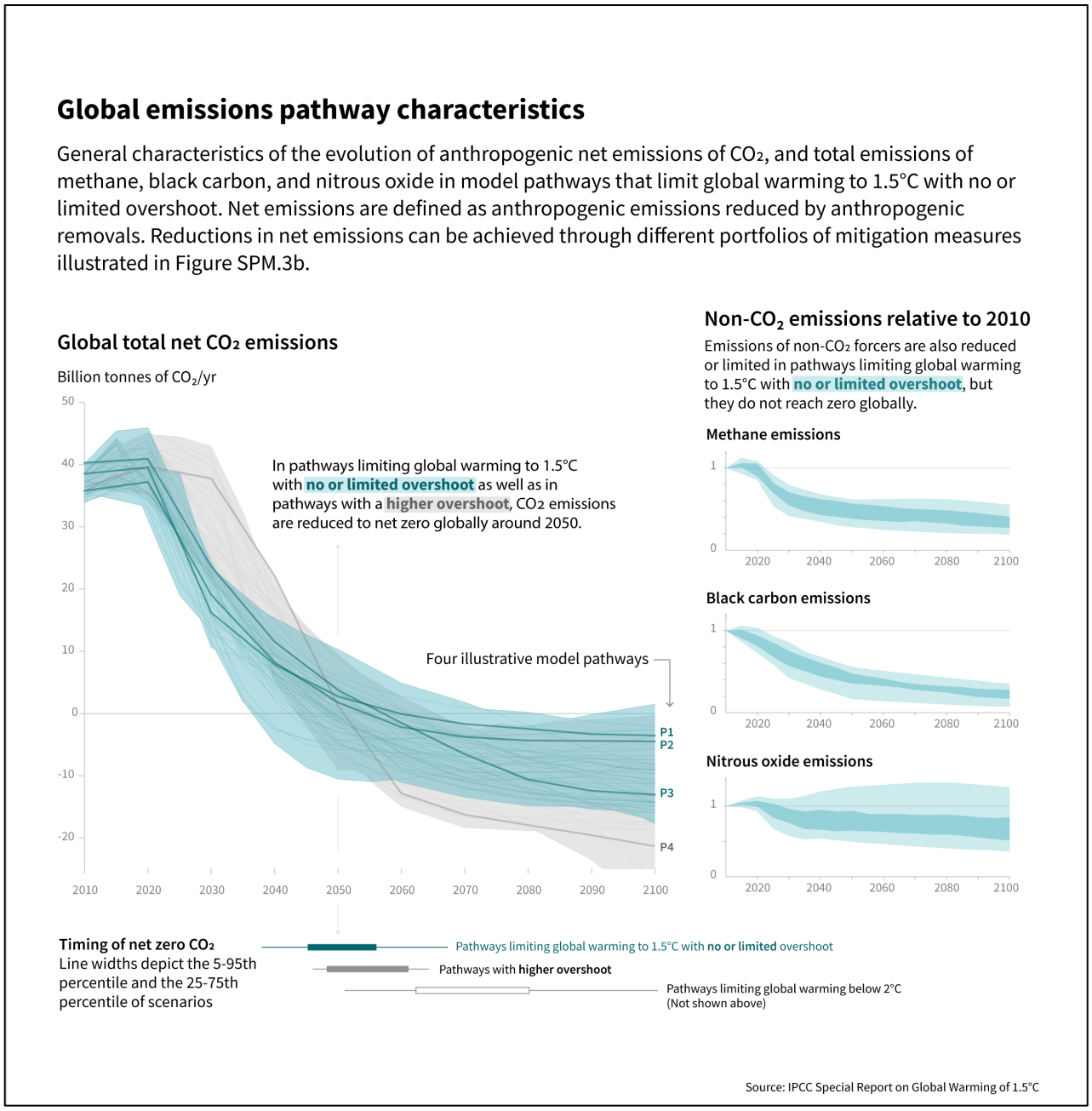

Figure 3 – Global emission pathways to limit temperature increase to 1.5 °C (IPCC 2018a)

As noted above, it is important to emphasise that the 2º scenarios modelled in the Special Report have a 66% probability of keeping temperature below 2 °C, which is roughly consistent with a 50% probability of 1.6 °C (Peters 2017), and that this can be taken as an approximation of the temperature outcome corresponding to "well below 2 degrees" in the Paris Agreement. Global carbon budgets (GCB) were determined on this basis – both what has already been used historically, and the limited remaining future global carbon budget (IPCC 2018b). Historical emissions from pre-industrial times to 2017 reduced the GCB by 2200 ± 320 GtCO2 (medium confidence). Each year, the GCB shrinks another 42 ± 3 GtCO2 (high confidence), in other words, we collectively spend between 39 and 45 Gt CO2 each year. The remaining future GCB 770 Gt CO2 for a 50% chance and 570 Gt CO2 for 66% chance of keeping below 1.5 °C. This means that emission pathways that keep

global temperature limits of well below 2 °C in reach are challenging, and more so 1.5 °C. A key finding in the SR1.5 Summary for Policy-makers is:

> "In model pathways with no or limited overshoot of 1.5 °C, global net anthropogenic CO_2 emissions decline by about **45% from 2010 levels by 2030** (40–60% interquartile range), reaching **net zero around 2050** (2045–2055 interquartile range). For limiting global warming to below 2°C CO_2 emissions are projected to decline by about **25% by 2030** in most pathways (10–30% interquartile range) and reach **net zero around 2070** (2065–2080 interquartile range). Non-CO_2 emissions in pathways that limit global warming to 1.5 °C show deep reductions that are similar to those in pathways limiting warming to 2°C. (high confidence)." (IPCC 2018b, p. 12 emphasis added)

Of the scenarios modelled, all of them showed a dramatic reduction in the use of coal globally, with its complete phase-out in the power sector by the 2040s. The reduction in CO_2 emissions was accompanied by "deep reductions" in emissions of other GHGs as well as black carbon. In many scenarios, negative CO_2 emissions are required in the post-2050 period to attain the 1.5 degree temperature goal.

The emissions pathways assessed in SR 1.5 have the following characteristics:

- Emission reduction rates
- Time of peaking
- Low-carbon energy deployment rates (IPCC 2018b, p. 99)

These characteristics are based on the dynamics of each different integrated assessment model, and are not requirements of attaining a global goal of 1.5 °C *per se,* but necessary to model pathways consistent with that level. SR1.5 focuses on scenarios that never exceed 1.5 °C. Unlike previous IPCC reports, SR 1.5 tends to avoid overshoot scenarios, in which temperature increases above a certain level but stabilize in the long-term.

In summary: a limit of 1.5 °C implies rapid reductions of global net CO_2 reduced 45% below 2010 levels by 2030, net zero around 2050; "well below 2 °C" implies global net CO_2 reduced 20% below 2010 levels by 2030, net zero by 2070.

These are findings applicable on a global level; implications for South Africa of these findings are assessed below. It is important to emphasise that although the findings of the Special Report are extremely important in guiding the global response to climate change, it is NOT equitable to simply translate the imperatives of the required global CO_2 emissions pathway ("net zero around 2050") into country-level targets of net zero CO_2 emissions by 2050. An equitable and achievable 1.5 degree pathway of this kind, involving rapid reductions for all countries, can only be achieved by a) earlier net zero targets for developed countries (for a global target of net zero by 2050), both to create the emissions space and also to provide the necessary investments in zero-carbon technology, achieved DOMESTICALLY (without offsets, especially to other countries which have not achieved net zero), i.e. without offsets, b) the enhancement of carbon sinks globally, which are mostly in developing countries, and c) the accelerated provisions of support for developing countries. Current net zero targets are not sufficient to achieve this without the other elements being in place. Long-term trajectories for countries which would be compatible with these pathways have not been assessed from an equity point of view yet, but initial 2050 analyses by CAT indicate that developing countries would be on track to reach net zero later than developed countries[7]. However, depending on the size of available sinks globally, it is reasonable to speculate that developing countries would need to reach net zero CO_2 emissions within a decade of 2050 at most, and probably before[8]. Long-term objectives are not further considered here, but need to be borne in mind in relation to GHG emissions trajectories over the next decade.

[7] CAT's analysis is limited in various respects regarding net zero target and only extends to 2050, andis not designed to address this question, but a scan of CAT's "fair share" ranges of major developed and developing countries (USA, EU, China, India) that the former should reach negative emissions before 2050, whereas the latter should reach it sometime thereafter.

[8] The extent to which a global 1.5 degree emissions pathway can reach net zero beyond 2050 depends on the extent of rapid reductions before this, and the extent to which carbon sinks will absorb CO_2 thereafter.

4 South Africa's current contribution to global emissions

This section briefly reviews South Africa's ranking in terms of some key GHG emissions and development indicators cited in equity literature, which provides a basis for the results of the quantitative analysis in the next section – specifically, South Africa's share of global emissions, per capita emissions, historical responsibility and the relationship between development status and GHG emissions. In 2016 South Africa contributed almost exactly 1% of global anthropogenic GHG emissions[9], and was the 15th-largest GHG emitter in the world, as presented in . South Africa's share of global emissions, as well as the share of other major emitters in 2016 is presented in Figure 5, constituting 1% of global emissions (including all gases and land use emissions)[10]. All other countries (with lower annual emissions than South Africa, constitute 24.8% of global emissions (excluding bunker fuels). The significance of this is that the climate crisis cannot be addressed by large emitters alone, and countries with GHG emissions the size of South Africa's are far from "too small to matter".

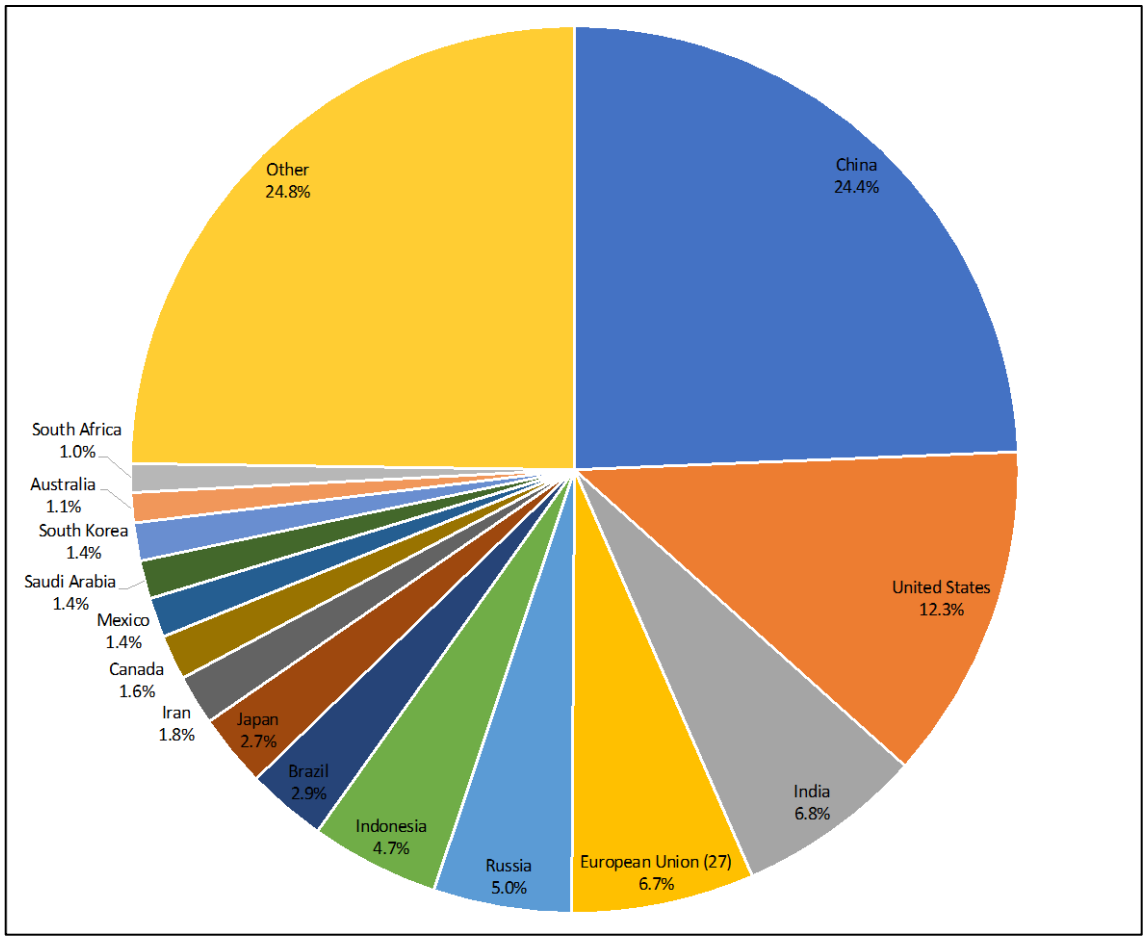

Figure 4 – Shares of global GHG emissions in 2016 (including land use, EU countries grouped)

[9] All data in this section, unless otherwise specified, is sourced from WRI's Climate Watch - https://www.climatewatchdata.org/data-explorer/historical-emissions; totals are calculated excluding emissions from bunkers and international aviation and include land use emissions.

[10] The ranking in Figure 5 by net GHG emissions includes the EU as one entity. If disaggregated, of the EU 27 states, only Germany has larger emissions than South Africa, and so South Africa would remain the 15th largest GHG emitter.

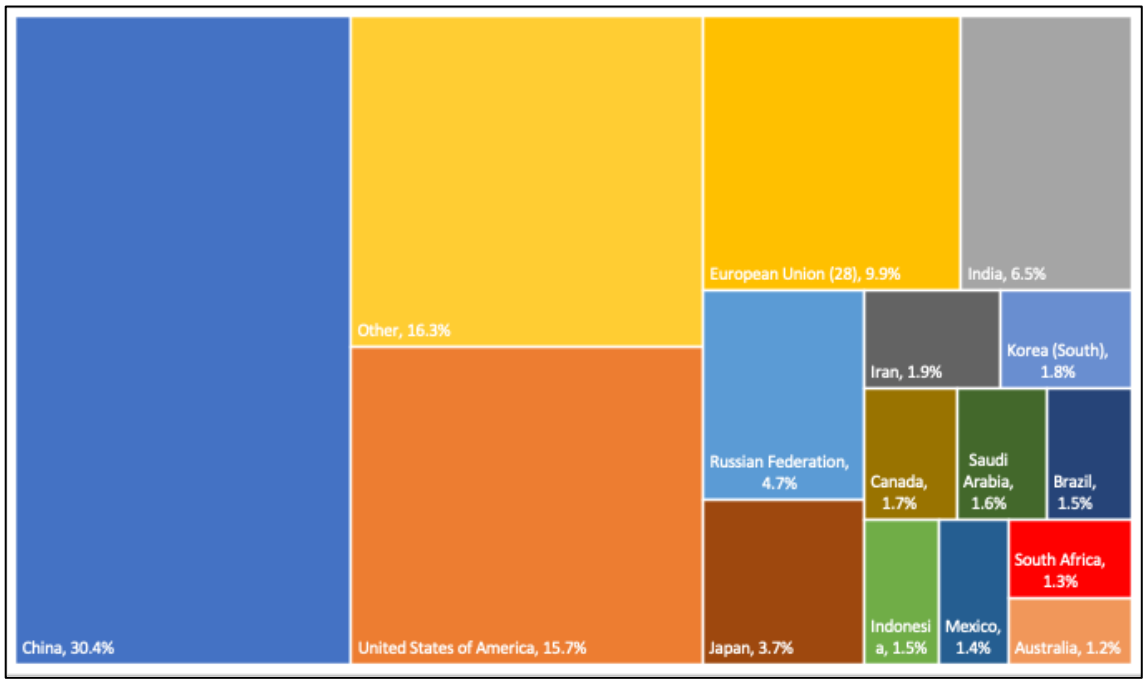

Figure 5 – Shares of global emissions of CO2 (excluding land use) for the year 2014

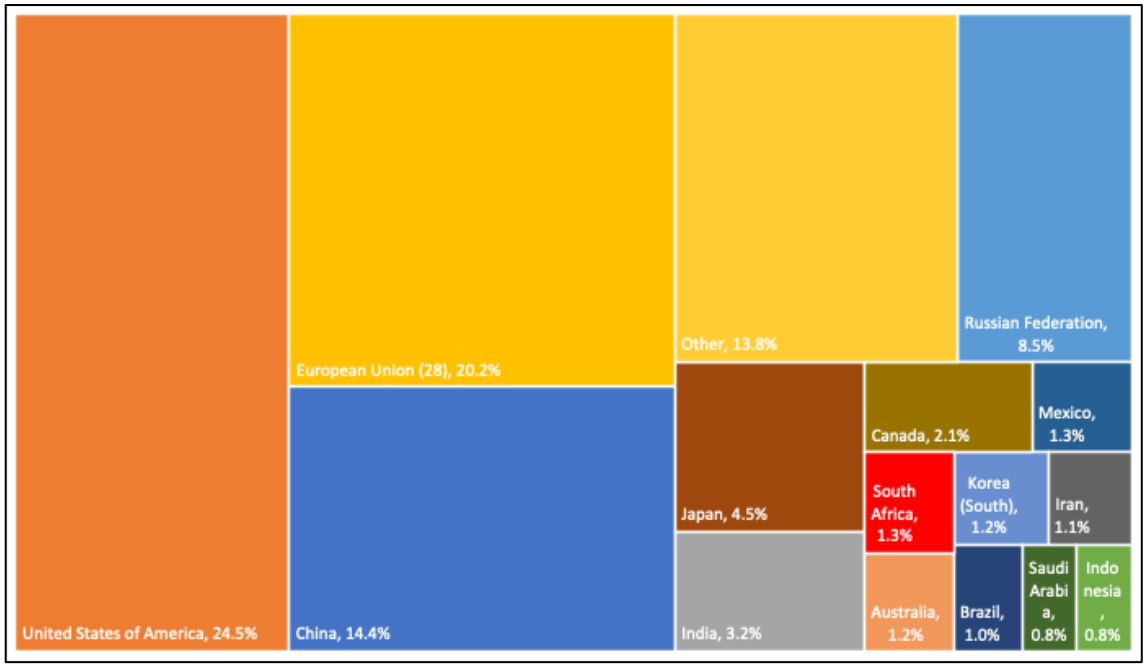

Figure 6 – Shares of global cumulative emissions of CO2 (excluding land use) (1950-2014)

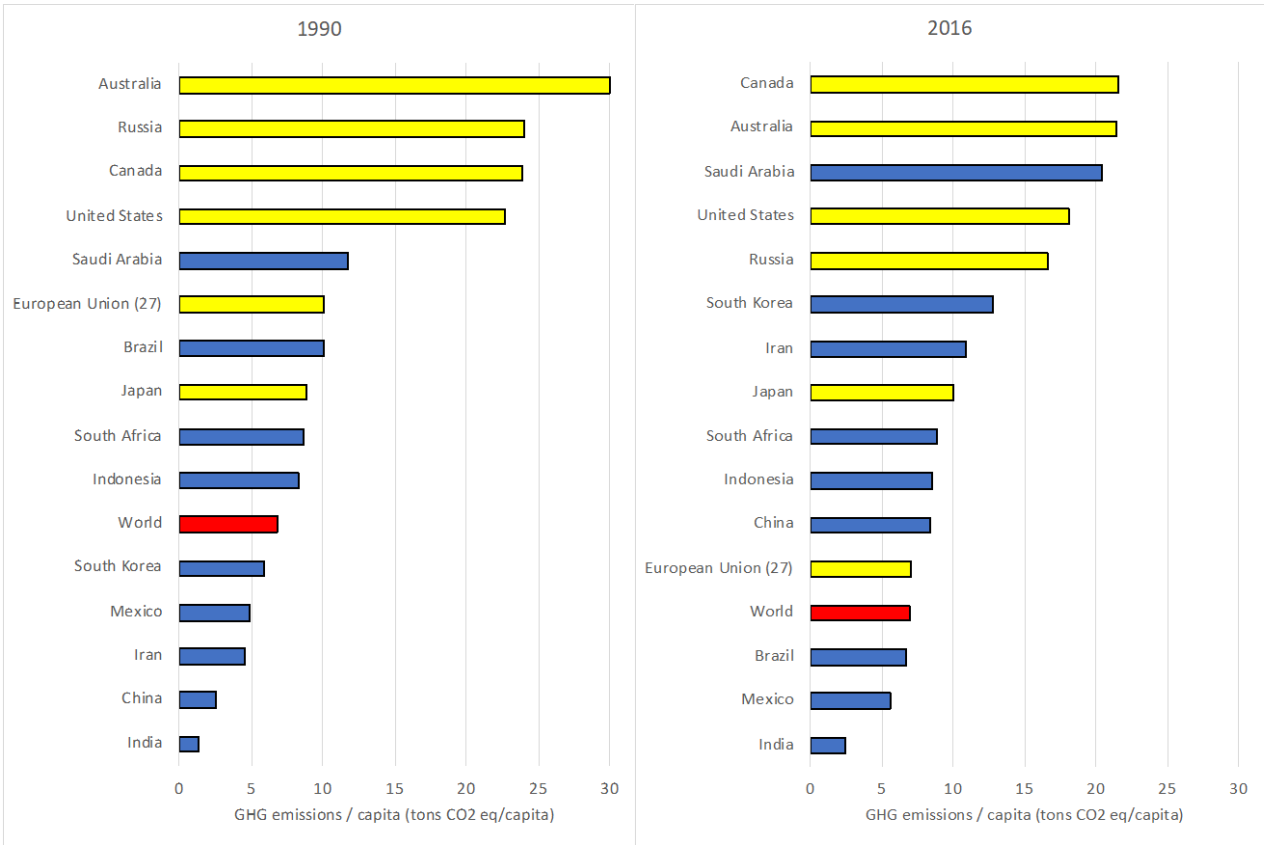

Figure 7 – 1990 and 2016 GHG emissions per capita (including land use) for the top 15 emitters – developing countries are coloured blue, developed countries are coloured yellow.

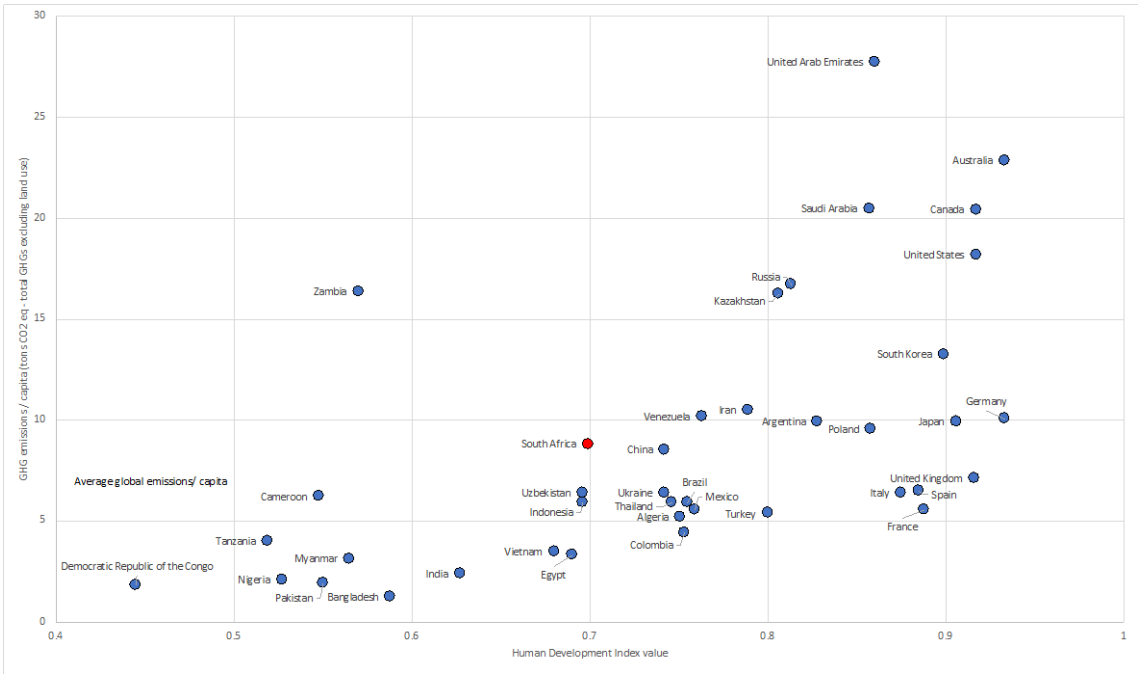

Figure 8 – GHG emissions per capita (without land use) vs Human Development Index value for the top 40 emitters (EU states are represented individually).

Figure 6 presents shares of global emissions of CO_2 excluding land use in 2014, and Figure 7 presents shares of cumulative global emissions of CO_2 excluding land use from 1950 to 2014. Cumulative emissions data in most cases shows that at least up to 2014, the historical contribution of developing countries to GHGs in the

atmosphere has been much greater from developed countries, which started using fossil fuels much earlier, and on a much greater scale. Even though China's CO_2 emissions in 2014 were twice those of the USA, since 1950 their cumulative CO_2 emissions are almost half of those of the USA. South Africa's share of cumulative CO_2 emissions since 1950 is almost the same as its share of global CO_2 emissions in 2014, reflecting a long history of carbon-intensive growth. For a developing country South Africa therefore has a relatively high degree of historical responsibility.

South Africa's GHG emissions per capita (all GHGs, including land use), in comparison to other large emitters, in presented in Figure 8, for 1990 and 2016, during which time period South Africa's emissions per capita remains very similar (8.58 tons/capita in 1990 and 8.85 tons/capita in 2016), and remains significantly above the global average (6.9 tons/capita in 1990 and in 2016), and relatively high for developing countries. Of major GHG emitting developing countries, South Africa's emissions per capita are the highest except for those of South Korea (which is relatively developed), and the oil producers Iran and Saudi Arabia.

Finally, Figure 9 presents the relationship between development level (represented by the UNDP's Human Development Index) and GHG emissions per capita in 2016. The GHG emissions per capita are excluding land use emissions, since the relationship between land use emissions and development is not clearly established. Resource-based economies such as Australia, Canada and the oil-producing developing countries have relatively high emissions per capita, whereas other developed countries (with an HDI of 0.8 or above) have per capita emissions around or slightly higher than the world average. South Africa's emissions per capita are clearly much higher for its corresponding development level, and its associated development challenges.

5 Burden-sharing literature review and analysis

The IPCC's Special Report on 1.5 degrees, as outlined above, provides a clear view on the basis of the latest science where global GHG emissions need to go over the next century to achieve the long-term temperature goal of the Paris Agreement. What it does not provide is a specification of what each country's contribution to this effort should be, or in other words, how the global mitigation burden should be shared amongst countries, or what the "fair share" of each country should be, based on the agreed principles of the UNFCCC and the Paris Agreement. This section discusses conceptualisation of a fair share 'lens' for South Africa's emission trajectory, based on a burden-sharing approach and using an equity framework that supports principles of fairness and justice that South Africa has historically aligned with.

Various burden-sharing tools and frameworks exist in academic and grey literature that calculate 'fair share' allocations of the global mitigation burden, interpreted as a gap between a baseline emission trajectory and a pathway determined to achieve a temperature outcome (e.g. well below 2 °C increase), or as a fraction of the remaining GHG budget implied by the global GHG emissions pathways necessary to meet the global temperature goal, to countries on the basis of a varying set of equity principles and metrics, leading to a wide range of outcomes for individual countries. Since there is no overall approach to this which has been agreed, countries have tended to favour in most but not all cases to favour approaches which allocate lesser burdens to themselves and greater burdens to others. This of course means that if each country only pursues the approach most favourable to itself, the overall outcome will be a global emissions trajectory far higher than is necessary to meet the long-term temperature goal, even though this is the intention of each individual approach. We have thus used two approaches – one which is based on South Africa's preferred implementation of equity principles, and a second approach which places South Africa's "fair share" in the context of a diverse range of other approaches.

Whilst other tools are available that, for example, share carbon budget quotas based solely on historic emissions (Raupach et al. 2014), IPCC shared socio-economic pathway scenarios (Leimbach and Giannousakis 2019), or distribution and associated costs of loss and damage (Costantini et al. 2018), we have concentrated on two specific tools for evaluating a "fair" allocation of mitigation to a country in the context of allocations to other countries and in order to meet the Paris goals.

The first of these tools is the Climate Equity Reference Calculator (Kemp-Benedict et al. 2019)[11], which we have used on account of the consistency between its underlying principles and the principles of the UNFCCC and the Paris Agreement. Up to now South Africa has strongly supported these principles as a basis for determining countries' fair shares to the global mitigation burden, including in the existing NDC[12], namely historical responsibility, capability and access to equitable sustainable development. In addition to this tool, in order to situate South Africa's in a broader context, we have also used the Climate Action Tracker (CAT 2019)[13], which draws on as wide a range as possible of different burden-sharing approaches as possible, and gives a corresponding "fair share range", representing the diverse outcomes of applying a large number of different approaches to calculating South Africa's fair share. Both these approaches give results for South Africa's fair share of global emissions in 2025 and 2030, in relation to the overall global GHG emissions pathway necessary to meet the global temperature limits (1.5 degrees, and "well below 2 degrees").

We therefore review these tools in depth, and propose that they form the basis of the lens for assessing the fairness of South Africa's mitigation potential. CERC is found to align well with the approach taken by South Africa to equity, and is hence used as a primary tool, with CAT used to validate results in relation to a broader set of perspectives on equity.

NOTE: Both tools were recently updated. The implications of this are set out in an addendum, in section 5.4 below.

5.1 The Climate Equity Reference Calculator

The *Climate Equity Reference Calculator* (CERC) is an online[14] equity reference tool and database developed by the Climate Equity Reference Project, designed to examine the potential 'fair share' of contributions of countries, regions or other international groupings to the global mitigation requirement (measured in $MtCO_2$-eq (excl. LULUCF)) estimated to achieve the Paris Agreement temperature goals, as interpreted by a selection of three global mitigation pathways (Holz et al. 2019). The Climate Equity Reference Framework is an evolution of the previous Greenhouse Development Rights (GDR) framework (Baer et al. 2008), which formed the basis, with some adjustments, of the previous work that demonstrated the fairness of South Africa's INDC (Winkler et al. 2013).

5.1.1 CERC Methodology

A full description of the methodology and input data for CERC can be found in Holz et al (2018) (including Supplementary Information). A summary description follows here. CERC begins with a global emission baseline[15] determined to 2050 (shown only to 2030 in the online user interface) based on EMF27Base-FullTech scenarios, as included in the IPCC AR5 Scenario Database (see e.g. Blanford et al. 2014; Krey et al. 2014b; Kriegler et al. 2014), coupled with projections of income (GDP) and population from the same models (which in turn are based on IMF, World Bank and UN data sources). Historical emissions data are sourced from the PRIMAP-hist database[16]. Historical GDP data is collected from the World Bank and historical population data is collected from UN data. As will be further discussed below in the addendum to this section, the global baseline and each country baseline are dependent on a projected economic growth rate. The baseline is quite sensitive to this assumed growth rate, which has consequences for the determination of each country's "fair share".

CERC then determines three global temperature pathways, defined as follows:

[11] https://calculator.climateequityreference.org/

[12] South Africa's current NDC states that that "..in the absence of a multi-laterally agreed equity reference framework, South African experts, applying Convention principles of responsibility, capability and access to equitable sustainable development, determined a carbon budget that is larger than the PPD trajectory range outlined in this INDC. South Africa has used this evidence base to evaluate whether its INDC is a relative fair effort." Technical analysis referred to in the NDC is available in (Winkler et al. 2013)

[13] https://climateactiontracker.org/

[14] The web interface is available here: https://calculator.climateequityreference.org/

[15] See also https://climateequityreference.org/calculator-information/gdp-and-emissions-baselines/

[16] See https://www.pik-potsdam.de/paris-reality-check/primap-hist/

1. The '2°C Standard' pathway (referred to here as "***Well below 2°C***"), which is based on the median of the scenarios reported in IPCC AR5 that have at least a 66% probability of staying below 2°C by 2100. This is consistent with analysis of Peters (2017) which defines "well below 2 °C" as analogous to a ≥66% chance of staying below 2 °C in the 21st century. It should be noted that the authors of CERC do not support the interpretation of the '2°C Standard' pathway as synonymous with "well below *2°C*.
2. A '1.5°C Low Energy Demand' pathway (referred to as "***1.5°C LED***"), based on the IPCC SR1.5 pathway with very low energy demand assumptions and avoidance of (BE)CCS or other CDR technology up to 2050.
3. A '1.5°C Standard' pathway, estimated to have ≥50% probability of staying below 1.5°C in 2100. The pathway is based on the median of scenarios reported in IPCC AR5 that have at least a 50% probability of staying below 1.5°C.

Our analysis considers the range resulting from using the ***Well below 2 °C*** pathway and both 1.5 degree pathways. Global mitigation requirements for each pathway are determined as the difference in emissions between the global baseline and each temperature pathway. Counterfactual baselines for each country are the calculated based on emissions intensity in 2015, which declines over time, and which are indexed to economic growth. The result of this is that the economic growth projections are a very important determinant in the trajectory of a country's baseline, and these are not sensitive to burden-sharing criteria in CERC. A more negative view on a country's economic future will thus result in far more steep absolute emissions reductions, since the "fair share" of the global mitigation burden per country is not affected by the economic outlook which CERC chooses for each country. In theory, this is because countries with lower anticipated economic growth rates need less emissions space, but since the country mitigation burden is not proportionally reduced, this can result in countries with very low economic growth prospects having to make very steep emissions reductions, which may exceed their capacity. This problem as it applies to South Africa is discussed more specifically in section 2.5. This characteristic of CERC also implies that longer-term burden-sharing analyses would amplify this problem, and applications of baseline methodologies for long-term GHG emissions budgets should be approached with caution.

CERC then allocates "fair shares" of the global mitigation requirements to countries or regions based on computations of countries' historic responsibility for emissions, capability to invest in mitigation (measured in terms of GDP) and development needs (measured in terms of distribution of a country's population living below a specified income threshold). CERC refers to this quantification of metrics as the country's 'RCI Index', which is calculated as described below.

5.1.1.1 Responsibility ('R')

CERC measures historic responsibility as the cumulative sum of all emissions in proportion to consumption above a *specified development threshold* from a given start year (1850, 1950 or 1990). The development threshold is specified in GDP_{PPP} per capita terms, with the default set at – 7,500 (specified in 2005 PPP USD). Emissions are excluded from the CERC responsibility measure in proportion to the proportion of population within the country or region living below the development threshold (estimated according to national Gini coefficients).

CERC does not support include LULUCF emissions in its fair share calculations, owing primarily to inconsistencies and unreliability of available, harmonised land-use data[17].

5.1.1.2 Capability ('C')

Capability is defined in income terms (MER GDP) of a country or region. As with responsibility, "progressivity" can be incorporated into the fair share calculations, whereby GDP is 'discounted' in proportion to the share of the population living below the specified development threshold, and their income is excluded from the capability calculation. The development threshold is specified in GDP_{PPP} per capita terms, with the default set

[17] A detailed explanation of CERC's decision to exclude LULUCF from fair share calculations is available here: https://calculator.climateequityreference.org/glossary.php#lu_emissions

at – 7,500 (2005 PPP USD), and distribution across a population estimated according to national Gini coefficients.

5.1.1.3 Weighting of Responsibility and Capability

CERC gives users the option to adjust the 'weighting' of responsibility and capability in fair share allocation calculations, which are by default set at 1:1. CERC notes that, generally speaking, responsibility and capability tend to be (but are not always) correlated. Under the set-up of the CERC framework, any adjustment from an equal weighting of capability and responsibility would represent a value judgement on the part of the user. Given the importance South Africa has previously placed on both capability and responsibility as equity principles, calculations demonstrated in this work using CERC assume an equal weighting of R and C.

RCI for a given country in a given year is thus determined as the product of the country's responsibility (R) and capability (C) in that year, as calculated depending on the development threshold set.

That country is then allocated a "fair share" of the global mitigation requirement for that year according to the proportion of the country's RCI with the global RCI

(i.e. $M_{a,b} = \left(\left(\frac{RCI_a}{RCI_{World}} \right) (M_{World}) \right)_b$ where $M_{a,b}$ is mitigation allocation of country a in year b and M_{World} is global mitigation requirement in year b.

CERC analysis is shown up to 2030 on the online user interface. Downloadable datasets from the interface show further projections up to 2050. However, CERC have given a strong caveat and urged caution regarding use and reliability of their post-2030 projected data, due to the increasing uncertainty of the GDP and GHG projections used in the underlying data beyond 2030. The global baseline and the portion of that baseline attributed to individual countries becomes increasingly uncertain and unreliable in years beyond 2030.

The CERC methodology closely aligns with South Africa's position that, essentially, those with the broadest shoulders should be asked to lead, while protection is given to those in greatest need. It is also a relatively accessible and transparent approach that can be applied indiscriminately to all countries, with parameters that can readily be adjusted in accordance with the specifics of a country's equity principles, without altering the fundamental structure of those principles. Notably, CERC has been referred to in other prominent literature, such as the 2018 Civil Society Equity Review of NDCs (Civil Society Review 2018), as well as in analysis by other South African experts on the potential costs of implementing a "fair share" mitigation policy (Van Zyl et al. 2018).

5.1.2 CERC Application to South Africa

As with the Climate Action Tracker, the quantification of burden-sharing in CERC excludes the land sector. In order to compare these results to South Africa's current and updated NDC targets, and to the "peak, plateau and decline" emissions trajectory rage (PPD), specified in the National Climate Change Response White Paper and in South Africa's first NDC, we have therefore adjusted these results to include land use, using updated baseline projections for the land use sector from (UCT 2021). Table 1 below shows the input parameters used in this analysis. Calculations were performed using the web interface.

Table 1 – CERC input equity principle assumptions

Historic responsibility (cumulative emissions start year):	1950
Development (income distribution) threshold:	USD 7,500 per capita (2005 USD PPP)
Weighting of responsibility to capability:	50:50 (can be adjusted – see Figure 11 below)
LULUCF emissions	Excluded

Table 2 shows the results for South Africa's fair share from CERC[18], with and without land use emissions. These have been converted into a range to reflect South Africa's fair share for "well below 2 degrees" and 1.5 degrees for 2025 and 2050, then ranges being a reflection of the ranges in the Paris Agreement long-term temperature goal. The "well below 2 degrees" range extends from the "well below 2 degree" point to the highest 1.5 degree point, and the 1.5 degree range extends between the two 1.5 degree points.

Table 2 – CERC results for South Africa, with and without land use (all figures in Mt CO_2 eq)

	Pathway	Year	
		2025	2030
Results for CERC excluding land use	Well below 2 degrees	461	478
	1.5 degrees standard	421	429
	1.5 degrees low energy demand, low carbon sinks use	442	401
Baseline emissions for South Africa's land use sector		-10.3	-11.2
Results for CERC adjusted to include land use	well below 2 degrees	451	467
	1.5 degrees standard	411	418
	1.5 degrees low energy demand, low carbon sinks use	432	390
Fair share ranges derived from above results (including land use)			
	Well below 2 degrees	432-451	418-467
	1.5 degrees	411-432	390-418

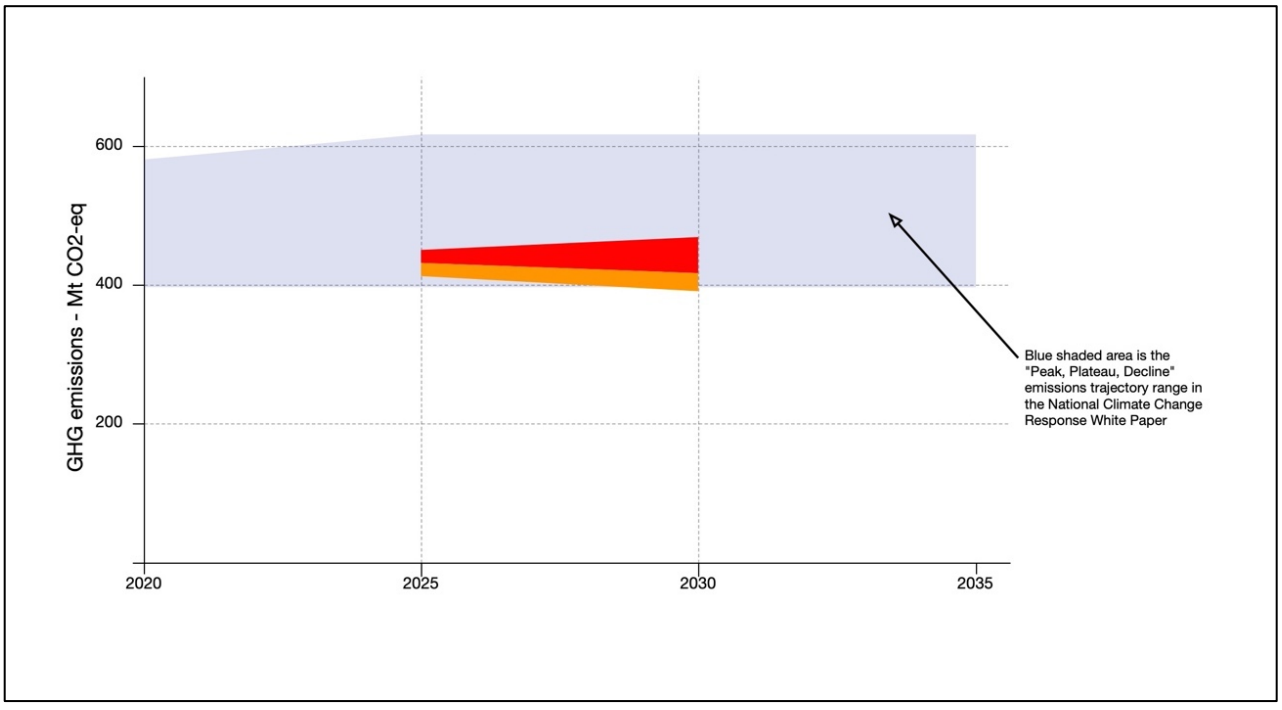

Figure 9 – South Africa's PPD compared to fair share allocations determined by CERC, adjusted to include land use between 2025 and 2030. Ranges specified as above.

[18] These results were obtained from the pre-COVID version of CERC. Please see the addendum for the post-COVID results from CERC, and how these compare.

5.1.3 Sensitivity analysis and caveats

CERC determines different 'fair share' emission levels for South Africa, for a well below 2 °C pathway, depending on how equity principles (input parameters) are adjusted. For example, Figure 6 shows different 'fair share' emissions levels for South Africa in 2030 by varying the start year for aggregating emissions (cumulative responsibility) and the relative weighting applied to responsibility and capability in the burden-sharing calculations.

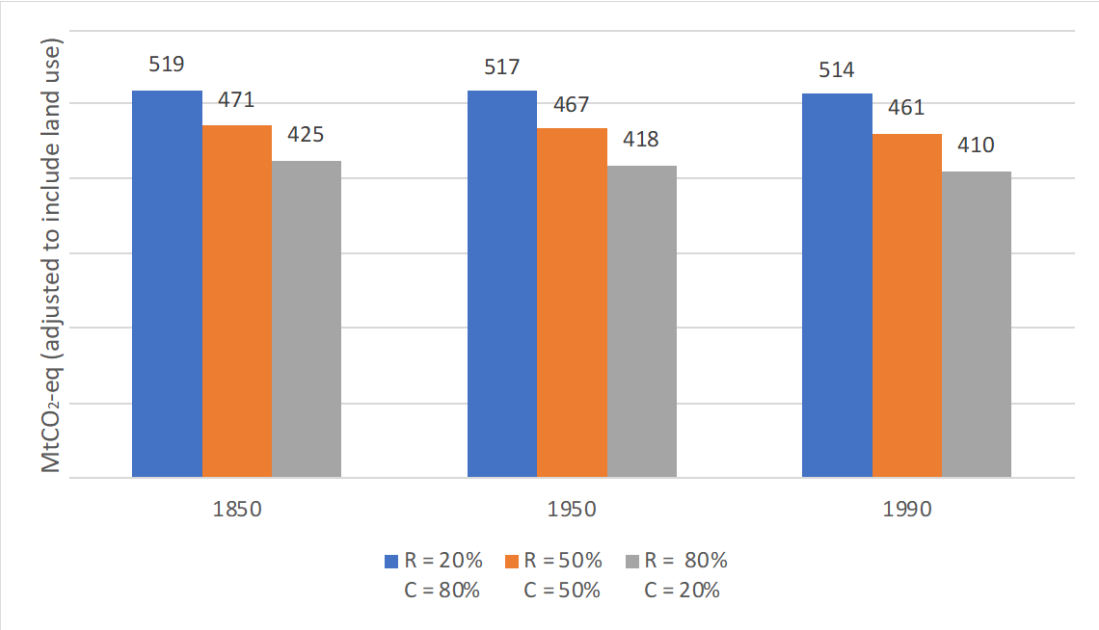

Figure 10 – CERC sensitivity analysis - emission allocations for South Africa in 2030 with varying cumulative responsibility and ratio of responsibility to capability (well below 2 °C pathway)

In the South African case, CERC is not very sensitive to the start year for historical responsibility, since South Africa's cumulative historical GHG emissions are relatively high for a developing country. The difference between the 1850 and 1990 starting points for considering historical responsibility is therefore negligible in South Africa's case. On the other hand, the approach is highly sensitive to the responsibility/capability ratio, with a 20% higher allocation with a low "responsibility" weighting, which again reflects South Africa's combination of development challenges with relatively high historical emissions.

It should also be noted that CERC's baseline GHG emissions value for 2017 is 528 Mt CO^2 eq; the underlying PRIMAP-hist value is 533 Mt CO2 eq, both values *excluding* land use emissions. The South African draft NIR released for public comment in 2020 reports a value of 555 Mt CO^2 eq, and the current technical analysis for the NDC update (detailed in the accompanying report) reports a value for 2017 of 495 Mt CO^2 eq. In addition, CERC uses common metrics from the IPCC's 4th Assessment Report, whereas both the NIR and the current technical analysis use common metrics from the IPCC's 2nd Assessment Report. Also, as noted above, CERC, in common with most other quantified burden-sharing analysis, excludes land use emissions / sinks. The impact of variations in historical emissions will result in an error roughly equal to the difference in emissions between the last historical value in CERC and actual historical emissions, multiplied by the relative hypothetical growth of the economy. This can be quantified precisely once the current draft NIR is finalised. The exclusion of land use emissions will have a negligible impact on the allocation of South Africa's "fair share", given CERC's methodology, in the period up to 2030, but could have a far more significant impact up to 2050 for more ambitious emissions trajectories.

5.2 Climate Action Tracker

The fair share analysis under the CERC tool is contrasted with analysis developed by the Climate Action Tracker (CAT 2019), which takes a broader approach to quantifying emissions pathways in the light of equity, without necessarily taking a viewpoint on the effort-sharing approaches used, and without specifically prioritising

particular equity principles, in the way that CERC prioritises capability, responsibility and right to promote sustainable development.

5.2.1 CAT Methodology

The Climate Action Tracker (CAT) is an online data tool that tracks and evaluates the climate commitments and actions of 32 countries with significant annual emissions. CAT is developed and maintained by a consortium of three European research institutes, namely Climate Analytics[19], New Climate Institute[20] and Potsdam Institute for Climate Impact Research (PIK)[21], with analysis based on PRIMAP datasets and future projections based on country pledges, NDCs, and current policy projections (drawn from a combination of country, independent and international aggregate – e.g. IEA World Energy Outlook – analysis). As with CERC, there are two global emissions scenarios used in CAT: the first assume a 66% probability of keeping global temperature increase below 2 °C, and the second is based on keeping global temperatures within 1.5 degrees, with some limits imposed on the use of carbon absorption in the second half of the century. As with CERC, CAT EXCLUDES land use emissions, which have been added here on the same basis as for CERC (using the land use baseline from this study). Global pathways for 1.5°C and 2°C are derived from a collection of underlying climate models from the IPCC AR5 Scenarios Database (see Krey et al. 2014a). We have here equated "well below 2 degrees" with a 66% chance of keeping below 2 degrees, even though this is not a view supported by CAT.

CAT attempts to tackle the challenge of competing principles in different equity frameworks by combining the emission results of multiple (more than 50) underlying mitigation effort-sharing studies – including the GDR – and categorising the studies into sets of normative equity 'categories', namely 'responsibility', 'capability', 'equality', 'equal cumulative per capita emissions', 'responsibility, capability and need', 'cost effectiveness', and what they term 'staged approaches' which resemble some progressive combination of multiple approaches. Data from each of these studies undergoes a harmonisation process in order to be comparable, by scaling the emissions levels of a particular historic year to the PRIMAP data point for that year. A detailed breakdown of the studies and 'categories' used and the data harmonization process is provided in a publication and supplementary material by CAT authors (Höhne et al. 2014). It should be noted that, contrary to what is suggested by the authors, the IPCC does not endorse any approach or set of approaches to equity benchmarks, frameworks or effort-sharing paradigms.

Nevertheless, the CAT tool provides a useful aggregation of fair share analyses for countries, from a wide range and diverse range of literature that operationalises equity according to different principles. The harmonisation of data drawn from multiple sources provides a robust, readily comparable dataset by which to objectively analyse individual countries. For this reason, we propose to refer to CAT's analysis to complement the more specific and relevant results determined from the CERC, and situate South Africa's fair share within a broader set of perspectives.

5.2.2 CAT ratings and caveats

A number of caveats regarding the CAT analysis, including the normative treatment of equity, and the inclusion of questionable equity principles in its pool of analyses, such as 'grandfathering' emissions allocations based on existing proportions (Böhringer and Welsch 2006)(Robiou du Pont et al. 2016) which cannot be reconciled with the principles of historic responsibility or right to sustainable development, and arguably embed bias against developing countries in such analyses (Kartha et al. 2018). One element of their methodology which potentially introduces elements of bias is that in aggregating burden-sharing approaches for each country, "outliers" are excluded purely on the basis of lying at the top and bottom of each country's emissions allocation for a specific year. This is based on a false equivalence between statistical data on normatively-based equity analyses. Another problem, which is unavoidable, is that many burden-sharing analyses in the literature are out of date, either in terms of their approach to the global temperature /

[19] https://climateanalytics.org/

[20] https://newclimate.org/

[21] https://www.pik-potsdam.de/

emissions goal, or more commonly in terms of their use of outdated baselines, given the dramatic shift in mitigation costs over the last decade.

Another particularly noteworthy element of CAT is the normative rating system it applies to countries' NDCs, based on a further elaboration of the aggregation of countries 'fair share ranges' derived from the underlying 50+ equity analyses. CAT goes further, and aggregates these individual fair share ranges into a 'global fair share range'. CAT then overlays the global pathways it aggregated previously, for 1.5°C and well below 2°C, over the global fair share range, and by this means the global fair share range is divided into 3 bins – "1.5°C Compatible", "2°C Compatible" and "Insufficient" (the green, yellow and orange bars, respectively, as illustrated in Figure 7). The equivalent proportions between these three bins are then retroactively applied to each of the afore-mentioned country fair share ranges; the implication is that if country A's emission level is within the "Insufficient" range, then country B would have to take an "extra" share, in order for the global aggregate to be within the 1.5°C/2°C. This leads to the slightly contradictory situation that a specific country's fair share for a specific temperature limit in the first part of the methodology is contradicted by the last step, which effectively produces a different "fair share" for the same temperature limit. The virtue of this step is that it does (without stating this) indicate what, given a set of different burden-sharing approaches, would constitute a progressive choice in terms of NDC target, which would be less dependent on other countries choosing a burden-sharing approach not favourable to them.

While this methodology contains a certain degree of merit, it also lends itself to the false notion that there any form of direct link can be drawn between an individual country's emissions and policies and a resultant global temperature outcome. A clear example of the shortcomings of this reduction approach to equity is found in a paper based on the Paris Equity Check (Robiou du Pont et al. 2016), where such direct links are explicitly made: "When taken as benchmark by other countries, the NDCs of India, the EU, the USA and China lead to 2.6 °C, 3.2 °C, 4 °C and over 5.1 °C warmings, respectively."(du Pont and Meinshausen 2018) In simple terms, this approach lends itself to the unfortunate, and incorrect, conclusion that an individual country can be "blamed" for a particular temperature outcome[22], whereas global temperature increase is a function of global cumulative emissions over long periods.

Bearing in mind these shortcomings, we apply an 'adjusted' CAT approach to contextualise the outcomes determined by CERC against an aggregation of other burden-sharing approaches. At the same time, we have also reflected CAT's actual analysis to give an indication of how South Africa's NDC target will be rated by CAT. In this regard, the aggregation of underlying burden-sharing analyses provide multiple perspectives from which to contextualise a country's fair share, and we refer to this element of the CAT methodology in our framework here. We should reiterate that the value of applying elements of CAT's analysis is that the approach does attempt in its methodology to take into account as many approaches as possible.

5.2.3 CAT (adjusted) application to South Africa

Figure 7 below portrays the CAT underlying burden-sharing results, adjusted for land use, organised into categories and temperature pathways, the ranges for each category being represented by the black vertical lines, the medians in each category represented by the green points, the upper and lower ranges of the corresponding "fair share" ranges portrayed by the dashed orange and red lines, and the average of medians per temperature category represented by the dotted red lines. The distribution of the range of results using different approaches to the equity question qualifies the overall range, which is broad and contained in Table 3 below.

[22] See, e.g., The Guardian

Table 3 – Emission level ranges derived for South Africa under CAT analysis, drawn from a range of equity benchmarks , compared to the NDC ($MtCO_2$-eq (excl. LULUCF)) (Climate Action Tracker 2019)

	Emission level	2025	2030
Excluding land use	Lower bound of equity range (1.5°C)	282	193
	Upper bound of equity range (1.5°C)	591	590
	Lower bound of equity range (well below 2°C)	290	240
	Upper bound of equity range (well below 2°C)	536	521
Land use emissions baseline		-10.34	-11.18
Adjusted to include land use emissions	Lower bound of equity range (1.5°C)	272	182
	Upper bound of equity range (1.5°C)	581	579
	Lower bound of equity range (well below 2°C)	280	229
	Upper bound of equity range (well below 2°C)	526	510
	Fair share range, including land use	272-581	182-579

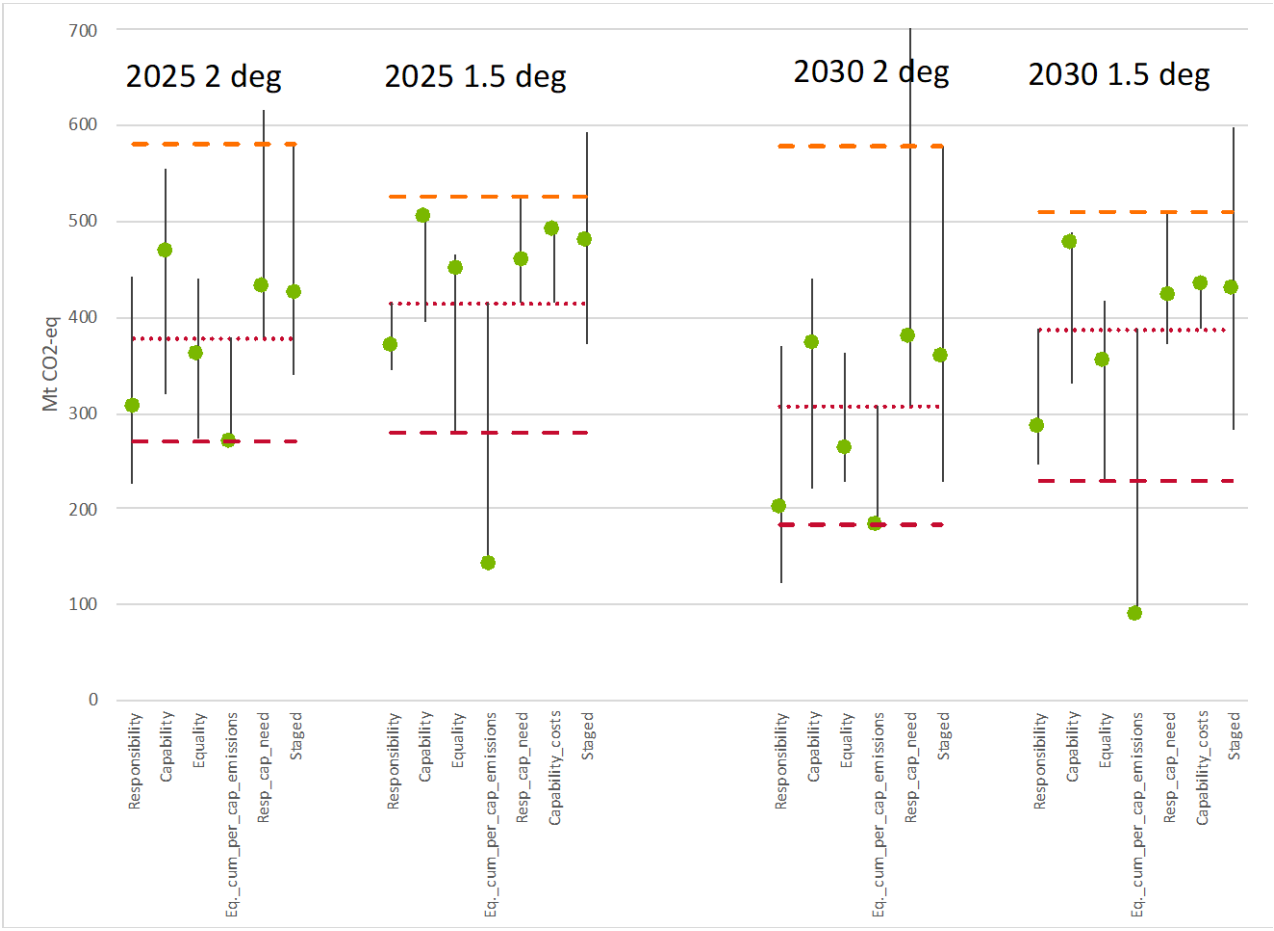

Figure 11 – CAT burden-sharing analysis for South Africa divided by category, with median and "fair share" ranges for 2025 and 2030

Table 4 is a summary of the 'fair share' emission level ranges CAT determines for South Africa, across the multiple equity studies, for 1.5°C and 2°C pathways, adjusted for land use. Figure 8 shows the ranges for 2025 and 2030, compared to the PPD (adjusted to exclude LULUCF). Note that, due to the selection of studies CAT makes for the equity analyses, the fair share range it determines for South Africa is actually higher for 1.5°C than for well below 2°C[23]. The fair share range which CAT defines for each country extends from the lower value to the higher value for both temperature ranges, which gives the fair share ranges in the last line. The wider extent for the 1.5 degree pathway is the result of a slightly different combination of approaches (since not all approaches include a 1.5 degree pathway). Figure 8 portrays the "fair share" range (in shaded yellow) for 2025 and 2030, contrasted with the PPD. The dashed lines are the average of the median values for 2 degrees and 1.5 degrees respectively. While the fair share range is very broad and encompasses most of the PPD range, the PPD only covers HALF of the fair share range, the median averages indicate a) that most approaches decline from 2025 to 2030, and b) that the averages lie in the bottom half of the fair share range and mostly below the PPD. The red, yellow and green labelled bars on the right of the fair share range show the end point of the CAT methodology, i.e. how South Africa's fair share is currently assessed by CAT.

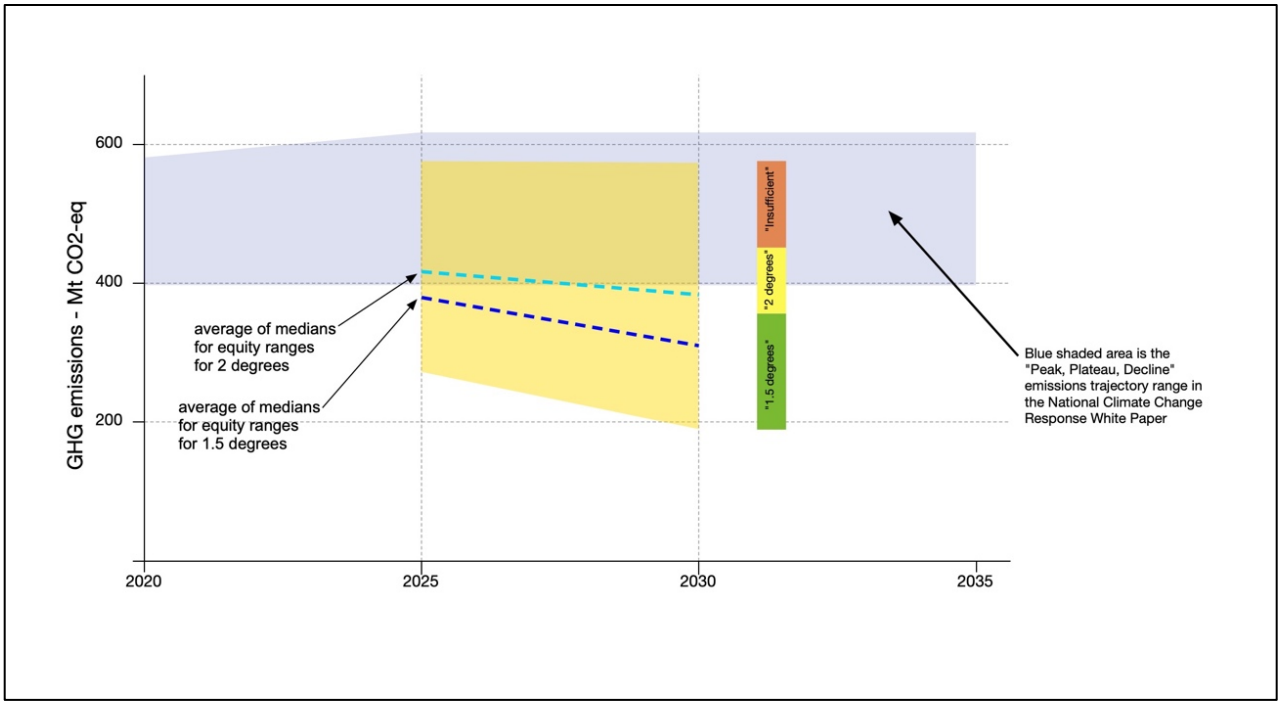

Figure 12 – "Fair share" ranges for South Africa compared to the PPD in 2025 and 2030 based on CAT analysis for 1.5°C and 2°C pathways

5.3 Equity lens: CERC with CAT (adjusted)

Combining CERC and CAT analysis as above (adjusted for land use, and using elements of the underlying CAT data and some of the CAT methodology), we show the proposed equity lens through which the fairness of South Africa's mitigation potential can be considered for the purposes of updating South Africa's NDC in 2020. The lens is portrayed in Figure 9 below, comparing the CERC allocation range for South Africa (orange and red shaded areas in the centre), the CAT fair share ranges (in yellow), the CAT category median averages (dotted lines), the PPD (blue shaded area) and the current NDC ranges for 2025 and 2030 (black bars). The figure also portrays CAT's current assessment scale for South Africa (yellow, green, red bars). This equity lens will be applied to potential NDC ranges for the update as well as to GHG emissions modelling results for 2025 and 2030 in the main technical report.

[23] As with CERC, scenarios from CAT assume a 66% probability of keeping global temperature increase below 2 °C, and are labelled "well below 2 °C" in this analysis.

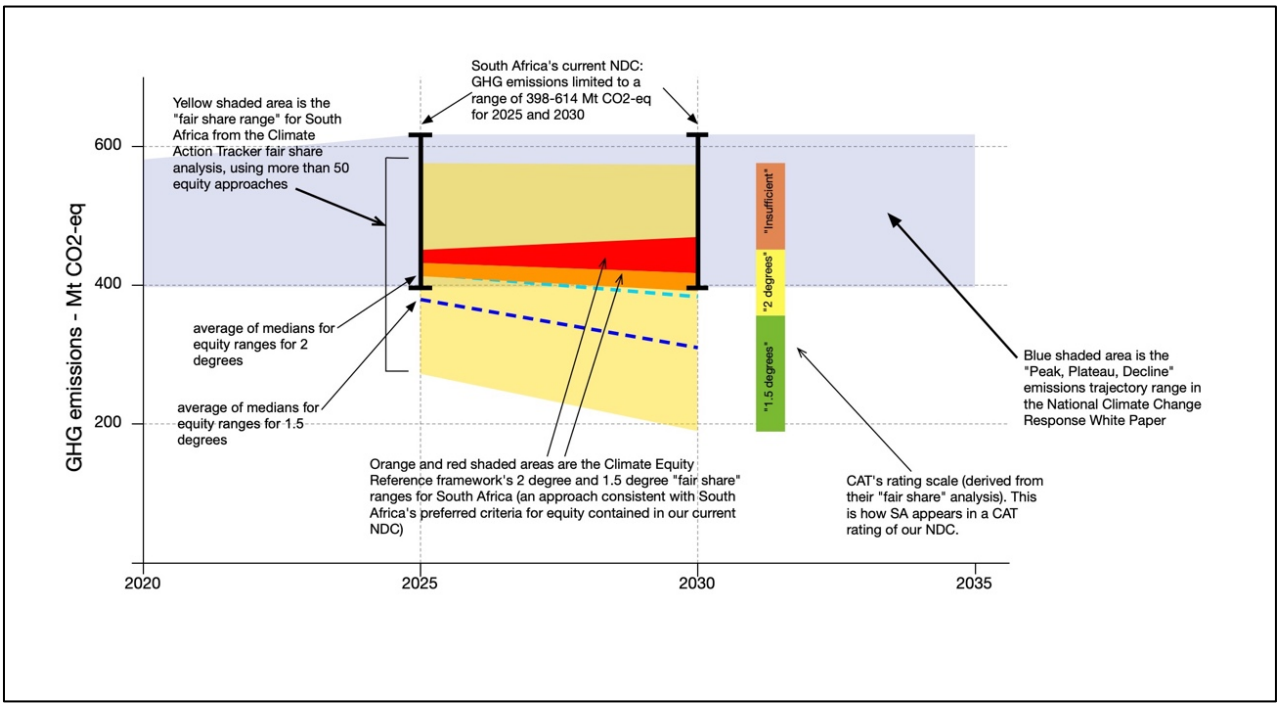

Figure 13 – CERC/CAT equity lens for South Africa's NDC update, 2025 and 2030

5.4 Addendum – updated estimates for South Africa's fair share based on the post-COVID version of CERC, and the CAT update

Since the above analysis was conducted, The Climate Equity Reference Project (CERP), which maintains the CERC, has indicated in correspondence with the authors of this report that the CERC will be updated to reflect more recent data and economic growth projections of the post-COVID era, which will change the assessment of South Africa's "fair share". Additionally, analysis based on the new data has been used as the basis for an assessment by the Climate Equity Reference Project, using the CERC, of South Africa's fair share, titled "Comparison of South Africa's draft updated mitigation NDC to its mitigation fair share", commissioned by Earth Justice and the Centre for Environmental Rights (CER), and dated April 25, 2021. The assessment notes that:

> "The Climate Equity Reference Calculator version used in this memo utilized version 7.3.0 of the calculator core database. This version is not yet publicly available (but access can be arranged upon request) and the public version of the Calculator (calculator.climateequityreference.org) is utilizing version 7.2.0. The main differences between version 7.3.0 and 7.2.0 is that the former accounts for updated GDP data and GDP growth projections that are a result of the Covid-19 pandemic. GDP data and projections, in turn, strongly impact the baseline projections of the Calculator for all countries, and the world, including South Africa." (Climate Equity Reference Project 2021)

The assessment was attached to CER's submission to DFFE on the draft updated NDC, and CER drew on the assessment to make the claim in their submission that the CERP assessment does not support the contention made in the NDC that the mitigation target range constitutes South Africa's "fair share". The nature of the deviations are explored below, as well as some of the differences between the approach used here (and by DFFE in their presentations on the NDC target range). Comparisons here are for 2030 only (i.e. not for 2025) since the assessment only considers 2030.

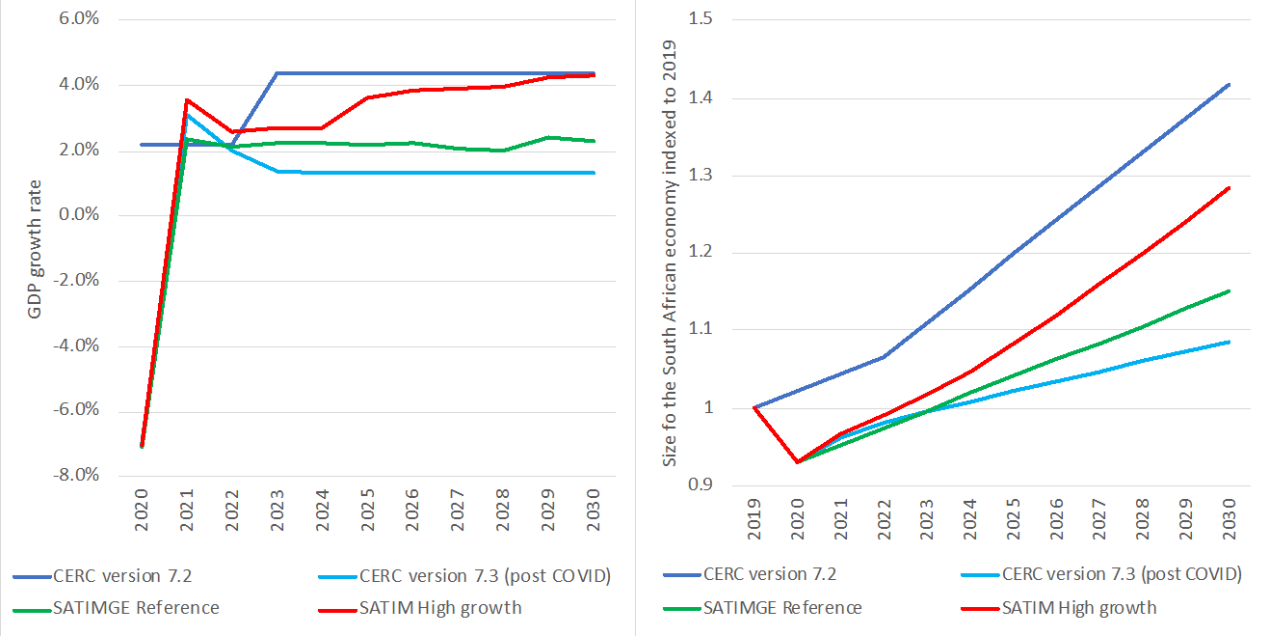

Figure 14 – Comparison of South African GDP growth rates used in CERC versions 7.2 and 7.3, and SATIMGE growth projections (left), and the resulting size of the South African economy.

The assessment used a slightly different approach to the analysis conducted here. In addition, the assessment provides detailed information on the underlying GDP projections (used to calculate the South African baseline), and includes a sensitivity analysis using the SATIMGE GDP projections used in the SATIMGE model for the modelling of South Africa's future GHG emissions in the technical work carried out by UCT to support DFFE's identification of the proposed NDC update target ranges. Since the level of the baseline determines the GHG emissions level of a country's fair share in the CERC framework, the fair share is very sensitive to changes in the baseline. From versions 7.2 to 7.3 of CERC, South Africa's baseline value in 2030 changes from 652 Mt CO2-eq to 498 Mt CO2-eq as a result of very different economic growth rate assumptions adopted in the wake of COVID. The underlying growth rates are presented in Figure 15 below. The CERC 7.2 assumed growth rate is relatively optimistic and does not take into account the COVID shock. The CERC 7.3 assumed growth rate is sourced from the International Monetary Fund's April 2021 World Economic Outlook[24], which is pessimistic, forecasting growth for South Africa of 1.3% to 2026. CERC version 7.3 uses the same growth rate to 2030. It is probably true in retrospect that the much higher growth rate in CERC 7.3 overallocated South Africa's fair share. The use of the pessimistic growth rate in CERC 7.3 results in a much lower share, but in order to compare the analysis which CERP the differences in methodology are first described.

As above, CERC uses three global GHG emissions pathways – one which has a 66% chance of keeping temperature rise under 2degrees C, a 1.5 degree pathway, and a 1.5 "low energy development" (LED) pathway, which depends more on higher energy efficiency / lower energy intensity and less on natural and artificial sinks to keep temperature rise to within 1.5 degrees. The methodologies used in the current study and the CERP NDC assessment are contrasted as follows:

- Current (ESRG UCT) study: a "fair share range" is identified using CERC, using settings as follows: i) 1950 for historical emissions; ii) a USD7500 income threshold, and no "progressivity" (i.e. all emissions from people above the USD7500 threshold are counted). The upper point of the 2 degree range is the point using a 2 degree global pathway, and the lower point of the 2 degree range is the point using the 1.5 degree global pathway. The 1.5 degree range extends from the point using the 1.5 degree range to the point using the 1.4 LED range.

[24] Data downloaded from https://www.imf.org/en/Publications/WEO/weo-database/2021/April/weo-report?c=199,&s=NGDP_R,NGDPD,&sy=2019&ey=2026&ssm=0&scsm=1&scc=0&ssd=1&ssc=0&sic=0&sort=country&ds=.&br=1

- CERP NDC assessment: The assessment defines a 2 degree fair share range and a 1.5 degree fair share range, using the 2 degree global pathway and the 1.5 LED pathway. The range for each temperature level is derived from using the CERC with two sets of parameters. For the upper end of each range, i) 1850 is used for historical emissions; ii) a USD 7500 income threshold is used, and the "progressivity" option is used. For the lower end of each range, i) 1950 is used for historical emissions, ii) a USD 7500 income threshold is used, without any progressivity.

The results of both the CERP and ESRG analyses, with sensitivity analyses with different growth rates, are presented in Figure 16 below, and contrasted with both the proposed NDC targets, the CAT fair share range, and likely GHG emissions outcomes with different levels of growth and degrees of implementation of mitigation policies.

The CAT also updated their fair share ranges slightly in September 2020. The previous version, updated in 2019, was used for the above analysis. A comparison between the values is contained below in Table 4.

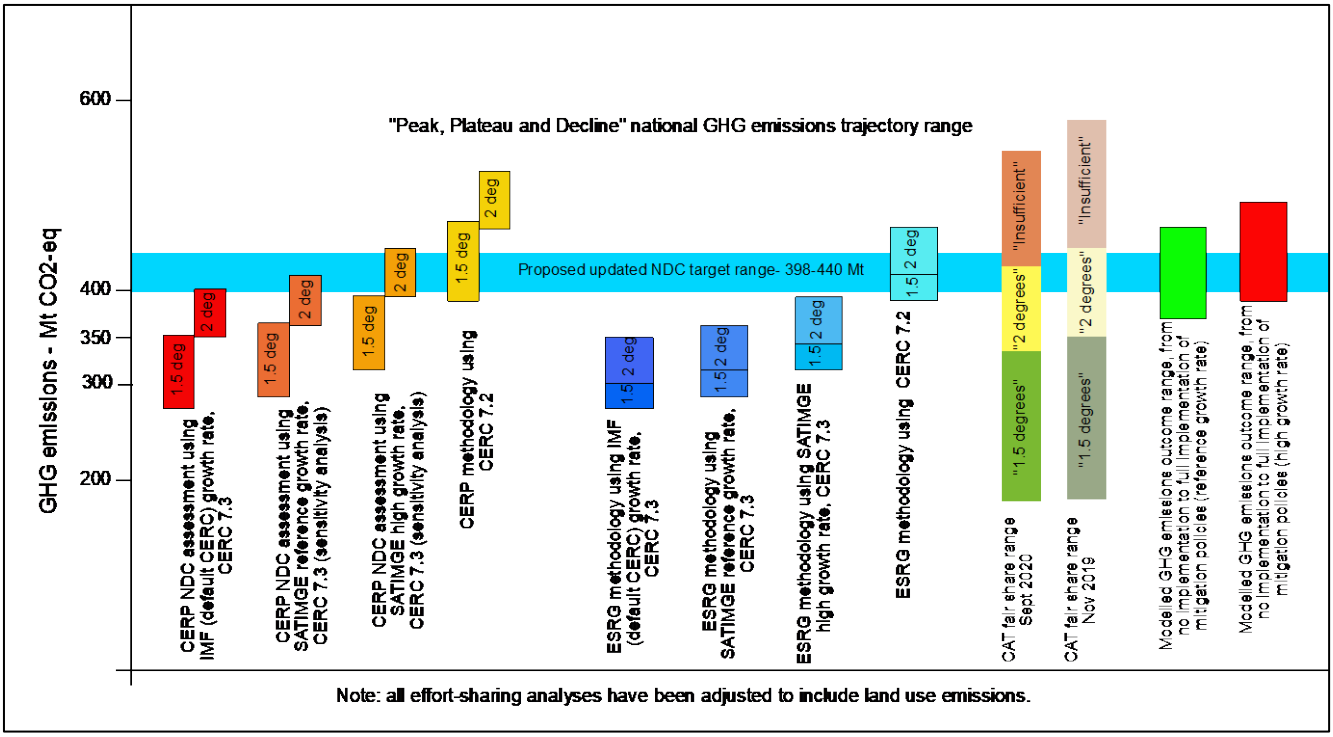

Figure 15 – Comparison of fair shares for 2030: on the left 1.5 and 2 degree ranges a) as contained in the CERP NDC assessment, b) and c) sensitivity analyses from the CERP NDC assessment using the SATIMGE growth projections, and d) the CER assessment methodology using CERC 7.2 (the previous version of CERC which was used for the analysis here). And on the right, d), e) and f) – using the same set of growth rates and CERC 7.3, but using the ESRG methodology, and g) the current assessment using CERC 7.2 above. To the right of this is the CAT fair share range (updated – 22 Sept 2020 version), for comparison, which is slightly lower than the version used in this analysis below – see below). All results have been adjusted to include land use emissions, to allow comparison with the proposed NDC target range. The two bars on the far right are the results of SATIMGE GHG emissions modelling (with reference and high growth rates). The top of each GHG emissions range represents GHG emissions outcomes with no policy implementation, and the bottom of each range represents emissions outcomes with full implementation of mitigation policies.

In the 2019 CAT fair share, the upper end of the proposed NDC range would have been classified by CAT as "2 degree compatible". But in the updated version, the upper end of the NDC range is classified as "insufficient".

The result of these two updates (of CERC and CAT) is that whereas previously there were strong reasons to believe that the 2030 South African NDC target could be considered South Africa's "fair share", the updated values place only the lower value of the 2030 target in CAT's 2 degree category, and in the CERC 2 degree category (using the CERP methodology). The changes are driven by two impacts of the post-COVID world: the

first is an expectation of lower global emissions (hence a lower burden to be divided), and the second is driven by lower growth expectations for South Africa. For the purposes of this analysis, the updated values of CAT and the CERC values derived from the sensitivity analyses using consistent economic growth rates with the technical analysis of GHG emissions pathways for South Africa (UCT 2021) have been added to Figure 12, and are presented in Figure 15 below.

Table 4 – A comparison between the CAT fair share ranges for 2019 and the September 2020 update.

	Without land use		With land use[25]	
	2020	**2019**	**2020**	**2019**
Bottom of fair share range (limit between Role Model and 1.5°C Paris Agreement Compatible)	188	193	177	182
Limit between 1.5°C Paris Agreement Compatible and 2°C Compatible	348	364	337	353
Limit between 2°C Compatible and Insufficient	437	457	426	446
Upper end of fair share range or limit between Insufficient and Highly insufficient	559	590	548	579

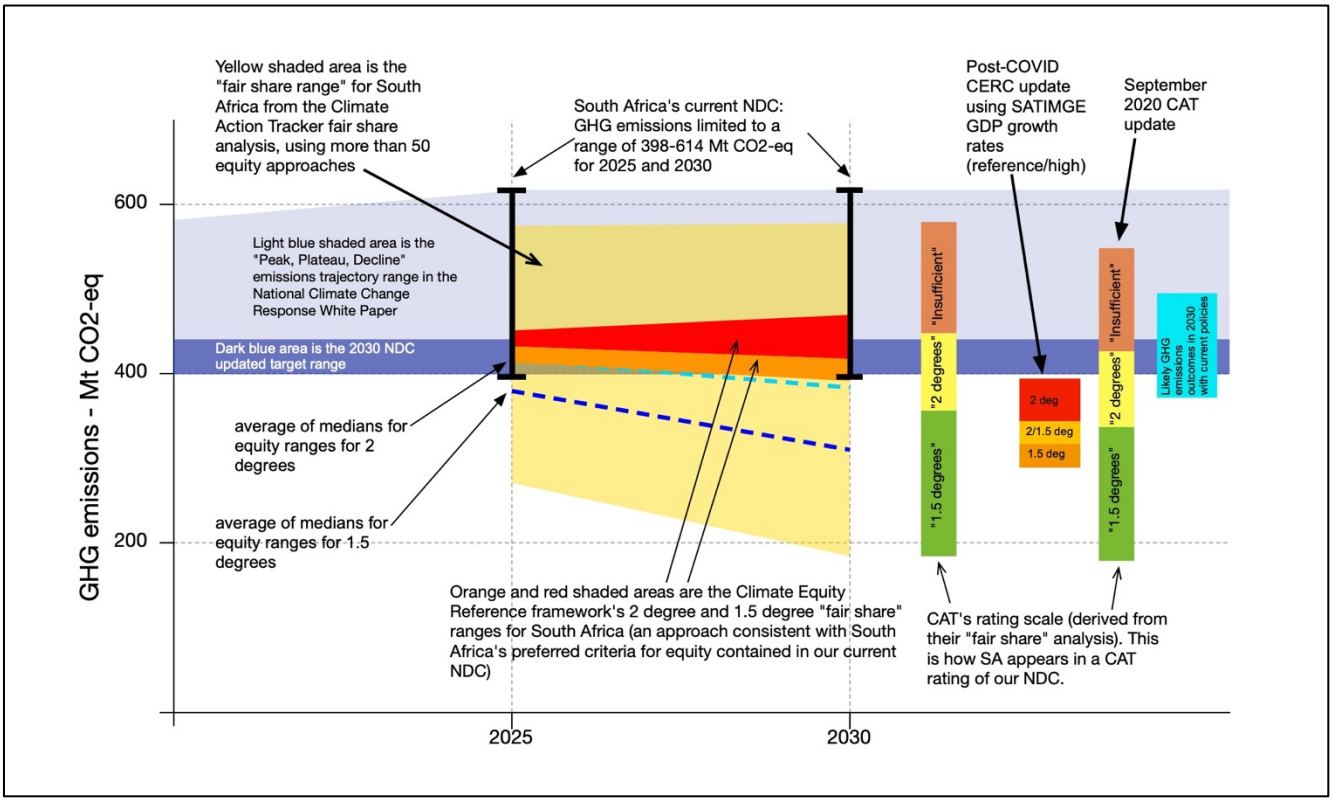

Figure 16 – CERC/CAT equity lens for South Africa's NDC update, 2025 and 2030, with added updated "fair share" ranges for CAT (post September 2020) and CERC (May 2021). The CERC range here is derived from a sensitivity analysis using SATIMGE growth rates as described above. The single bar (with 2, 2/1.5 and 1.5 divisions) combines the reference and high growth rate sensitivity analyses presented in Figure 14 and described above. The 2/1.5 block is where the two ranges overlap. The bar on the right indicates likely GHG outcomes in 2030 with different growth rates and degrees of policy implementation, of the implementation of currently planned policies.

[25] Note that as above, CAT converts target values which include land use by adding 16 Mt, based on average historical land sector emissions for South Africa. Here a value of 11.3 Mt has been used, based on a projected land use baseline.

6 South Africa's international positioning

While the actions of every country are important in reaching the Paris goals, it is particularly important to consider the mitigation ambition of major emitters in establishing reasonable minimum expectations for the levels of mitigation effort required by developing and developed countries. The political understanding reached between China and the US in the runup to the Paris Agreement was particularly important in establishing a balance between developed and developing countries in the context of reaching the Agreement in Paris. This was based partly on a commitment to mitigation actions in the 2020s, and given that the architecture of the Paris Agreement is based on nationally-determined commitments, commitments by the two largest emitters is politically very significant. While the Trump era in the USA led to the withdrawal from the Paris Agreement of the world's second-largest emitter, and largest developed country emitter, the Biden Administration has since re-joined the Agreement and submitted a new NDC. The commitments of China and the EU to their respective net zero emissions targets in 2050 and 2060 provides an initial framework for a net zero global pathway. How do other major emitters compare in terms of their "fair shares"? This is an important question, as SA considers increasing its level of ambition. This section provides a review of four key Parties (China, EU, USA, India), which comprise between them around 50% of current annual global emissions.

6.1.1 China peaking level and year

Although China has not communicated an updated NDC, a long-term net zero target has been announced for 2060, a very significant move for the world's largest emitter.

Figure 15 presents CERC and CAT fair share ranges for China, applying a 50:50 weighting of Responsibility and Capability, with historical emissions cumulative since 1950. China's NDC is rated "highly insufficient" by CAT, but probably falls within CERC's fair share range. The target range is based on an assessment by CAT based on a range of possible outcomes for China's emissions intensity target. It is not clear at this stage whether China will formally update its NDC this year.

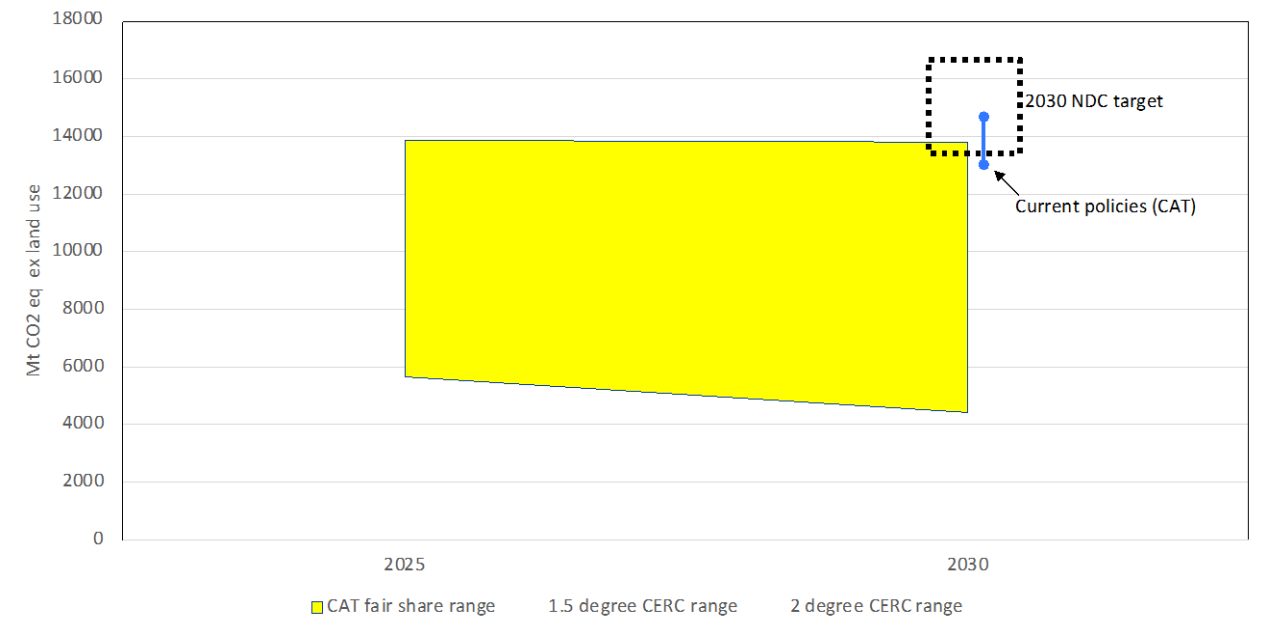

Figure 17 - China's fair share for CAT and CERC compared to their NDC target

6.1.2 European Union

The European Union communicated an updated NDC to the UNFCCC in December 2020. The updated NDC specifies an increase in their mitigation target from 40% reduction below 1990 levels to 55% below 1990 levels. Although this new target has not been rated by CAT, their estimate is that the outcome would rank the EU's new target as "inadequate". Figure 16 shows the CERC and CAT fair share for the European Union, applying the CERC with a 50:50 weighting of Responsibility and Capability, with historical emissions since 1950.

The CERC rating of the EU's NDC target would be significantly harsher, and on account of the EU's historical responsibility and capability, would require the EU to take on a much bigger proportion of the global mitigation burden to be Paris-compatible.

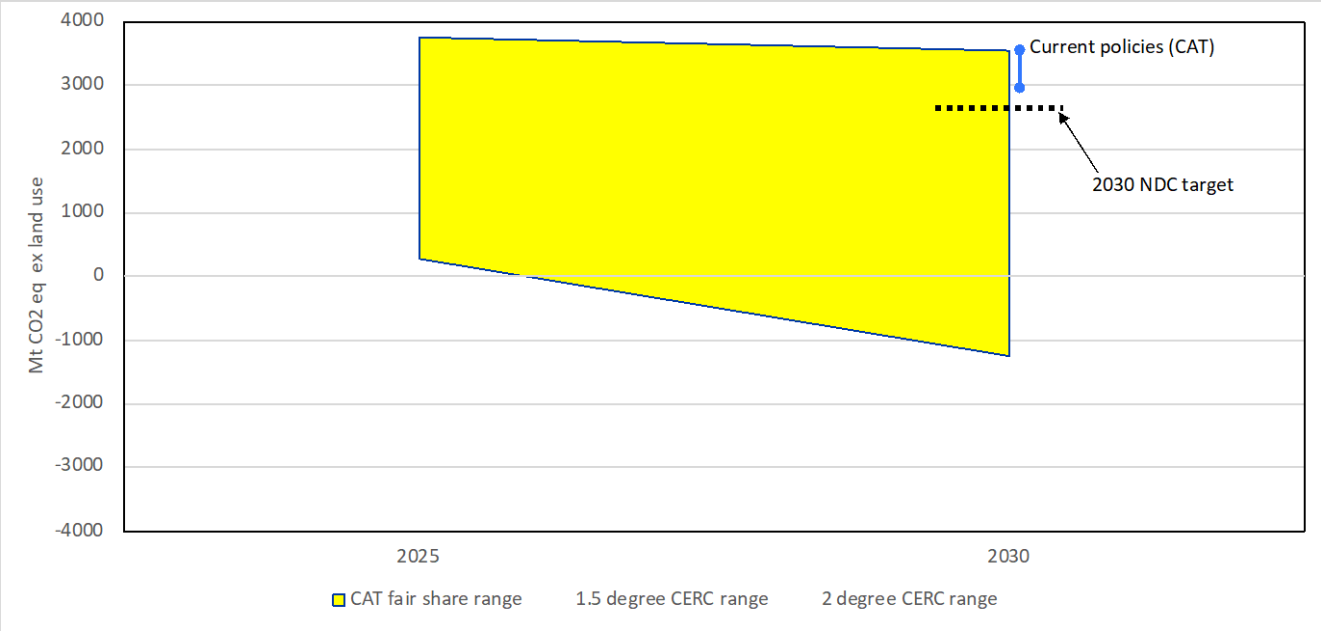

Figure 18 – The EU's fair share for CAT and CERC compared to their NDC target

6.1.3 United States

The United States, shortly after rejoining the Paris Agreement under the Biden Presidency, submitted a new NDC in April 2021. Their previous NDC contained a 2025 target, and ceased to have any legal significance when the US withdrew from the Paris Agreement in 2020. The new NDC contains a 2030 target of a 55% reduction of emissions below 2005 levels. Figure 17 shows the CERC and CAT fair share for the United States, applying the CERC with a 50:50 weighting of Responsibility and Capability, with historical emissions since 1950. The new Cat ranking would be "insufficient". The CERC raking, as in the case of the EU, would require the USA to source additional emissions reductions elsewhere to be "Paris compatible".

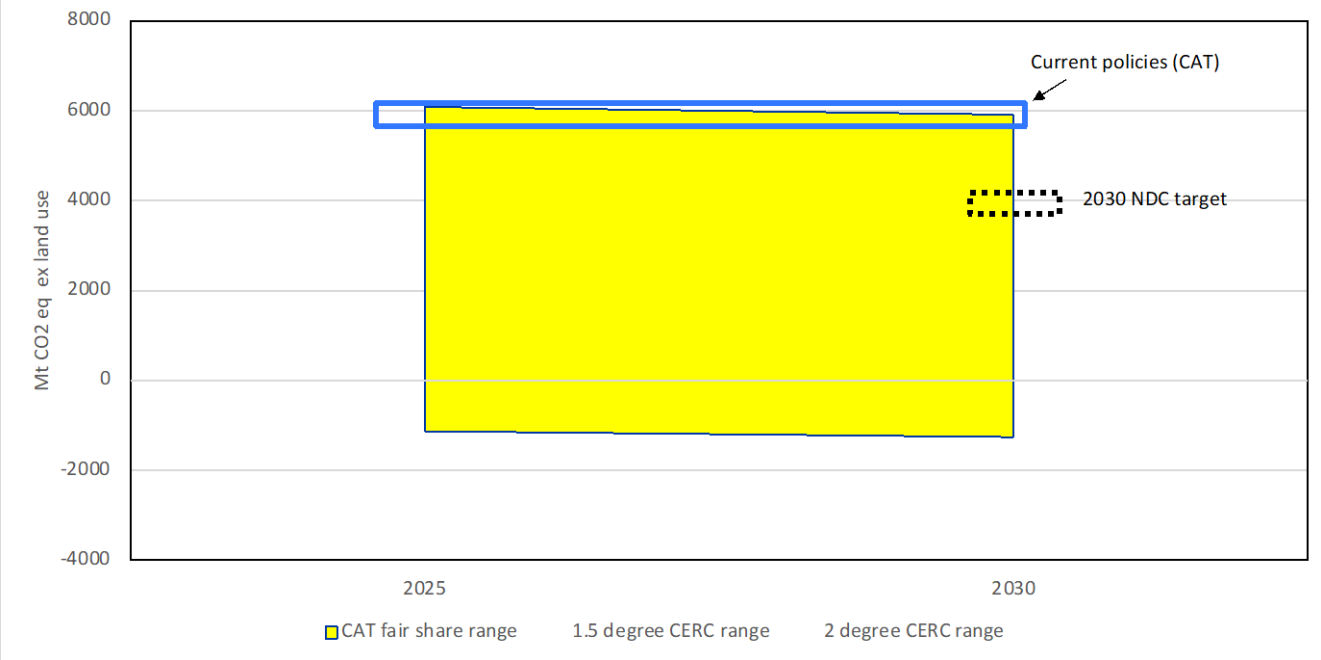

Figure 19 – The USA's fair share for CAT and CERC compared to their NDC target

6.1.4 India

India has announced that it has no plans to update its NDC in2020/21. . Figure 18shows the CERC and CAT fair share for India, applying the CERC with a 50:50 weighting of Responsibility and Capability, with historical emissions since 1950. Cat rates India's NDC as "2 degrees compatible.

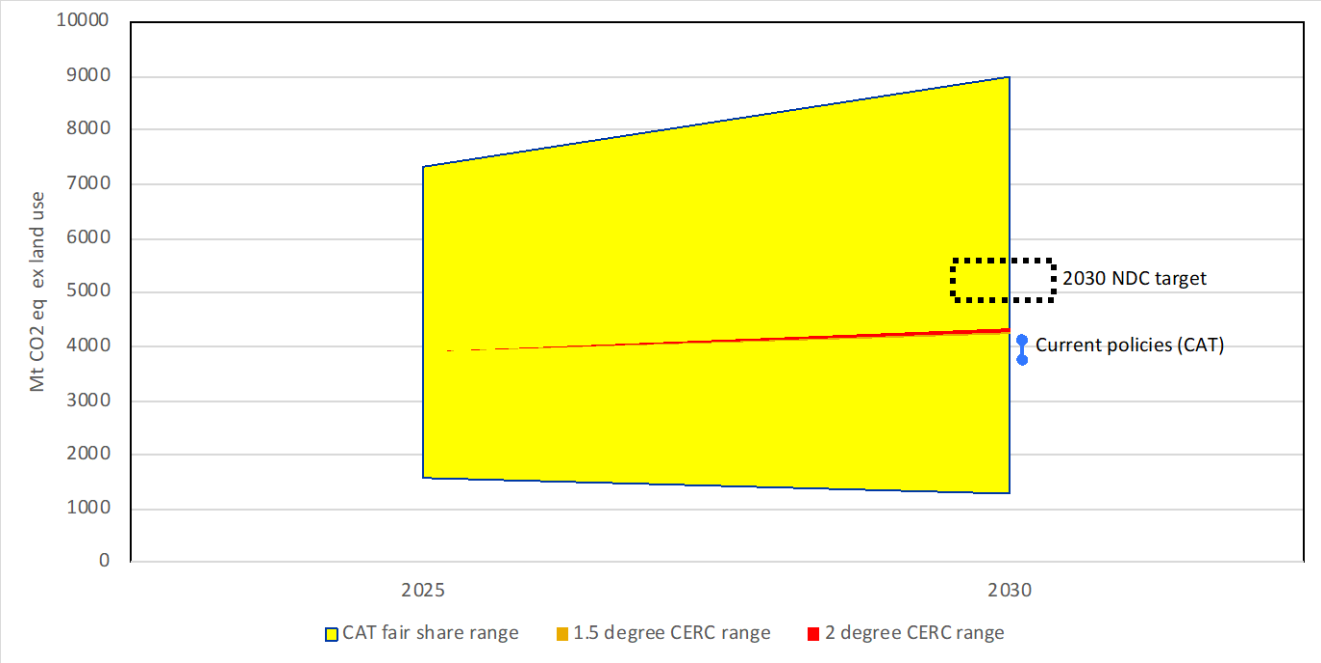

Figure 20 – India's fair share for CAT and CERC compared to their NDC target

6.1.5 A comment on overall rankings of other countries

Of the 29 countries (including the EU, and separately, some of its member states) which CAT ranks, only two are "1.5 degree compatible" (Morocco and The Gambia) and another 6 are "2 degree compatible". This is not really a surprise, and an indication of the fact that overall, mitigation ambition is not sufficient to reach either 2 degrees or 1.5 degrees.

7 Conclusion: The Framework

7.1 Burden-sharing analysis of the mitigation targets

Based on this review, it is recommended that the CERC be used as core to the approach. CERC has a good fit with the approach taken by South Africa, emphasising historic responsibility, capability and right to promote sustainable development as equity principles, based upon which it allocates shares of the global mitigation burden, for well below 2 °C and 1.5 °C. This is consistent with the equity principles and values that have informed South Africa's decision-making in the past, and will continue to be fundamental to a global response to climate change that is just and fair. This should be considered in the context however of the caveats on the approach to the baseline, and the sensitivity of the resulting fair share outcomes. CERC analysis should be compared to the CAT (adjusted) approach described above, to provide validation and further insight into contemporary perspectives on South Africa's, and others', fair shares. CAT is an influential tool and, whilst its various interpretations of NDCs as 'insufficient' or 'role model' have flaws which have been highlighted above, the underlying aggregation of multiple burden-sharing analyses provide a comprehensive evidence base that offers multiple different perspectives on equitable mitigation contributions. It is also the most often cited equity reference framework. Combining CERC and CAT provides the following potential "equity lens" for South Africa's fair share emission allocation in 2025 and 2030, for a pathway consistent with keeping temperature increase well below 2 °C, as described in Section 3.3 above. An amended version of Figure 12 with the updated assessments from CAT and CERC has been provided in Figure 15, with the proposed NDC target range for 2030

(contained in the updated NDC released for public comment in April 2021) included for comparison. The implication of the revised equity lens is that South Africa's target range in 2030 is not ambitious enough in terms of the revised CERC and CAT assessments to be consistent with the Paris Agreement's temperature goal. This should be considered in the context of how the NDC target range is framed. It may be possible to consider making the bottom end of the range more ambitious. Within the range, however, South Africa will have to decide on what opportunities exist to achieve a more or less ambitious outcome by 2030. A more ambitious outcome will probably require significantly larger degrees of international cooperation and support.

7.1.1 Investments in mitigation and international support – relative fair shares

South Africa is making significant domestic investments in mitigation. For example, South African investors accounted for four-fifths (80%) of equity and financing in the REI4P programme over the first four bid windows (IPP office 2019). that has dramatically increased the installed capacity since 2010. The official electricity plan foresees 8 288 MW of solar PV and 17 742 MW of onshore wind by 2030, together accounting for a third of total installed capacity by 2030. This is likely not to require any international climate finance.

However, to further enhance the ambition of targets in our current mitigation NDC, and this includes a bold programme targeting key emissions sources. Some of these sources require support, notably in the electricity sector going beyond the investments in RE.

> "To this end, a proposed 11 Billion US dollar Just Transition Transaction is being developed under the auspices of the Eskom Sustainability Task Team. The 11 billion dollars would consist of a blended finance facility and would be the largest climate finance transaction to date, having a significant emissions impact." (President Ramaphosa, in his communication to the UN Secretary General, 2019)

7.1.2 Relative fair shares in meeting costs of adaptation

In its first NDC, the following statements were made:

> "South Africa views adaptation as a global responsibility in the light of Article 2 of the Convention as further codified in the UNFCCC as a temperature goal. Further understanding climate impacts as being driven by global inaction / action on mitigation, the adaptation burden is therefore a global responsibility. It is in that light that South Africa considers its investments in adaptation as a contribution to the global effort, which should be recognised as such. Further information is provided in the equity section of the INDC."
>
> "An assessment of equity also needs to take into account means of implementation. Generally, South Africa needs time for development, which is necessary to eliminate poverty, reduce inequality, increase employment and promote inclusive economic growth, while simultaneously seeking to contribute to mitigation and assist our vulnerable communities in adapting to climate impacts. Some specific finance and investment requirements for both adaptation and mitigation have been initially quantified above." (RSA 2015).

South Africa continues to hold that it is particularly vulnerable, that is own investments in adaptation are a contribution to the global effort and that equity means that support should be provided, where SA's adaptation needs exceed its capacity to adapt.

8 References

Baer, P., G. Fieldman, T. Athanasiou, and S. Kartha, 2008: Greenhouse Development Rights: towards an equitable framework for global climate policy. *Cambridge Review of International Affairs*, **21**, 649–669, https://doi.org/10.1080/09557570802453050.

Blanford, G. J., E. Kriegler, and M. Tavoni, 2014: Harmonization vs. fragmentation: Overview of climate policy scenarios in EMF27. *Climatic Change*, **123**, 383–396, https://doi.org/10.1007/s10584-013-0951-9.

Böhringer, C., and H. Welsch, 2006: Burden sharing in a greenhouse: Egalitarianism and sovereignty reconciled. *Applied Economics*, **38**, 981–996, https://doi.org/doi: 10.1080/00036840500399453.

CASS / DRC Joint Project Team, 2011: Equitable access to sustainable development: Carbon budget account proposal. *Equitable access to sustainable development: Contribution to the body of scientific knowledge*, BASIC Expert Group.

Civil Society Review, 2018: After Paris: Inequality, Fair Shares, And the Climate Emergency. *A Civil Society Science- And Equity-Based Assessment of the NDCS*, **6**, https://doi.org/10.4324/9781315212470-11.

Climate Action Tracker, 2019: South Africa. https://climateactiontracker.org/countries/south-africa/.

Climate Equity Reference Project, 2021: *Comparison of South Africa's draft updated mitigation NDC to its mitigation fair share*.

Costantini, V., A. Markandya, E. Paglialunga, and G. Sforna, 2018: *Impact and distribution of climatic damages: a methodological proposal with a dynamic CGE model applied to global climate negotiations*. Springer International Publishing, 809–843 pp.

CSO Equity Review, 2016: *Setting the path towards 1.5°C: A civil society equity review of pre-2020 ambition report*. CSO Equity Review Coalition,.

Cunliffe, G., C. Holz, K. Mbeva, P. Pauw, and H. Winkler, 2019: Comparative Analysis of the NDCs of Canada, the European Union, Kenya and South Africa from an Equity Perspective. 1–86.

Höhne, N., M. Den Elzen, and D. Escalante, 2014: Regional GHG reduction targets based on effort sharing : a comparison of studies Regional GHG reduction targets based on effort sharing : a comparison of studies. *Climate Policy*, **14**, 122–147, https://doi.org/10.1080/14693062.2014.849452.

Holz, C., S. Kartha, and T. Athanasiou, 2018: Fairly sharing 1.5: National fair shares of a 1.5°C-compliant global mitigation effort. *International Environmental Agreements: Politics, Law and Economics*, **18**, 117–134, https://doi.org/10.1007/s10784-017-9371-z.

——, E. Kemp-Benedict, T. Athanasiou, and S. Kartha, 2019: The Climate Equity Reference Calculator. *Journal of Open Source Software*, **4**, 1273, https://doi.org/10.21105/joss.01273.

IPCC, 2014: *Climate Change 2014 Mitigation of Climate Change. Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. O. Edenhofer et al., Eds. Cambridge University Press,.

——, 2018a: Global warming of 1.5 °C: Summary for policymakers.

——, 2018b: Global warming of 1.5°C An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change,. *Intergovernmental Panel on climate change*, 1–32, https://doi.org/10.1017/CBO9781107415324.

IPP office, 2019: Independent Power Producers Procurement Programme (IPPPP): An overview, as at 31 March 2019.

Jayaraman, T., T. Kanitkar, and M. Dsouza, 2011: Equitable access to sustainable development : An Indian approach. *Equitable access to sustainable development: Contribution to the body of scientific knowledge*, BASIC Expert Group, 59–77.

Kartha, S., and Coauthors, 2018: Cascading biases against poorer countries. *Nature Climate Change*, **8**, 348–349, https://doi.org/10.1038/s41558-018-0152-7.

Kemp-Benedict, E., C. Holz, P. Baer, T. Athanasiou, and S. Kartha, 2019: *Climate equity reference calculator*. Climate Equity Reference Project (EcoEquity and Stockholm Environment Institute),.

Klinsky, S., and Coauthors, 2017: Why equity is fundamental in climate change policy research. *Global Environmental Change*, https://doi.org/10.1016/j.gloenvcha.2016.08.002.

Krey, V., and Coauthors, 2014a: Annex II: Metrics & Methodology. *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, 1281–1328.

——, G. Luderer, L. Clarke, and E. Kriegler, 2014b: Getting from here to there - energy technology transformation pathways in the EMF27 scenarios. *Climatic Change*, **123**, 369–382, https://doi.org/10.1007/s10584-013-0947-5.

Kriegler, E., and Coauthors, 2014: The role of technology for achieving climate policy objectives: Overview of the EMF 27 study on global technology and climate policy strategies. *Climatic Change*, **123**, 353–367, https://doi.org/10.1007/s10584-013-0953-7.

Leimbach, M., and A. Giannousakis, 2019: Burden sharing of climate change mitigation: global and regional challenges under shared socio-economic pathways. *Climatic Change*, **155**, 273–291, https://doi.org/10.1007/s10584-019-02469-8.

Müller, B., N. Höhne, and C. Ellermann, 2009: Differentiating (historic) responsibilities for climate change. *Climate Policy*, **9**, 593–611, https://doi.org/10.3763/cpol.2008.0570.

NPC, 2011: *National Development Plan 2030: Our future - make it work*. National Planning Commission, The Presidency, South Africa, 489 pp.

Peters, G., 2017: What does «well below 2°C» mean? http://energiogklima.no/articles-in-english/what-does-well-below-2c-mean/.

du Pont, Y. R., and M. Meinshausen, 2018: Warming assessment of the bottom-up Paris Agreement emissions pledges. *Nature communications*, 1–10, https://doi.org/doi: 10.1038/s41467-018-07223-9.

Rajamani, L., and J. Werksman, 2018: The legal character and operational relevance of the Paris Agreement's temperature goal. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, **376**, 20160458, https://doi.org/10.1098/rsta.2016.0458.

Raupach, M. R., and Coauthors, 2014: Sharing a quota on cumulative carbon emissions. *Nature Climate Change*, **4**, 873–879, https://doi.org/10.1038/nclimate2384.

Robiou du Pont, Y., M. L. Jeffery, J. Gütschow, J. Rogelj, P. Christoff, and M. Meinshausen, 2016: Equitable mitigation to achieve the Paris Agreement goals. *Nature Climate Change*, **7**, 38, https://doi.org/10.1038/nclimate3186 https://www.nature.com/articles/nclimate3186#supplementary-information.

RSA, 2015: South Africa's Intended Nationally Determined Contribution (INDC). online 25 September 2015.

Scenario Building Team, 2007: *Lont Term Mitigation Scenarios: Strategic Options for South Africa, Scenario Document*. Department of Environmental Affairs and Tourism, 34 pp.

South Africa, 2011: National Climate Change Response White Paper. Government Gazette No. 34695, Notice 757 of 2011.

UCT, 2021: Technical Analysis to support the update of South Africa's First NDC's mitigation target ranges.

UNEP, 2017: *The Emissions Gap Report 2017 - A UN Environment Synthesis Report*. United Nations Environment Programme (UNEP), 116 pp.

——, 2019: *Emissions Gap Report 2019*. 82 pp.

UNFCCC, 1992: United Nations Framework Convention on Climate Change.

——, 2014: Decision 1/CP.20: Lima Call for Action. Document FCCC/CP/2014/10/Add.1.

——, 2015: Decision 1/CP.21 and Annex (Paris Agreement), document FCCC/CP/2015/10/Add.1, 29 January 2016.

——, 2018a: Decision 4/CMA.1: Further guidance in relation to the mitigation section of decision 1/CP.21. Decision x/CMA.1, document FCCC/PA/CMA/2018/3/Add.1.

——, 2018b: *20/CMA.1 Modalities and procedures for the effective operation of the committee to facilitate implementation and promote compliance referred to in Article 15, paragraph 2, of the Paris Agreement*. https://unfccc.int/sites/default/files/resource/CMA2018_03a02E.pdf (Accessed May 18, 2021).

United States of America, 2021: The United States' Nationally Determined Contribution Reducing Greenhouse Gases in the United States: A 2030 Emissions Target.

Waisman, H., and Coauthors, 2019: A pathway design framework for national low greenhouse gas emission development strategies. *Nature Climate Change*, **9**, https://doi.org/10.1038/s41558-019-0442-8.

Winkler, H., T. Letete, and A. Marquard, 2013: Equitable access to sustainable development: operationalizing key criteria. *Climate Policy*, **13**, https://doi.org/10.1080/14693062.2013.777610.

Winkler, H., N. Höhne, G. Cunliffe, T. Kuramochi, A. April, and M. J. de Villafranca Casas, 2018: Countries Start to Explain How Their Climate Contributions Are Fair: More Rigour Needed. *International Environmental Agreements: Politics, Law and Economics*, **18**, 99–115, https://doi.org/10.1007/s10784-017-9381-x.

Van Zyl, H., Y. Lewis, J. Kinghorn, and J. Reeler, 2018: The cost of achieving South Africa's 'fair share' of global climate change mitigation. *Climate Policy*, **0**, 1–13, https://doi.org/10.1080/14693062.2018.1437019.