POLICY BRIEF
July (No. 2020/03)

WHAT MIGHT A PARIS-ALIGNED EMISSIONS PROFILE LOOK LIKE FOR THE SOUTH AFRICAN POWER SECTOR?

Authored by Dr Emily Tyler, with internal review and graphics by Celeste Renaud and Adam Roff [1]

1 POLICY BRIEF CONTEXT

This Brief was written in the context of analysis undertaken by Meridian Economics together with the Centre of Scientific and Industrial Research[2] for the project *'A Vital Ambition – determining the cost of additional CO_2 emission mitigation in the SA electricity system'* (the "**Ambitions**" project).

The modelling work required an understanding of the level of emissions mitigation that might be required from the South African electricity system in order to align with South Africa's international Paris Agreement commitments. Assessing 'Paris-alignment' is a complex exercise that extends well beyond the technical to encompass issues of equity at the international level and policy priorities domestically. Whilst policies are in place to aid consideration of this for South Africa as a whole, the allocation of effort between sectors remains policy work-in-progress. Therefore, the analysis in this brief utilises (sparse) existing data points to identify a possible range for South African power sector level 'Paris-alignment' for the purposes of the Ambitions modelling work. This range is not intended to be definitive.

Because the identification of sector level effort is still being determined, however, the Ambitions project outputs themselves are then able to contribute additional cost-optimal perspectives to the policy deliberations. There is therefore an iterative nature to the analysis in the brief when it comes to considering the adequacy of power sector budgets (Section 3). Given the recent revolution in renewable energy power generation technology costs globally, the South African power sector contains the potential to make a significant and cost-efficient contribution to the country's mitigation efforts. Therefore, the cost of mitigation in the power sector such as that contained in the Ambitions analysis should equally inform an assessment of the sector's appropriate contribution. This brief is thus written from the following two perspectives: first, the impossible but requisite identification of 'Paris-aligned' mitigation constraints as input to the modelling work, and second, the implications of the modelling for an adequate mitigation contribution from the South African power sector.

2 SOUTH AFRICAN CLIMATE CHANGE MITIGATION POLICY AND COMMITMENTS

Since 1992 and the advent of the United Nation's Framework Convention on Climate Change (UNFCCC), South Africa has been developing its international and domestic policy relating to climate change, including climate change mitigation. During this time, knowledge about climate mitigation has been growing in both domestic and international domains, informing the evolving policy environment.

2.1 SOUTH AFRICAN DOMESTIC CLIMATE MITIGATION POLICY

The National Climate Change Response White Paper of 2011 provides the basis for South Africa's domestic

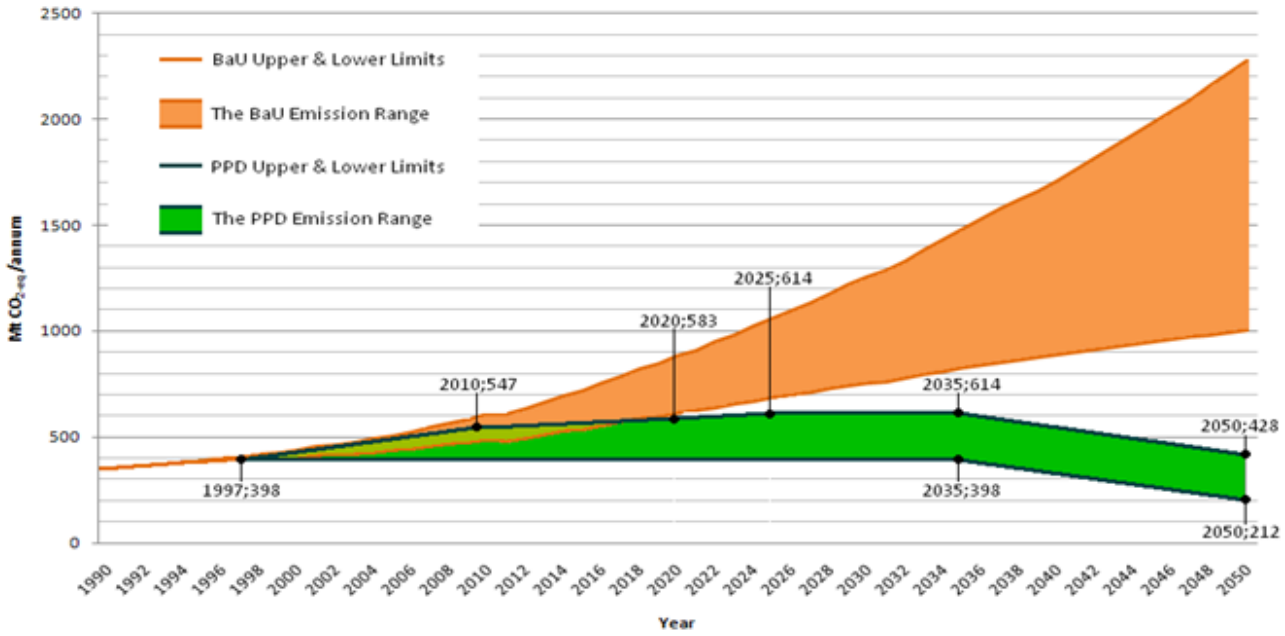
[1] *We acknowledge the support of Agora Energiewende and the Children's Investment Fund Foundation, with valuable review input by Jesse Burton, Dr Andrew Marquard, Dr Brett Cohen and Professor Harald Winkler. All errors and perspectives in the brief remain those of the author.*

[2] CSIR, 2020. Systems analysis to support increasingly ambitious CO_2 emissions scenarios in the South African electricity system. Technical Report. Available: http://hdl.handle.net/10204/11483

climate change policy, including its undergirding principles and objectives. Relating to mitigation it addresses South Africa's mitigation potential, targets and policy initiatives to achieve these.

In the White Paper, a National Benchmark Greenhouse Gas Emissions Trajectory Range is established as 'the benchmark against which the efficacy of mitigation action will be measured' (Republic of South Africa, 2011, p. 27). This range has a 'Peak, Plateau and Decline' shape, is economy-wide, and expressed in absolute tonnes of GHG, projected to 2050. It is shown in Figure 1 below (the relation to a 'Business as Usual projection' is historical[3] and no longer relevant given that the Range itself is expressed in absolute terms). By implication, a national carbon budget[4] range for the period 2020 - 2050 is simultaneously established as 10.8Gt CO2e for the Lower Trajectory, and 17.3Gt for the Upper Trajectory (EScience Associates & Energy Research Centre, 2018).

Figure 1. The defined Peak, Plateau and Decline Greenhouse Gas Benchmark Emissions Trajectory Range (Source: DEA, 2011).



The White Paper has initiated the development of a number of policy instruments and measures to align the country's greenhouse emissions with the Trajectory Range. These include an economy-wide carbon tax which was implemented mid-2019; Sector Emission Targets (not yet defined); and company level Carbon Budgets (a voluntary phase of this instrument is running to 2020 where-after the Budgets are anticipated to become mandatory. Enforcement however depends on the successful promulgation of the Climate Change Bill which has been in process since its first consultation in 2018).

In addition to the Trajectory Range, the South African National Planning Commission (NPC) is developing a low carbon vision for the country for 2050. The vision is currently articulated as being either 'zero carbon' or 'net zero carbon' by 2050 (NPC, 2019). The policy work to position this vision against the Trajectory Range has not yet been done.

[3] Figure 7 in Marquard, 2020 demonstrates powerfully 'Business as Usual' baselines have evolved for South Africa over the past twelve years.

[4] A carbon budget is a number representing cumulative emissions over a timeframe i.e. the area below an emissions trajectory. By defining the trajectory, the budget is implied.

2.2 SOUTH AFRICA'S INTERNATIONAL CLIMATE CHANGE COMMITMENTS

In addition to the domestic policy arena, South Africa is required to prepare a number of submissions under the United Nations Framework Convention on Climate Change (UNFCCC)'s 2015 Paris Agreement. The country's *Nationally Determined Contribution* (NDC) was submitted in 2016. In this document South Africa presents two points on the Trajectory Range (2025 and 2030), implicitly specifying a commitment to an absolute economy-wide range of greenhouse gas emissions between end 2020 and 2030, which is the conventional NDC timeframe. The NDC states that the extent to which South Africa will implement the commitment is dependent on technical, financial and capacity support from the international community being forthcoming (Republic of South Africa, 2015). The Paris Agreement reiterates the UNFCCC principle that developed countries have an obligation to support developing countries respond to climate change, and South Africa's NDC references this.

The international process established under the Paris Agreement requires that countries increase the ambition of their NDCs every five years from 2025 (Voigt & Ferreira, 2016); every subsequent NDC must be more stringent that its predecessor, the so-called 'ratchet mechanism'. President Ramaphosa, in a statement to the 2019 United Nations Secretary General's Climate Summit[5], committed to enhancing the ambition of South Africa's NDC by the end of 2020.

South Africa is also in the process of drafting a *Low-Emission Development Strategy* (LEDS), for submission to the UNFCCC, which provides a long- term vision for mitigation, to 2050. This vision is expected to be aligned with that emerging from the NPC process.

3 CONSIDERING THE ADEQUACY OF SOUTH AFRICA'S INTERNATIONAL CLIMATE MITIGATION COMMITMENTS

The adequacy of South Africa's mitigation commitments can be considered against the Paris Agreement goal of containing global temperature rise to 'well below 2˚C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5˚C' (UNFCCC Paris Agreement, Art.2.s1a). A political compromise, the Paris Agreement articulation is unhelpfully broad in relation to the task of this brief, but at the very least, the 2˚C warming limit provides an upper bound.

There is a huge amount of interpretation and uncertainty to consider in analyses of the adequacy of the South African climate mitigation policy positions - at an economy-wide level, let alone at a power sector level. **There is at present no definitive way of ascertaining adequacy**. Apart from complexities in the climate science itself (including the treatment of carbon sinks), factors that need to be considered include equity of effort, capabilities, existing fossil fuel intensities, domestic policy objectives, the timing of peak emissions, greenhouse gas inventory accuracy, the timing difference between the 2015 submission of the NDC and the 2020 start date of the budgets presented here, and when the Secunda coal-to-liquids plant retires[6]. The analysis in this section therefore provides a relatively high- level map of the terrain.

Climate science expresses the link between emissions and temperature rise using the language of probabilities; a particular level of emissions would be considered likely to achieve a particular warming level with a certain probability. This language interacts with the policy language of 'well below'. In the case of the temperature points identified in the Paris Agreement, it is argued that a 66% probability of achieving 2˚C reflects a median temperature increase of 1.6 - 1.7˚C (Peters, 2017), which is 'well below 2˚C'. Peter's argument is not universally accepted, with some arguing a more stringent goal is required (Marquard, 2020).

Whether the global 'well below 2˚C' target can be met is determined, in the UNFCCC nation-focused system, on what individual countries collectively can do in terms of decarbonisation. Country level commitments are demonstrated in country NDCs - the first round of NDCs was due immediately on ratification of the Paris Agreement, and are available on the UNFCCC website[7]. Cumulatively, the current country NDCs represent in

[5] http://www.dirco.gov.za/docs/speeches/2019/cram0923.htm

[6] For a deeper analysis see Marquard (2020)

[7] https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx

the region of 3.2˚C of warming (UNEP, 2019), i.e. they are inadequate for meeting the Paris target. The importance of the ratchet mechanism is therefore thrown into sharp relief.

What constitutes a 'fair share' of mitigation for any one country is a highly value-laden, politicised and difficult issue, and one which has not yet been able to be defined in the UNFCCC process. Over time, numerous methodologies have been proposed towards this end, making use of generally accepted parameters such as historical responsibility, developmental needs, natural energy resource endowments, and existing economic and governance capabilities. Using a combination of these, and considering adequacy against the Paris target, the independent scientific analysis of Climate Action Tracker (CAT) finds that the Upper Trajectory of the South African NDC range is 'highly insufficient', as is its corresponding target for 2050[8]. The Lower Trajectory in both 2030 and 2050 is considered compatible with containing warming to 2˚C, but not below this. In a separate analysis, Marquard (2020) argues that the Lower Trajectory is deemed a fair contribution (based on the argument that a 66% probability of containing the global temperature to a 2˚C rise and a 50% probability of containing warming to a 1.5˚C increase represent the Paris agreements' 'well below 2˚C above pre-industrial levels, and pursuing efforts to limit the temperature increase to 1.5˚C').

It is worth recalling at this point that South Africa's commitment to NDC implementation will be enabled by international support.

In addition to a consideration of adequacy in the context of the NDCs, analysis has also been undertaken to assess emissions that can be emitted specifically from coal burnt for power generation to 2050[9], relative to achieving Paris targets. Coal is the single largest source of emitters today[10]. The United Nations Environment Programme's Emissions Gap reports (2017, 2019) indicate that all unabated[11] burning of coal in the power sector has to be significantly reduced by 2030 (roughly halved from 2019 levels, according to Carbon Brief), and entirely discontinued by 2050 in order to limit warming to 2˚C. Climate Analytics (2020) argue based on the scenarios considered in the Intergovernmental Panel on Climate Change (IPCC)'s Special Report on 1.5 ˚C that 97% of coal for power generation globally needs to be off by 2040 to contain warming to 'well below 2˚C', with coal in the African region being exited by 2034. Of course, the principles of equity and national context are less well articulated in these coal analyses compared to those of the carbon budgets. A coal-off date for the South African power sector is considered in more detail in the subsequent section.

Finally, adequacy can be considered against the target of 'net-zero carbon'. Analysis of this metric at the global level suggests that achieving net zero global CO_2[12] emissions around 2050 will be necessary to keep warming levels to 1.5˚C (IPCCC, 2018), and net zero global CO_2 emissions by 2070 to keep temperature rise below 2˚C (Marquard, 2020). South Africa would likely need to achieve net zero CO_2 emissions between 2050 and 2060, considering equitable sharing of mitigation efforts between countries.

To summarise at this point, then, given the substantial uncertainties involved, it is not possible to be definitive in terms of metrics to assess South Africa's Paris-alignment. However, the below provide some markers for the likely effort required:

- The effective commitment in the Upper Trajectory Range of South Africa's NDC has been deemed **highly insufficient** as a contribution to the Paris goal of keeping temperature rise well below 2˚C. The Lower Trajectory could be deemed Paris-aligned.
- The implementation of the South African NDC commitment is articulated as being enabled by international support.

[8] https://climateactiontracker.org/countries/south-africa/ Update as of 2 December 2019, accessed 21 April 2020.

[9] Coal is used in other processes. The analysis here only considers coal for power.

[10] https://www.carbonbrief.org/analysis-why-coal-use-must-plummet-this-decade-to-keep-global-warming-below-1-5c

[11] i.e. without carbon capture and storage or utilisation.

[12] The NPC document does not specify whether 'carbon' means CO_2 or all greenhouse gases. This level of technical detail is not held to be material to the analysis in this paper.

- The ratchet mechanism of the Paris Agreement implies that South Africa will be required to submit increasingly ambitious future NDCs.
- Analysis on the potential to use coal in the power sector in the context of the Paris goal suggests 2040 as a coal exit date for the South African power sector.
- South Africa is likely to be required to achieve net zero CO_2 emissions between 2050 and 2060 in order to be Paris-aligned.

4 CONTEXTUALISING THE SOUTH AFRICAN POWER SECTOR'S CONTRIBUTION TO ITS ECONOMY-WIDE TARGETS

There has not yet been any official guidance given by the custodian of climate mitigation policymaking, the Department of Environment, Forestry and Fisheries (DEFF) on sectoral allocations under the National Benchmark GHG Emission Trajectory Range. The mechanism for this, the Sector Emission Reduction Targets (SETS) remains under development at the time of writing.

In addition to emissions trajectories, carbon budgets represent a rigorous yet flexible metric for considering mitigation effort over time, one that is easily incorporated into an electricity system modelling exercise such as that of the Ambitions project. A carbon budget is a number representing cumulative emissions over a timeframe (typically for mitigation policy, from a recent / present date until 2050). A carbon budget corresponds to the area below an emissions trajectory. By defining the trajectory, the budget is implied.

A company level Carbon Budget for Eskom would give a clear indication of an anticipated electricity sector allocation given that Eskom generates around 95% of South Africa's electricity currently. The utility has taken on a Budget in the voluntary period to 2020 (Eskom Integrated Report, 2019), although the quantum of this budget has not been made public. The electricity sector also currently receives an exemption from the carbon tax promulgated mid 2019 due to there being an environmental levy in place on all power generated from fossil fuels. This situation is set to be revised in 2023.

In 2010, a year prior to the White Paper's publication, an emissions constraint of 275Mt CO2e between 2025 and 2030 was adopted in South Africa's first Integrated Resource Plan (IRP) for the electricity sector (DoE, 2011). The constraint was included to reflect South Africa's Pledge under the UNFCCC's Copenhagen Accord (2009), which referenced the PPD trajectory from the Long Term Mitigation Scenario planning process. The IRP, similar to the NDC, is a plan to 2030.

The level of the IRP 2010 carbon constraint was determined by applying the electricity sector's contribution to South Africa's emissions at the time (45%)[13] to the Upper Trajectory of the Range. The IRP 2010 carbon constraint has been retained in the 2019 IRP update, although it is no longer a binding constraint on a least cost plan due to the dramatic decline in renewable energy power generation costs (i.e. the least cost plan at all times emits less than the Upper Trajectory). The IRP 2019 also provides a graph indicating that the constraint declines to 200Mt in 2050 (IRP 2019 Figure 8). The IRP 2019 further refers to an indicative carbon budget of 5.4 Gt from 2020-2050[14] which was introduced together with the constraint in an earlier IRP draft, (2018 IRP), in order to align with the White Paper's carbon budget policy architecture. There is no indication in either document how this budget was determined.

The IRP 2010/19's carbon constraint is depicted in Figure 2 below, as a portion of the National Benchmark GHG Emissions Trajectory Range. The constraint follows the same trend as the Lower Trajectory, but only to 2030, the timeframe of the IRP.

Modelled emissions from a Current Policy Reference Scenario used in the Ambitions project[15] show that anticipated emissions from the implementation of the

[13] This percentage is not disclosed in policy documents, but can be deduced by working back from the 275Mt figure identified in the 2010 IRP as the constraint between 2025 and 2030, as a percentage of the national Upper Trajectory.

[14] This timeframe is not 100% clear from the draft IRP 2018, which describes it as such: 'The scenario was based on carbon targets divided into 10-year intervals which meant a total emissions reduction budget for the entire electricity sector up to 2050 must be 5470Mt CO2 cumulatively' (IRP 2018 draft, p 35).

[15] The Ambitions models include the Sasol generation capability as well as Kelvin (owned by the City of Johannesburg) in addition to the Eskom fleet.

IRP 2019 (depicted in Figure 3 below) are well below the 2010/19 constraint throughout the period. In addition, the associated cumulative carbon emissions for the period from 2020-2050 is 4Gt, well below the IRP 2019's indicative budget of 5.4Gt (RSA, 2019).

Energy planning in South Africa has not yet caught up with the techno-economic shift in the power sector. This is not unusual across the developing world (see for example E3G, 2020a; E3G, 2020b).

Figure 2. The power sector's 2010/19 carbon constraint against the National Benchmark GHG Emissions Trajectory Range (Source: DEA, 2011; DMRE, 2019)

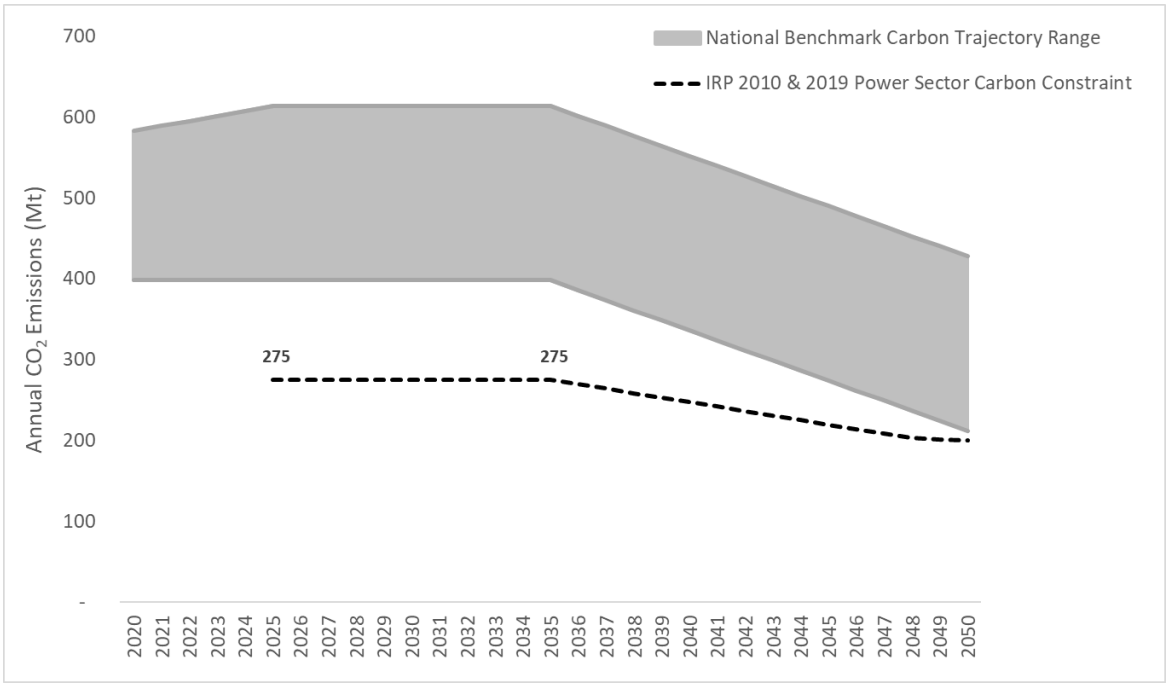
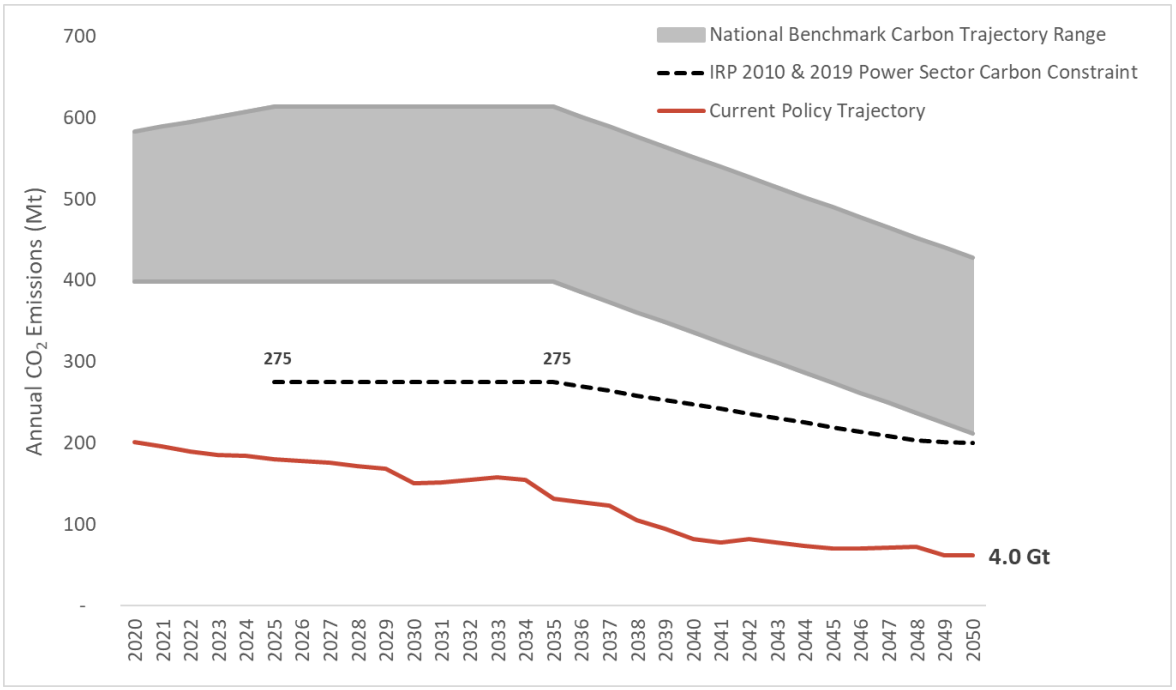


Figure 3. GHG Emissions associated with an IRP-based Current Policy Trajectory against the National Benchmark GHG Emissions Trajectory Range[16] (Source: DEA, 2011; DMRE, 2019; ME, 2020; CSIR, 2020)



[16] The renewable energy build constraint contained in the IRP 2019 modelling to 2030 is assumed to be lifted post 2030 in ascertaining the IRP 2019 emissions trajectory.

4.1 CONSIDERING AN ADEQUATE POWER SECTOR CONTRIBUTION

The IRP 2010 adopted a carbon constraint based on the electricity sector's historical emissions as a proportion of economy-wide emissions. Whilst this may have been appropriate at the time, there has been a dramatic change in relative prices of energy technologies in the subsequent decade. Now, the bulk of least cost mitigation options across the economy are found in the electricity sector due to the rapid decline in cost of renewable energy power generation technologies (EScience Associates & Energy Research Centre, 2018; Mccall et al., 2019).

Recalling the summary in section 3, together with South Africa's own domestic vision of zero / net-zero carbon by 2050, there is likely to be increasing pressure on the country to move at least to the Lower Trajectory into the future. A low carbon electricity sector represents the country's least cost route to achieve this. Therefore whilst a strict policy-compliance based view of the NDC and IRP 2019 suggest that South Africa may be on track to achieving its international commitments, a longer term view suggests that the country will need to look towards structural economic and electricity sector change if it is to achieve a least cost, fair contribution to an adequate global mitigation effort by 2050 (EScience Associates & Energy Research Centre, 2018). The Ambitions modelling emphasises this: it is the action of the coming decade that is critical for enabling cost effective power sector mitigation going forward.

What level of mitigation contribution from the electricity sector would put South Africa in a position where it is able to follow a cost effective and adequate mitigation path to 2050? Two metrics from which to consider this are employed here, carbon budgets and a coal-off-by date.

From the discussion in section 3, a carbon budget equal to or smaller than that represented by the Lower Trajectory (10.8 Gt) could be considered Paris- aligned at the national level. The modelling work done by the University of Cape Town's Energy Systems group apportions a national level budget[17] and allocates mitigation effort in terms of feasible technology pathways at lowest cost. The 'Alt IRP' study (Mccall et al., 2019) interprets 'well below 2˚C' as a carbon budget 20% below that of the Lower Trajectory, and is modelled as 7.8 Gt. A carbon budget for the electricity sector of 2.3Gt is thus derived. Another UCT study, using the same modelling approach but aiming only for 2˚C (Burton et al, 2018) allocates a budget of 9,5Gt[18] and derives electricity sector budgets of between 2.9 and 3.4 Gt, depending on assumptions relating to the retirement date of the Secunda coal-to-liquids facility[19].

To compound the inherent uncertainty in ascertaining carbon budgets per se, there are very few data points at the sectoral level, and these are all derived from cost optimisation modelling, i.e. they don't include consideration for other policy objectives that South Africa might wish to achieve in a sectoral carbon space allocation exercise. Nevertheless, these data points are what we have, and from them we have assumed that a Paris-aligned, cost effective South African power sector budget might lie between 2.0[20] to 3.4Gt, with an emphasis on 2.3Gt.

Using a coal-off-by date is a simpler but less flexible approach. The exit date of coal is considered in the South African context in the UCT team's modelling. Here, a carbon constraint is introduced at the economy-level, and the extent to which coal remains in electricity generation is derived by the model, determined by cost and economic considerations. These studies confirm that coal for power generation is likely to need to exit by 2040[21]. McCall et al (2019) find that if some coal is left on the electricity system post 2040, this will impact

[17] Technically, this is an energy system model (and as such excludes the Agriculture, Forestry and Other Land Use (AFOLU) sectors. The budget used is adjusted accordingly.

[18] The energy system portion of the Lower Trajectory budget.

[19] Secunda is the largest point source of carbon emissions in the world, and has such the date of its termination is highly relevant when considering South African carbon budgets.

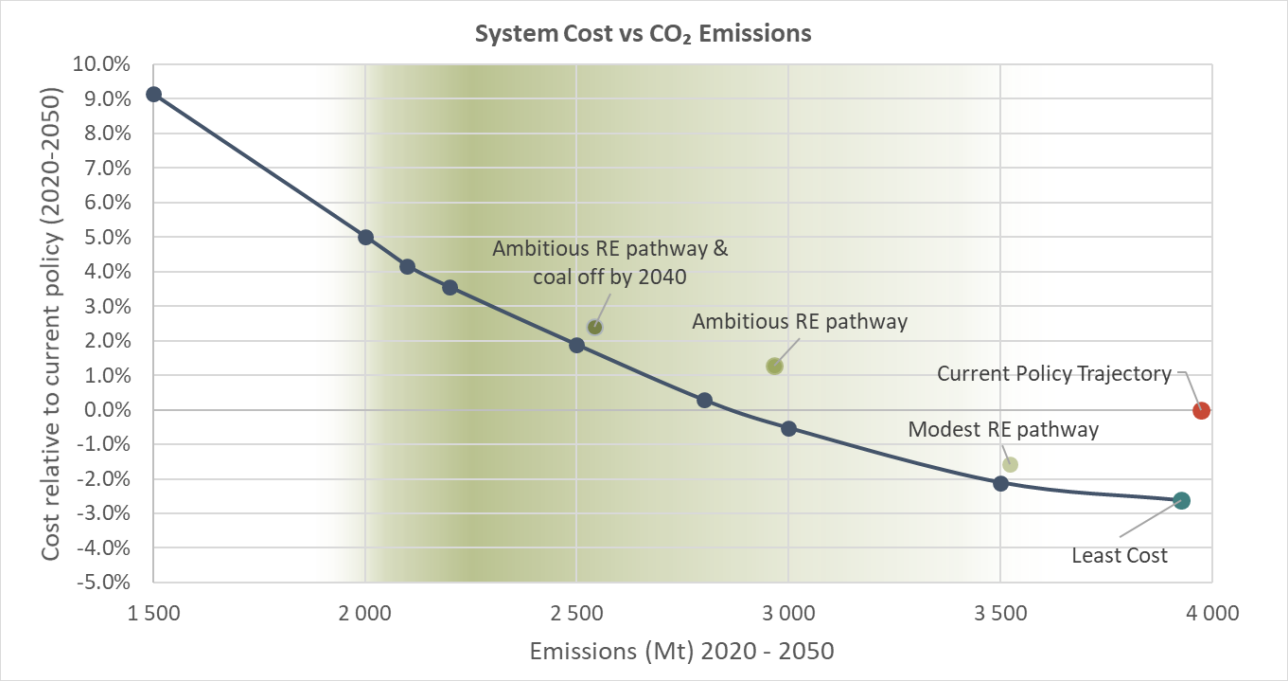
[20] Because we only had one data point for a budget derived from an economy-wide constraint corresponding to 'lower than 2˚C, we felt it prudent to include some space below this point.

[21] Certain industrial sectors and processes do not yet have commercial alternatives for coal (for example, steel and cement making) and the emissions space for coal combustion would need to be reserved for these sectors.

on the level of natural gas that can be included, i.e. there is a trade-off in carbon constrained scenarios between different fossil fuels. If the coal to liquids plant at Secunda is allowed to run post 2040, this may require coal for power generation to exit even earlier (Burton et al, 2018).

The outcomes of the Ambitions study support the lower end of the budget range we assumed (see Figure 4 below). Even when taking real-world constraints into account, the cost increase of the most ambitious mitigation scenario considered (combining an ambitious RE pathway and coal off by 2040) is associated with an electricity system cost increase of less than 2.5% compared to the Current Policy Reference Scenario. This ambitious mitigation scenario has cumulative carbon emissions of around 2.5Gt, close to that found by McCall et al (2019) to be associated with a mitigation scenario aligned with 20% lower than 2˚C (2.3Gt).

Figure 4. System cost vs CO2 Emissions for the Ambitions Project Mitigation Scenarios (ME, 2020).



5 REFERENCES

Burton, J., Caetano, T., McCall, B. (2018). Coal transition in South Africa - Understanding the implications of a 2°C-compatible coal phase-out for South Africa. IDDRI & Climate Strategies.

Climate Analytics (2020). Global and regional coal phase-out requirements of the Paris Agreement: Insights from the IPCC Special Report on 1.5°C. Authors: Paola A Yanguas Para, Guarav Ganti, Robert Brecha, Bill Hare, Michiel Schaeffer, Ursula Fuentes.

Department of Environmental Affairs (DEA). (2011). Defining South Africa's Peak, Plateau and Decline Greenhouse Gas Emission Trajectory. Pretoria, South Africa.

DEA. (2014). South Africa's Greenhouse Gas (GHG) Mitigation Potential Analyis: Technical Summary. In South Africa's Greenhouse Gas Mitigation Potential Analysis. https://doi.org/10.4159/harvard.9780674864092.c26

Department of Mineral Resources and Energy (DMRE). (2019). Integrated Resource Plan (IRP 2019). [Online]. Available: http://www.energy.gov.za/IRP/2019/IRP-2019.pdf

Department of Energy (DoE). (2011). Integrated Resource Plan for Electricity 2010-2030. March 2011. [Online]. Available: http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf

Department of Energy (DoE). (2018). Integrated Resource Plan 2018: Draft for comments. August 2018. [Online]. Available: http://www.energy.gov.za/IRP/irp-update-draft-report2018/IRP-Update-2018-Draft-for-Comments.pdf

E3G (2020a). India: Coal Priorities. Coal Diplomacy Country Briefing - April 2020.

E3G (2020b). Kenya: Coal Priorities. Coal Diplomacy Country Briefing – April 2020.

EScience Associates, & Energy Research Centre. (2018). Department of Environmental Affairs, Policies and Measures draft for comments. [Online]. Available: https://www.environment.gov.za/sites/default/files/docs/policyandmeasures_draftreport.pdf

Ireland, G., & Burton, J. (2018). An assessment of new coal plants in South Africa's electricity future: The cost, emissions, and supply security implications of the coal IPP programme.

Kok, I. (2017). Coal transition in the United States.

Marquard, A. (2019). The development of South Africa's energy emissions path and the implications for our Nationally Determined Contribution. Presented at SA-TIED workshop, 2019. [Online]. Available: https://sa-tied.wider.unu.edu/sites/default/files/pdf/Event-28August2019-Marquard.pdf

Marquard, A. (2020). Considerations for enhancement of South Africa's current NDC and framing of the next. In COP21: Results and implications for pathways and policies for low emissions European societies. [Online]. Available: https://www.cop21ripples.eu/wp-content/uploads/2020/03/RIPPLES-D2.5.pdf

Mccall, B., Burton, J., Marquard, A., Hartley, F., Ahjum, F., Ireland, G., & Merven, B. (2019). Least-cost integrated resource planning and cost-optimal climate change mitigation policy : Alternatives for the South African electricity system. Retrieved from http://www.erc.uct.ac.za/sites/default/files/image_tool/images/119/Papers-2019/Alt IRP final 07022019_2.pdf

Meridian Economics. (2020). A Vital Ambition – Determining the cost of additional CO2 Emissions Mitigation in the SA Electricity System. Available: https://meridianeconomics.co.za/wp-content/uploads/2020/07/Ambition.pdf

Peters, G. (2017). What does 'well low 2°C' mean?" CICERO blog post. [Online]. Available: https://cicero.oslo.no/no/posts/klima/well-below-2c

President Ramaphosa. (2019). President Ramaphosa Statement to the United Nations Secretary General's 2019 Climate Summit. Republic of South Africa.

Republic of South Africa (RSA). (2011). National Climate Change Response White Paper.

Republic of South Africa (RSA). (2015). South Africa's Intended Nationally Determined Contribution (INDC).

United Nations Environment Programme. (2019). Emissions Gap Report 2019. UNEP, Nairobi.

Voigt, C., & Ferreira, F. (2016). "Dynamic Differentiation": The Principles of CBDR-RC, Progression and Highest Possible Ambition in the Paris Agreement. Transnational Environmental Law, 5(2), 285–303. [Online]. Available: https://doi.org/10.1017/S2047102516000212