Project report

Alignment of South Africa’s NDC with 1.5°C global goal

Technical Research done for GREENPEACE

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List of Acronyms

Acronym	Description
AFOLU	Agriculture, Forestry and Other Land Use
CDP	Current Development Plans
CO_2e	Carbon dioxide equivalent
CSP	Concentrated Solar Power
DEA	Department of Environmental Affairs
DEFF	Department of Environment, Forestry and Fisheries
ERC	Energy Research Centre
EV	Electric Vehicles
FOLU	Forestry and Other Land Use
GHG	Greenhouse Gas
ICE	Internal Combustion Engines
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
IRP	Integrated Resource Plan
LTMS	Long Term Mitigation Scenarios
MPA	Mitigation Potential Analysis
Mt	Million tonnes
NDC	Nationally Determined Contribution
NIR	National Inventory Report
PPD	Peak, Plateau and Decline
Ppm	Parts per million
PV	Photovoltaic
SA	South Africa
SBT	Scenario Building Team
TJ	Tera Joules
UNFCCC	United Nations Framework Convention on Climate Change
WOM	Without Measures
WAM	With Additional Measures
WEM	With Existing Measures

1 Introduction

1.1 Background

Global greenhouse gas (GHG) concentrations in the atmosphere are rapidly increasing as a result of anthropogenic activities. Due to their radiative properties, GHGs are attributed to global warming and climate change. The world is continuously witnessing impacts of climate change in the form of destructive floods, droughts, tropical storms and other forms of unprecedented weather. Scientific studies show that unless the world stops emissions of GHGs by 2050, the global climate will unbearable to humankind.

Global policy framework was formed over two decades ago to address climate change, its challenges and to grab any opportunities in it. The United Nations Framework Convention on Climate Change (UNFCCC) was initiated and ratified by many countries in the 1990s to guide global activities aimed at both climate change adaptation and mitigation of GHGs. Continuous deliberations have taken place and several agreements reached.

In their meeting in Paris in 2015, Parties to the UNFCCC agreed that countries need to periodically submit to the Convention Secretariat, their revised and updated plans to reduce their respective emissions. The central aim of the Paris Agreement is limit global rise of global warming to levels below 2°C but preferably to less than 1.5°C compared to pre-industrial average temperatures. The world is running against time to reach this milestone that requires peaking of global emissions as quickly as possible and to reach global net emissions of not more than zero by 2050.

The Paris Agreement uses a 5-year reporting framework which requires countries to submit their Nationally Determined Contributions (NDCs) to achieve the no-emissions world by 2050. South Africa submitted its first NDC to the UNFCCC in 2015 and is working on its second report. In the first report the country was primarily aiming at reaching temperature increases to below 2°C. The NDC and national GHG inventories show that the national GHG emissions are dominated by the energy sector which is responsible for over 75% of the total emissions.

National governments develop plans and set GHG reduction goals or targets in order to mitigate their emissions. These plans need to be assessed for their potential prior to implementation and they also require to be monitored during or after implementation to evaluate their effectiveness. South Africa has since the early 2000s developed plans to reduce its emissions. The plans are generally informed by the Long-Term Mitigation Scenarios (LTMS) analytic work concluded in 2007 (Winkler et al., 2007). The mitigation scenarios were revised in 2014 (DEA, 2014) and there is currently another update due to be published (DEFF, 2020). GHG scenarios in all these reports based on projected economic conditions as modelled with current conditions.

Rationale for this work

Through the Long-Term Mitigation Scenarios (LTMS), South Africa undertook its first mitigation assessment exercise to inform policy in 2007. Thus, the LTMS informed South Africa's Climate Change Response Policy of 2011 as well as the country's NDC under the Paris Agreement. The LTMS, however, was based on the IPCC's fourth assessment report which focused on keeping average global warming below 2oC compared to pre-industrial levels. With the mitigation focus in the Paris Agreement moving towards keeping global warming to below 1.5oC compared to pre-industrial levels, the results of the LTMS, particularly the Required by Science Target, may not be relevant anymore.

1.2 Objective

The objective of this study was to understand what an updated RBS target based on the Paris Agreement goal of keeping average global warming below 1.5°C compared to pre-industrial levels would look like and to determined what it would take for South Africa to reach that target. .

2 Overall Approach

A three-step approach was followed for this project, as shown in Figure 1 below.

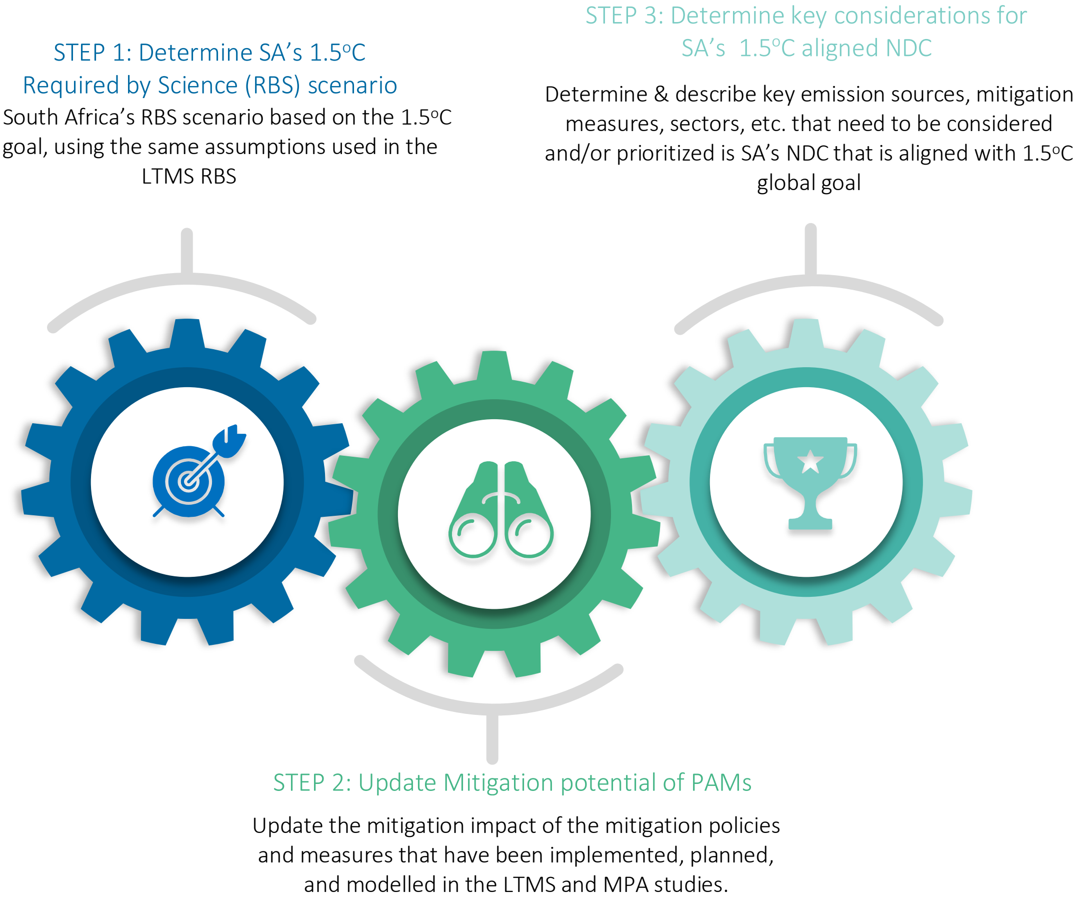


Figure 1: Overall project approach

The first step focused on determining South Africa's science-based target trajectory aligned with the global target of keeping the global temperature increase below 1.5ºC above pre-industrial levels. This is the trajectory that was referred to as the "Required by Science" (RBS) scenario in the LTMS.

The second step entailed updating the various mitigation scenarios that were modelled in the Mitigation Potential Analysis (MPA) based on the latest information. This step was aimed at determining the extent to which the country's existing mitigation measures, Current Development Plans (CDP) and the measures that were considered additional in the MPA study can mitigate the country's GHG emissions in comparison with to what is required to achieve the updated 1.5ºC aligned RBS scenario.

Finally, additional considerations for South Africa to achieve its 1.5°C aligned RBS were determined and described.

Figure 2 below shows and describes the scenarios as modelled in this project. Because the latest published national GHG inventory goes up to 2015, all scenarios have been modelled from that year up to 2050. This means that the "With Existing Measures" (WEM) scenario includes those mitigation measures that existed and had been implemented by 2015. Mitigation measures that were implemented after 2015 are included in the "Current Development Plans" (CDP) together with those that are in still in the planning phase. "With Additional Measures" (WAM) contains any additional mitigation measures that have not already been included in the preceding scenarios.

Further details about each of these steps are given in the next chapters.

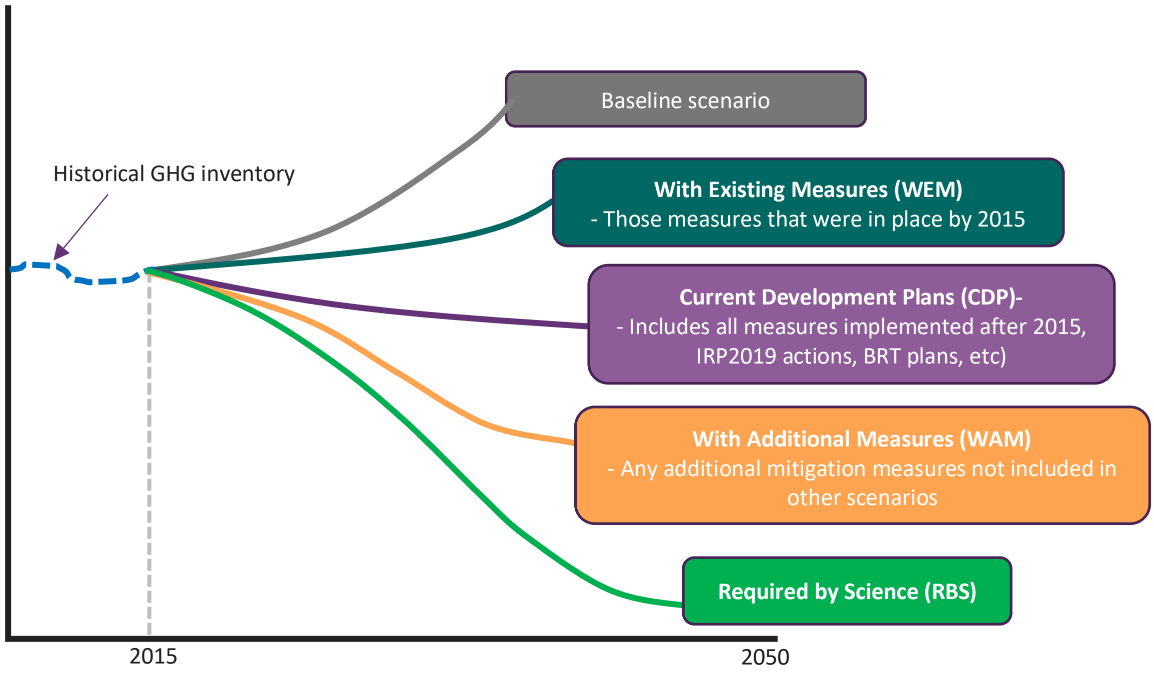


Figure 2: Scenarios assessed

The rest of the chapters below are ordered according to the steps presented in this chapter. Chapter 3 presents SA’s 1.5°C aligned RBS scenario as well as the rationale and data used to determine it.

3 SA's 1.5°C aligned RBS Scenario

3.1 Origins of the RBS Scenario

The RBS scenario is a scenario that was first coined in the LTMS process. At the time, South Africa was undertaking its first scenario-based climate change assessment and planning process to guide the country's climate change mitigation policy.

The LTMS RBS scenario was informed by the Intergovernmental Panel on Climate Change's (IPCC) fourth assessment report, which stated that *"Using the 'best estimate' assumption of climate sensitivity, the most stringent scenarios (stabilizing at 435- 490 ppmv CO2-eq) could limit global mean temperature increases to 2-2.4°C above the pre-industrial level, at equilibrium, requiring emissions to peak within 15 years and to be around 50% of current levels by 2050" (Rogeli et al, 2018)*. That meant that countries needed to cut their GHG emission levels at the time by an average of 50% by 2050 to keep the average global temperature increase from pre-industrial levels to no more than 2 – 2.4°C.

Based on that information, the LTMS Scenario Building Team (SBT) then agreed to consider reductions of - 30 – 40% of the base year levels by 2050 for South Africa, as the scenario of actions 'required by science' (Winkler (ed), 2007). This is 10% – 20% below the required global reduction by 2050.

Figure 3 below shows the LTMS RBS scenario and how it was used to formulate the country's Peak, Plateau and Decline (PPD) trajectory, which is at the heart of South Africa's Climate Change Mitigation Policy and its NDC under the Paris Agreement (Winkler and Marquard,2011).

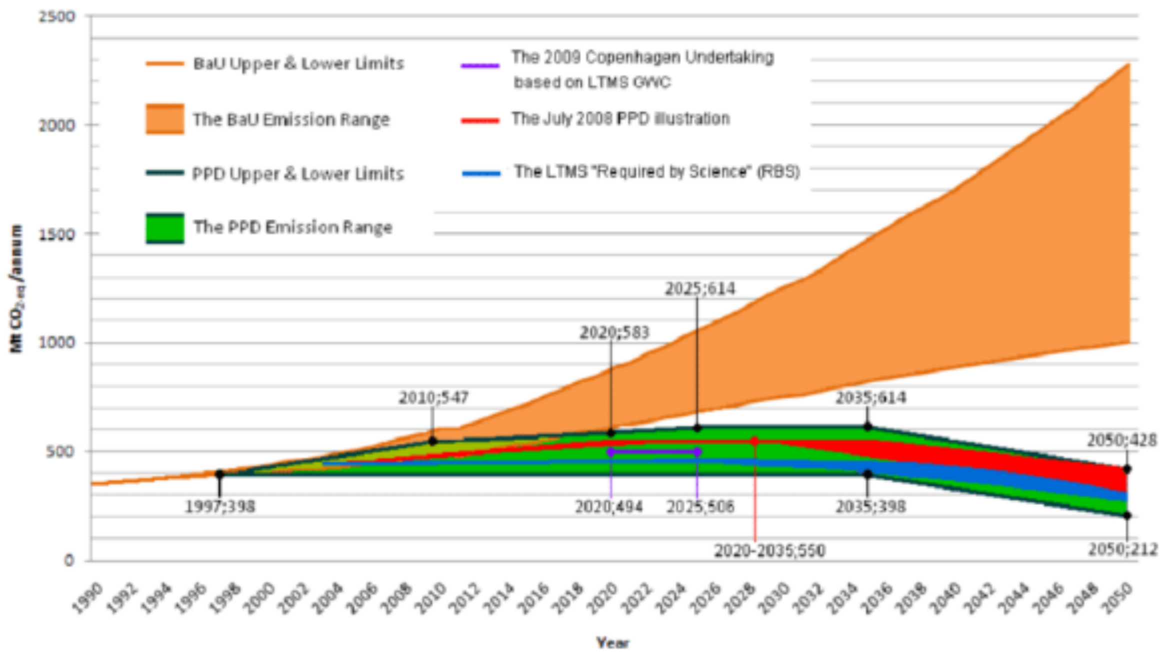


Figure 3: South Africa's Baseline and Target emission scenarios

3.2 Updating the RBS Scenario

On the 12th of December 2015, Parties to the UNFCCC agreed to a historic, legally binding international treaty on climate change, termed the Paris Agreement. In this treaty, Parties agreed to limit global warming to well below 2°C compared to pre-industrial levels, and preferably keep the increase to no more than 1.5°C. As part of pursuing this global target, the UNFCCC then commissioned the IPCC to undertake a special assessment of the implications and mitigation requirements of keeping average global warming to 1.5°C compared to pre-industrial levels.

In 2018 the IPCC finally published its special report on global warming of 1.5°C. In this report, the IPCC models showed that to achieve no or limited overshoot of 1.5°C, the net global GHG emissions have to "*decline by about 45% from 2010 levels by 2030, reaching net zero around 2050*" as shown in Figure 4 below (Rogeli et al, 2018).

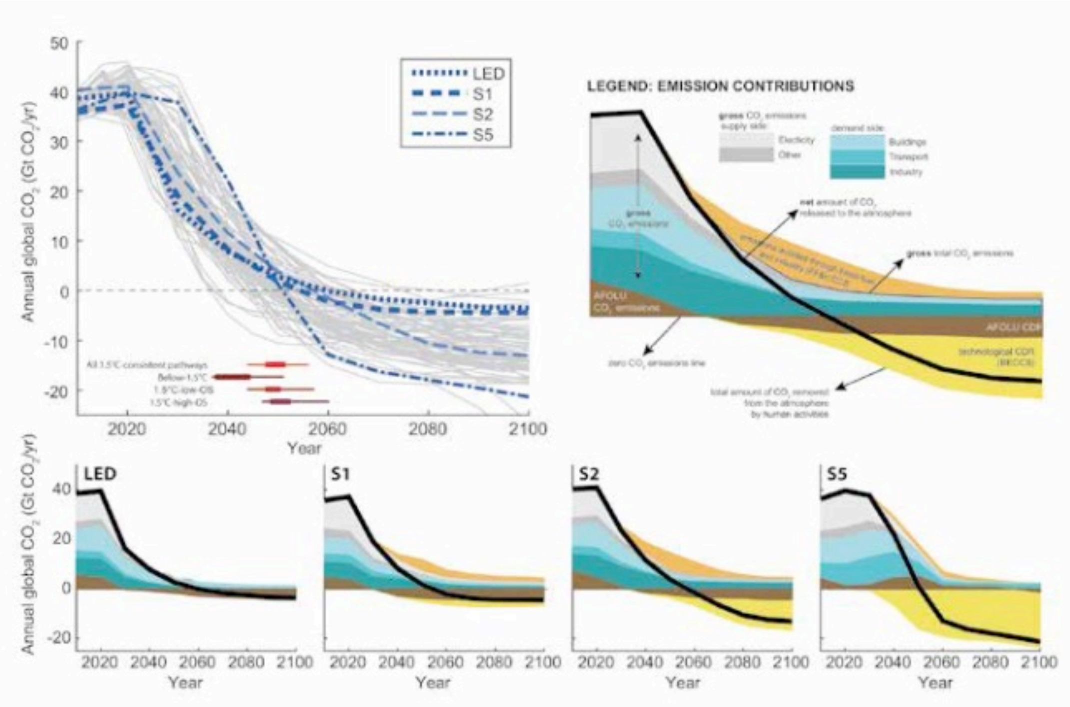


Figure 4:Global GHG emission trajectories required to keep temperature increase below 1.5°C

If this requirement of 45% reduction of GHG emissions from 2010 levels by 2030 and net zero by 2050 is applied to South Africa, it translates to reducing the country's net GHG emissions to 288 $MtCO_2e$ (55% of 524 $MtCO_2e$) by 2030 and net zero by 2050, based on the latest published national GHG inventory. This is illustrated in Figure 5 below.

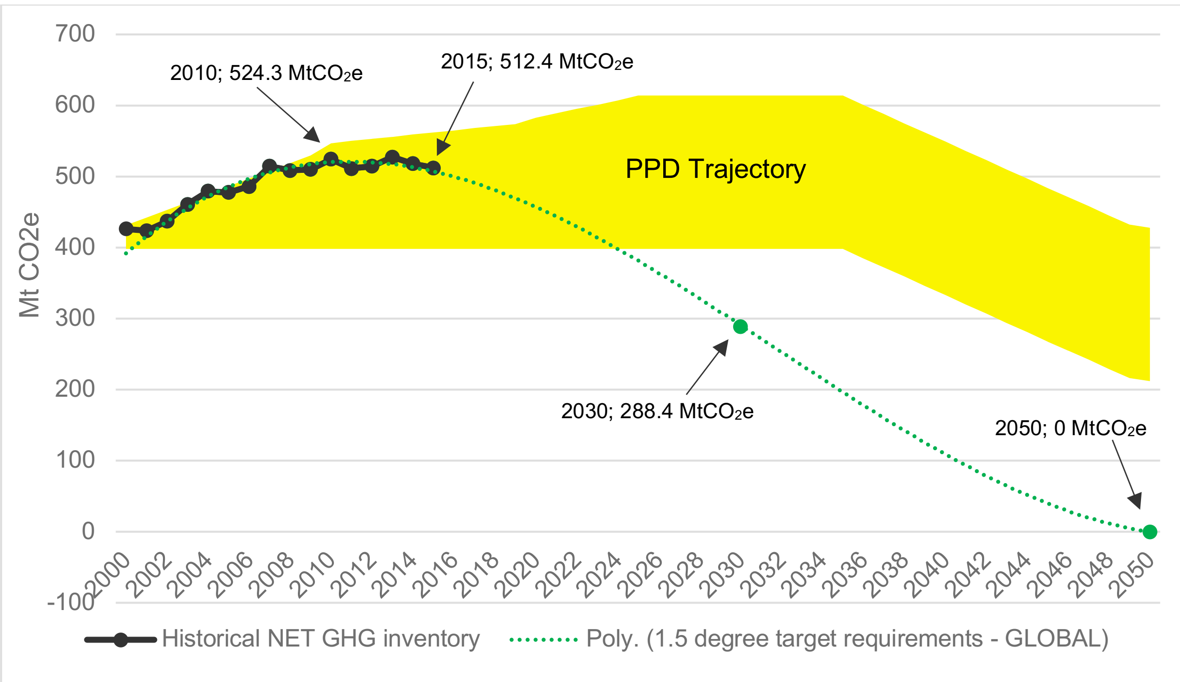


Figure 5: Application of the IPCC Special report mitigation requirements to South Africa

If the approach of reducing South Africa's global mitigation burden by 10%, as applied in developing the 2-degree based RBS scenario in the LTMS, was to be applied to the country's 1.5°C based RBS scenario, then this would imply a requirement for South Africa to reduce its net emission levels to only 341 $MtCO_2e$ in 2030 and 52.4 $MtCO_2e$ by 2050. This means reducing the country's net emissions by only 35% and 90% below 2010 levels by 2030 and 2050 respectively. In this report, this is termed the "-10% Adjusted" RBS scenario.

However, if it is considered that the RBS scenario in the LTMS was developed in the era of a global climate change regime that strongly differentiated between the mitigation requirements of developed countries and those of developing countries (i.e the Kyoto Protocol), while the current Paris Agreement makes no distinction between those groups in terms of mitigation requirements, then it may be argued that the -10% adjustment approach of the LTMS is no longer necessary.

An alternative to this approach could be for South Africa to take up more stringent reduction targets than the average reductions required by the IPCC Special Report on 1.5°C, with aim of demonstrating leadership in climate change response and encouraging ambitious targets by other countries. This could be done by flipping the "-10% Adjustment" adopted in the LTMS process to a "+10% Adjustment". The latter would imply that South Africa needs to reduce its net GHG emissions by 55% below 2010 by 2030 and reach net zero emission levels before 2050. This is termed the "+10% Adjusted" RBS Scenario in this report.

The "-10% Adjusted" RBS scenario and the "+10% Adjusted" RBS scenario are illustrated in Figure 6 below.

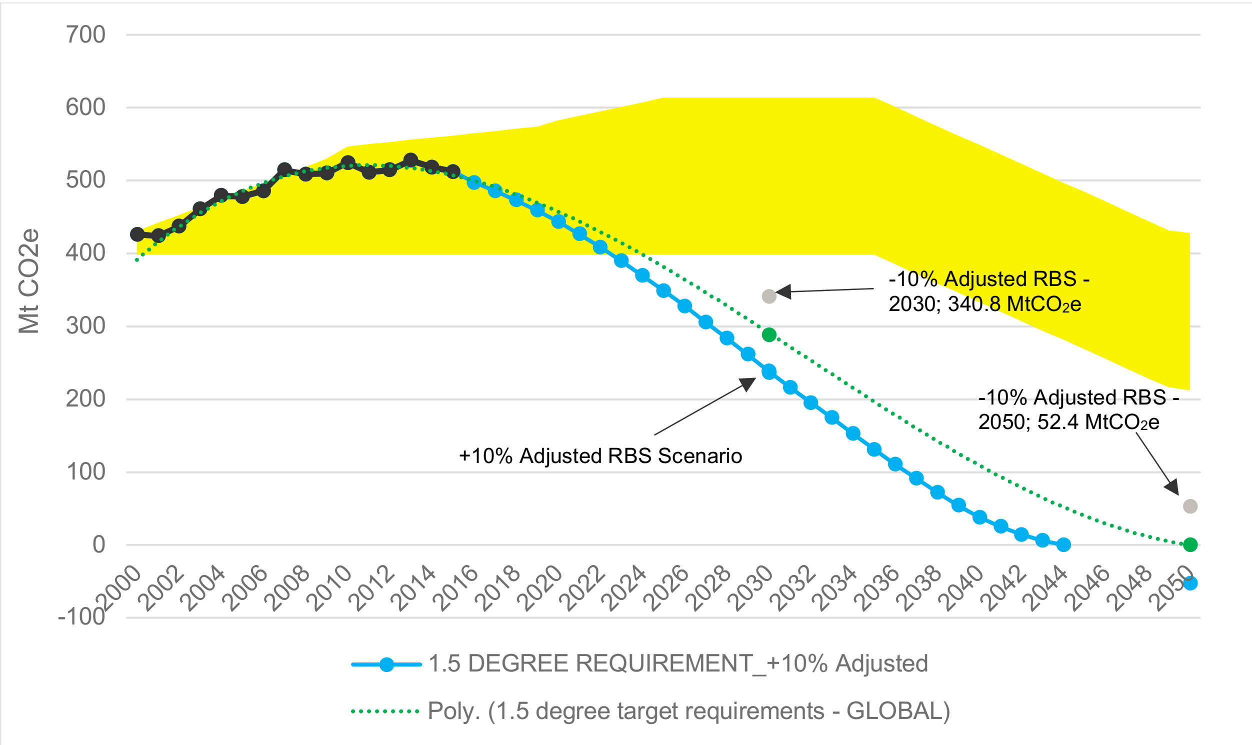


Figure 6: RBS scenarios based on adjusting South Africa' RBS scenario by 1.5oC global mitigation requirement by +10% and by -10%.

Figure 6 shows that an ambitious +10% Adjusted 1.5°C RBS scenario would require South Africa to reach net zero emission levels by 2045 at the latest. The emission levels of the full +10% Adjusted RBS scenario can be found in Appendix A.

The rest of this report looks at how far the existing, the planned and any additional mitigation measures can take South Africa towards achieving this +10% Adjusted 1.5°C RBS scenario.

4 Updated Mitigation potential of PAMs

In this chapter, the updated mitigation potential of the various mitigation scenarios identified and assessed in the LTMS and the MPA is presented. As outlined in Chapter 2 above, all scenario projections have been done from 2015, since it is the last year for which the national GHG inventory has been published.

4.1 Methods for updating Mitigation potential

The Department of Environment, Forestry and Fisheries (DEFF) has recently updated the MPA study. While the updated MPA report was published in March 2020, it has not taken into account some key developments that happened in 2019 including the published 2019 Integrated Resource Plan (IRP 2019). As a result, a combination of the results of the updated MPA report and own assessments has been used in updating the mitigation scenarios in this report.

In carrying out both ex-ante impact assessments (which estimates expected future GHG effects of a policy or action) and ex-post impact assessments (which estimates historical effects of a policy or action on GHG emissions), the equation below, based on the World Resources Institute's GHG Protocol on Policy and Action Standard (WRI, 2014), was used:

Total net change in GHG emissions resulting from the policy or action (CO_2e) =

Total net policy scenario emissions (CO_2e) – Total net baseline scenario emissions (CO_2e)

where:

- Baseline scenario represents the events or conditions most likely to occur in the absence of the policy or action (or package of policies and actions) being assessed
- Policy scenario represents the events or conditions most likely to occur in the presence of the policy or action (or package of policies and actions) being assessed.

Calculating baseline emissions for each PAM

Baseline scenario (Growth Without Constraints or Without Measures – as described below) represent emissions that would likely be produced if no mitigation efforts were taken. For the energy related policy or action, emissions in this scenario were calculated assuming current Eskom emission factors. A baseline of a policy or action was calculated assuming that it directly reduces emissions generated from coal-powered plants.

The following factors were used to calculate the baseline emissions in the energy sector. The energy availability factors of the different energy types were coal (64.78%), hydropower (67.12%), solar PV (27.94%), wind (36.88%), CSP (36.88%) and gas and diesel (7.49%). Eskom (2018; 2019) coal emission factor was used for carbon dioxide (CO_2; 1.04 tonnes CO_2 per MWh) and the IPCC default values were used for methane (CH_4; 3 kg TJ^{-1}) and nitrous oxide (N_2O; 0.6 kg TJ^{-1}) for both diesel and petrol. CO_2 emission factor for gas and diesel was the default Intergovernmental Panel on Climate Change (IPCC, 2006) value of 74,100 kg TJ^{-1}). The CH_4 and N_2O emissions were converted to their respective 100-year global warming potential equivalents using the IPCC Third Assessment Report values of 25 for CH_4 and 298 for N_2O.

Calculating policy and action (project) emissions in this study

Policy or project scenarios were calculated based on direct emissions produced by the policy or the action that is being implemented. Development of renewable technologies to mitigate the GHG emissions did not result in emissions in the analysis performed in this study. Default IPCC emission factors for stationary sources of CO_2 (74 100 kg TJ^{-1}), CH_4 (3 kg TJ^{-1}) and N_2O (0.6 kg TJ^{-1}) were used for diesel/gas project emissions.

4.2 National mitigation results

4.2.1 The updated baseline

South Africa's baseline trajectory was modelled as the "Growth Without Constraints" (GWC) scenario in the LTMS and as the WOM scenario in the MPA study. The LTMS had projected the country's emissions to reach 1,639 $MtCO_2e$ by 2050, and the original MPA study revised this value to 1,692 $MtCo_2e$ (Winkler (ed), 2017; DEA,2014). The updated 2020 MPA study has further revised this value to 783.4 $MtCO_2e$.

The huge difference between LTMS and original MPA national baselines on the one hand and the updated 2020 MPA baseline on the other hand could be caused mainly by a significant decline of economic outlook used in the latter. In addition, it could also suggest that there were no major technological improvements used in modelling of the 2020 update. Slow uptake of technologies that are important in reducing the emissions could prevent the country from reaching its target. Stagnant economic conditions which the country has experienced in the past years reduce capacity to afford technologies, electricity supply and demand are below the national plans since 2013, and poor financial situation of Eskom and ongoing removal of energy intensive smelters (Eskom, undated) contributed to reduced overall emissions.

Figure 7 below compares these three baseline scenarios modelled under the LTMS, the first MPA study and the updated MPA study.

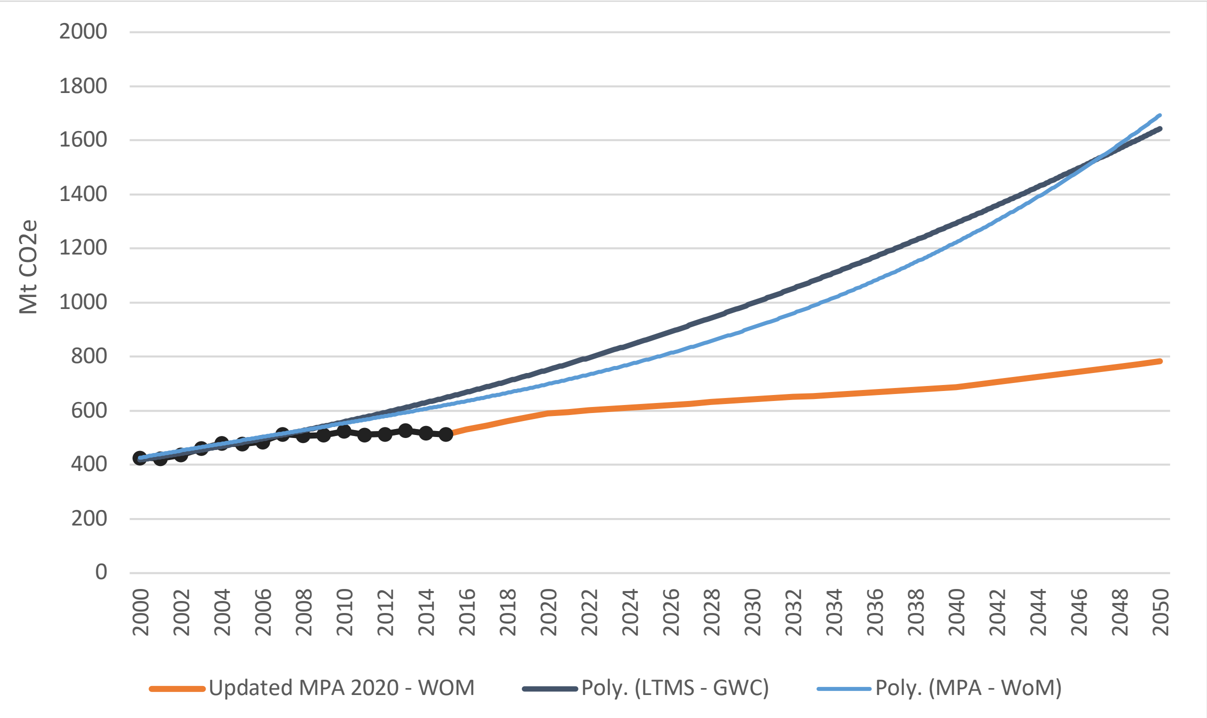


Figure 7: Comparison of the three baseline scenarios

In this study the WOM baseline scenario from the updated 2020 MPA study has been adopted and compared with other scenarios in the rest of the report. In Figure 8 below, this adopted baseline scenario is compared with the updated RBS scenario.

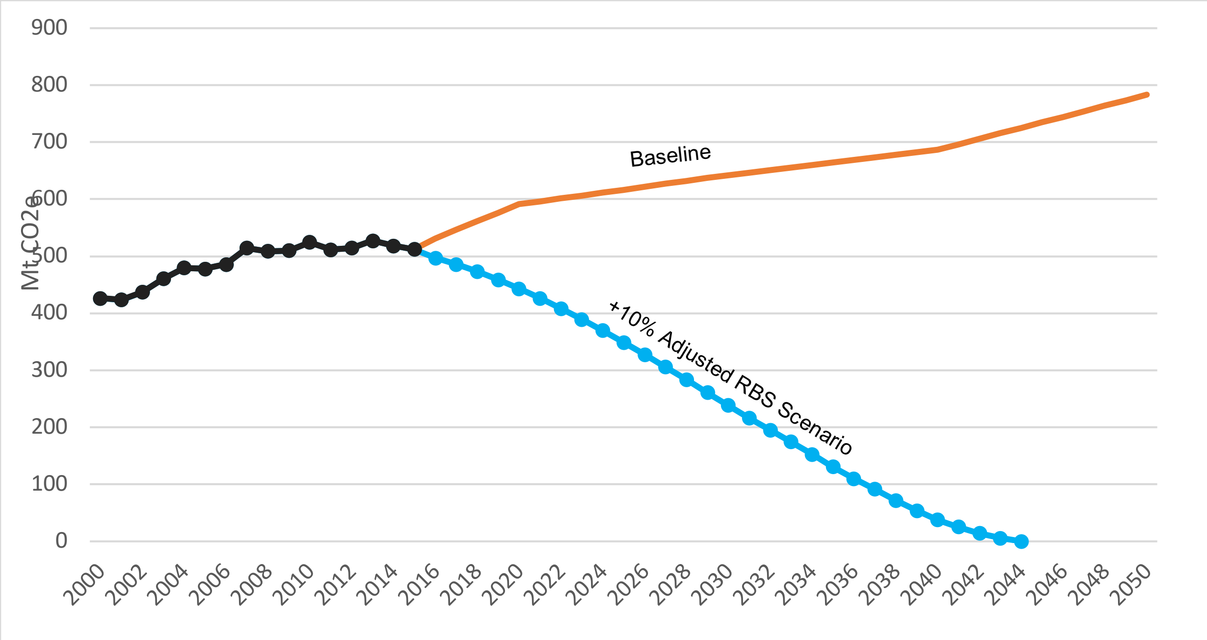
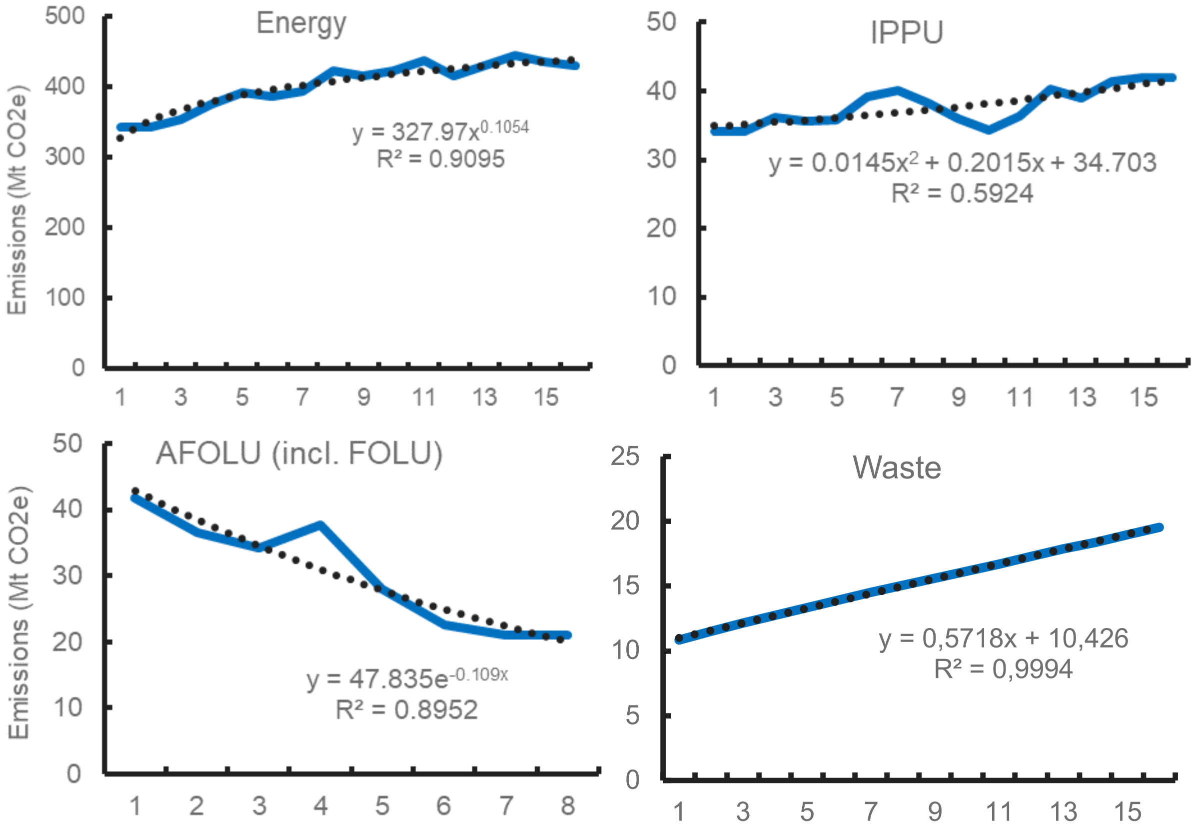


Figure 8: Comparison of the emission of the baseline emissions with the required +10% Adjusted RBS Scenario

4.2.2 The Updated WEM Scenario

This scenario assumes all measures planned from 2000 to 2015 are implemented through to 2050. The WEM scenario was determined by establishing trends from the 2000 to 2015 data presented in the national GHG report (NIR; DEFF, 2019). These trends were made for all the IPCC sectors (Energy, Industrial Processes and Product Use (IPPU), Agriculture, Forestry and Other Land Use (AFOLU), and Waste (See Figure 9 below). Trend relationships (in the form of equations) were used to project emissions through to 2050. Net emissions in the NIR report were used (i.e. total emissions inclusive of Forestry and Other Land Use).



*The value 39.38 Mt CO_2e omitted in the trend.

Figure 9: Trends of sectoral GHG emissions between 2000 and 2015 (DEF, 2019)

Figure 10 below presents the resulting projected WEM Scenario. The Figure shows that in the absence of if now new mitigation measures were implemented from 2015 the country's net GHG emissions would reach 616 MtCO_2e by 2050. This projected WEM Scenario is consistent with the WEM scenario modelled in the updated 2020 MPA study because the latter projects South Africa's emissions to reach 619 MtCO_2e in the absence of new mitigation measures from 2015 (DEFF, 2019).

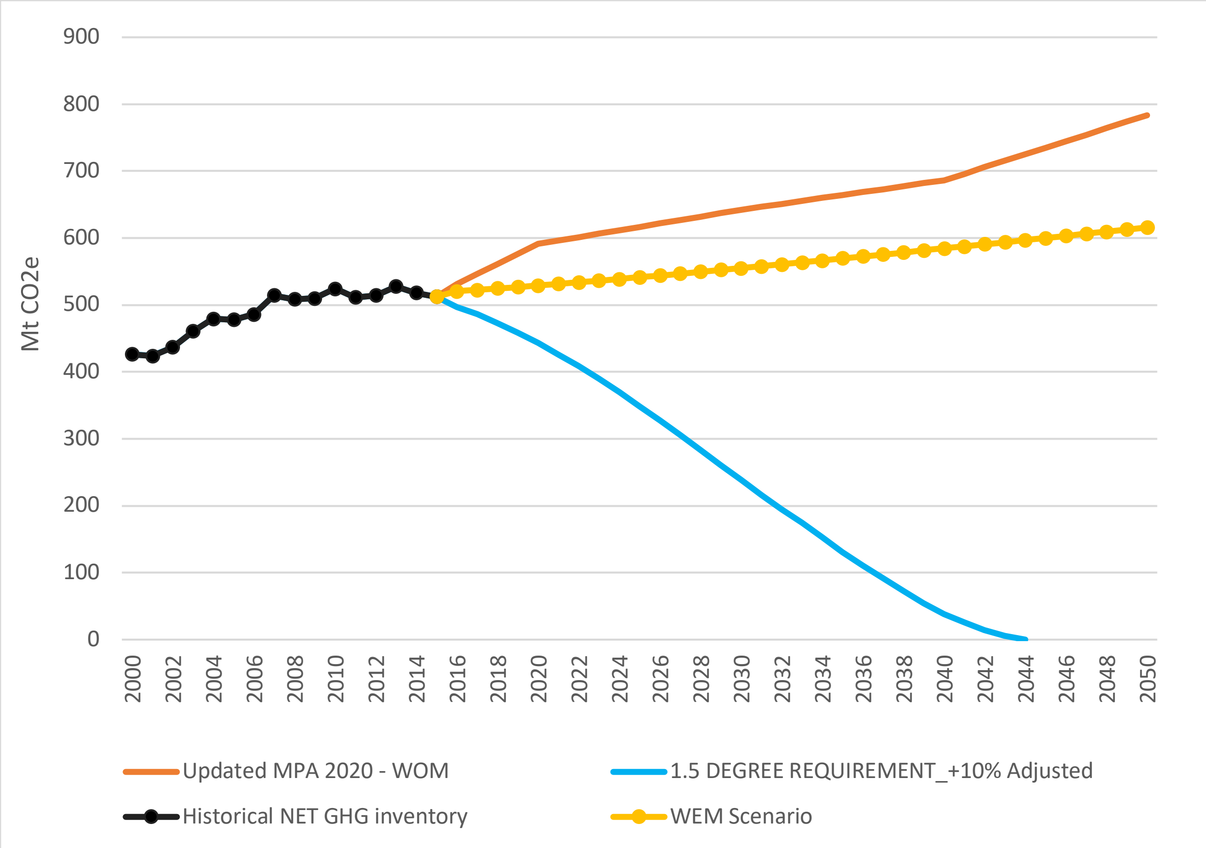


Figure 10:Projected WEM Scenario in comparison with the WOM and the RBS scenarios

4.2.3 The Updated CDP Scenario

CDP scenario was developed using data from IRP 2019 and other policies planned between that have been implemented after 2015. This includes projects of under the Renewable Energy Independent Power Procurement Programme as well as municipal projects like Bus Rapid Transit (BRT) systems that started operating after 2015.

Data for national energy planning from 2020 to 2030 was obtained from Integrated Resource Plan (IRP) of 2019 (Table 1; IRP 2019).

Table 1: Integrated Resources Planning for South Africa of 2019 (IRP,2019)

		Coal	Coal plants decommissioned	Hydro	Storage	Solar PV		Wind	CSP	Gas & Diesel
2018	MW	37149		2100	2912	1474		1980	300	3830
2019	MW	2155	-2373					244	300	
2020	MW	1433	-557			114		300		
2021	MW	1433	-1403			300		818		
2022	MW	711	-844		513	400	1000	1600		
2023	MW	750	-555			1000		1600		
2024	MW							1600		1000
2025	MW					1000		1600		
2026	MW		-1219					1600		
2027	MW	750	-847					1600		2000
2028	MW		-475			1000		1600		
2029	MW		-1694		1575	1000		1600		
2030	MW		-1050	2500		1000		1600		

[MW = Mega Watts; CSP = Concentrating Solar Power; PV = Photo Voltaic]

The decommissioning of the coal plants, however, was based on Eskom's latest decommissioning plan, which states that decommission of power plants has been delayed to start only in 2025-/2026 (Eskom, undated).

Table 2 below shows the mitigation measures modelled under the CDP scenario, together with their respective mitigation contribution. These measures have the potential to reduce the country's annual net GHG emissions by 91.0 MtCO2e. As expected, the IRP is the largest contributor to mitigation under the CDP, followed by wind and PV respectively. The results show that once fully implemented, the 2019 IRP has the potential to reduce the country's net GHG emissions by 84.6 $MtCO_2e$ annually.

Table 2: Mitigation measures modelled in the CDP Scenario

Mitigation measure	Annual GHG reduction ($MtCO_2e$)
Integrated Resource Plan 2019	84.6
Co and tri-generation projects	0.34
Landfill Gas	0.03
Onshore Wind	3.44
Photovoltaic Crystalline- Single Axis	1.18
Photovoltaic Thin Film Fixed	1.29
Roof-top Photovoltaic	0.07
Hydropower systems	0.05
Electric vehicles	0.00
New Bus rapid transit systems	0.02
TOTAL	**91.0**

The resulting CDP scenario is presented in Figure 11, showing that the country's net GHG emissions are projected to reach 525 MtCO2e by 2050 under the scenario.

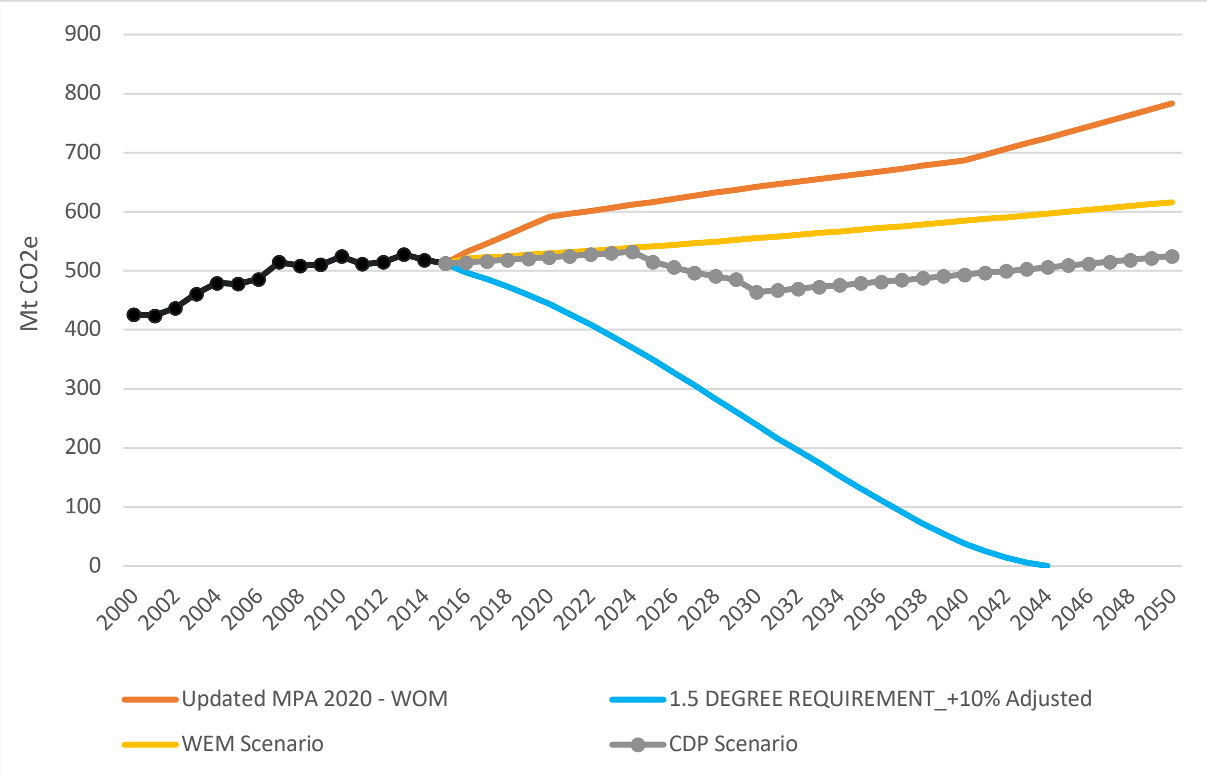


Figure 11: Projected CDP Scenario in the context of the other scenarios

4.2.4 The Updated WAM Scenario

The final scenario to be updated was the WAM Scenario. The results of the updated 2020 MPA study were used to construct this scenario. WAM Scenario mitigation measures in the updated 2020 MPA study were obtained from the stakeholders (DEFF, 2020). Table 3 shows the additional mitigation measures modelled under the WAM scenario as well as their estimated mitigation potential over the 2016 – 2050 period.

Table 3: Additional mitigation measures modelled under the WAM Scenario (DEFF 2020)

	Mitigation measure	Mitigation potential $MtCO_2e$ (2016 – 2050)
1	1^{st} gen Biofuels	229.0
2	Import hydro	214.1
3	Energy Efficiency in boilers and kilns	114.8
3	EAF and secondary production route in aluminium production	110.4
4	Alternative fuels – EV	102.8
5	3^{RD} Gen Biofuels	89.0
7	Restoration of sub-tropical thicket, forests and woodlands	72.3
8	Restoration and management of grasslands	53.7
9	Paper recycling	47.8
10	Alternative fuels - Diesel PHEV	47.2
11	Landfill gas recovery and generation	41.5
12	Alternative fuels - Petrol PHEV	41.0
13	Use of 2nd generation biodiesel (B100) for transport and handling equipment	38.0
14	LFG recovery and flaring	34.8
15	Biomass - forestry residue	28.6
16	Use of 2nd generation biodiesel (B50) for transport and handling equipment	28.5
	TOTAL over the period 2016 - 2050	**1,293.6**

The results show that these additional measures modelled under the WAM scenario have the potential of reducing South Africa's annual GHG emissions by about 38 $MtCO_2e$. Figure 12 shows that all the mitigation measures have to potential to reduce the country's net annual emissions to 467 MtCO2e and 486 MtCO2e by 2044 and 2050 respectively. In comparison, the updated 2020 MPA study projects that the WAM scenario can get South Africa to 386 MtCO2e. The main reason for the discrepancy is the inclusion of scaled-up renewable energy in modelling the WAM scenario of the updated 2020 MPA study, while in the current study this forms part of additional considerations for achieving South Africa's 1.5oC RBS scenario as discussed in the next chapter.

Essentially the next chapter qualitatively considers further interventions that can be considered for implementation in the country in order to achieve the updated +10% Adjusted RBS scenario target.

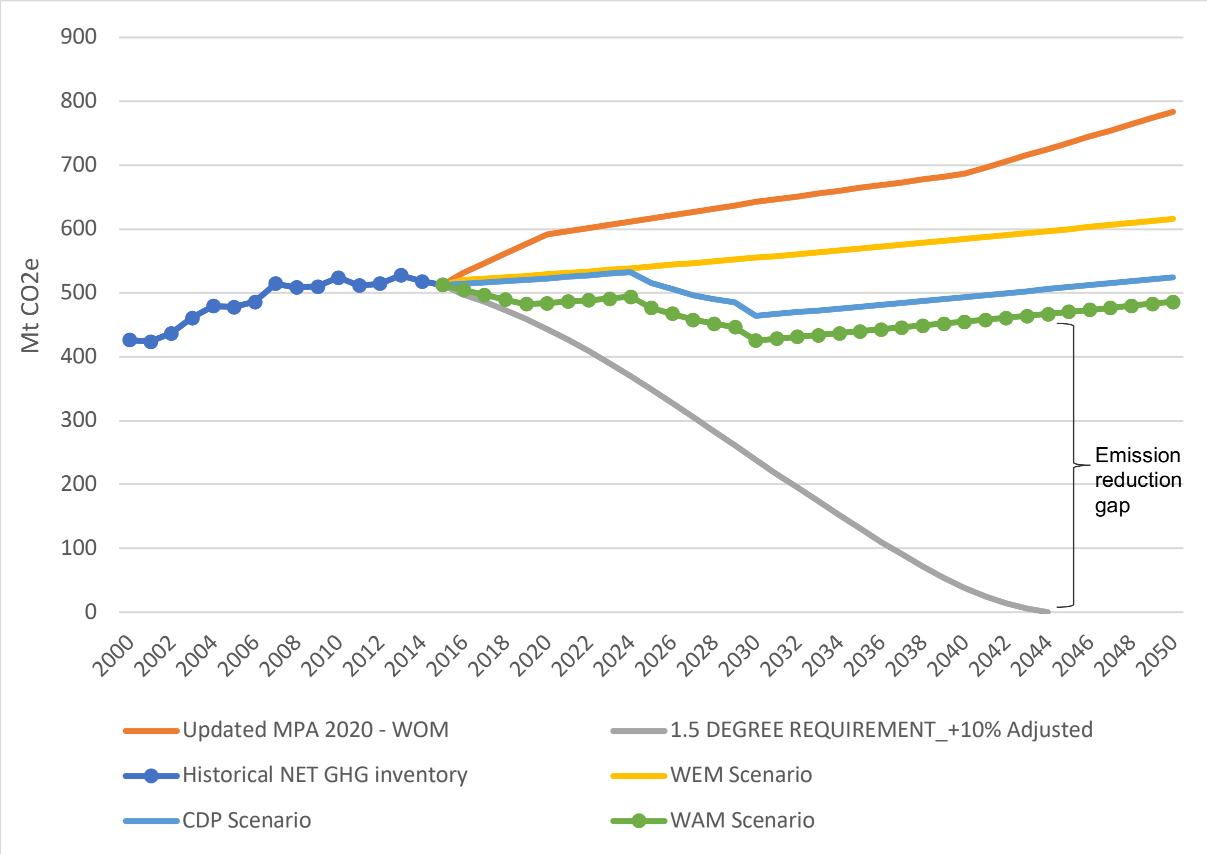


Figure 12: The updated WAM scenario and the resulting emissions gap

5 Other considerations for achieving SA's 1.5°C aligned NDC

This study indicates that South Africa will not achieve net zero GHG emissions by 2050. The country does not have demonstrable plans beyond 2030 to reduce the emissions so that the Paris Agreement objectives can be achieved. Furthermore, lack of mitigation plans in all sectors but energy will not assist the national goals.

Policy actions implemented by 2015, planned measures until 2030 and identified additional efforts fall short of the required target. This is a concern because without concrete additional efforts to reduce GHG emissions, current levels are expected to increase to over 450 – 500 parts per million by 2050, the concentrations required to achieve a global average increase of 1.5 °C (Edenhofer et al., 2014). The upward growth of emissions is projected to be due to increases in global population and economic activities. The emissions will rise despite advances and achievements in energy efficiencies throughout the energy spectrum (Edenhofer et al., 2014).

Since over three quarters of GHG emissions come from the energy sector in South Africa, bulk of mitigation actions are expected to be in this sector. However, current abatement efforts focus on energy supply but emission reduction plans on the consumption side are limited. Energy efficiencies and renewable energy uptake in the mining sector, the known large energy consumer in the country are not known. For the country to achieve its share of less than 1.5 °C global target by 2050, demonstrable milestones for each sector of the economy are needed.

Greenhouse gas emissions in the IPPU sector are projected to increase with no indications of mitigation activities. The iron and steel industry declares that although they are main producers of emissions in this sector, their mitigation potential is very limited due to the nature of their operations that heavily use carbon as input (Arcelormittal South Africa, 2017). Similar challenges can be expected in other related industries (i.e. cement production and ceramic industries). The industry should, however, be encouraged to pursue robust mitigation plans that looks into improving efficiencies of production amongst other things.

Net GHG emissions in the AFOLU sector are decreasing with time in South Africa. Successive NIRs indicate decline in emissions from both animal and crop production systems in the country. The declines are largely attributed to improved production efficiencies and overall yields due to advances in machinery (for crops) and consumer choices (animal products especially beef). These are production intensity related mitigation activities (Smith et al., 2014). Mitigation scenarios in this sector are highly influenced by land use dynamics and efficient use of the land including enhancements of GHG sinks (Edenhofer et al., 2014). However, increase in source emissions (i.e. AFOLU excl. FOLU) indicate that other land use (FOLU) sector may remain an area of mitigation focus. Trends of emissions in the country show that major sources of emissions are as a result of land conversions especially from forest lands and grasslands to croplands which cause changes in soil carbon pool dynamics (DEFF, 2019). Net effect of these conversions is the reduction of carbon sinks and increase of the sources. Actions to mitigate the emissions in this sector may include lifestyle and diet changes with plant-based diets shown to be less carbon intensive than dishes containing animal products (Smith et al., 2014).

Waste sector is smallest source of GHG emissions in the country. There is some potential to mitigate waste generated particularly in metropolitan areas in many parts of the country. However, not much has been planned for waste-to-energy generation facilities that have a potential to mitigate the emissions.

South Africa needs to scale up GHG mitigation measures in all sector of the economy if it is to realize net zero emissions required by science to limit global warming to less than 1.5 °C. Current policy direction that almost exclusively focuses on energy supply will definitely not be enough. Planning to 2030 and little or no information beyond the next decade limit comprehensive analysis to track the national track to the 1.5 °C pathway. Countries are cautioned that delaying mitigation efforts will decrease chances of limiting concentrations of GHGs to the required threshold of 450 to 500 parts per million and will increase the vulnerability of the planet to climate change (Edenhofer et al., 2014).

In order to close the mitigation gap identified in the preceding chapter and to achieve net zero emissions by 2044 – 2050, the following are some of the interventions that will need to be considered:

- Aggressively scaling up renewable energy in the electricity sector beyond 2030 and building no new coal fired power plants beyond that year
- Implementing Flue Gas Desulphurization in Kusile, Medupi and all new coal-fired power plants included in IRP 2019
- Implementing aggressive measures in the transport sector, including non-motorized transport systems, scaling up electric vehicles and implementing mass rapid transit systems in all Metros and secondary cities around the country
- Implementing mitigation measures in the AFOLU sector in large scale, including smart agriculture and manure management programmes
- Lastly, moving towards zero solid waste going to landfills through alternative waste management practices.

6 Appendix A: Table of all the trajectories modelled

Scenario / Trajectory	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
1.5 degree Global requirement - FULL TRAJECTORY	503	494	484	472	460	446	431	416	399	382	364	345	327	307	288
1.5 DEGREE REQUIREMENT_+10% Adjusted	497	486	473	459	443	427	409	390	370	349	328	306	284	261	239
WEM Scenario	520.5	522.5	524.6	526.8	529.1	531.4	533.8	536.3	538.9	541.5	544.1	546.8	549.5	552.3	555.1
CDP Scenario	514.1	516.1	518.2	520.4	522.6	525.0	527.4	529.9	532.4	514.9	506.0	496.7	490.4	485.3	464.1
WAM Scenario	504.6	497.1	489.6	482.3	484.0	486.3	488.8	491.2	493.8	476.3	467.4	458.0	451.8	446.6	425.4

2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
268	248	229	209	190	171	152	134	117	100	85	70	56	43	31	21	12	6	2	0
216	195	174	152	131	110	91	72	54	38	25	14	6	0						
557.9	560.8	563.7	566.6	569.5	572.5	575.5	578.5	581.5	584.6	587.6	590.7	593.8	596.9	600.0	603.2	606.3	609.5	612.7	615.9
466.9	469.8	472.7	475.6	478.5	481.5	484.5	487.5	490.5	493.5	496.6	499.6	502.7	505.8	509.0	512.1	515.3	518.4	521.6	524.8
428.2	431.1	434.0	436.9	439.8	442.8	445.8	448.8	451.8	454.9	457.9	461.0	464.1	467.2	470.3	473.5	476.6	479.8	483.0	486.2

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