South Africa's Net-Zero Transition

NBI
National Business Initiative

TOWARDS A JUST, CLIMATE-RESILIENT, PROSPEROUS FUTURE FOR SOUTH AFRICA

JUST TRANSITION AND CLIMATE PATHWAYS STUDY FOR SOUTH AFRICA

IN PARTNERSHIP WITH

BCG BOSTON CONSULTING GROUP

BUSA BUSINESS UNITY SOUTH AFRICA

Acknowledgements

RESEARCH SUPPORTED BY

UK PACT South Africa: UK PACT has partnered with South Africa to support action on Just Transition pathways and a low-carbon economic recovery. As the third largest economy in Africa, South Africa plays a critical role in economic and policy priority setting at a continental level and across the Southern Africa region. South Africa's longstanding participation in the United Nations Framework Convention on Climate Change (UNFCCC) processes creates a solid platform for an impactful and transformational UK PACT partnership. Moreover, UK PACT seeks to support climate action that will contribute to the realisation of other development imperatives in South Africa, such as job creation and poverty alleviation. Priority areas of focus for UK PACT in South Africa are aligned with key national priorities in the just energy transition, renewable energy, energy efficiency, sustainable transport, and sustainable finance. UK PACT projects can contribute to addressing industry-wide constraints, common metropolitan challenges, and bringing city, provincial and national level public and private partners together to address climate priorities.

We Mean Business: This is a global coalition of nonprofit organisations working with the world's most influential businesses to take action on climate change. The coalition brings together seven organisations: BSR, CDP, Ceres, The B Team, The Climate Group, The Prince of Wales's Corporate Leaders Group and the World Business Council for Sustainable Development. Together we catalyze business action to drive policy ambition and accelerate the transition to a zero-carbon economy. NBI has been a regional network partner to WMB since the beginning of 2015.

Strategic Partnerships for the Implementation of the Paris Agreement (SPIPA): Climate change is a global threat that requires a decisive and confident response from all communities, particularly from major economies that represent roughly 80 % of global greenhouse gas emissions. The 2015 Paris Agreement complemented by the 2018 Katowice climate package, provides the essential framework governing global action to deal with climate change and steering the worldwide transition towards climate-neutrality and climate-resilience. In this context, policy practitioners are keen to use various platforms to learn from one another and accelerate the dissemination of good practices. To improve a geopolitical landscape that has become more turbulent, the EU set out in 2017 to redouble its climate diplomacy efforts and policy collaborations with major emitters outside Europe in order to promote the implementation of the Paris Agreement. This resulted in the establishment of the SPIPA programme in order to mobilise European know-how to support peer-to-peer learning. The programme builds upon and complements climate policy dialogues and cooperation with major EU economies.

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The African Climate Foundation: The ACF is the first African-led strategic climate change grant-making foundation on the continent. Building on the success of partner organisations like the European Climate Foundation and ClimateWorks Foundation, the ACF was established to provide a mechanism through which philanthropies can contribute to Africa's efforts to address climate change. As an African-led and African based foundation, we are committed to supporting African solutions to the climate change challenges facing the continent.

The Confederation of Danish Industry: The DI is Denmark's largest, most representative, and most influential business and employers' organisation, covering manufacturing as well as service industries across sectors such as transport, energy, IT, health, trade, and professional services. DI believes that a strong society needs strong companies – just as strong companies benefit from a strong society. Thus, DI is committed to creating a society in growth and balance, helping Danish companies to win both at home and abroad. DI believes that the private sector plays a crucial role in the just, green transition and in achieving the UN's 17 Sustainable Development Goals. A strong private sector creates jobs and develops the innovative solutions that are essential to create decent living conditions and sustainable development in developing economies. DI believes that societies need a strong private sector voice and thus partners with other employer and business membership organisations like the NBI, as well as Danish and local unions all around the world in order to create local jobs, improve business conditions, contribute to a green transition and sustainable development as well as improve labour market stability and conditions.The Confederation of Danish Industry has partnered with the NBI on a range of projects, and most recently on the Just Transition Pathways project, to support the development of decarbonisation pathways for the Cement and Transport sectors.

The Banking Association South Africa: The BASA advances the interests of the industry with its regulators, legislators, and stakeholders, to make banking sustainable, profitable and better able to contribute to the social and economic development and transformation of the country. As the national association of domestic and international banks operating in South Africa, BASA advocates the views of the banks on legislation, regulation, social, and economic issues that affect the industry. It engages with its members through committees and work groups and facilitates the sustainable transformation of the banking industry. It promotes inclusive economic growth by working with legislators, regulators, as well as other business associations and stakeholders, to establish a stable, conducive policy and business environment. It seeks to find sustainable solutions to the challenges of poverty, unemployment, and inequality by mobilising the skills and resources of the industry. BASA has partnered with the NBI on the Just Transition Pathways project to support research into understanding the funding requirements for a Just Transition in South Africa.

PARTNERS

National Business Initiative

At the National Business Initiative (NBI), we believe in collective action and collaboration to effect change; building a South African society and economy that is inclusive, resilient, sustainable and based on trust. We are an independent, business movement of around 80 of South Africa's largest companies and institutions committed to the vision of a thriving country and society. The NBI works with our members to enhance their capacity for change, leverage the power of our collective, build trust in the role of business in society, enable action by business to transform society and create investment opportunities, common metropolitan challenges, and bringing city, provincial and national level public and private partners together to address climate priorities.

Business Unity South Africa

BUSA, formed in October 2003, is the first representative and unified organisation for business in South Africa. Through its extensive membership base, BUSA represents the private sector, being the largest federation of business organisations in terms of GDP and employment contribution. BUSA's work is largely focused around influencing policy and legislative development for an enabling environment for inclusive growth and employment.

Boston Consulting Group

BCG partners with leaders in business and society to tackle their most important challenges and capture their greatest opportunities. BCG, the pioneer in business strategy when it was founded in 1963, today works closely with clients to embrace a transformational approach aimed at benefitting all stakeholders — empowering organisations to grow, build sustainable competitive advantage, and drive positive societal impact. Their diverse global teams are passionate about unlocking potential and making change happen, and delivering integrated solutions.

Executive Summary

The world is embarking on an ambitious decarbonisation journey to avoid catastrophic climate change. An increasing number of governments and companies have committed to transition to net-zero economies by 2050. For South Africa, responding to climate change is fundamentally about ensuring future economic competitiveness and lifting its people out of poverty, inequality, and unemployment while contributing to the global goal of reducing carbon emissions.

The NBI-BUSA-BCG Climate Pathways and Just Transition study assesses what it would take for South Africa to reach net-zero by 2050 and to ensure a Just Transition. It is one of the most robust, transparent, and inclusive climate studies in South Africa. The work was undertaken over two years and led by a group of 30+ CEO Champions from a range of sectors. It has involved more than 400 stakeholders from business, government, civil society, and labour over nearly 200 hours of technical workshops as well as through a robust series of 1:1 engagements. Throughout this process, evidence-based inputs were developed that informed – and continue to inform – the critical national discussion on South Africa's climate response. The work is ongoing, and 6 detailed analytical and model-based sector-level reports have been released thus far. A further 4 reports are in publication. This report consolidates the key findings from the individual sector analyses into a consolidated national picture, and the key actions South Africa needs to pursue to realise this transition.

The study finds that the cost of inaction to climate change in South Africa is massive: in a decarbonised world where trade partners act on their net-zerov commitments, ~50% of South Africa's export value, ~1 m direct jobs, and ~15% of GDP could be at risk if current high carbon emissions are maintained. This will exacerbate South Africa's already challenging inequality, poverty and unemployment. However, the transition to a net-zero South Africa can provide a solution to many of these problems. South Africa's world-class renewable energy resources, access to key mining commodities, expertise in key industries such as synthetic fuels production, existing trade relationships, and a young, growing population, provide an opportunity to capture new markets to drive its economic growth and job creation.

The imperative is clear: South Africa needs to act now and transition to a low-carbon, climate-resilient, and competitive economy to unlock new green opportunities and avoid the massive cost of inaction. This endeavour needs to be just: the transition must address the triple challenge of inequality, poverty, and unemployment and lead to a future economy that is socially resilient and inclusive.

South Africa can pursue an ambitious pathway to reach net-zero by 2050, and meet its 2030 Nationally Determined Contribution (NDC) of 350 to 420 $MtCO_2e$. This pathway includes ambitious actions such as:

- the deployment of renewable energy 10x faster than the current rate, at ~6-7 GW p.a., to decarbonise the power sector, with this doubling to capture the green H_2 opportunity,
- the phase out coal power by the mid-2040s,
- the rapid electrification of transport with 700,000 electric vehicles on the road by 2030,
- the banning of conventional vehicle sales by 2035, and
- a 15% and 20% increase in passenger and commercial rail use respectively.

Renewables-based power will become the primary energy carrier in the economy, as heating and mobility – which are currently fossil fuel-based – are electrified. Beyond these actions, there will also need to be significant behavioural changes from individual South Africans, such as a shift to a low-red meat, sustainable diet, increased public transport use, and smaller, more sustainable homes.

Even with implementing all these ambitious actions South Africa will not meet the lower bounds of its internationally committed emission reduction targets. This pathway will result in 409 $MtCO_2e$ emissions in 2030 (only a 20% reduction from the 2017 baseline) – nearly 60 $MtCO_2e$ away from the NDC lower bound. Further, the pathway has ~9 $GtCO_2e$ cumulative emissions, which just meets the anticipated fair share carbon budget of 7-9 $GtCO_2e$. More than 50% of the fair share carbon budget upper bound is used up by 2030. This is due to the limited emissions reduction in the 2020s, with only the power and petrochemicals sectors driving significant national emissions reduction in the 2020s.

Therefore, to reach the lower bound of the 2030 NDC, and stay within its fair share carbon budget, South Africa requires even more disruptive decarbonisation action across all sectors, starting in the 2020s already. This includes, for example, lower coal utilisation in the power sector, faster electric vehicle adoption, an increased shift to public transport, early deployment of disruptive levers in heavy manufacturing, and faster uptake in society of low-red meat sustainable diets.

Given the socio-economic risks, such as the impact on individual South Africans' ability to afford potentially more expensive green technologies earlier, and the impact of reduced income due to lower coal utilisation on coal communities, among others, that arise with more disruptive action and the limited capacity of the public sector to financially support these actions, South Africa will not be able to do this without international support.

The support required is not only financial – South Africa requires support across financing; trade (for example, cost-competitive electric vehicle imports, and risk mitigation of foreign currency fluctuations); technology (such as IP sharing to enable the green H_2 economy); and skill and capacity development.

South Africa's transition will require more than ZAR6 trillion in investments by 2050, half of which (~ZAR2.8 trillion) is required by the power sector. However, the annualised investment rate required in power is ~ZAR 100 billion p.a., compared to the current primary energy spend of ZAR 120 billion[1] – the investment into a renewable energy power system actually saves South Africa money in the long-term. Furthermore, in the 2020s, 60% of South Africa's mitigation investments can be primarily funded from commercial sources. Therefore, many of these investments are already commercially viable. However, international development finance will be critical to fund 'non-bankable' investments (for instance, social costs and re-skilling costs) and cover the 'economic gap' in new green industries to crowd-in private sector investment (to subsidise green H_2 costs and stimulate supply-side investments, for example).

South Africa's net-zero transition will see a fundamental change in the economy: a rapid shift from being the 2nd most carbon intense economy in the world to a new green, carbon-neutral economy within 3 decades. New green industries such as electric vehicle manufacturing, green H_2-based industries, and green minerals, among others, can drive job creation, with a renewables-based power system creating ~2.4 million net cumulative job years by 2050 alone. However, displaced workers cannot simply be 'absorbed' by these new jobs due to a difference in skill requirements. Furthermore, these new green industries, set against the backdrop of increasing digitisation and automation as well as the need for higher wages to enable individual South Africans to afford the cost of the transition (including the 4x higher cost of a sustainable diet), will require a more highly skilled workforce.

1. ESKOM, Annual Financial Statements, 31 March 2021

Given the rapid pace of this transition, the workforce transition cannot be left to the market, but instead will need to be proactively orchestrated. A national, coordinated effort involving the private sector, public sector, and civil society will be crucial to co-develop the strategic workforce plan for South Africa.

Finally, although transitioning to net-zero can preserve the South African economy, secure long-term competitiveness, and create new green industries, more than job creation is needed to ensure that the transition is just. The transition must therefore be coupled with deliberate efforts to ensure that this it leaves no one behind and meets South Africa's developmental needs.

Reaching net-zero is a challenge that will see a significant transformation of South Africa's energy system, building and vehicle stock, infrastructure, and large parts of industry all while addressing South Africa's socio-economic challenges. The sum of individual actions, even bold ones, will not be enough to meet this challenge – we need collaboration and a coordinated approach to successfully decarbonise and ensure a Just Transition.

To achieve a Just Transition South Africa needs to urgently:

01

Make the ramp-up of renewables a national priority

02

Coordinate a national green industries incubation and an economic diversification approach

Introduction

The foundation of this study is a broad and inclusive stakeholder engagement process through which the methodological approach, key assumptions, underlying analysis and broader framing of recommendations were discussed and jointly refined **(Figure 1)**.

The project was funded by development finance institutions and non-governmental organisations. The donors include the UK Pact, Strategic Partnerships for the Implementation of the Paris Agreement (SPIPA), The Confederation of Danish Industry, Banking Association South Africa (BASA), We Mean Business Coalition (WMBC), and the African Climate Foundation (ACF). All stakeholder opinions and inputs were considered, and fact-based suggestions were systematically incorporated.

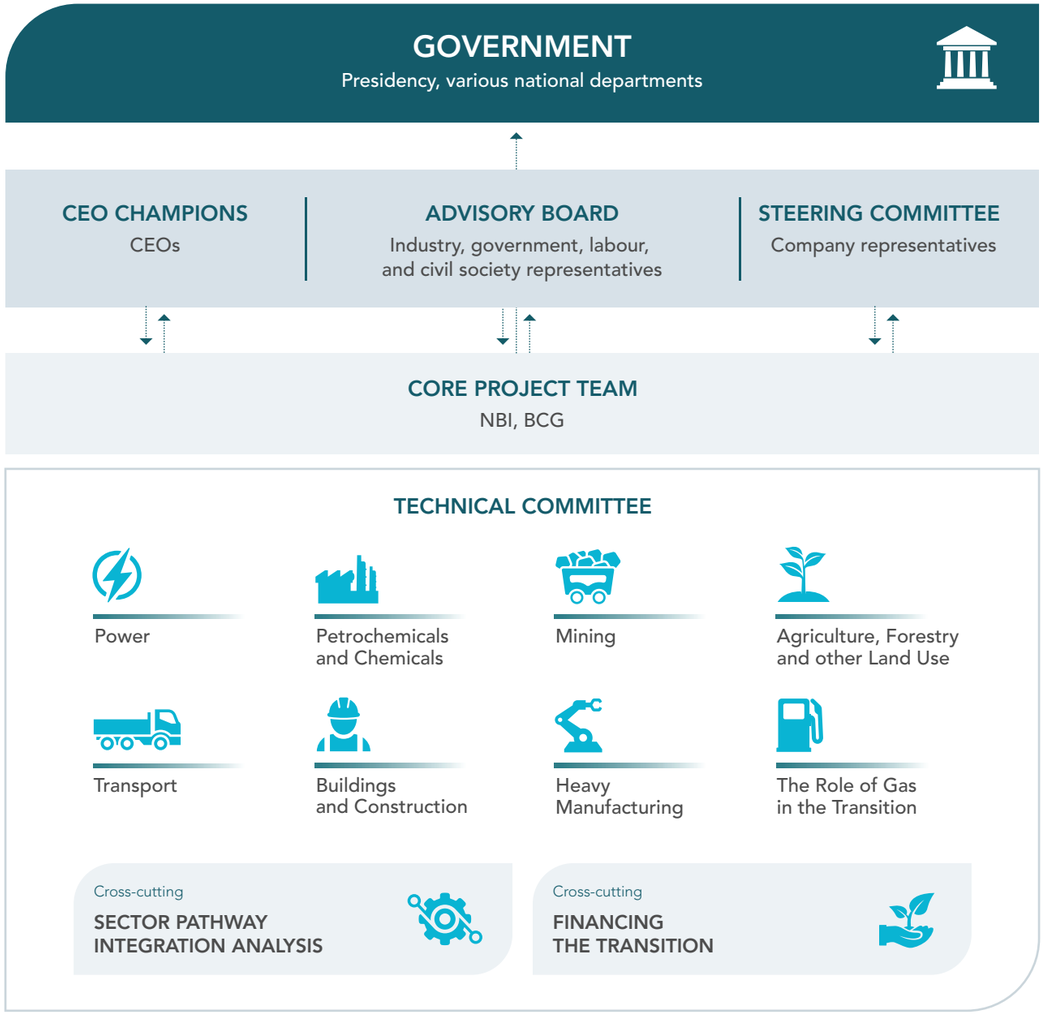
The conclusions of this work were accepted by the diverse advisory board, steering committee, and the study's 30+ CEO Champions **(Figure 2).** The transparent, inclusive, and independent[2] project governance and multi-stakeholder processes ensured that the NBI-BUSA-BCG Climate Pathways and Just Transition study is to date one of the most robust, transparent, and inclusive climate studies in South Africa.

This report consolidates the critical findings of this multi-year study. It should be read alongside the sector technical reports, which provide details that underpin the conclusions presented.[3] This includes the following publications:

1. Decarbonising South Africa's Power Sector (2021)
2. Decarbonising the South African Mining Sector (2021)
3. Decarbonising South Africa's Petrochemicals and Chemicals Sector (2021)
4. Decarbonising the Agriculture, Forestry and other Land Use Sector in South Africa (2021)
5. The Role of Gas in South Africa's Path to Net-Zero (2022)
6. Decarbonising South Africa's Transport Sector (2022)
7. Decarbonising South Africa's Heavy Manufacturing Sector (2022)
8. Decarbonising South Africa's Buildings and Construction Sector (2022)
9. Financing South Africa's Transition to Net-Zero (2022)
10. It All Hinges On Renewables – The Massive And Urgent Energy Transformation South Africa Needs To Get Right (2022)

2. Independent of private sector financing, and thus undue influence to include non-fact-based results
3. https://www.nbi.org.za/climate-pathways-and-a-just-transition-for-south-africa/

Figure 1 | Overview of governance structure and stakeholder engagements of this study



Source: NBI-BCG Project Team

Figure 2 | Overview of CEO champions

ONBOARDING OF ADDITIONAL CEOS ONGOING

Joanne Yawitch
NBI CEO

Cas Coovadia
BUSA CEO

Paul Hanratty
Sanlam CEO

Shirley Machaba
PwC CEO

Lungisa Fuzile
Standard Bank CEO

Leila Fourie
JSE Group CEO

André de Ruyter
Eskom CEO

Arrie Rautenbach
ABSA CEO

Ian Williamson
Old Mutual CEO

Alan Pullinger
First Rand CEO

Portia Derby
Transnet CEO

Stuart Kent
Aurex CEO

Mark Dytor
AECI CEO

Nolitha Fakude
Anglo American SA Chairperson

Taelo Mojapelo
BP Southern Africa CEO

Deidré Penfold
CAIA Exec Director

Theo Boshoff
AgBiz CEO

Seelan Naidoo
Engen CEO

Mohammed Akoojee
CEO Imperial Logistics

Stuart MacKenzie
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Exxaro CEO

Gavin Hudson
Tongaat Hulett CE

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GE SA CEO

Bertina Engelbrecht
Clicks CEO

Tshokolo Nchocho
IDC CEO

Hloniphizwe Mtolo
Shell SA CEO

Vivien McMenamin
Mondi SA CEO

Andrew Robinson
Norton Rose Fulbright CEO

Roland van Wijnen
PPC Africa CEO

Njombo Lekula
MD SA Cement
and Materials, PPC

Alex Thiel
SAPPI CEO

Fleetwood Grobler
Sasol CEO

Key Findings

1. ***A transition to net-zero can lead to a just, prosperous and climate-resilient South Africa. South Africa must act now to unlock this opportunity, and avoid the massive cost of inaction.***

2. ***South Africa can be net-zero and capture new green opportunities by 2050 – ten critical actions need to be pursued to achieve this. However, South Africa cannot do this alone; international support will be critical.***

   i. *To enable a rapid renewables roll-out, South Africa's power grid needs to urgently be expanded, strengthened and modernised*

   ii. *To decarbonise power, renewables need to be rolled out in South Africa at an unprecedented rate of ~6-7 GW per year. To capture the green H_2 opportunity, an additional ~6-12 GW of renewables need to be deployed per year*

   iii. *To drive economic growth, South Africa needs to leverage its structural advantages and establish a green H_2 industry for local demand and exports*

   iv. *South Africa's rail infrastructure needs to be expanded and upgraded to enable a shift to rail transport away from carbon-intensive, inefficient, and expensive road transport*

   v. *Cities and urban areas in South Africa need to be densified to reduce commuter travel demand and to achieve adequate, less carbon-intensive residential housing*

   vi. *South Africa's road transport needs to be electrified and consumers incentivised to shift to electric mobility – ~750 000 electric vehicles need to be on South Africa's roads by 2030. The sale of conventional combustion engine vehicles needs to be banned from 2035*

   vii. *Reaching full decarbonisation of the transport sector requires a behavioural shift: South Africans will need to shift from private to public transport*

   viii. *A shift to nutritional, sustainable diets among South Africans is critical to improve health and drive 4% of emissions reduction. However, this can only be achieved if food becomes more affordable to South Africans*

   ix. *South Africa needs to act now before the cost of key heavy manufacturing commodities increases as global economies transition to net- zero*

   x. *If South Africa wants to meet the lower bounds of its internationally committed emissions reduction targets, even more disruptive action is needed across all sectors. Given the socio-economic risks that arise with more disruptive action, South Africa will not be able to do this without international support.*

3. ***As a result of decarbonisation, renewable-based power will become the primary energy carrier in South Africa's net-zero economy ~ZAR 6 trillion is required in infrastructure investments to transition to net-zero by 2050, with ~ZAR 1 trillion required by 2030, which is offset by reduced expenditure on fossil fuels***

4. ***The public sector must unlock sufficient private sector investment, particularly in bankable investments such as renewables, to finance the transition***

5. ***The net-zero transition will see a fundamental change in the economy - new economic opportunities will arise and many new jobs can be created. However, the jobs of the future will require a different workforce from today***

6. ***Although transitioning to net-zero can preserve the economy, secure long-term competitiveness and create new green industries, it must be well managed to ensure Just Transition outcomes that address South Africa's development needs***

7. ***Reaching net-zero will impact the entire economy and all members of society, and action and collaboration are needed across all sectors to achieve it by 2050***

01

A transition to net-zero can lead to a just, prosperous and climate-resilient South Africa. South Africa must act now to unlock this opportunity, and avoid the massive cost of inaction

South Africa faces a uniquely difficult starting point: the country has a triple challenge of record-high unemployment, rising inequality, and poverty. Additionally, South Africa has the second most carbon-intensive economy globally.[4] This carbon-intensive economy will face mounting trade risks, and against the backdrop of stalled GDP growth, this will exacerbate an already challenging starting point **(Figure 3)**. Finally, South Africa faces severe physical risks due to climate change – a global average temperature increase of 1.5°C translates to an average 3°C increase for Southern Africa **(Figure 4)**.

The net-zero transition also presents an opportunity to address some of South Africa's pressing challenges. South Africa's world-class renewables, access to key mining commodities, expertise in key industries such as synthetic fuels production, existing trade relationships, and a young, growing population, provide an opportunity to capture new emerging markets. For example, a green H_2 economy could create up to 2.4 million cumulative job years by 2050. Capturing this opportunity will drive job creation, and economic growth, diversification and competitiveness, but to capture the full value of this opportunity we need to act fast. There is also an opportunity to transition to a renewable-dominant power system to address South Africa's current energy security issues—addressing this is critical to strengthening the economy. Finally, the transition provides an opportunity to both protect people and the economy through climate adaptation.

The economic and social cost of inaction for South Africa is massive. With six out of ten key export markets moving to net-zero, ~50% of South Africa's export value, ~1 million direct jobs, and ~15% of GDP could be at risk if decarbonisation is not pursued.[5] This is because a carbon-intensive South African economy will face mounting trade risks and decreasing competitiveness should trade partners act on their net-zero commitments **(Figure 5)**. For example, the European Union (EU) plans to implement a carbon border tax, which would make carbon-intensive goods less competitive.[6]

More of the same will not be enough. South Africa needs to transition to a low-carbon, climate-resilient, and competitive economy that captures new green economic opportunities. This endeavour needs to be just: it will need to address South Africa's triple challenge of inequality, poverty, and unemployment and lead to a future economy that is socially resilient and inclusive. To achieve this, the communities and workers most affected by both the physical impacts of climate change and the decarbonisation of the economy must be at the centre of the transition, with the aim that no one is left behind.

The imperative is clear: South Africa cannot sit idle, it needs to act now. South Africa must decarbonise its economy in the next three decades and transition toward a low-carbon, climate-resilient, and competitive economy.

4. GDP >$500 billion
5. Estimated as the loss of the coal and petrochemicals industries due to the shift to greener commodities, and the loss of the current export potential in heavy manufacturing commodities and AFOLU due to climate regulations in key export markets
6. Carbon border tax is an import duty on based on the carbon emissions from the production of a good. Importers will have to pay the same carbon price as if the good was produced within the EU. The objective of the carbon border tax is to protect local industries from regions with less stringent carbon policies and taxes. The tax is planned to be enforced from 2026 to certain commodities, but range is likely to be encompassing in the future

Figure 3 | South Africa's status quo is already socio-economically unsustainable, and requires significant change towards climate sustainability and social justice

01

South Africa is one of the most carbon intense major economies

South Africa's economy is heavily reliant on coal, with

86% of power being coal-based[1]

With a carbon intensity of 0.6kgCO_2e/$ PPP GDP South Africa is the

2nd most carbon intense major economy[2] in the world

South Africa is the largest emitter in Africa, driving

40% of the continent's emissions[3]

02

South Africa is the most unequal country in the world

South Africa has with 0.63 the **largest GINI** coefficient globally

The top **10%** of South Africa's population owns **86%** of aggregate wealth[4]

Over **34%** of South Africans are unemployed, with youth unemployment reaching a record of **65.5%** in 2021[5,6]

55% of South Africans live in poverty with more than **10%** living in extreme poverty[5]

03

South Africa's economy is weak

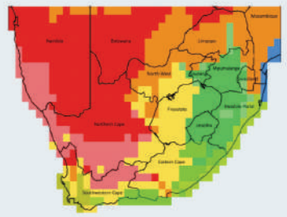
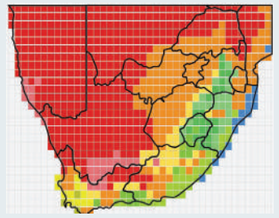
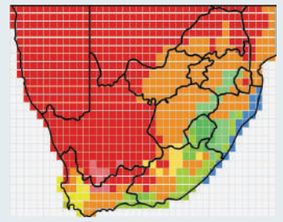
Economic growth has stalled over recent years, with **~1% GDP growth** for the last 5 years, and an overall decline of **~-0.2%** in 2010-2020[7]

DEBT

The debt to GDP ratio is increasingly growing, at **8% p.a.** between 2016 (47.13%) and 2021 (68.83%), constraining South Africa financially[8]

1. South Africa overview; The Mail & Guardian: South Africa tops G20 coal-reliance list in 2020; 2. Major economy = GDP in excess of USD 500 billion per annum. Only Iran precedes South Africa; 3. Oxford Economics, Global Carbon Atlas, 4. The World Bank. 2021. 'South Africa Overview'; 5. StatsSA. 2017. 'Poverty Trends in South Africa. An examination of absolute poverty between 2006 and 2015'; 6. Chatterjee, A., et al. 2020. 'Estimating the Distribution of Household Wealth in South Africa'; 7. Oxford Economics, Carbon Atlas, GDP by Country. 2022; 8. Statista: South Africa: National debt in relation to gross domestic product (GDP) from 2016 to 2026

Figure 4 | South Africa is at increasing climate risk. A significant increase in hot desert zone and shift from warm to hot temperature zones is projected in South Africa across climate scenarios

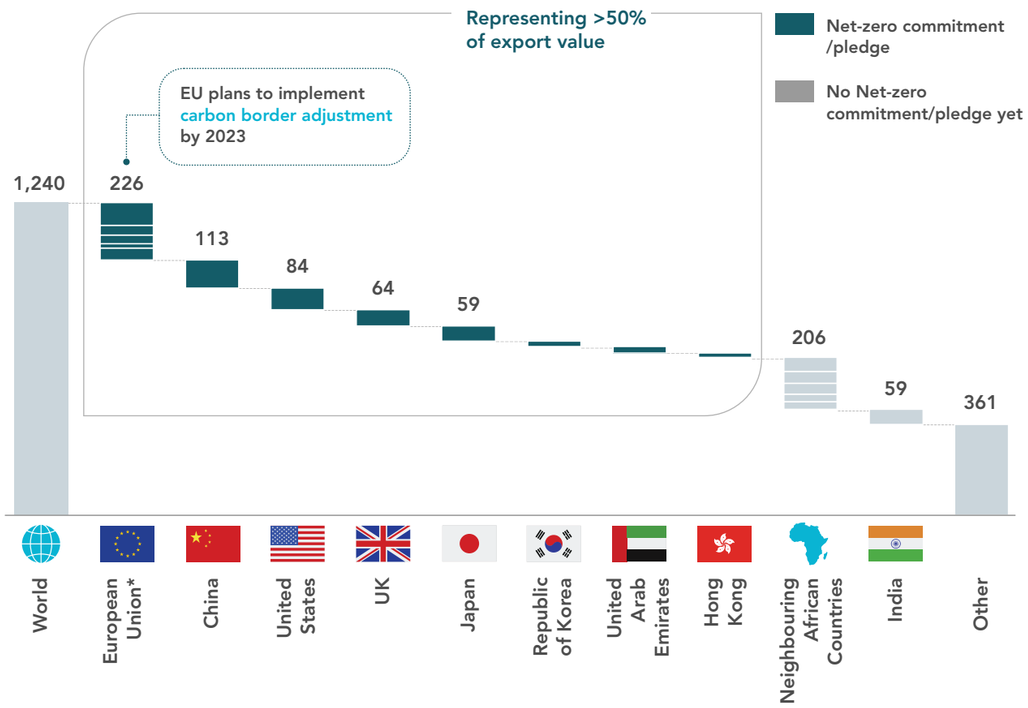
KOPPEN GEIGER CLIMATE ZONES IN SA (1961- 1990)	RCP4.5 (EQ.[1]) (2040-2060; 2°C MIROC3.2-MEDRES MODEL)	2050 RCP8.5 (EQ.[2]) (2040-2060; 3°C MIROC3.2-MEDRES MODEL)
		
Cold and hot desert in the West	~25% increase in size of hot desert	~48% increase[3] in size of hot desert
Cold steppe in the center & south-west	~18% increase in size of hot, arid steppe	~34% increase[3] in size of hot, arid steppe
Warm temperature regions in the east & south-east	Warm temperate partially replaced by hot temperate	Warm temperate replaced by hot temperate except in Lesotho. ~124% increase[3] in size of tropical savannah (east coast)

Arid, Desert, Hot | *Arid, Desert, Cold* | *Arid, Steppe, Hot* | *Arid, Steppe, Cold* | *Temperate, Dry & Hot Sum.* | *Temperate, Dry & Warm Sum.* | *Temperate, Dry Win., Hot Sum.* | *Temperate, Dry Win., Warm Sum.* | *Temperate, no dry season, Hot Sum.* | *Temperate, no dry season, Warm Sum.* | *Tropical, Savannah*

1. 2°C global temperature increase 2. 3°C global temperature increase 3. Relative to base period
Source: Theoretical and Applied Climatology (2015); Agricultural Research Council & DAFF; NBI-BCG team

Figure 5 | Trade-related risks pose additional threats to South Africa's economy if it does not transition

Volumes of South Africa's exports to leading partners in 2018 (billion ZAR)



* Top 4 trade partners within EU are Germany, Netherlands & Belgium, and among those with most aggressive targets. Note: Exchange rate based in 2018 average = R 13:24/US$ | Source: World Integrated Trade Solution 2018; Press research

02

South Africa can be net-zero and capture new green opportunities by 2050 – ten critical actions need to be pursued to achieve this. However, South Africa cannot do this alone; international support will be critical

South Africa can reach net-zero by 2050. Achieving this will require significant changes both in the economy and through behavioural changes of individual South Africans. The energy sector will shift away from coal to a renewables-dominant system. Renewables-based power will become the primary energy carrier, as heating and mobility – which are currently fossil fuel-based – are electrified, while economic growth will be driven by new green industries. Individual South Africans will increasingly have to use public transport, and have low- to no-red meat, sustainable diets.

South Africa can pursue an ambitious pathway to reach net-zero emissions by 2050, and meet its 2030 Nationally Determined Contribution (NDC)[7] of 350 to 420 $MtCO_2e$. This emissions reduction by 2030 is driven primarily by a rapid ~6-7 GW p.a. renewables roll-out in the power sector, and a feedstock shift from coal to less emissions-intensive gas in petrochemicals.

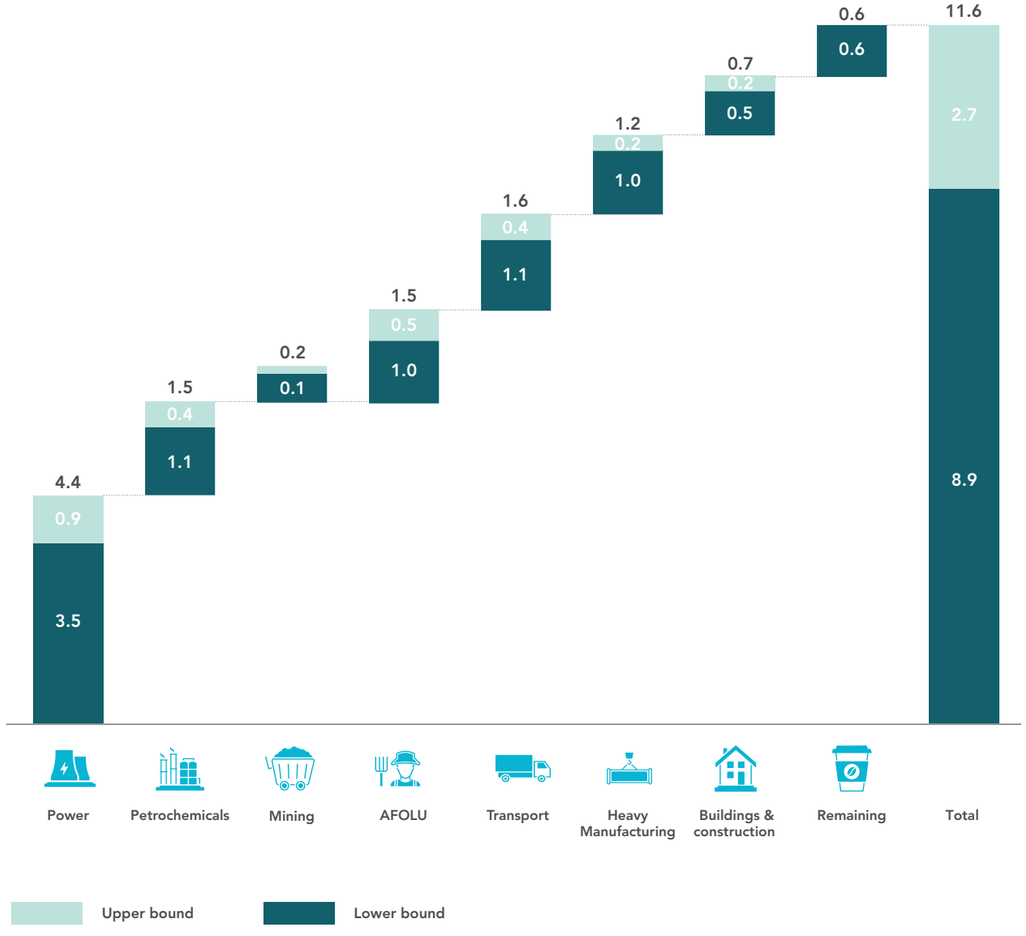
This pathway will result in ~9 $GtCO_2e$[8] cumulative emissions over 2020-2050 **(Figure 6)**. This is just within South Africa's estimated fair share carbon budget of 7-9 $GtCO_2e$.[9] However, this does not account for emissions that will arise from new industries, and economic diversification, with this resulting in the fair share upper limit being exceeded.

When considering the allocation of South Africa's carbon budget, the distribution of the budget will not be the same as today's annual emissions. Some sectors, such as the power sector, will have to decarbonise faster due to its lower switching cost, while other sectors such as steel and cement are harder to decarbonise and will have increased demand due to the growing infrastructure need of the transition. South Africa's carbon budget, therefore, needs to balance increased allowance for harder to abate sectors, with faster emissions from sectors with lower switching costs.

7. A Nationally Determined Contribution (NDC), is a climate action plan to cut emissions and adapt to climate impacts. Each party to the Paris Agreement is required to establish a NDC and update it every five years; UN Climate Action. Achieving the NDC is part of each country's common, but differentiated responsibility of the Paris Agreement.
8. In achieving this ~9 $GtCO_2e$, all sectors are maintained in the economy (except for grey industries such as coal mining) as a means to ensure employment.
9. Extrapolation of the medians of various methodologies described by Climate Action Tracker. The full range is 4–11 $GtCO_2e$.

Achieving net-zero by 2050 within a fair share carbon budget is not easy, and requires deliberate, ambitious action across all sectors. Considering South Africa's current challenging socio-economic context, and the developmental targets that it also needs to address, securing international support is critical. This international support is not limited to financial support, but also includes technology sharing, trade support, and capacity building. Without this support, and deliberate action, South Africa cumulative emissions could be as high as 13 $GtCO_2e$.

Figure 6 | South Africa's 2020-2050 cumulative emission distribution by sector



Source: BCG-NBI Project Team

2.1 To enable a rapid renewables roll-out, South Africa's power grid needs to urgently be expanded, strengthened and modernised

The South African power grid faces significant capacity and connection constraints. As of today, only ~30 GW of generation capacity can be added to the grid by 2024. To put this into perspective, this represents only 15% of the ~190GW of renewables needed by 2050 to decarbonise the South African power system. Constrained connection capacity is also an issue in the regions with the highest solar and wind potentials, such as the Northern Cape **(Figure 7)**. This poses a serious obstacle to renewables deployment at scale. This has already been the case in the latest Renewable Energy Independent Power Producer Programme (REIPPP), where commercially viable renewable energy projects could not be realised due to capacity constraints in the Northern and Eastern Cape.[10]

Therefore, **South Africa's power grid needs to urgently be expanded and strengthened** to accommodate large, utility-scale renewable energy capacity – but also to cope with increasing power demand arising from a growing, ever more electrified economy. This requires, for example, the construction of new power lines and new transformer capacity **(Side Box 1)**.

Beyond expanding and strengthening the grid, **the grid also needs to be modernised and become "smarter"** and more intelligent with increased automation.[11] A smart grid is more efficient and resilient. It allows for improved management of power supply and demand – which is critical to ensure system stability – particularly in a renewables-dominated power system that needs to meet the demand of an increasingly electrified economy.

SIDE BOX 1

THE STEP CHANGE NEEDED IN SOUTH AFRICA'S GRID EXPANSION

Eskom plans to double investments in grid strengthening and expansion over the next 10 years to meet the needs of the 2019 IRP. The plan includes the roll-out of 8 406 km of new power lines, as well as the introduction of 58 970 MVA of transformer capacity.[12] However, the 2019 IRP, which urgently needs to be updated as it currently includes building new, uneconomical and GHG emissions producing coal power stations, is well short of the renewables required for the transition. Although decommissioning coal power stations will free up grid capacity, the total coal capacity in the plan is well short of the renewables required. Thus, South Africa requires a significant step change in grid investments as it transitions to a renewables-dominant system.

10. Department of Mineral Resources and Energy, 28 October 2021 media briefing on REIPPP Bid Window 5
11. SANEDI (South African National Energy Development Institute) defines a smart grid as "an electricity network that can intelligently integrate the actions of all users connected to it – generators, consumers and those that do both – in order to efficiently deliver sustainable, economic and secure electricity supplies"
12. The Eskom Transmission Development Plan (TDP) for 2022-2031

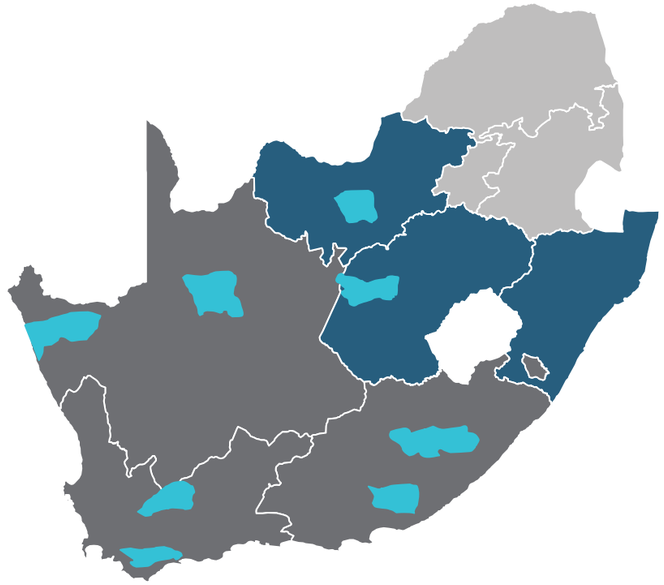
Figure 7 | South Africa's power grid connection capacity by 2024[13]

Grid connection capacity

~30 GW of existing connection capacity could be used for renewables – most of this in Mpumalanga - if the grid is strengthened and upgraded

Additional ~30 GW of connection capacity needs to be built to achieve the overall 60 GW required by 2030

Optimal renewables sources are in coastal areas with today only limited grid connection



~5.1 GW Connection capacity available

~13.7 GW Connection capacity available

~13.5 GW Connection capacity available

Renewable Energy Development Zones

13. ESKOM Grid Connection Capacity Assessment, 2024

2.2 To decarbonise power, renewables need to be rolled out in South Africa at an unprecedented rate of ~6-7 GW per year. To capture the green H_2 opportunity, an additional ~6-12 GW of renewables need to be deployed per year.

Renewable energy deployment alone enables a nearly 60% reduction of South Africa's annual emissions (Figure 8). Two-thirds of this reduction (40% of the national emissions footprint) results from the decarbonisation of South Africa's coal-intensive power generation. The last third of renewables reduction results from electrification across industries. Electrification leads to the substitution of fossil fuels via renewable power. One key example is the electrification of road transport, where internal combustion engines are replaced by electric vehicles. As a result, renewable power becomes the primary energy source across sectors.

Around 190 GW of renewables capacity is required by 2050 to decarbonise South Africa's power sector, and meet the economy's increasing power demand. This is nearly 5 times the total (primarily coal) power capacity installed in South Africa today. By 2050, South Africa's power system will be renewables-dominated, which is the most cost-effective power system option for South Africa **(Side Box 2)**.

Achieving this requires a renewables roll-out at an unprecedented rate of ~6-7GW each year **(Figure 9)**. To put that into perspective, South Africa has an installed capacity of ~5GW of renewables today, which took over 10 years to build. To enable the deployment of utility-scale renewables, a limited amount of gas will be required within the 2020s-2040s for balancing renewables, with naturals to be phased out by 2050 **(Side Box 3)**. The turbines built now to run on natural gas must by H_2-ready, in preparation for the phase out of natural gas, and introduction of green H_2.

Large-scale renewable energy capacity is also required for green H_2 production. Green H_2 production will nearly double the renewables requirement by 2050: an additional ~170-200 GW of renewables will be needed to reach the 2050 annual green H_2 demand of ~8.5-9.5 Mt. This requires an additional renewables deployment of 6-12 GW p.a., with the 12 GW p.a. reached post-2040, as this is when many industries will be able to afford the switch to green H_2 and introduce it at scale. Therefore, the green H_2 production will significantly increase the total renewable roll-out to ~18 GW p.a. (6-7 GW p.a. for the power sector, and ~12GW p.a. for green H_2) in the 2040s.

The scale and complexity of this challenge cannot be emphasised enough. South Africa's entire transition hinges on renewables. Although the required renewable energy roll-out rate is unprecedented in South Africa, it is not unprecedented in the world: China, for example, installed 120GW of wind and solar in 2020 alone[15] – showing that the required deployment rate is not insurmountable. Further, South Africa itself has shown significant progress with the REIPPP Bid Window 6, doubling the procured capacity to 4.2 GW[16] – more of this is needed.

SIDE BOX 2

NO NEED FOR NUCLEAR OR BASELOAD GAS

South Africa is endowed with abundant, high-quality renewable energy resources – among the best in the world – with complementary wind and solar energy potential across the country. These renewable-energy resources are available on vast amounts of unused land, making it possible to deploy renewables at the scale required. A nuclear-based power system is ~10% more expensive than a renewables-dominant system, while baseload gas is even more expensive.[14]

14. Baseload-gas refers to gas power plants run at high utilisation rates (>50%).
15. IEA, Renewables 2021 Data Explorer
16. https://www.gov.za/speeches/update-procurement-process-renewable-energy-ipp-procurement-programme-bid-window-6-11-sep

SIDE BOX 3

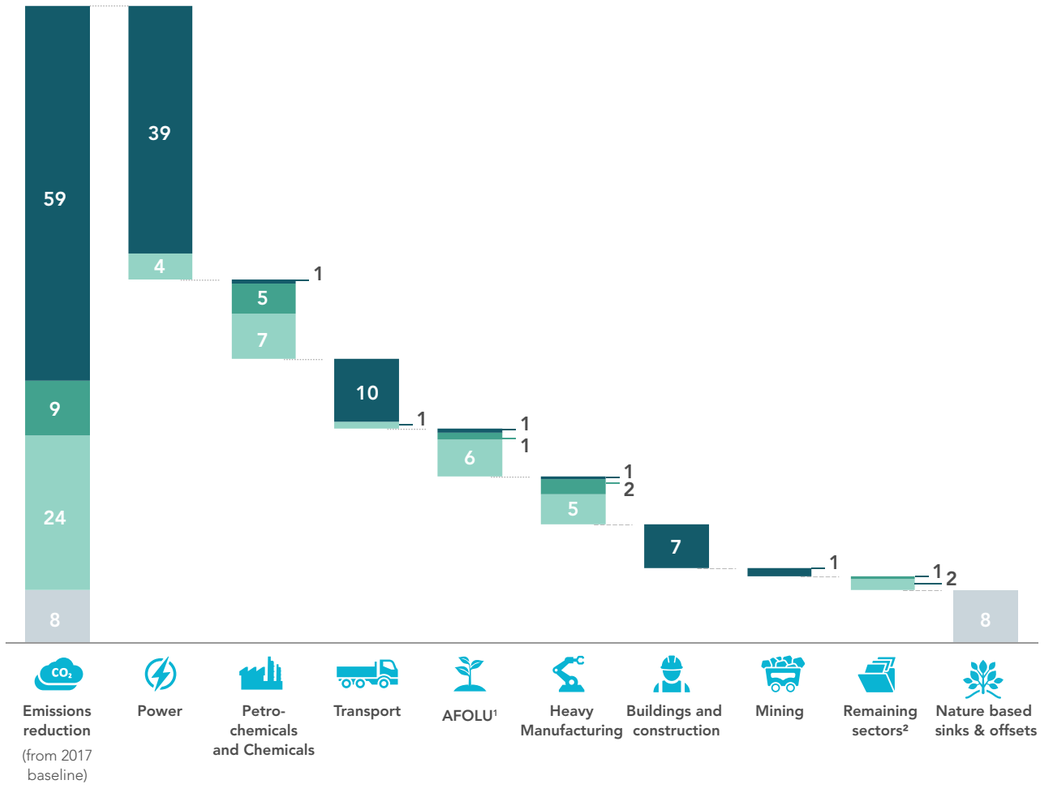
THE NEED FOR PEAKING GAS TO ENABLE RAPID RENEWABLE DEPLOYMENT

South Africa's transition requires gas in limited volumes and for a limited period of time with a flexible and short payback on liquefied natural gas (LNG) infrastructure (for example, floating storage). Gas will balance and enable a larger and faster scale-up of renewables. This is because, unlike conventional power stations, renewables have variability within a day to across seasons. Therefore, peaking capacity is needed to ensure energy security. Gas will also enable the competitive decarbonisation of other sectors.

Gas will only play a short-term role, and will be replaced with batteries (for short-term power balancing) and green hydrogen (for seasonal balancing), sustainable sources of carbon (for feedstock substitution) and direct electrification (for industrial process heat) as soon as cost parity can be achieved with these green alternatives. H_2-ready gas turbines should be installed in the power sector to enable a switch over to green H_2 as soon as cost parity is reached, and to minimise stranded assets.

Figure 8 | Renewable energy drives ~60% of emissions reduction in South Africa

National direct annual emissions abatement potential by decarbonisation lever category (%)



Renewables
(Primarily solar PV and wind, and renewable-based electrification such as electrified transport, heating, etc.)

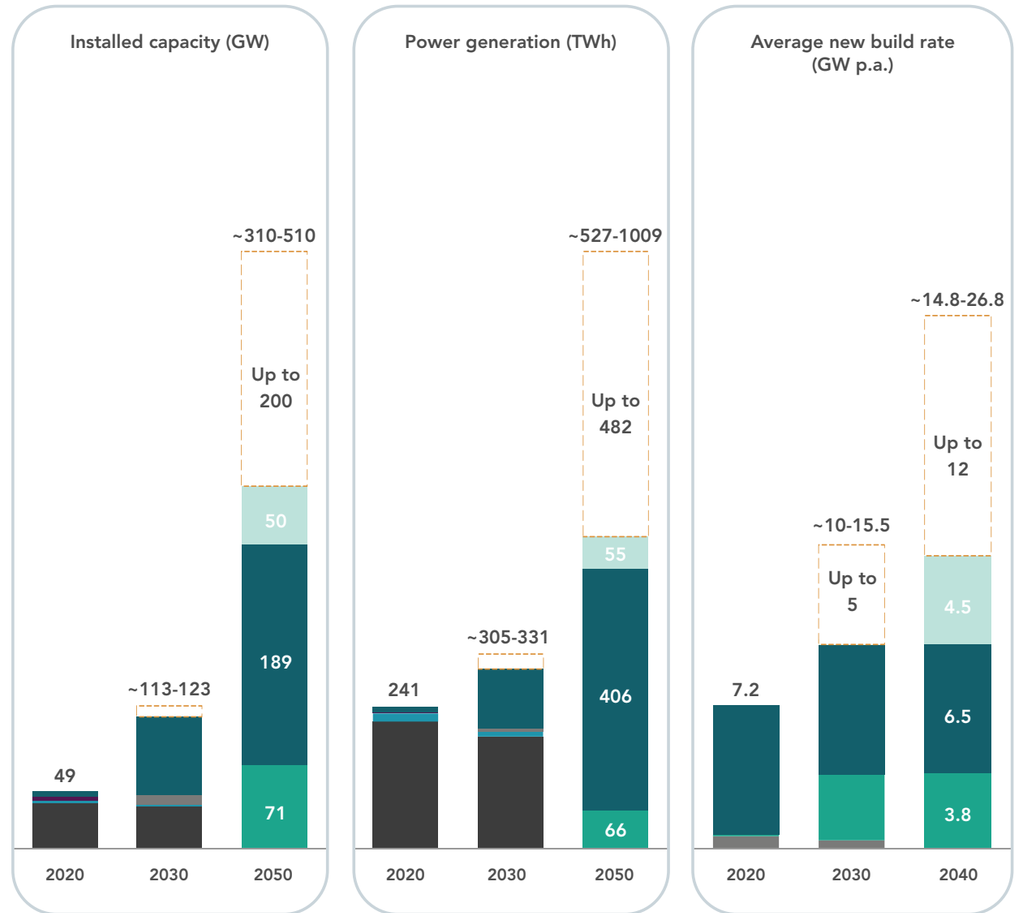
Other mature tech levers
(e.g., process efficiencies, gas as petchem feedstock, etc.)

Tech in early adoption
(e.g., carbon capture tech, Green H_2 and behavioural changes such as shift to sustainable diets, etc.)

Require nature-based sinks & offsets

1. AFOLU: Agriculture, Forestry and Other Land Use; 2. Remaining sectors includes: consumer and commercial waste, and other sub-categories from mineral & metal production not part of Heavy Manufacturing; Source: GHGI (2017), IEA (2015), WEO (2019), CDP (2015), GHGI (2015), CAT, NBI-BCG Project team

Figure 9 | The rapid renewables rollout rate to achieve energy security, decarbonise the power sector and capture the green H_2 opportunity



Source: BCG-NBI Project Team

2.3 To drive economic growth, South Africa needs to leverage its structural advantages and establish a green H_2 industry for local demand and exports

South Africa needs access to green H_2 at scale to decarbonise its economy and reach net-zero by 2050. Green H_2 serves as a net-zero energy carrier in industrial processes such as steel, cement, glass, and chemicals production. It serves as an alternative transport fuel, primarily in heavy-duty fuel cell electric vehicles, and as a feedstock for synthetic fuel production, such as sustainable aviation fuel. It also enables last-mile decarbonisation in power, where it can replace natural gas in gas-peaking plants.

South Africa has a competitive advantage in the production of green H_2. Its world-class renewable energy resources, available on vast amounts of unused, cheap land, and its expertise in heavy manufacturing (such as steel production) and petrochemicals and synthetic fuels production enable South Africa to produce green H_2 and green H_2-based products such as e-fuels (including e-kerosene), green ammonia, and green steel at a globally competitive cost, especially as carbon pricing increasingly penalises the hydrogen produced at present from natural gas. For example, by 2030 South Africa could produce green H_2 at a globally competitive cost of ~2.0 USD/kg. These structural advantages, combined with an increasing global demand for cost-competitive green H_2 and green H_2-based products, as well key trading partners such as the EU relying on imports to meet their local Green H_2 demands,[17] present South Africa with the opportunity to become a leading global green H_2- based production hub for local and global demand.

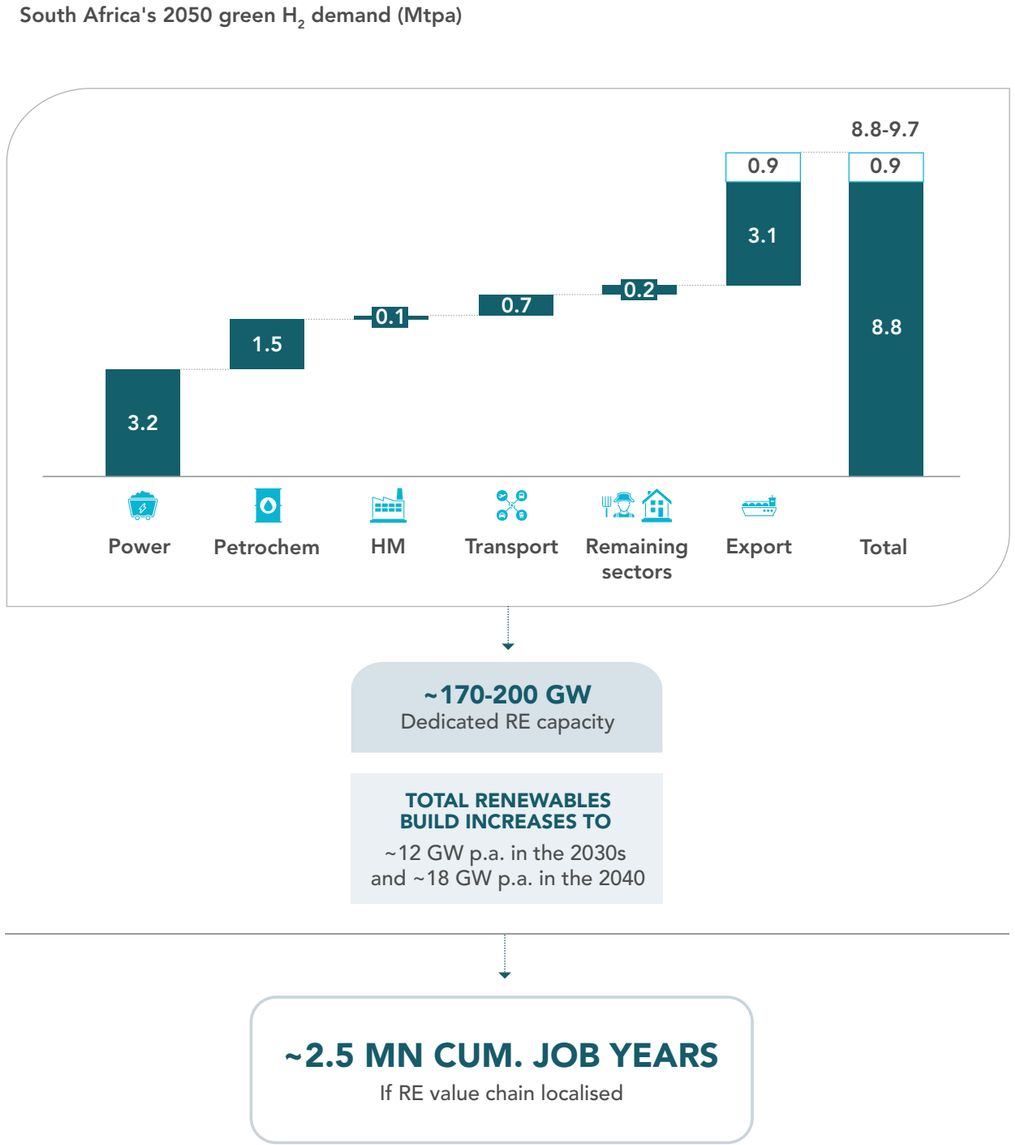
By 2050, South Africa's annual green H_2 demand could reach ~9.5 Mt. Of this, ~6 Mt could be linked to local demand-driven by South Africa's power, transport, heavy manufacturing, and petrochemicals sectors **(Figure 10)** – and exports could make up ~3-4 Mt (this is less 1% of the ~500 Mt p.a. global green H_2 demand estimated by the IEA in its net-zero report).

Developing a local green H_2 industry can drive significant job creation and socio-economic development for South Africa. By 2050, ~2.5 million cumulative jobs years could be created if elements of the renewable energy and green H_2 value chain can be localised. To capture the green H_2 opportunity, South Africa needs to:

- Secure global offtake to anchor demand for South Africa's green H_2 industry and thus justify investing in local green H_2 production capacity, as local demand will still be limited in 2030
- Collaborate with key stakeholders to design and develop a national green H_2 supply and demand landscape – the green H_2 opportunity is too big for a single stakeholder. Thus, South Africa will need to work together to ensure the most competitive supply for export and local consumption
- Make South Africa an attractive green H_2 investment proposition to international governments, funders, equipment manufacturers, and potential off-takers
- Use public finance players as catalysts to unlock much-needed private capital to fund green hydrogen projects along their project lifecycle, especially for high-risk elements such as the electrolyser design and construction phase

17. REPowerEU: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition, https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131

Figure 10 | South Africa's potential 2050 green H_2 demand, its potential job creation potential, and the renewables required



Assumptions: 60% electrolyser utilisation; 65% electrolyser efficiency; 1 MW solar PV & 1 MW wind required for 1 MW electrolyser
Source: NBI-BCG Project Team

2.4 South Africa's rail infrastructure needs to be expanded and upgraded to enable a shift to rail transport away from carbon-intensive, inefficient, and expensive road transport

Rail is one of the most efficient and least-emitting transport modes for moving passengers and freight. Globally, urban and high-speed rail infrastructure has expanded significantly in the past decades – making the movement of goods and people more convenient, faster, cheaper and less carbon-intensive.[18] Even before using renewable energy sources, shifting from air and road to rail can reduce energy consumption by 60-70% and emissions by the same amount for comparable transport tasks.[19]

However, converse to global trends, South Africa has experienced a reduction in passenger and freight transport via rail. This is due to the inadequate state of South Africa's rail network today – which is suffering from "a massive capital investment backlog and inadequate funding, obsolete and ageing infrastructure, deteriorating rolling stock and outdated technologies, and limitations of narrow gauge", as well as vandalism and theft.[20] This resulted in at least 20 freight train journeys cancelled per day in 2020.[21] Overall, the continuous deterioration of South Africa's rail network has led to an increasing reliance on more expensive, inefficient, and carbon- intense road transport for private and commercial transport.

Going forward, South Africa needs to fix and expand its rail network, given the critical role rail plays in enabling decarbonisation **(Side Box 4)** and supporting and driving economic growth by unlocking more efficient and affordable movement of goods and people across the country – rail is the backbone of the transport system across urban spatial development. To stimulate this road-to-rail modal shift, the country's existing rail infrastructure needs to be both refurbished and expanded.

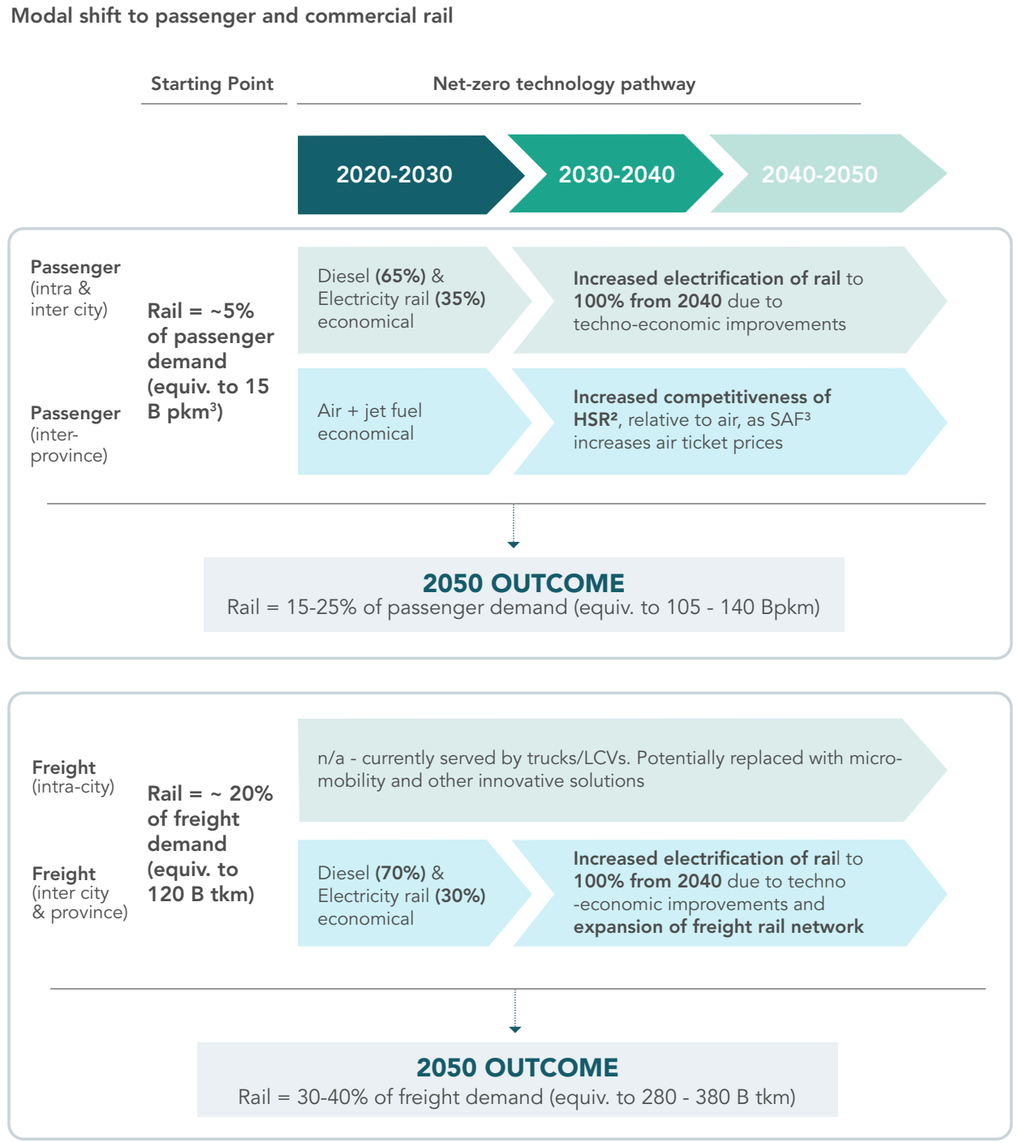
SIDE BOX 4

THE ROLE OF RAIL IN DECARBONISING TRANSPORT

South Africa's rail network is a critical enabler for the decarbonisation of South Africa's transport sector. It allows for shifting road and partially (domestic) air transport to less carbon-intensive rail transport. A 20% increase from road freight to commercial rail transport to ~40% of total commercial demand, and a 15% increase in passenger rail use to ~20% of total passenger demand is required by 2050 to ensure that the transportation sector's emissions can be eliminated (Figure 11). The emissions from rail can be completely eliminated by the adoption of electric trains by 2050.

18. IEA: Rail; available at: https://www.iea.org/fuels-and-technologies/rail
19. National white paper on rail, 2022
20. Department of transport: National rail policy draft white paper, 2017. Available at: https://www.gov.za/sites/default/files/gcis_document/201708/draftwhitepapernationalrailpolicy.pdf
21. Engineering News: Transnet bemoans cable theft at Pretoria Complex, rolls out diesel locos

Figure 11 | South Africa's road-to-rail modal shift roadmap



1. pkm: passenger kilometer, which is the transport of one passenger by a defined mode of transport;
2. HSR: High Speed Rail;
3. SAF: Sustainable Aviation Fuel

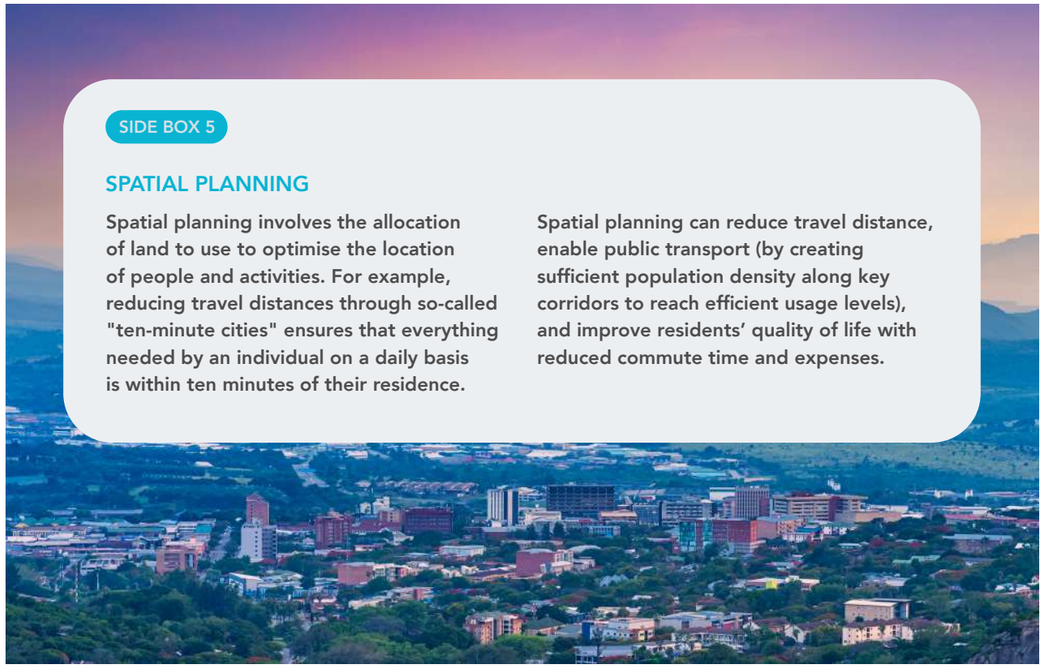
Source: NBI-BCG project team

2.5 Cities and urban areas in South Africa need to be densified to reduce commuter travel demand and to achieve adequate, less carbon-intensive residential housing for all

South Africa's cities are typically disorganised urban sprawls. Many residents live in unplanned informal settlements far from their workplaces, with inadequate road or transport infrastructure. This is a legacy of Apartheid spatial planning with a disproportionate impact: previously disadvantaged communities have an average commute time of 102 mins, compared to the advantaged communities' commute time of 68 mins.[22]

Densifying and redesigning cities, which is a form of spatial planning (Side Box 5)**, will lower transport demand, and enable the shift to public transport** (Figure 12)**.** This reduced transport demand will lower emissions. Densifying and redesigning cities along key transport axes will make it easier to provide – and access – public transport for all, thereby beginning to address historical spatial planning issues.

Additionally, shifting consumer preferences to smaller homes in these denser, redesigned cities will allow South Africa's housing gap to be closed, and ensure housing for all. By 2050, the average home size will decrease from 120m^2 to 80m^2.[23] Although this appears to be a significant decrease to smaller, inadequate housing, it is important to note that the current average home size is skewed upwards due to the lack of low-income housing. As a point of reference, the current average European home size is 77-98m^2.[24] Beyond addressing this key development goal, smaller, simpler homes are cheaper to abate and require less carbon-intensive materials such as cement and steel to construct.



SIDE BOX 5

SPATIAL PLANNING

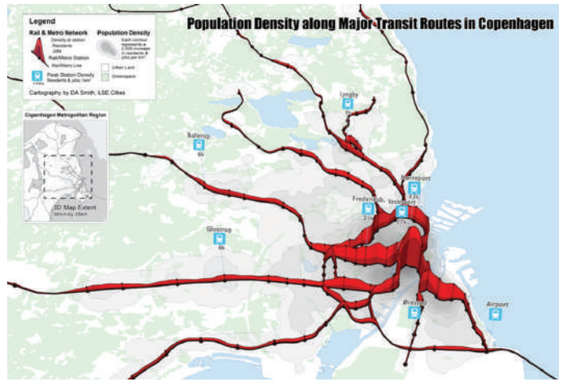
Spatial planning involves the allocation of land to use to optimise the location of people and activities. For example, reducing travel distances through so-called "ten-minute cities" ensures that everything needed by an individual on a daily basis is within ten minutes of their residence.

Spatial planning can reduce travel distance, enable public transport (by creating sufficient population density along key corridors to reach efficient usage levels), and improve residents' quality of life with reduced commute time and expenses.

22. Mail and Guardian, Commuting costs the poor dearly (2015)
23. Stats SA Building Market Assessment (2017)
24. Statista, Average floor space of houses in selected European countries as of 2014

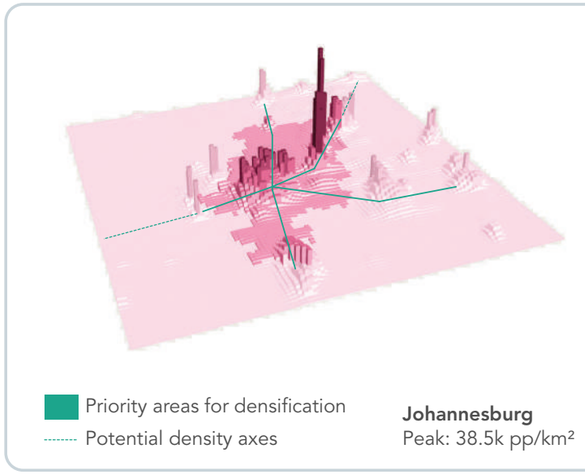
Figure 12 | Densifying and improving urban area spatial planning to create cities with reduced travel distances, and achieve adequate, low carbon residential housing

Global leaders in efficient transport and cities densify along clear transport corridors…



Population Density along Major Transit Routes in Copenhagen

… and cities like Johannesburg could develop similarly, linking clusters with dense corridors



This shift could be achieved through zoning laws along critical transport corridors, although it would require a behavioural shift to smaller, more efficient dwellings to affordably and equitably achieve the necessary density for efficient public transport

Source: LSE Cities; NBI-BCG project team

2.6 South Africa's road transport needs to be electrified and consumers incentivised to shift to electric mobility – ~750 000 electric vehicles need to be on South Africa's roads by 2030. The sale of conventional combustion engine vehicles needs to be banned from 2035

In South Africa, road transport accounts for ~90% of the transport sector's emissions. So decarbonising transport in South Africa will hinge on the ability to decarbonise road transport. Besides demand management (reducing demand through efficiently designed cities, for example) and mode shifting (moving road to rail transport), the electrification of road transport is the key to achieving this **(Side Box 6)**.

By the early 2030s, EVs (BEVs and FCEVs) will reach cost-parity on a total cost of ownership basis,[25] with conventional internal combustion engine (ICE) vehicles across all vehicle classes.[26] However, despite reaching cost-parity by the early 2030s, South Africa could see a slow uptake of EVs, due to the dependence on consumer preferences, which tend to lag behind technological maturity, and the impact of local policy choices, such as the adjustment of the current higher import levies that EVs have compared to conventional ICE vehicles. As a result, by 2030 South Africa might only see ~750 000 EVs on the road (representing ~6% of the total vehicle fleet, from ~1 000 today). To achieve this will be a significant challenge, as ~100 000 EVs or 30% of all vehicle sales[27] are required per year between now and 2030.

To achieve a net-zero road transport sector, ~600 000 new electric vehicles would need to on average be sold each year post-2035, resulting in ~8 million EVs on the road by 2050. It is important to note that by 2050 there should be fewer vehicles on South Africa's roads as a result of a modal shift to cheaper, more efficient rail, and the increased adoption of public transport **(Figure 13)**.

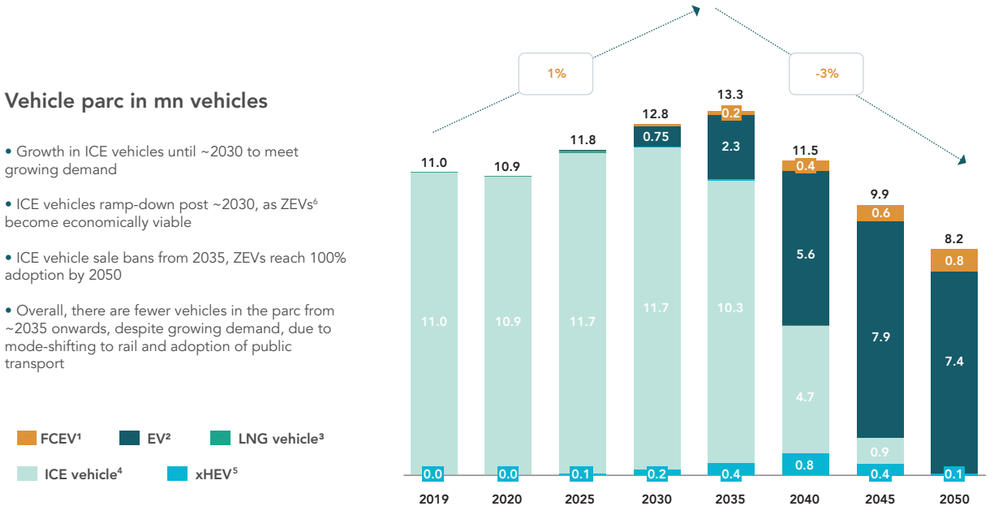
This rapid increase in electric vehicle adoption is only possible with deliberate and coordinated policy action. This includes banning conventional vehicle sales by 2035 to create a fully electrified road transport sector by 2050, and to accelerate the roll-out of ~600 000 charging stations by the 2030s (which is also key to shifting consumer preferences). Furthermore, ensuring the continued existence of local auto manufacturing activities will hinge on the scale-up of electric mobility in South Africa **(Side Box 7)**.

25. Total cost of ownership includes the upfront cost of purchasing a good, in addition to its costs of operation over its lifetime. By way of example, electric vehicles have a high upfront cost, but it has a significant lower operating cost (R/km) that results in the total cost over the lifetime of the electric vehicle being the same as traditional combustion vehicle by the mid-2020s for light vehicles.
26. Passenger and commercial vehicles evaluated. Passenger vehicles: Private passenger vehicles (cars, SUVs) and public passenger vehicles (bus, minibus taxis, etc.) Commercial vehicles: Light (<3 500 kg), medium (>3 500 kg and < 15 000 kg) and heavy (>15 000 kg) Light commercial vehicles reach cost parity around 2023-2025, whilst heavy vehicles reach cost parity by 2030-2032
27. https://tradingeconomics.com/south-africa/total-vehicle-sales

Figure 13 | The evolution of South Africa's vehicle fleet as road transport decarbonises and the economy transitions to increased public transport and net-zero

Vehicle parc in mn vehicles

- Growth in ICE vehicles until ~2030 to meet growing demand
- ICE vehicles ramp-down post ~2030, as ZEVs[6] become economically viable
- ICE vehicle sale bans from 2035, ZEVs reach 100% adoption by 2050
- Overall, there are fewer vehicles in the parc from ~2035 onwards, despite growing demand, due to mode-shifting to rail and adoption of public transport



1. FCEV: Fuel cell electric vehicle; 2. EV: Electric vehicle; 3. LNG: Liquified natural gas; 4. ICE: Internal combustion engine; 5. HEV: Hybrid electric vehicle; 6. ZEV: Zero emission vehicle | Source: NBI-BCG project team

SIDE BOX 6

THE DIFFERENT TYPES OF ELECTRIC VEHICLES (EVS) RELEVANT IN SOUTH AFRICA

Battery electric vehicles (BEVs): A fully electric vehicle that uses a chargeable battery. BEVs can meet the technical and affordability thresholds for light passenger transport, minibus taxis and light freight vehicles.

Fuel cell electric vehicles (FCEVS): A fully electric vehicle that uses a fuel cell, powered by hydrogen, to generate electricity instead of batteries. For heavy freight vehicles, the evolution of BEVs relative to FCEVs is a key signpost to monitor, given the uncertainty on whether BEVs can overcome existing charging and range limitations needed for heavy freight.

Hybrid electric vehicles (HEVs): Combine conventional combustion engine with batteries. HEVs are useful as a transitionary lever and for long-distance travel, as BEVs currently have long charging times and limited range. However, HEVs are not net-zero. Therefore, considering the limited time in which South Africa has to reach net-zero, BEVs and FCEVs are the preferred technology choices.

Zero-emission vehicles (ZEVs): This refers to both battery and fuel cell electric vehicles, which do not produce harmful tailpipe emissions.

SIDE BOX 7

THE NEED TO ESTABLISH LOCAL ELECTRIC VEHICLE MANUFACTURING

South Africa has a strong local vehicle manufacturing sector based on conventional ICE vehicles. ~60% of this local vehicle production is exported, of which the European market accounts for ~60%. However, these export markets are increasingly shifting to ZEVs, and introducing bans on ICE vehicles. This is resulting in the primary market for the local vehicle manufacturing sector shrinking. Further, local ICE vehicle demand alone is insufficient to justify continued local production. In addition to this, major original equipment manufacturers (OEMs) are also shifting towards ZEVs. Therefore, South Africa needs to accelerate the uptake of ZEVs in South Africa to anchor OEMs and ZEV production in the country.

2.7 Reaching full decarbonisation of the transport sector requires a behavioural shift: South Africans will need to shift from private to public transport

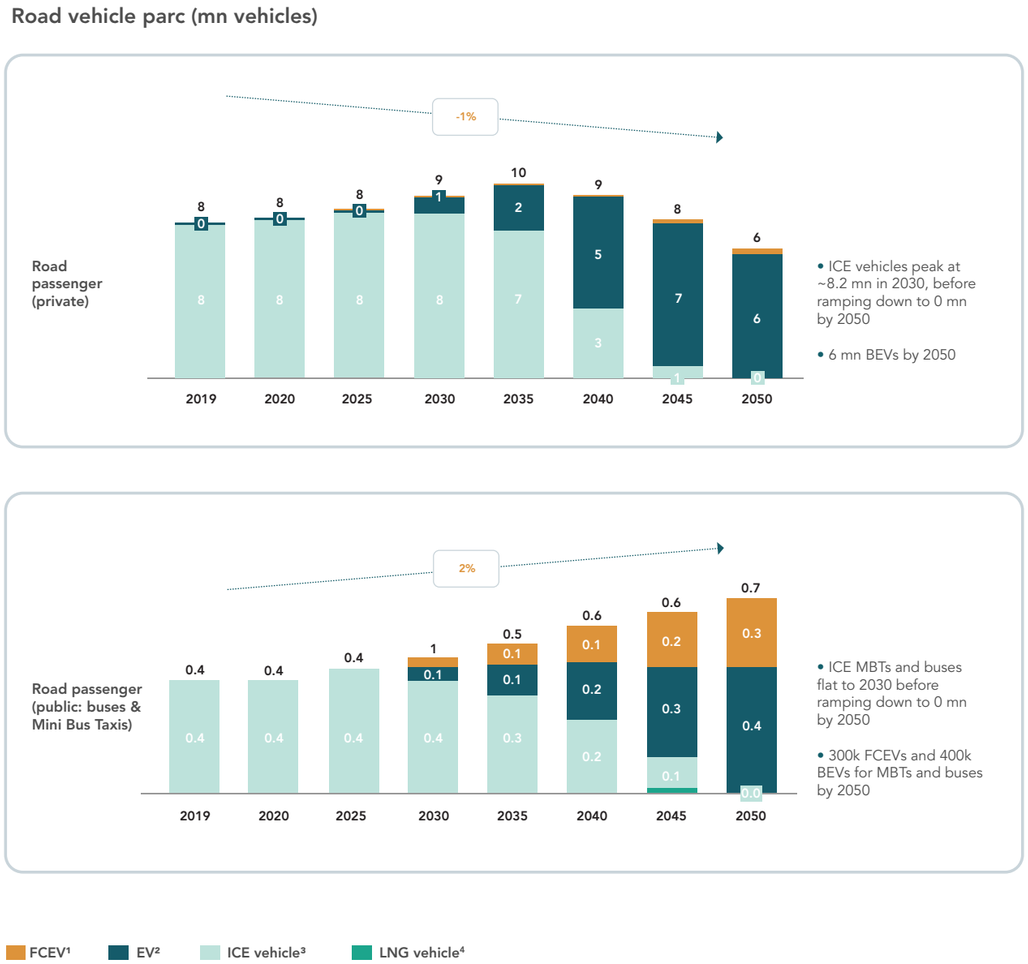
The shift from private car usage to public transport and non-motorised mobility is key to reduce transport emissions. At least a 15% increase in public rail use – a significant increase from only ~5% of all passenger transport today – is needed in the transition to a net-zero transport sector. Overall, private passenger vehicle ownership will decline from its peak in the mid-2030s, and road passenger transport, such as buses and minibus taxis will nearly double by 2050 **(Figure 14)**, in addition to the increase in passenger rail use. Without this increased public transport adoption, it will be incredibly difficult to decarbonise the transport sector.

Beyond the emissions reduction that public transport affords, it can also address historical social issues by providing safe, reliable, affordable transport for all South Africans.

However, key to achieving this behavioural shift is improving the accessibility, reliability and safety of the public transport system. This is because, even though the public bus and train systems are currently more affordable than minibus taxis, ~70% of households use the more costly minibus taxis due to their higher accessibility and flexible routes. Passenger rail has the added disadvantage of nearly 2x higher cost than minibus taxis for fixed routes.

Therefore, this required shift to public transport needs investments in reliable, efficient rail systems for intercity and longer intracity transport, and Bus Rapid Transit (BRT) infrastructure and systems for short intracity transport. Beyond this, public transport needs to be promoted and incentivised to overcome the perception of socio-economic status through owning private transport.

Figure 14 | The decline in private vehicle ownership, as South Africans shift to public transport



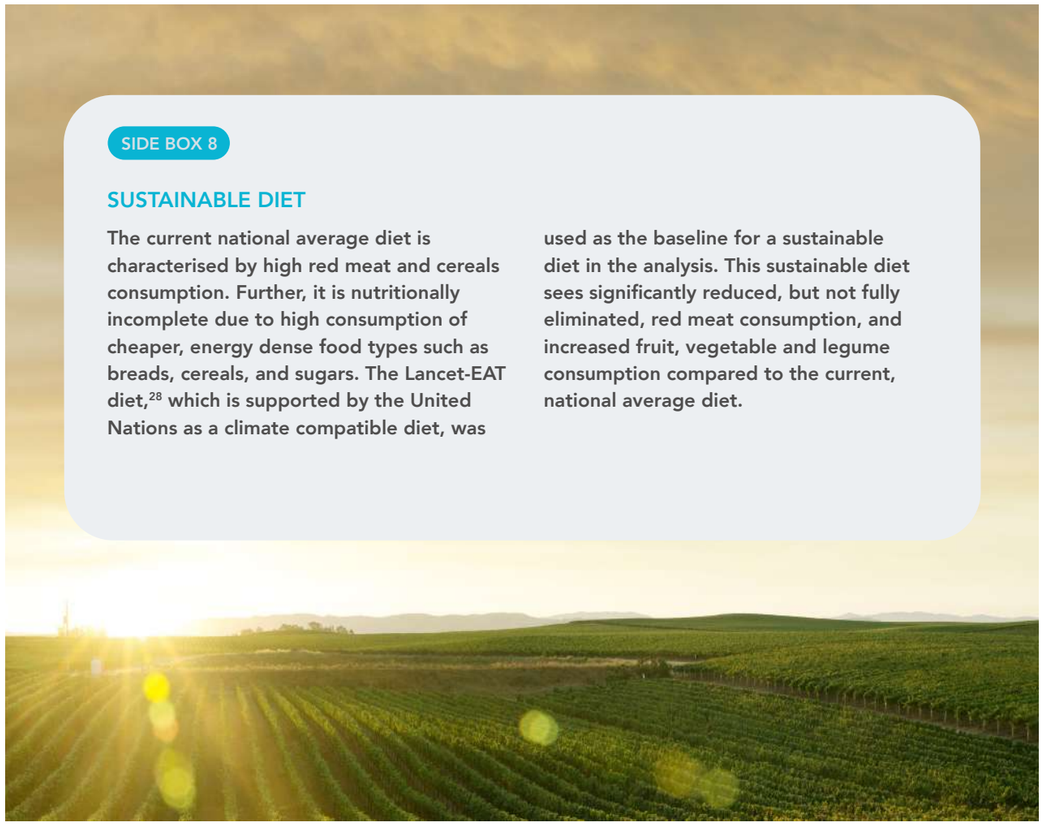
1. FCEV: Fuel cell electric vehicle; 2. EV: Electric vehicle; 3. ICE: Internal combustion engine; 4. LNG: Liquified natural gas
Source: NBI-BCG project team

2.8 A shift to nutritional, sustainable diets among South Africans is critical to improve health and drive 4% of national emissions reduction. However, this can only be achieved if food becomes more affordable to South Africans

Deploying farming and forestry best practices such as organic fertilisers, improved herding practices, and shifting to a sustainable, low-red meat diet (Side Box 8) can reduce agriculture and farming emissions by ~70% to 16 $MtCO_2e$ p.a. This rises to 39 $MtCO_2e$ p.a., only a ~40% reduction if the current nutritionally incomplete diet is maintained **(Figure 15)**.

South Africa has a limited nature-based sink potential of only ~30 $MtCO_2e$ p.a. Therefore, even if the entire country shifts to a sustainable diet, more than ~50% of the nature-based sink potential will need to be allocated to the agriculture sector to reach net-zero. This leaves little abatement potential from nature-based sinks for hard-to-abate sectors such as cement. Since there is still uncertainty surrounding the technical viability of permanent carbon capture and storage in South Africa, not exceeding these nature-based sink potentials is critical to reaching net-zero.

However, the sustainable diet costs ~4x the current average diet. Therefore, it will be critical to ensure the affordability of future food supply to ensure that all South Africans can move to a healthier, sustainable diet.



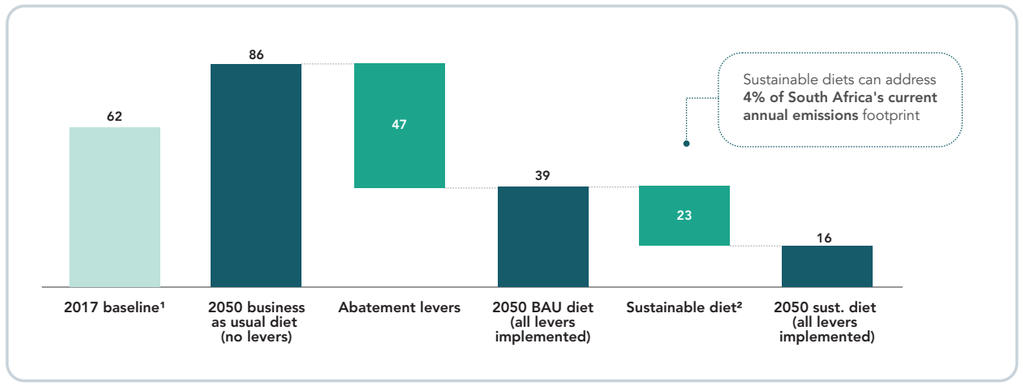
SIDE BOX 8

SUSTAINABLE DIET

The current national average diet is characterised by high red meat and cereals consumption. Further, it is nutritionally incomplete due to high consumption of cheaper, energy dense food types such as breads, cereals, and sugars. The Lancet-EAT diet,[28] which is supported by the United Nations as a climate compatible diet, was used as the baseline for a sustainable diet in the analysis. This sustainable diet sees significantly reduced, but not fully eliminated, red meat consumption, and increased fruit, vegetable and legume consumption compared to the current, national average diet.

28. There are alternates to the Lancet sustainable diet, such as obtaining an equilibrium between nature-based sinks and enteric emissions. These were not explored in detail in this report.

Figure 15 | The emissions and cost impact to consumers of the shift to a sustainable diet



R1027 /month

Stats SA Living Conditions Survey (LCS)

- Real average household food expenditure in South Africa (2014/15)
- Nutritionally incomplete, but cheap and energy dense

R4300 /month

Lancet EAT sustainable healthy diet

- Healthy diet, optimised to minimise carbon intensity of basket
- Affordable for ~20-30% of SA households[1]

1. 2017 GHGI used; 2. Lancet-EAT healthy/sustainable diet. Diet supported by FAO & UN as climate compatible diet | Source: DALRRD, FAO (2021): South Africa - Soil Organic Carbon Sequestration Potential National Map; Hirvonen et al "Cost and Affordability of the Lancet-EAT Diet"; BFAP 2020 Baseline; Stats SA Living Conditions Survey; NBI-BCG Project Team

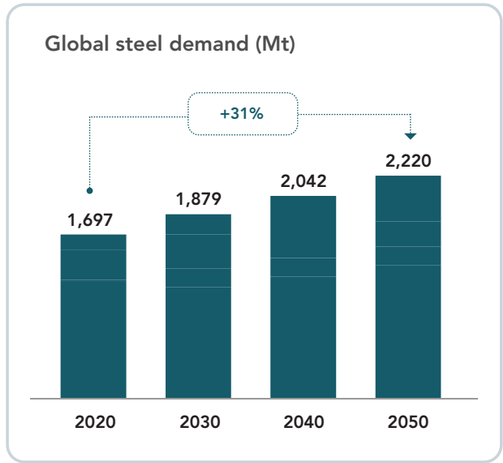
2.9 South Africa needs to act now before the cost of key heavy manufacturing commodities needed for the transition increases as global economies transition to net-zero

In the net-zero transition, all economies will require heavy manufacturing commodities, such as steel, aluminium and cement for the construction of wind turbines and solar PV, to transition their economies to net-zero. The global demand for steel is predicted to increase by ~30%, while aluminium will increase by ~180% **(Figure 16)**.

Acting now takes advantage of the current prices, before demand increases and supply chain bottlenecks cause an increase in the price and limit the speed at which key infrastructure needed for decarbonisation can be deployed. Moreover, acting immediately ensures that there is access to these heavy manufacturing commodities, and allows South Africa to meet its infrastructure needs as it transitions to a net-zero economy and addresses its development needs.

Further, this increased demand in heavy manufacturing commodities provides an export opportunity. If South Africa can expand its heavy manufacturing production capacity within the next decade as demand begins to ramp up, it can export heavy manufacturing products. This export opportunity can create further economic growth and jobs to drive South Africa's development needs.

Figure 16 | The need for South Africa to act now before heavy manufacturing commodities costs increase as economies transition to net-zero



Demand for heavy manufacturing commodities (e.g., steel, aluminium, etc.) will increase significantly as economies transition to net-zero. **By acting now SA can**:
- Ensure security of supply
- Capture opportunity to sell to export markets

Source: International Aluminium Institute; IEA; Wood Mackenzie; NBI-BCG project team

2.10 If South Africa wants to meet the lower bounds of its internationally committed emissions reduction targets, even more disruptive action is needed across all sectors. Given the socio-economic risks that arise with more disruptive action, South Africa will not be able to do this without international support

Driving these disruptive actions across sectors would enable a transition of South Africa's economy to net-zero. However, despite ambitious, fast and large-scale decarbonisation underpinned by radical transformation of the economy, South Africa would potentially still be at risk of not meeting its internationally pledged reduction target for 2030 (Nationally Determined Contribution, NDC) and of exceeding its fair share carbon budget **(Side box 9).**

To reach the lower bound of the 2030 NDC and stay within the fair share carbon budget requires even more disruptive actions across all sectors – particularly within the 2020s in sectors with the largest emissions footprints (power, petrochemicals, and transport). Achieving further reductions in the power sector is possible. This could be realised if the utilisation of coal plants is further reduced in the 2020s.[29] This would require that coal plants are run on a seasonal or intermittent basis at minimum load. Reducing the utilisation of coal plants could achieve a reduction of South Africa's national emissions to ~370 $MtCO_2e$ p.a. **(Figure 18)**. This is closer to the 2030 NDC lower limit of 350 $MtCO_2e$ and results in cumulative emissions of ~9.3 $GtCO_2e$ to 2050, which is within the considered fair share carbon budget. However, the commercial viability of a lower utilisation coal power fleet is unclear. It will see reduced income to the coal power plants and adjacent value chains, with this seeing potential job losses. South Africa will require international support to manage these commercial and social risks. In addition to the power sector, further decarbonisation would need to be driven across all other sectors in the 2020s, particularly in the transport and AFOLU sectors, which are – after the power and petrochemicals sector – the third and fourth most emitting sectors. Achieving further reduction would largely hinge on enabling and accelerating a shift in consumer behaviour – such as speeding up the the shift from private to public transport and conventional to electrified vehicles and the adoption of sustainable, healthier diets.

Key to achieving these shifts is to improve the affordability and availability of these greener alternatives. South Africa will not be able to do this without international support. The support required is not only financial – South Africa requires support across financing, trade (such as cost competitive electric vehicle imports and risk mitigation of foreign currency fluctuations), technology (including IP sharing to enable green H_2 economy and early adoption), and skill and capacity development.

29. Achieving lower emissions from the power sector requires removing the coal minimum load constraint of 50% (coal power stations are inherently inflexible), and commit criteria. The commit criteria sees coal power stations run even though it may not be the most economical option, as coal is inherently inflexible

SIDE BOX 9

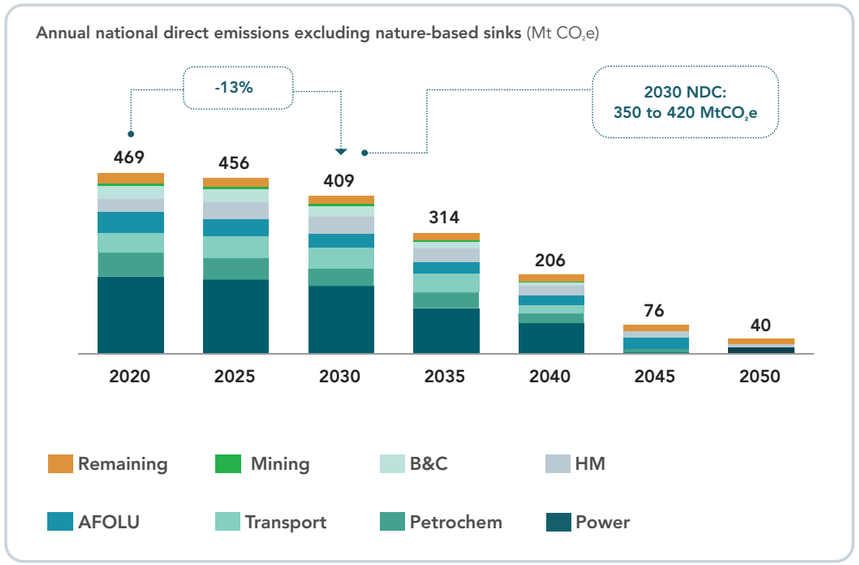
THE RISK OF MISSING SOUTH AFRICA'S NDC AND EXCEEDING ITS FAIR SHARE CARBON BUDGET

South Africa has set the target of reducing its emissions to 420-350 $MtCO_2e$ by 2030 from 500 $MtCO_2e$ in 2017. However, the laid-out pathway would result in 409 $MtCO_2e$ – hence, nearly 60 $MtCO_2e$ above the lower limit of the NDC. Reductions by 2030 are driven by the decarbonisation of power and petrochemicals which account for ~75% of the total reduction. In addition to this, a ~30% adoption of a sustainable, healthier diet among South Africans would be required to achieve 409 $MtCO_2e$ by 2030. If the diet shift does not materialise, South Africa would be likely to miss the upper range of its 2030 NDC of 420 $MtCO_2e$ (Figure 17).

South Africa's fair share carbon budget is estimated to be 7-9 $GtCO_2e$. More than 50% of the upper bound of South Africa's fair share carbon budget of 9 $GtCO_2e$ is used up by 2030. This is due to the limited emissions reduction in the 2020s – with emissions reduction significantly increasing post-2030. The laid-out pathway results in ~9 $GtCO_2e$ (2020-2050) cumulative emissions. This meets the upper bound of the fair share carbon budget, although any deviation from this pathway or growth from new industries and economic diversification will result in this limit being exceeded

Figure 17 | South Africa requires more disruptive action to meet the lower bounds of its internationally committed emission reduction targets

Even with key decisions, SA is nearly 60 $MtCO_2e$ away from the 2030 NDC lower limit



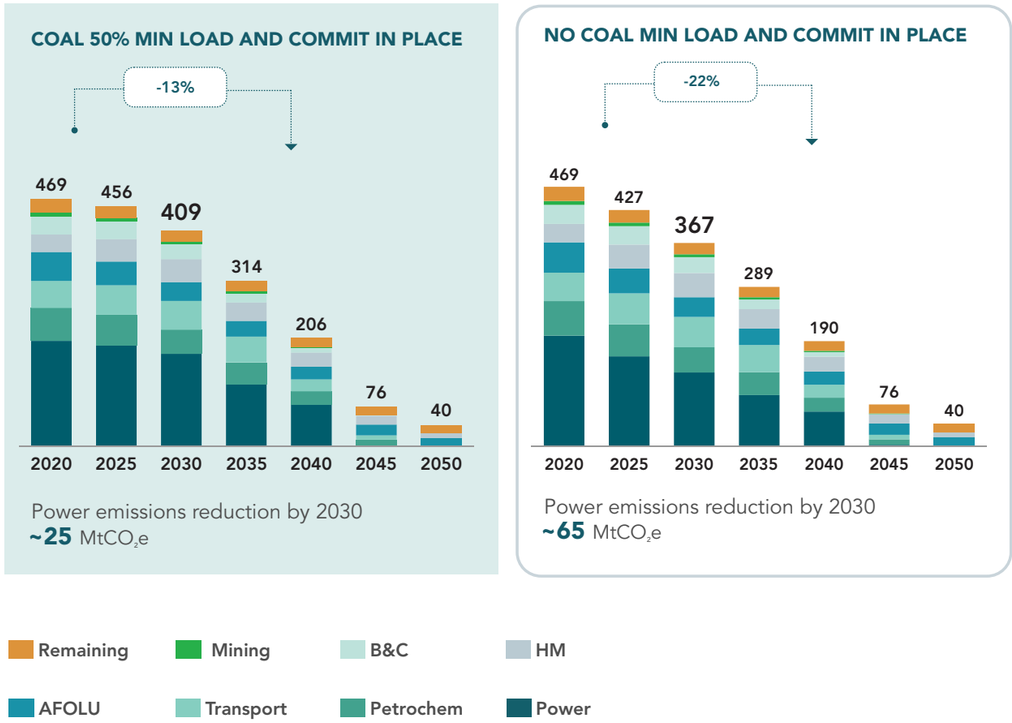
Annual emissions reduction from 2020 by 2030 ($MtCO_2e$ p.a.)

Power	56 GW RE deployed, 6 GW coal offline and diesel replaced by gas	25
Petrochem	~60 PJ p.a. additional gas as feedstock, and efficiency gains	20
AFOLU	Farming & forestry best practices deployed with sust. diet shift (~30%)	20
Transport	750 K EVs, slow uptake even with cost parity; transport demand increases	-4
HM	Demand uptake post Covid-19. Energy and process eff., fuel switch and recycling	-10
B&C	Optimise constr. sites, 20% penetration of retrofitting & green new builds	6
Mining	Electrification of assets rolled out, and efficiency gains	2

The reductions by 2030 are driven by the power, and petrochem, with the reduction from AFOLU uncertain

Source: NBI-BCG Project Team

Figure 18 | Achieving lower coal power plant utilisation rates can drive a further ~40$MtCO_2e$ reduction by 2030 from the power sector, seeing South Africa close to its 2030 NDC lower bound of 350 $MtCO_2e$



- **Coal minimum load:** Min % of rated capacity that coal power plant cannot go below to due technical limitations of the boiler
- **Commit requirement:** Coal is run even though there may be more economical options as coal is inherently inflexible

Source: NBI-BCG Project team

03

3. As a result of decarbonisation, renewables-based power will become the primary energy carrier in South Africa's net-zero economy

The net-zero transition will drive a fundamental shift in South Africa's energy mix away from fossil fuels, with renewable power becoming the economy's primary energy carrier **(Figure 19)**. From only ~3% of power generation today, renewables will be deployed rapidly to reach 80% of power generation by 2050. Coal will be phased out by the mid-2040s. Conventional liquid fuel demand will be nearly zero by 2050, primarily due to declining conventional liquid fuels demand from an increasingly electrified road transport sector.

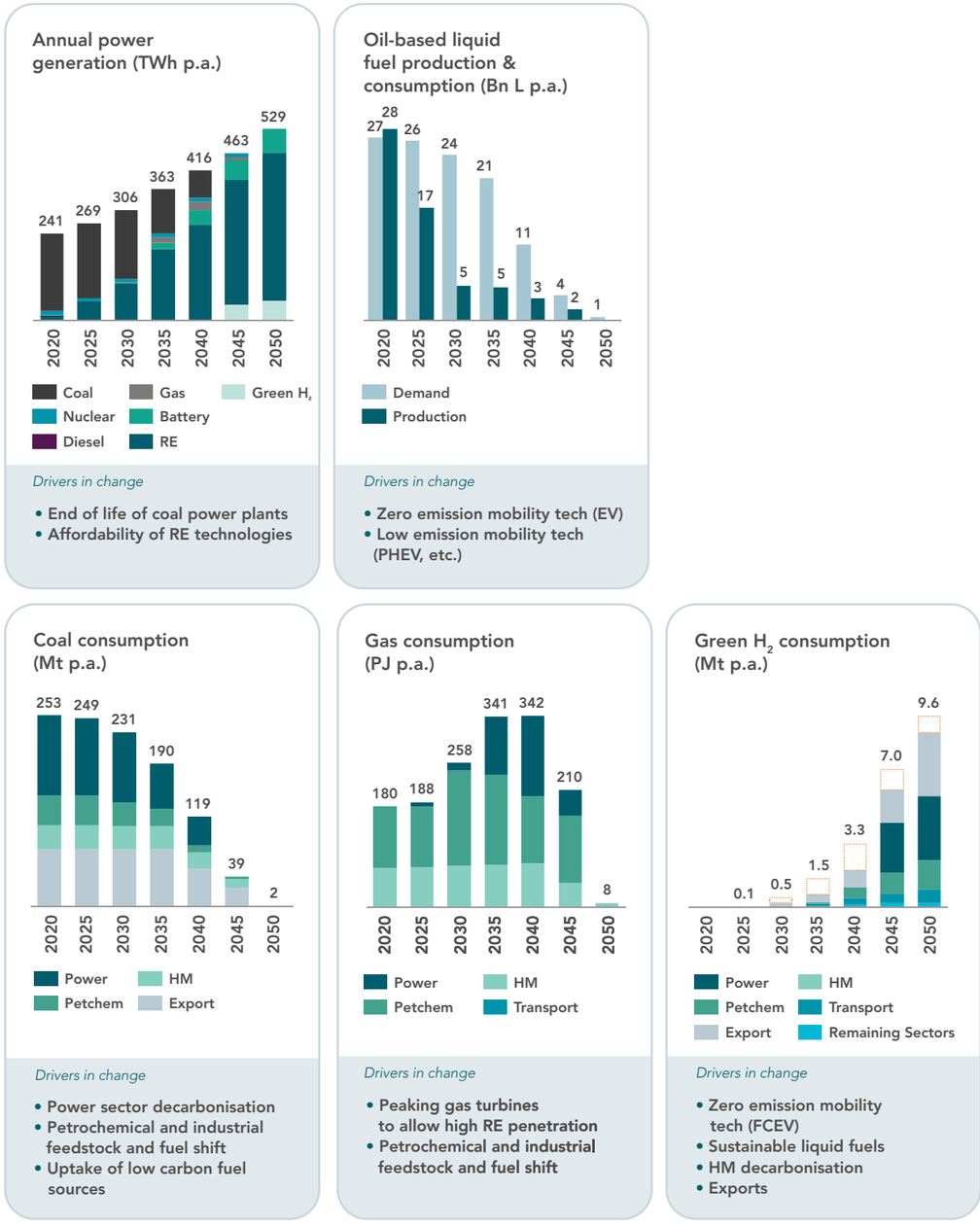
Locally produced green H_2 will become an important energy carrier in the South African economy. By 2050, green H_2 demand could reach ~9.5 Mt per year. Local green H_2 demand will be driven by the power, transport, petrochemicals and heavy manufacturing sectors **(Figure 20)**. Exports of green H_2 products could make up ~3-4 Mt of the total 2050 green H_2 demand – representing around 1% of the estimated global green H_2 demand in 2050.[30]

Gas will be needed as transition fuel, in limited volumes and for a limited period of time, with a flexible and short payback on liquified natural gas infrastructure (such as floating storage units). Gas enables a larger and faster scale-up of renewables. Gas also enables decarbonisation of other sectors, where it enables the phase out of more carbon-intense coal and diesel feedstock. Towards 2050, gas will need to be phased out of South Africa's economy. In the power sector, gas will need to be replaced with batteries (for short-term power balancing) and green H_2 (for seasonal balancing), and in industrial applications with sustainable sources of carbon (for feedstock substitution) and direct electrification (for industrial process heat where possible). H_2-ready turbines will be used in the power sector to enable a enable a faster switchover to green H_2 and to limit the cost of stranded gas assets.

It is important to highlight that there is no need for exploiting 'untapped gas reserves' in Southern Africa, given the long lead times for first production and long payback period yielding a high risk of stranded assets which outweighs the socio-economic benefit of gas reserve development.

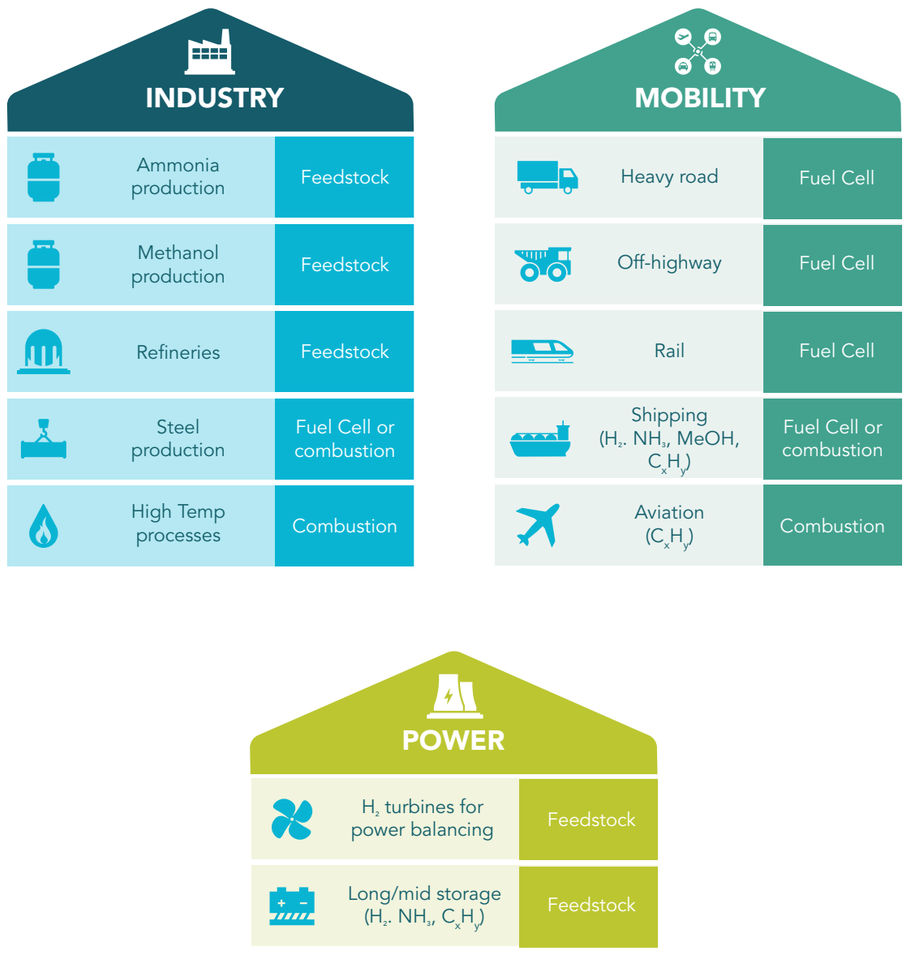
30. IEA net-zero scenario

Figure 19 | South Africa's energy mix shifts from coal-based power & oil-based fuels to renewable based power & Green H_2, with gas as transitionary fuel



Source: Eskom annual report (2021), Sasol annual report (2021), Mineral council of South Africa: Coal, SAPIA refining capacity, NBI-BCG Project team

Figure 20 | Green H_2 use cases



EXPORT | Use cases across industry, mobility, power & heating

4. ~ZAR 6 trillion is required in infrastructure investments to transition to net-zero by 2050, with ~ZAR 1 trillion required by 2030, and a large portion of this cost offset by reduced operating expenses on fossil fuels

South Africa's transition to net-zero will require infrastructure investments of ~ZAR6 trillion over the next 3 decades (Figure 21). This is equivalent to ~4.7% of South Africa's current GDP being spent on the transition every year until 2050. Furthermore, beyond the ~ZAR 6 trillion required for mitigation efforts, more funding is required for a Just Transition and adaptation needs **(Side Box 10)**.

The ~ZAR 6 trillion required by 2050 needs South Africa to invest ~ZAR 100 billion annually in the 2020s, growing to ~ZAR 300 billion annually by the 2040s. Assuming an historical GDP growth rate of 2.4%, this investment is equal to ~1.5% of GDP in the 2020s and ~3% of GDP by 2050. In the long-term, as the transition drives more affordable, reliable electricity supply and a new green hydrogen value chain is established, target GDP growth should exceed the historical average of 2.4% p.a.

The decarbonisation of South Africa's power sector requires nearly half of this total investment, with around ~ZAR 2.8 trillion. However, overall this pathway for the power sector is cheaper than coal- or nuclear-based power systems due to reduced expenditure on fuel. For example, the annualised investment rate required in the power sector is only ~ZAR 100 billion p.a., compared to Eskom's current primary energy spend, which sits at ~ZAR 120 billion p.a. Therefore, the power sector's transition – which is the single biggest investment need for South Africa – is cost-effective **(Figure 22)**.

The 2020s is a crucial decade in making South Africa's transition successful, and early investments in the power system are vital. The power system requires ~ZAR 690 billion, just under 70% of the total spend in the 2020s. Of this, grid expansion will require ~ZAR 170 billion (~25% of the power sector's needs), while renewable energy generation capacity will require ~ZAR 310 billion (45%). These investments are commercially bankable and technically mature, and have seen significant reductions in cost in recent years, with REIPPP round 5 costs (per MWh) ~25% and 30% lower than round 4 costs for solar PV and wind respectively.[31]

In the 2020s, ~60% of South Africa's mitigation investments can be funded from mostly commercial

31. At the time of writing, a majority of the REIPPP5 bids did not reach financial close. Therefore, the REIPPP5 cost may slightly underestimate the RE cost

sources (Figure 23), with only ~7% requiring mostly concessional financing. Therefore, many of these investments are commercially viable. Given that many investments are mature technologies, the implementation is also technically feasible. The issue is the sheer pace that these investments are required at.

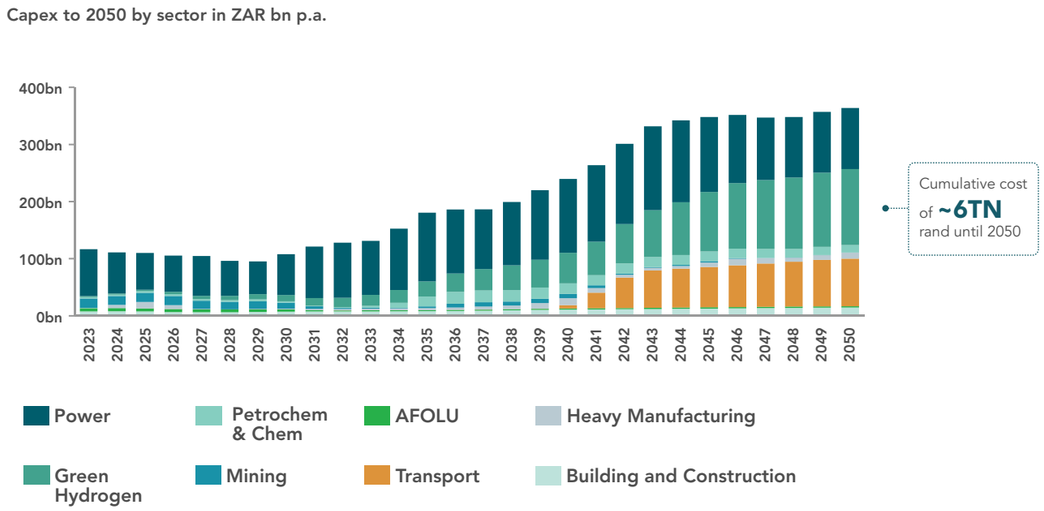
SIDE BOX 10

SIGNIFICANT ADDITIONAL FUNDING WILL BE REQUIRED FOR ADAPTATION AND SOCIAL EXPENDITURE

Social and adaptation investments will require substantial additional funding by 2050. Education, reskilling and coal-decommissioning will require as much as ~ZAR 1.2 trillion by 2050.[32] This is but one of the many social aspects that require funding. Therefore, the total funding need will be higher. Adaptation investments that create an economy that is more resilient to the inevitable impacts of climate change require more detailed research, with the National Adaptation Strategy estimating as much as ~ZAR 300 billion in funding needs by 2030, but with no view beyond 2030. Further research is needed to determine adaptation and social funding needs

Figure 21 | South Africa's transition to net zero by 2050 could cost over ~ZAR 6tn for mitigation investments alone

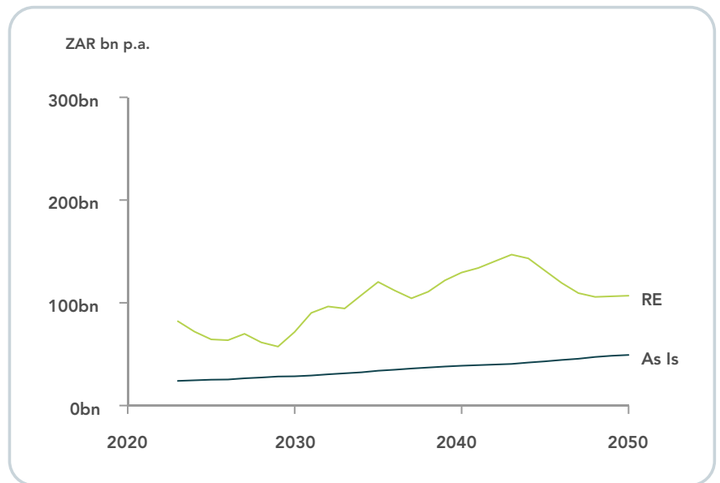
Near-term costs primarily in power sector, with Green Hydrogen and Transport scaling up towards 2050



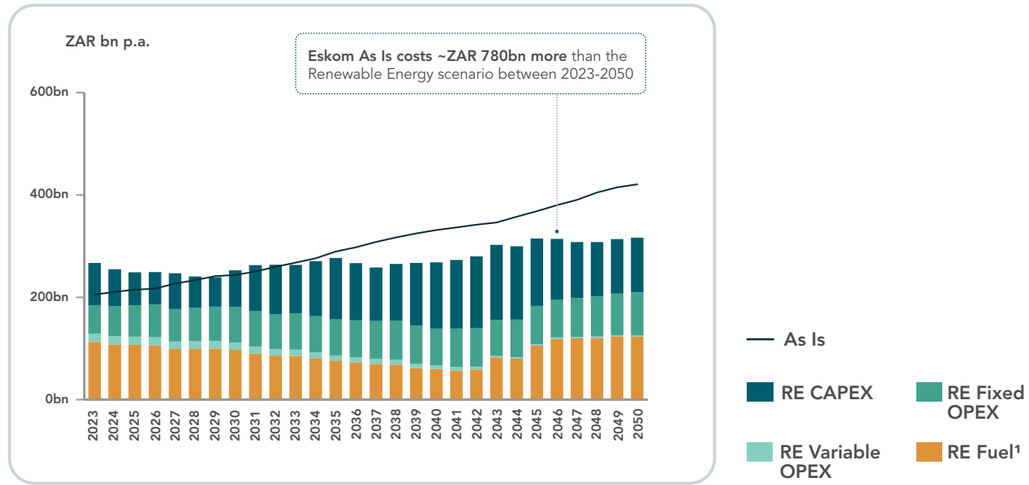
32. Based on the estimated job creation from this study's projected pathway and the expected decommissioning timeline for coal-fired power stations

Figure 22 | While CAPEX costs are greater on a Renewable Energy pathway, the total costs of a status quo far outpace Renewable Energy in the long run

Estimated CAPEX 2023-2050 comparison between "Eskom As Is" & Renewable Energy Scenarios

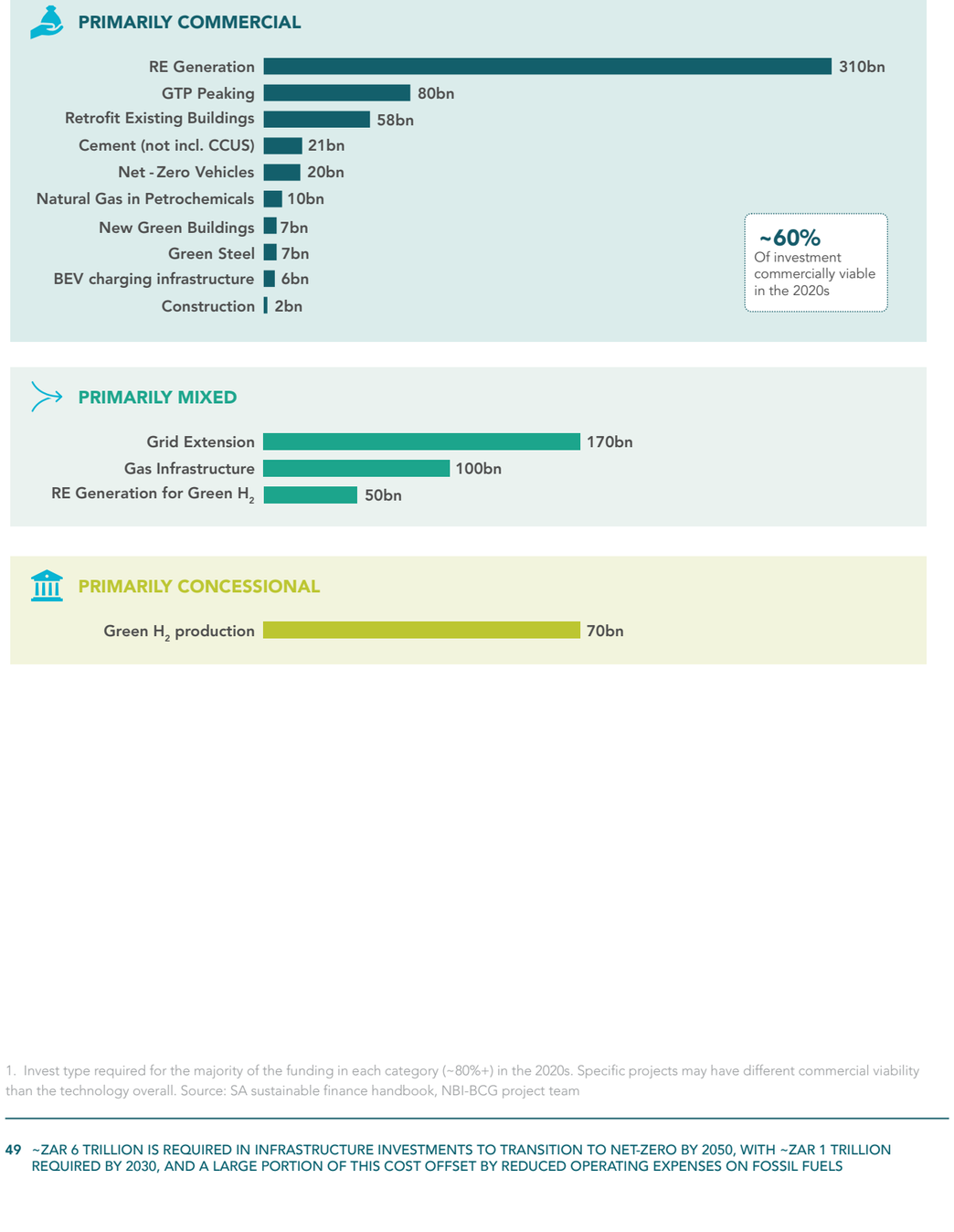


Estimated CAPEX & OPEX to 2023 -2050 comparison between "Eskom As Is" & Renewable Energy Scenarios



Note: "Eskom As Is" CAPEX based on FY21 Statement of Cashflows "Acquisitions of property, plant and equipment and intangible assets"; OPEX estimated from FY21 Revenue – EBITDA. Both grown in proportionally to the Renewable Energy scenarios growth in kWh. "Eskom As Is" costs conservatively do not include fuel cost (i.e., coal and diesel) growth. Increase in RE Fuel in the 2040s driven by Hydrogen replacing remaining carbon-based fuels.
Source: Eskom FY21 annual report, NBI-BCG project team

Figure 23 | Majority of technologies required in the 2020s are commercially viable while some infrastructure and Green H_2 require concessional support



1. Invest type required for the majority of the funding in each category (~80%+) in the 2020s. Specific projects may have different commercial viability than the technology overall. Source: SA sustainable finance handbook, NBI-BCG project team

05

5. The public sector must unlock sufficient private sector investment, particularly in bankable investments such as renewables, to finance the transition

Given South Africa's public financing constraints, large-scale private sector investment and international support are needed. To do this, actions are required to resolve the five key challenges that act as barriers to availability and access to finance **(Figure 24)**.

Priority investments in renewables, the grid, green H_2, the roll-out of electric mobility, and gas make up more than ~70% of South Africa's investment needs in the 2020s. However, cost is not the only factor to consider as these investments are implemented. Each investment has multiple implementation risks that will need to be managed, including commercial, technology, and forex risks. Whether concessional or commercial sources of finance are deployed to mitigate these risks is dependent on the technical maturity and commercial desirability of an investment. Further, different stakeholders in the economy are better positioned to manage risk. For example, the owner of a gas asset is better placed to mitigate commercial or technical implementation risk than government. The distribution of risk among funding stakeholders for the priority abatement levers shows that the commercial sector can shoulder more of the risk for commercially viable and mature investments such as renewables **(Figure 25).**

Concessional capital will play a de-risking role to crowd in commercial finance for some other investments, such as in green H_2, where up-front commercial and technical risk is high. For other investments, such as in import-dependent EV technology, concessional finance can also play a limited de-risking role, such as by offering sub-market-rate currency hedging instruments.

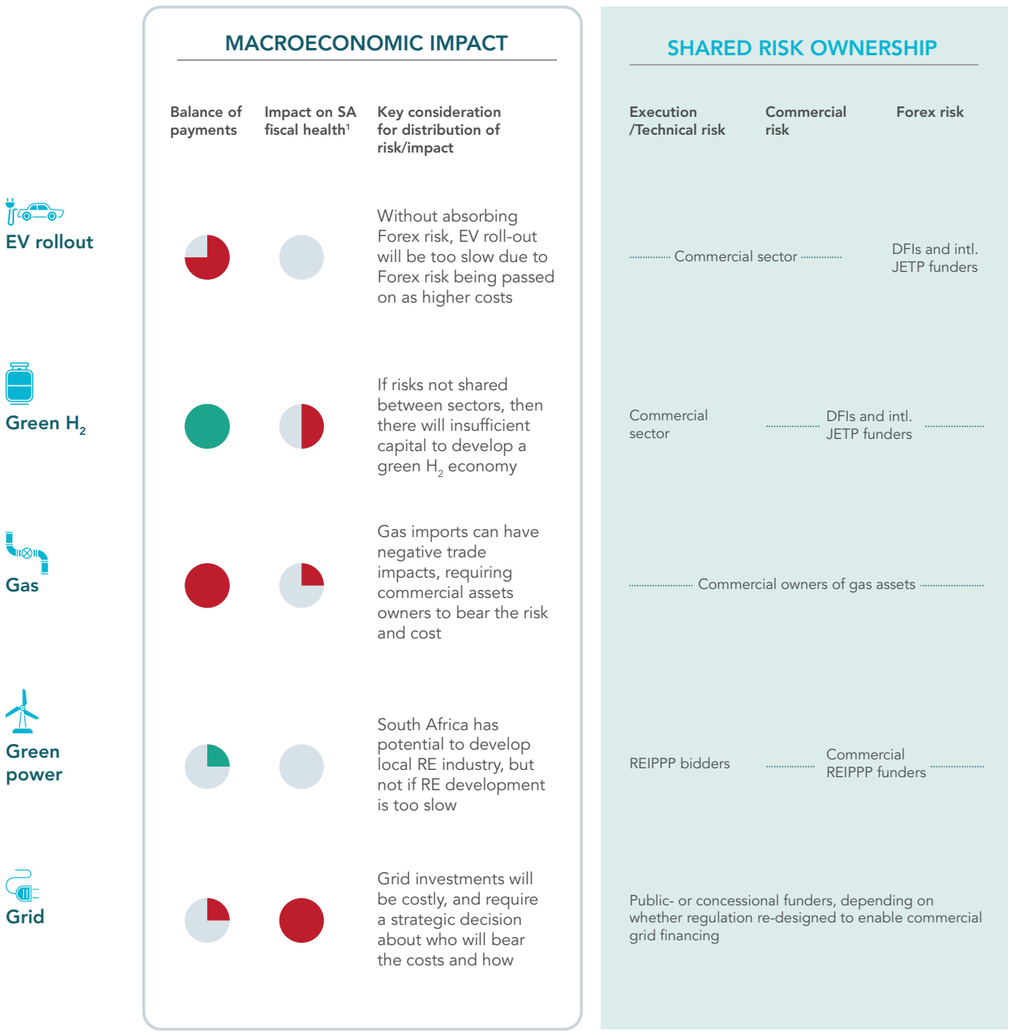
International support will also be needed to increase the availability of concessional finance, beyond the ~USD 8.5 billion Just Energy Transition (JET) Partnership. International support, from Development Financial Institutions (DFIs) for example, will bring much-needed funding, such as interest-free debt, that can be used as funding catalysts to crowd-in capital for more complex investments, such as in green H_2.

Figure 24 | The five distinct challenges facing climate finance in South Africa

01 LACK OF POLICY AND STRATEGY ALIGNMENT	• Multiple policies that are not linked to provide a coherent path • Different agencies in government following different strategies • Specific instances where policy inhibits projects[1]
02 HIGH RISK, LOW PERCEIVED REWARDS	• Some green projects have low return rates compared to others • Technologies with low maturity have greater implementation risk • High currency volatility in SA risks reducing capital available
03 LACK OF TRANSPARENCY ON PROJECT PIPELINE	• Few projects of sufficient size to attract large-scale investment • Lack of catalytic blended finance tailored to project lifecycle[2] • Low project preparedness for finance
04 LACK OF LOCAL BLENDED FINANCE	• Low levels of cooperation between commercial and concessional funders • Public-private blended finance in SA green projects is 100% from international sources
05 INCONSISTENT AND STRICT STANDARDS AND RULES	• No global definition of "green" for many investments[3] • Restrictive application of green standards[4] • Risk of greenwashing given different green standards

1. Such as EV import taxes, embedded generation limits) 2. Specifically, the evolution of the target capital stack (or mix od debt, equity and grant financing) required as project matures 3. For example, whether gas can be considered a transition fuel or not 4. Such as restrictions on selling surplus RE electricity generated specific for green H_2 production can be sold to the general grid
Source: NBI-BCG project team

Figure 25 | Risk ownership of priority investments must be shared across economy, with commercial funders bearing more risk in bankable, mature investments



Note: red and green indicate negative and positive impacts
1. Fiscal impact defined as impact on government debt and deficit
Source: BCG-NBI Project Team

6. The net-zero transition will see a fundamental change in the economy - new economic opportunities will arise and many new jobs can be created. However, the jobs of the future will require a different workforce from today

Although there are significant risks associated with this transition, it also presents South Africa with an opportunity to tap into new green industries to drive economic growth and job creation.

Localising the renewable value chain has the potential to create more jobs than are lost in 'sunset industries', with ~2.4 million net cumulative jobs years in the power sector alone. Further, South Africa's world-class complementary solar and wind resources present it with an opportunity to capture ~2.5 million cumulative job years by 2050 in the green H_2 value chain if it becomes a global production hub. South Africa's motor vehicle manufacturing expertise could also be transitioned to electric vehicle production. The role of PGMs in hydrogen and fuel cell technology and the increased demand for certain mineral commodities, like copper for use in green technology, could bolster the mining sector. South Africa's experience with the Fischer–Tropsch process additionally positions it to be one of the world leaders in carbon-neutral fuels **(Figure 26)**.

Realising such opportunities requires more than technical and financial support. The opportunities, and more broadly the shift in economy away from fossil fuels towards new green industries, will require a workforce that is different to the workforce today. Set against the backdrop of increasing automation and digitisation, this will need to be a more highly skilled workforce.

This will be a significant shift for the South African workforce, and displaced workers cannot simply be 'absorbed' in new green industries due to this difference in skill requirements. By way of an example, ~50-70% of mining jobs require low-medium skills, with less than 20% of all employed having studied beyond grade 12 and acquired a Higher Education Certificate.[33,34] These workers will need to be skilled for new industries, with potentially higher skills requirement, within less than 3 decades.

Further, the transition will also result in higher costs to all South Africans, such as the 4x higher cost for a

33. 'Sector Skills Plan for the Mining and Minerals Sector', submitted by the Mining Qualifications Authority (MQA) to the Department of Higher Education and Training (2019–2020).
34. Schers, J., Burton, J., Bagilet, V. (2019). Managing the coal transition for workers in South Africa

sustainable, nutritionally balanced diet. Therefore, South Africans will need higher wages to be able to bear the cost of the transition. However, simply increasing wages will not work. This is because increasing wages will not increase the output from the economy - instead, the same output will be achieved with higher wages, which will lead to inflation. Increased skills and capacity development are needed to increase the output – fewer people required to produce the same output. This too is a shift away from today's current job-intensive economy towards a highly-skilled, efficient economy.

Given the rapid pace of climate transition, workforce transition cannot be left to the markets and to chance, but instead will need to be proactively orchestrated. A national, coordinated effort involving the private sector, public sector, and civil society will be crucial to co-develop the strategic workforce plan for South Africa.

The national strategic workforce plan will need to take into account the risks and opportunities a transition towards net-zero 2050 creates.

However, more than job creation is needed to meet South Africa's development needs and ensure that the transition is just.

Figure 26 | Key risks and opportunities in South Africa's transition

	OPPORTUNITIES	RISKS
Power	• **Affordable, reliable power supply** that drives growth across the economy • **Net positive job creation, with 2.4mn cum net job years by 2050** if elements of renewable energy manufacturing localised	• Continued **energy security issues**, and limited economic growth due to unreliable power supply
Petrochem	• **Green fuels and chemicals production hub** leveraging synfuels expertise and tech. • **Green H_2 production hub**, creating up to ~2.5mn cum job years by 2050 if elements of the renewables value chain are localised	• **~140,000 direct jobs** at risk in coal, refinery and adjacent value chains • Potential **energy security risks** in mid-term due to refinery shutdown
Transport	• **Reliable, affordable safe transport system** that addresses historical issues • **Efficient, reliable rail transport system** that enables economic growth across sectors	• **High transport costs limiting economic growth**, and exacerbating socio-economic challenges
AFOLU	• **Climate resilient, sustainable agricultural products** for local markets and exports	• **Food security** due to the climate risk the AFOLU sector faces **~450,000 direct jobs at risk**, particularly in the Western Cape and Northern cape which will be hardest hit by climate change, and drive export earnings
HM	• **Energy intensive, climate compatible manuf. hubs** for local and export markets • **Green H_2 based products production hub,** e.g. green steel • **Renewable energy product manufacturing** for local industry	• **~320,000 jobs loss** in automotive manuf. due to electric vehicle transition • **Potential relocation of manufacturing facilities** to renewable energy and green H_2 hubs with negative jobs impact on communities
B&C	• **Housing for all** to addresses socioeconomic issues • **Infrastructure needs of transition met** by construction sector	• **Increased material and construction costs** preventing housing gap from being closed
Mining	• **Shift to new green commodities** that are needed globally and locally • **Beneficiation of green commodities** to drive economic growth	• **~400,000 jobs, and 2-4 Mn livelihoods at risk in the coal value chain**, concentrated in Mpumulanga region

Source: NBI-BCG Project Team

07

7. Although transitioning to net-zero can preserve the economy, secure long-term competitiveness and create new green industries, it must be well managed to ensure Just Transition outcomes that address South Africa's development needs

A transition to net-zero emissions for South Africa by 2050 is in a context characterised by high levels of poverty, unemployment, and inequality. The transition must therefore be coupled with deliberate efforts to ensure that this transition leaves no one behind **(Side Box 11)** and meets the developmental needs for building a more sustainable society that is socially inclusive and fosters greater resilience to the impacts of climate and transition risk.

Given the scale of South Africa's socio-economic challenges, and the severity of climate risk it faces, South African business needs to take a transformative approach towards their participation in the Just Transition. A transformative approach, rooted in the values of democracy, encourages stakeholders to build trust for one another, and develop partnerships and initiatives that seek to address all three types of justice:[35]

1. Procedural Justice – enable stakeholders impacted by decisions to participate meaningfully in decision-making processes

2. Distributive Justice – ensure that the risks and benefits of the Just Transition are spread more evenly throughout society and that risks are not disproportionately borne by disadvantaged and/or disempowered sectors of society

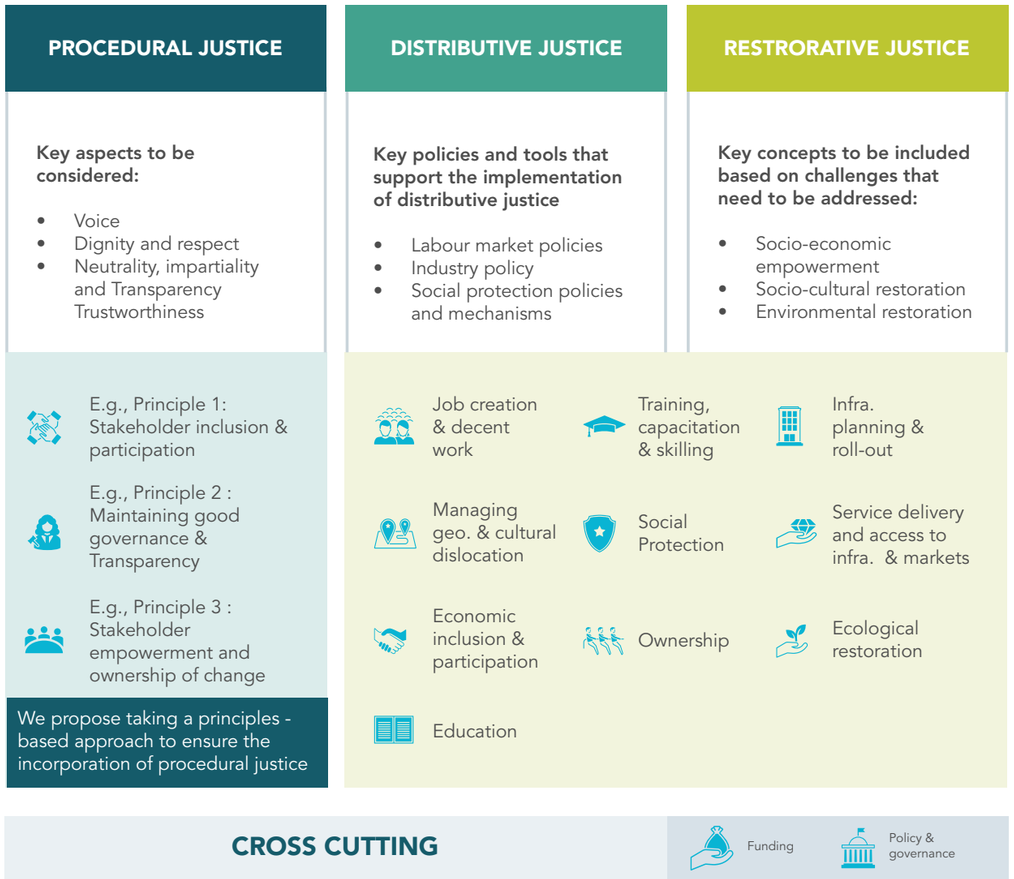
3. Restorative Justice – address historical wrongs and/or injustices created and imposed systemically, such as systemic inequality resulting from Apartheid segregation laws

The requirements of business, and other stakeholders, in a Just Transition context therefore extend beyond the need to manage job losses and re-skilling as sectors transition and must include efforts to address a range of socio-economic needs such as access to services and infrastructure, access to economic opportunity, education and social support mechanisms, as well as clean and healthy natural environments **(Figure 27)**.

A well-planned, coordinated and collaborative approach will be required across the economy by private and public stakeholders to ensure a Just Transition. Further work is needed to refine this initial framework, and determine what actions the private and public sectors should drive respectively.

35. This aligns with Just Transition framework developed by the PCC

Figure 27 | Unlocking South Africa's vision of a Just Transition, at national and sectoral levels, hinges on key building blocks



SIDE BOX 11

THE IMPACT OF THE TRANSITION WILL NOT BE EQUAL ACROSS VALUE CHAINS AND REGIONS, AND THESE RISKS NEED TO BE MANAGED TO ENSURE NO ONE IS LEFT BEHIND

South Africa's carbon-intensive economy will face mounting risks across all sectors. These risks range from the loss of deciduous fruit exports all the way to gold exports, the potential collapse of industries such as conventional vehicle manufacturing, and the shift away from grey industries such as coal and conventional liquid fossil fuels. Furthermore, the severe climate risk that South Africa faces threatens the economy, in particular the AFOLU sector. In total ~50% of South Africa's export value, ~1 million direct jobs, and ~15% of GDP could be at risk if decarbonisation and climate adaptation is not pursued. However, the regional impact of the transition may be even more severe. The Mpumalanga region accounts for ~80% of South Africa's coal production, concentrating the nearly 2-4 million coal value chains livelihoods at risk in the region. The sector-specific risks associated with South Africa's transition are shown in (Figure 26).

08

8. Reaching net-zero will impact the entire economy and all members of society, and action and collaboration are needed across all sectors to achieve it by 2050

Reaching net-zero is a challenge that will see a significant transformation of South Africa's energy system, building and vehicle stock, transport infrastructure, and large parts of industry all while addressing South Africa's socio-economic challenges. This is a significant challenge – the sum of individual actions, even bold ones, will not be enough to meet this challenge. We need collaboration and a coordinated approach to successfully decarbonise and ensure a Just Transition.

However, this is also a chance for South Africa to capture new economic opportunities in electric vehicle manufacturing, green H_2-based industries, new green minerals, heavy manufacturing commodities and many others, and develop an economy and society to uplift its people. This will require a high-level roadmap, with key milestones per sector to achieve this pathway (Figure 28).

This pathway to net-zero which includes ambitious actions such as 10x faster renewables roll-out, shutting down coal by the mid-2040s, complete penetration of ZEVs from effectively 0% within less than 3 decades, adoption of a sustainable diet by all South Africans, among others, sees South Africa meet its 2030 NDC and fall at the very upper end of its fair share carbon budget of 7-9 $GtCO_2e$ with ~9 $GtCO_2e$ cumulative emissions. However, it is important to note that the considered pathway does have uncertainties and signposts that need to be monitored (Side Box 12).

To achieve the lower bound of South Africa's emissions reduction targets, South Africa requires even more disruptive actions. This will introduce further socio-economic risks, for which South Africa will require additional international support. This international support includes finance for mitigation, adaptation and loss, in addition to non-finance support such as trade agreements, technical and capacitation support, and technology sharing, among others. However, it is important to put achieving South Africa's lower bound in the global context – South Africa's 2020-2050 cumulative emissions are equivalent to China's annual emissions of ~10 $GtCO_2e$.[36]

South Africa's Urgent Call to Action to Achieve a Just Transition:

1. Deploy renewables at scale

It is important to re-emphasise that decarbonising the power sector is the most critical part of the transition. The power sector is currently the largest source of South

36.World Bank, CO2 emissions (kt) – China, https://data.worldbank.org/indicator/EN.ATM.CO2E.KT?locations=CN

Africa's emissions, accounting for ~40% of the national emissions footprint, and renewables-based electrification is a critical cross-sector decarbonisation lever and driver of future economic growth. The entire transition hinges on our ability to rapidly transition to a renewables-dominant power system. In the context of South Africa's energy crisis – which reached new heights in 2022 – the transition to a renewables-dominated energy system becomes even more urgent, given that it is the key to addressing today's power supply shortfalls in a fast and affordable way.

Without fast and large-scale renewables deployment, with the commensurate grid investments, all other activities needed to achieve net-zero, capture new green economic opportunities, and maintain and grow trade opportunities will not be achievable. Delaying the roll-out of renewable energy capacity at scale will dramatically worsen South Africa's financial situation. It will increase the cost of creating an affordable, reliable, decarbonised power system; it will further decrease the global competitiveness of South Africa's economy and destroy opportunities to diversify the economy.

All existing roadblocks, such as unsupportive policies, slow regulatory processes and a lack of visibility on a clear pipeline of investible green projects need to be removed and addressed to enable the large-scale deployment of renewables. The work being done by Operation Vulindlela is a great example of the kind of collaborative and execution-focused interventions the country needs more of.

In addition, trade support and provision of concessional finance from developed countries to stimulate new green industries and mitigate transition risk will be critical.

With Africa having only contributed ~3% of cumulative emissions globally and expected to be disproportionately affected by the physical risk of climate change – developed countries must play their part in enabling South Africa's Just Net-Zero Transition.

2. COORDINATE A NATIONAL GREEN INDUSTRIES INCUBATION AND AN ECONOMIC DIVERSIFICATION APPROACH

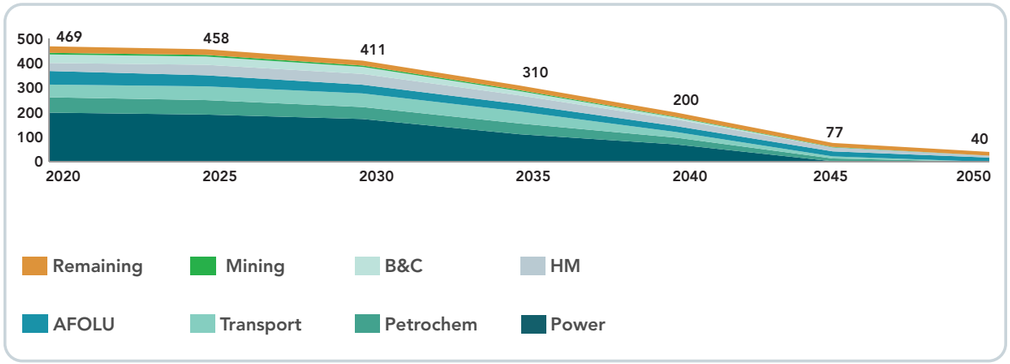
Building large-scale, renewable energy will alone create more jobs than are at immediate risk in "sunset" industries – such as the local coal or liquid fuels industry. For example, if South Africa can localise elements of the renewable energy value chain, ~2.4 million cumulative net job years can be created by 2050 in the power sector alone, and a further ~2.5 million cumulative net job years if South Africa captures the green H_2 opportunity.

However, this will not be enough to solve the existing structural challenges of the economy and ensure a Just Transition. New economic opportunities must be pursued with an unparalleled focus, leveraging South Africa's competitive advantages around the availability of high-quality renewables, access to key commodities, existing knowledge and skills, critical infrastructures – such as port and rail infrastructure – trade partnerships and a growing, young population.

This includes opportunities around the localisation of renewable energy value chains, the establishment of a globally competitive green H_2 ecosystem, and the creation of decarbonised, energy-intensive manufacturing hubs including, for example, an export corridor for green steel and synthetic fuels, electric vehicle manufacturing, and mining of green mineral commodities, among others. The window is now opened to create an enabling business environment and reset South Africa's socio-economic trajectory.

Figure 28 | Key milestones in the South Africa's pathway to net zero

Annual national direct emissions excluding nature-based sinks ($MtCO_2e$)



Power	• **No new coal or nuclear power plants,** RE deployed at ~6-7 GW p.a.	• **~70% of coal fleet (~27 GW) retired by 2040** • Battery deployment initiated at ~3 GW p.a. from 2030	• **Last coal power stations retired by 2042** ~50 GW peaking capacity provided by green H_2
Petrochem	• No new refineries, or oil & gas fields **60 PJ p.a. gas introduced** as a transitionary feedstock	• **Sustainable carbon sources and green H_2** introduced	• **Gas and coal fully replaced** by sustainable carbon sources and green H_2
Transport	• **Charging and H_2 infrastructure** rolled out • Slow consumer shift to ZEVs	• **ICE sales effectively eliminated** by mid 2030s • 750 K ZEVs on road, and **33% of sales by 2030**	• 7M BEVs, 1M FCEVs, and 15% & 20% pax & comm. Increase in rail respectively
AFOLU	• **Sustainable farming and forestry practices** rolled out	• Increased sustainable practices deployment, and **sustainable diet shift**	• **Red meat consumption effectively eliminated**
HM	• **Mature lever roll-out** (process efficiency, electrification with RE, material substitution, etc.)	• Mature lever rollout at full potential • **Green H_2 for DRI-EAF** route for steel prod. rolled out	• **Increased green H_2** for steel prod. • CCUS deployed to capture cement residual emissions
B&C	• **Phasing out of inefficient fossil fuels** • No new fossil fuel boilers sold from 2025	• **All new buildings NZ-ready from** 2030 ~99% electrification of existing buildings by 2040	• **~85% of existing buildings retrofitted** by 2050 Equip. & mobility electrification in construction
Mining	• **Asset electrification & RE deployment** rolled out • Exploration for green commodities started	• **~50% decline in coal production** by 2040 • ZEV mining mobility tech rolled out	• **Coal production stopped** • Production shifted to new green commodities

Source: Gaylor Montmasson-Clair, 2021, Working Paper: a Policy Toolbox for Just Transitions, TIPS; NBI-BUSA-BCG Climate Pathways Study: Just Transition Framework; NBI-BCG project team

SIDE BOX 12

THE UNCERTAINTIES IN THE ANALYSIS AND SIGNPOSTS THAT NEED TO BE MONITORED

Given that there will be significant changes between now and 2050, there are signposts that need to be monitored for changes to the pathway in addition to uncertainties in the analysis. These uncertainties and signposts will impact the speed of the transition, and "last-mile" decarbonisation technologies for hard-to-abate emissions. The key uncertainties and signposts are shown below.

Uncertainties in analysis:

Consumer behaviour shifts to more sustainable practices, such as public transport, smaller homes, and potentially more expensive levers such as a sustainable diet. The technical availability of alternatives to gas, including small modular nuclear reactors in power, and sustainable biomass availability as a feedstock. Pathway does not include emissions from new industries that may arise in the future, and economic diversification.

Signposts to be monitored for changes to the pathway:

Cost evolution of mature technologies such as electric vehicles, in addition to the cost and technology evolution of technologies not yet available at scale, such as green H_2, and the viability of permanent carbon storage in South Africa. Further, key regulation and policies like the Climate Bill, and greater government alignment needs to be monitored.

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