National Business Initiative

CHAPTER 01

JUST TRANSITION AND CLIMATE PATHWAYS STUDY FOR SOUTH AFRICA

# DECARBONISING SOUTH AFRICA'S POWER SYSTEM

IN PARTNERSHIP WITH

BUSA BUSINESS UNITY SOUTH AFRICA

BOSTON CONSULTING GROUP

# 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 long-standing 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.

Supported by:

Federal Ministry
for the Environment, Nature Conservation
and Nuclear Safety

of the Federal Republic of Germany

**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.

## 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.

### 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.

# TERMINOLOGIES

| | |
|---|---|
| **AFOLU** | Agriculture, Forestry and Other Land Use |
| **Base load** | Permanent minimum load a power supply system is required to deliver |
| **Bn** | Billion |
| **C&I** | Construction & Installation |
| **CAIA** | Chemicals & Allied Industries' Association |
| **CAPEX** | Capital expenditure |
| **CCGT** | Combined Cycle Gas Turbine |
| **CCUS** | Carbon Capture Utilisation & Storage |
| **CDP** | A disclosure platform for companies and cities to report on their carbon emissions, water usage, forest management and climate-related financial disclosures |
| **CGE** | Computable General Equilibrium (used in socio-economic modelling) |
| **COP26** | United Nations Conference of the Parties |
| **$CO_2e$** | Carbon dioxide equivalent |
| **CSIR** | Council for Scientific and Industrial Research |
| **CTL** | Coal-to-liquid |
| **DACCS** | Direct Air Carbon Capture and Storage |
| **DFFE** | Department of Forestry, Fisheries and the Environment |
| **DG** | Distributed Generation is an approach that employs small-scale technologies to produce electricity close to the end-users of power |
| **DMRE** | Department of Mineral Resources & Energy |
| **EG** | Embedded Generation is electricity generation which is connected to the distribution network rather than to the high voltage National Grid |
| **EPRI** | Electronic Power Research Institute |
| **EU** | European Union |
| **EV** | Electric vehicle |
| **FAO** | Food and Agriculture Organisation of the UN |

| | |
|---|---|
| **Feedstock** | Raw material to supply or fuel a machine or industrial process |
| **GDP** | Gross Domestic Product |
| **GHGI** | Greenhouse Gas National Inventory |
| **Green hydrogen** | Hydrogen produced from renewable energy sources |
| **GJ** | Gigajoule |
| **Gt** | Gigatonne (1 thousand million tonnes) |
| **GTP** | Gas-to-Power |
| **GW** | Gigawatt |
| **I-O** | Input Output model (used in socio-economic modelling) |
| **IDDRI** | Institute for Sustainable Development and International Relations |
| **IEA** | International Energy Agency |
| **IGUA** | Industrial Gas Users Association of Southern Africa |
| **IRENA** | International Renewable Energy Agency |
| **IPCC** | Intergovernmental Panel on Climate Change |
| **IPP** | Independent Power Producer |
| **IRP** | Integrated Resource Plan |
| **kg** | Kilogram |
| **LCOE** | Levelised cost of energy |
| **LCOH** | Levelised cost of $H_2$ |
| **Mha** | Million hectares |
| **MQA** | Mining Qualifications Authority |
| **Mt** | Megatonne (1 million tonnes) |
| **NDC** | Nationally Determined Contribution |
| **NG** | Natural Gas |
| **Nedlac** | National Economic Development and Labour Council |
| **NPV** | Net Present Value |
| **n/a** | Not applicable |
| **O&M** | Operation & Maintenance |
| **OCGT** | Open Cycle Gas Turbine |
| **OE** | Oxford Economics |
| **OECD** | Organisation for Economic Co-operation and Development |
| **OPEX** | Operating expenditure |

| | |
|---|---|
| **P2X** | Power-to-X |
| **Peak-load** | Maximum of electrical power demand |
| **PGM** | Platinum Group Metals |
| **PM** | Particular Matter |
| **PSP** | Pumped-storage plant |
| **PV** | Photovoltaic solar energy |
| **QES** | Quarterly Employment Survey |
| **QLFS** | Quarterly Labour Force Survey |
| **RE** | Renewable Energy |
| **REIPPPP** | Renewable Energy Independent Power Producer Procurement Programme |
| **SA** | South Africa |
| **SAM** | Social Accounting Matrix |
| **SAREM** | South African Renewable Energy Masterplan |
| **Scope 1 emissions** | All direct emissions from activities of an organisation under their control. Incl. process emissions, fuel combustion on site, such as gas boilers, fleet vehicles and air-conditioning leaks |
| **Scope 2 emissions** | Indirect emissions from electricity purchased and used by the organisation. Emissions are created during the production of the electricity that is used by the organisation |
| **SMR** | Small Modular Reactors |
| **SSA** | Sub-Saharan Africa |
| **SSP** | Sector Skills Plan |
| **Synfuels** | Synthetic Fuel |
| **TCFD** | Task-Force on Climate-Related Financial Disclosures |
| **TWh** | Terawatt-hour |
| **UCT** | University of Cape Town |
| **UN** | United Nations |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **WACC** | Weighted Average Cost of Capital |
| **WS#** | Workshop(#) |

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## JUST TRANSITION AND CLIMATE PATHWAYS STUDY FOR SOUTH AFRICA

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# OVERVIEW OF CEO CHAMPIONS

## Onboarding of additional CEOs ongoing

**Joanne Yawitch**
NBI CEO

**Cas Coovadia**
BUSA CEO

**Johan van Zyl**
Executive Chairman: Toyota South Africa

It is with great sadness that we heard of the passing of Dr. Johan van Zyl. We wish to extend our deepest condolences to his family, his friends, and to his team at Toyota. We will always be grateful for Dr. van Zyl's support as a CEO Champion and for the valuable contribution he made to this work.

**André de Ruyter**
Eskom CEO

**Fleetwood Grobler**
Sasol CEO

**Leila Fourie**
JSE Group CEO

**Mxolisi Mgojo**
Exxaro CEO

**Alan Pullinger**
First Rand CEO

**Hloniphizwe Mtolo**
Shell SA CEO

**Lungisa Fuzile**
Standard Bank South Africa CEO

**John Purchase**
AgBiz CEO

**Paul Hanratty**
Sanlam CEO

**Deidré Penfold**
CAIA Exec Director

Vivien McMenamin
Mondi SA CEO

Taelo Mojapelo
BP Southern Africa CEO

Roland van Wijnen
PPC Africa CEO

Njombo Lekula
PPC MD SA Cement and Materials

Gavin Hudson
Tongaat Hulett CEO

Vikesh Ramsunder
Clicks CEO

Nyimpini Mabunda
GE SA CEO

Nolitha Fakude
Anglo American SA Chairperson

Portia Derby
Transnet CEO

Mark Dytor
AECI CEO

Yusa Hassan
Engen MD and CEO

Tshokolo TP Nchocho
IDC CEO

Alex Thiel
SAPPI CEO

Stuart Mckensie
Ethos CEO

Marelise van der Westhuizen
Norton Rose Fulbright CEO

Ishmael Poolo
Central Energy Fund CEO

# 1. FOREWORD

JUST TRANSITION AND CLIMATE PATHWAYS STUDY FOR SOUTH AFRICA

South Africa is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and to the Paris Agreement. As an energy and emissions intensive middle-income developing country, it recognises the need for it to contribute its fair share to the global effort to move towards net-zero carbon emissions by 2050, taking into account the principle of common but differentiated responsibilities and the need for recognition of its capabilities and national circumstances.

South Africa is highly vulnerable to the impacts of climate change and will need significant international support to transition its economy and to decarbonise. Furthermore, given the country's high rate of inequality, poverty and unemployment and the extent of dependence on a fossil fuel-based energy system and economy, this transition must take place in a way that is just, that leaves no-one behind and that sets the country onto a new, more equitable and sustainable development path; one which builds new local industries and value chains.

In response to the above imperatives, the National Business Initiative, together with Business Unity South Africa and the Boston Consulting Group has worked with corporate leaders to assess whether the pathways exist for the country's economic sectors to decarbonise by 2050 and whether this can be done in such a way as to build resilience to the impacts of climate change and to put the country onto a new, low emissions development path.

The work done by the business community has interrogated the energy, liquid fuels, mining, chemicals, agriculture, forestry and other land use, transport and heavy industrial sectors. The results of the modelling and analytical work have been informed by numerous industry experts, academics and scientists. The results demonstrate that these pathways do exist and that even a country with an economy that is structurally embedded in an energy intensive production system can shift.

The results of this work to date have shown that this can be done, and that to realise these pathways, efforts must begin now. Timing is of the essence and the business community is of the view that there is no time like the present to create the regulatory and policy environment that would support transitioning the economy. **Accordingly, business can commit unequivocally to supporting South Africa's commitment to find ways to transition to a net-zero emission economy by 2050.**

Furthermore, in November, South Africa will table its revised Nationally Determined Contribution (NDC) to the UNFCCC. Business recognises the need for greater ambition to position the country as an attractive investment destination and increase the chances of accessing green economic stimulus and funding packages. Specifically, business would support a level of ambition that would see the country committing to a range of 440 to 350–370 Mt $CO_2$e by 2030. This is significantly

Upington, Northern Cape. Photo: scatec.com/locations/south-africa

more ambitious than the NDC put out for public comment and would require greater levels of support with regard to means of implementation from the international community than is currently the case. It is also consistent with international assessments of South Africa's fair share contribution to the global effort, and it would also ensure that the no-regret decisions, that would put South Africa onto a net-zero 2050 emissions trajectory, would be implemented sooner.

While South Africa has leveraged a degree of climate finance from the international community, the scale and depth of the transition envisaged will require substantial investments over an extended period of time. Critically, social costs and Just Transition costs must be factored in. Significant financial, technological, and capacity support will be required to support the decarbonisation of hard to abate sectors. Early interventions in these sectors will be critical.

Business sees the support of the international community as essential for the country to achieve its climate objectives. For this reason, business believes that a more ambitious NDC, and one that would place the country firmly on a net-zero emissions by 2050 trajectory, would have to be conditional on the provision of the requisite means of support by the international community. In this light the business community will play its part to develop a portfolio of fundable adaptation and mitigation projects that would build resilience and achieve deep decarbonisation.

Despite the depth of the challenge, South African business stands ready to play its part in this historical endeavour. Business is committed to work with government and other social partners, with our employees, our stakeholders, and the international community, to embark on a deep decarbonisation path towards net-zero and to build the resilience to the impacts of climate change that will ensure that our country contributes its fair share to the global climate effort.

# 2. INTRODUCTION

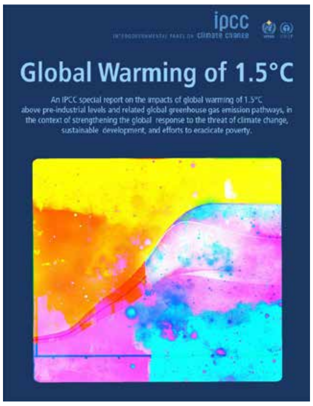
## 2.1 THE PURPOSE OF THIS REPORT

This report, focussing on the decarbonisation of South Africa's power sector, is the first in a series being released to illustrate the findings of this project. These reports are intended to leverage further engagement with sector experts and key stakeholders, beyond the extensive stakeholder engagement that has been undertaken from August 2020 to June 2021 within the respective technical working groups of this project. We hope this will foster continued dialogue during the project as we work towards a final report that will collate the individual sector findings and provide collective insight.

## 2.2 THE CASE FOR CHANGE

### 2.2.1 CLIMATE CHANGE AND THE RACE TO GLOBAL NET-ZERO EMISSIONS BY 2050

Climate change is the defining challenge of our time. Anthropogenic climate change poses an existential threat to humanity. To avoid catastrophic climate change and irreversible 'tipping points', the Intergovernmental Panel on Climate Change (IPCC) stresses the need to stabilise global warming at 1.5°C above pre-industrial levels. For a 66% chance of limiting warming by 2100 to 1.5°C, this would require the world to stay within a total carbon budget estimated by the IPCC to be between 420 to 570 gigatonnes (Gt) of $CO_2$, to reduce net anthropogenic emission of $CO_2$ by ~45% of 2010 levels by 2030, and to then reach net-zero around 2050.[1]




Hence, mitigating the worst impacts of climate change requires all countries to decarbonise their economies. In the 2019 World Meteorological Organization report, 'Statement on the State of the Global Climate', the United Nations (UN) Secretary-General urged: "Time is fast running out for us to avert the worst impacts of climate disruption and protect our societies from the inevitable impacts to come."

South Africa, in order to contribute its fair share to the global decarbonisation drive, bearing in mind the principle of 'common but differentiated responsibilities and respective capabilities', should similarly set a target of reaching net-zero emissions by 2050, **and also keep it within a fair share of the global carbon budget allocated, estimated to be between 7 and 9 Gt $CO_2$e**.[2]

Even if global warming is limited to 1.5°C, the world will face significantly increased risks to natural and human systems. For example, 2019 was already 1.1°C warmer than pre-industrial temperatures, and with extreme weather events that have increased in frequency over the past

1 IPCC. 2018. 'Special Report on Global Warming of 1.5°C'.

2 Extrapolation of the medians of various methodologies described by Climate Action Tracker. The full range is 4–11 Gt $CO_2$e.

Photo: UN Climate Action Summit

decades, the consequences are already apparent.[3] More severe and frequent floods, droughts and tropical storms, dangerous heatwaves, runaway fires, and rising sea levels are already threatening lives and livelihoods across the planet.

South Africa will be among the countries at greatest physical risk from climate change. South Africa is already a semi-arid country and a global average temperature increase of 1.5°C above pre-industrial levels translates to an average 3°C increase for Southern Africa, with the central interior and north-eastern periphery regions of South Africa likely to experience some of the highest increases.[4] Research shows that a regional average temperature increase of over 1.5°C for South Africa translates to a greater variability in rainfall patterns. Models show the central and western interiors of the country trending towards warmer and dryer conditions, and the eastern coastal and escarpment regions of the country experiencing greater variability in rainfall as well as an increased risk of extreme weather events.

Rising temperatures and increased aridity and rainfall variability may have severe consequences for South Africa's agricultural systems, particularly on the country's ability to irrigate, grow and ensure the quality of fruit and grain crops; and on the health of livestock, such as sheep and cattle which will see decreased productivity and declining health at temperature thresholds. Parasites tend to flourish in warmer conditions, threatening people as well as livestock and crops. Increasing temperatures and rainfall variability threaten South Africa's status as a megabiodiverse country. Severe climate change and temperature increases could shift biome distribution, resulting in land degradation and erosion. The most notable risk is the impact on the grassland biome, essential for the health of South Africa's water catchments, combined with the risk of prolonged drought.

3 World Meteorological Organization. 2019. 'Statement on the State of the Global Climate'.

4 Department of Environmental Affairs, Republic of South Africa. 2018. 'South Africa's Third National Communication Under the United Nations Framework Convention on Climate Change'.

Finally, rising ambient temperatures due to climate change and the urban heat effect threaten the health of people, particularly those living in cramped urban conditions and engaging in hard manual labour, as higher temperatures result in increased risk of heat stress and a reduction in productivity. Therefore, limiting global climate change and adapting to inevitable changes in the local climate will be critical to limit the direct, physical risks to South Africa. Like many developing countries, South Africa has the task of balancing the urgent need for a just economic transition and growth, while ensuring environmental resources are sustainably used and consumed, and responding to the local physical impacts of climate change.[5] While South Africa is highly vulnerable to the physical impacts of climate change, its economy is also vulnerable to a range of transition risks posed by the global economic trend toward a low-carbon future.

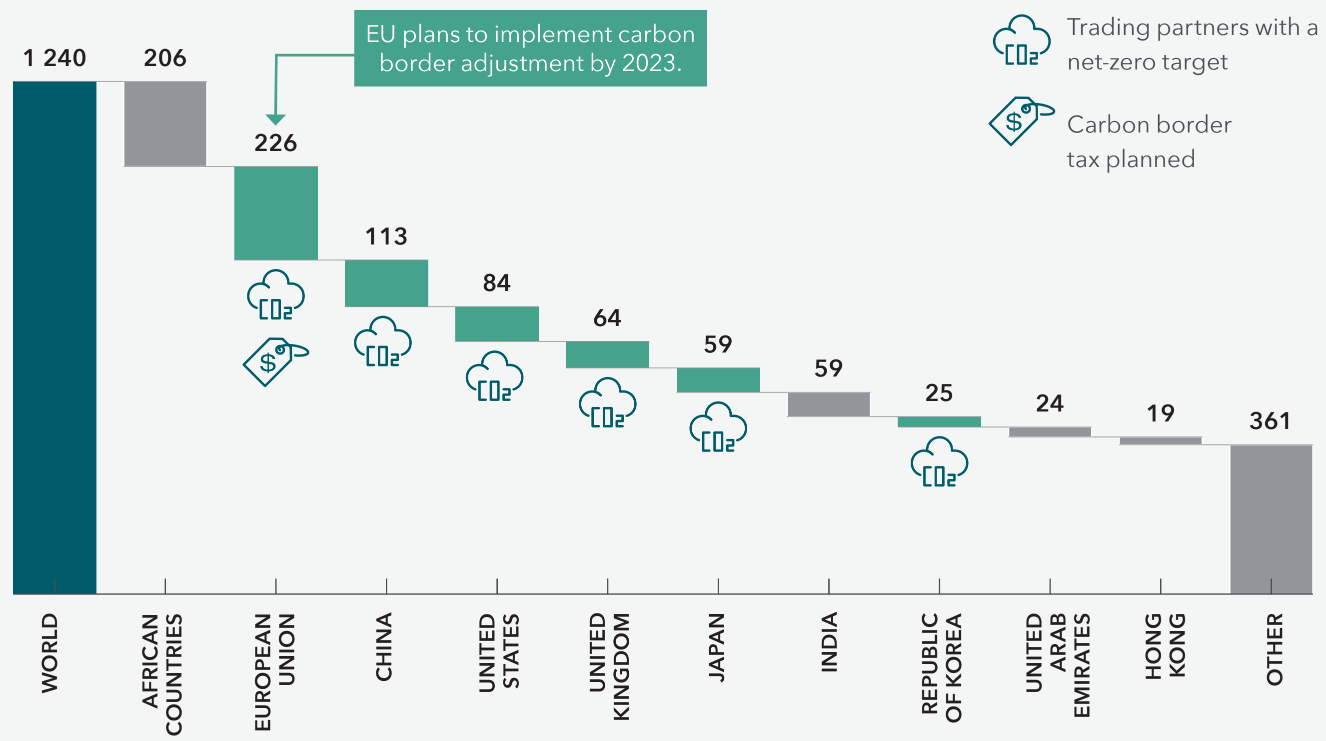
South Africa is also facing a significant trade risk. South Africa ranks in the top 20 most carbon intensive global economies on an emissions per Gross Domestic Product (GDP) basis, and in the top five amongst countries with GDP in excess of USD 100 billion per annum. The South African economy will face mounting trade pressure, as trade partners implement their low-carbon commitments.

South Africa has predominantly coal-based power generation, the coal-to-liquid process in the liquid fuels sector, and a coal-reliant industrial sector. In the mining sector, three of the four most significant minerals in South Africa's commodity footprint are at risk given the global efforts to curb emissions: thermal coal, Platinum Group Metals (PGMs) with mainly palladium, and iron ore. The fourth mineral is gold.

The bulk of South Africa's exports comprise carbon intensive commodities from the mining, manufacturing, and agricultural sectors which will become less competitive in markets in a future decarbonised world. These sectors also provide the majority of employment of unskilled labour at a regional level.

The carbon intensity of the South African economy, key sectors, and export commodities must be seen against the backdrop of the country's key trading partners committing to ambitious decarbonisation goals. By early 2021, countries representing more than 65% of global carbon dioxide emissions and more than 70% of the world's economy have made ambitious commitments to carbon neutrality. Seven of South Africa's key export markets have all set net-zero targets, including the European Union (EU),

**Figure 1: Volumes of South Africa's exports to leading partners in 2018 (ZAR billion)**




Source: World Integrated Trade Solution. 2018. 'Press research'.

5 Department of Environmental Affairs, Republic of South Africa. 2016. 'South Africa's 2nd Annual Climate Change Report'.


China, the United States, the United Kingdom, Japan, and South Korea.[6]

At the UN Climate Change Conference of the Parties (COP26) in November 2021, all countries are expected to set out more ambitious goals, including setting concrete mid-term reduction targets. The COP26 Presidency's stated priorities include 'seizing the massive opportunities of cheaper renewables and storage', 'accelerating the move to zero-carbon road transport', and 'the need to unleash the finance which will make all of this possible and power the shift to a zero-carbon economy'.

Over and above this, select geographies like the EU are also considering carbon border taxes which could impact future trade. It is therefore essential to consider how South Africa's competitiveness in global markets, and therefore the viability of its industries, will be affected should key trading partners start taking steps to protect their net-zero commitments and enable their net-zero carbon growth trajectories. South Africa will need to address the risks and seize the opportunities presented by climate change.

South Africa will also have the chance to tap into new opportunities. Goldman Sachs estimate that around 35% of the decarbonisation of global anthropogenic greenhouse gas emissions is reliant on access to clean power generation, and that lower-carbon hydrogen and clean fuels will be required for hard-to-decarbonise sectors.[7] South Africa has key strategic advantages which can be leveraged to tap into such emerging opportunities.

South Africa has a number of significant assets including plenty of sun and wind. Renewables-dominated energy systems and local manufacturing are key. South Africa's coal assets are aged, and decommissioning coal plants can be done within the carbon budget and with minimal stranded asset risk. South Africa's motor vehicle manufacturing expertise could be transitioned to electric vehicle production. The country's stable and well-regulated financial services sector, among the most competitive in the world, would make a strong base for green finance for the continent. The combination of wind and solar enables the right kind of conditions for green hydrogen, setting the stage for South Africa to be a net exporter. The role of PGMs in hydrogen and fuel cell technology and the increased demand for certain mined commodities, like copper for use in green technology, could bolster the minerals sector. South Africa's experience with the Fischer–Tropsch process positions it to be one of the world leaders in carbon-neutral fuels. And other innovations are thus waiting to be unlocked.

**The imperative is clear: South Africa must decarbonise its economy in the next three decades and transform it into a low-carbon, climate-resilient, and innovative economy. This transition also needs to take place in a manner that is just and simultaneously addresses inequality, poverty and unemployment to ensure that no-one is left behind and that our future economy is also socially resilient and inclusive.**

6 United Nations News. 2020. 'The race to zero emissions, and why the world depends on it'.

7 Goldman Sachs. 2020. 'Carbonomics: Innovation, Deflation and Affordable De-carbonisation'.

### 2.2.2 THE NEED FOR A JUST TRANSITION

With a Gini coefficient of 0.63, South Africa is one of the most unequal societies in the world today.[8] A recent study shows that the top 10% of South Africa's population owns 86% of aggregate wealth and the top 0.1% close to one-third. Since the onset of the COVID-19 pandemic, levels of poverty have further increased and have likely shifted beyond 55% of the population living in poverty. In July 2020, a record 30.8% of the population was unemployed.[9] Exacerbating this are levels of youth unemployment that are amongst the highest in the world.[10]

As South Africa grapples with the economic recession accompanying the pandemic, and copes with the need to rebuild the capacity of the State and its institutions following a decade of state capture, it must start rebuilding and transforming its economy to make it resilient and relevant in a decarbonised world. However, while a transition towards a net-zero economy will create new economic opportunities for South Africa, it is also a transition away from coal, which without careful planning and new investments, will put many jobs and value chains at risk in the short-term, and exacerbate current socio-economic challenges.

Today, the coal mining sector provides almost 0.4 million jobs in the broader economy, with ~80k direct jobs and ~200 to 300k indirect and induced jobs in the broader coal value chain and economy. The impact is even broader when it is taken into account that, on average, each mine worker supports five to ten dependents. This implies a total of ~2 to 4 million livelihoods.[11] The low-carbon transition must do more than simply address what is directly at risk from decarbonisation. The transition must also address the broader economic concern of stalled GDP growth of ~1% for the last five years, rising unemployment with ~3% increase over the last five years,[12] deteriorating debt to GDP ratio, with growth of ~6% for the last ten years, and the consistently negative balance of trade.[13]

These challenges are more severe given further deterioration during the COVID-19 pandemic. It is therefore critical that South Africa's transition is designed and pursued in a way that is just; meaning that it reduces inequality, maintains and strengthens social cohesion, eradicates poverty, ensures participation in a new economy for all, and creates a socio-economic and environmental context which builds resilience against the physical impacts of climate change.

This transition requires action, coordination, and collaboration at all levels. Within sectors, action will need to be taken on closures or the repurposing of single assets. Job losses must also be addressed with initiatives like early retirement and re-skilling programmes, with the latter having the potential for integration with topics like skills inventories and shared infrastructure planning and development. A national, coordinated effort to enble the Just Transition will also be crucial to address the education system and conduct national workforce planning. In order to implement its Just Transition, South Africa will need to leverage global support in the form of preferential green funding, capacity-building, technology-sharing, skills development, and trade cooperation.

**To move towards this net-zero vision for the economy by 2050, South Africa must mitigate rather than exacerbate existing socio-economic challenges and seize emerging economic opportunities to support its socio-economic development agenda. How to ensure a Just Transition towards net-zero and advancing South Africa's socio-economic context is therefore the key guiding principle of this study.**

## 2.3 OBJECTIVE AND APPROACH

**Key objectives of this study.** Achieving net-zero emissions in South Africa by 2050, whilst ensuring a Just Transition, is a complex and unique challenge. Extensive studies examining how a Just Transition towards a lower-carbon economy can be achieved in South Africa have already been conducted or are currently underway. There are many different views on what defines a Just Transition in South Africa, which decarbonisation ambitions South Africa is able to pursue and commit to, and how a transition towards a lower-carbon economy can be achieved.

8 The World Bank. 2021. 'South Africa Overview'.

9 StatsSA. 2017. 'Poverty Trends in South Africa. An examination of absolute poverty between 2006 and 2015'.

10 Chatterjee, A., et al. 2020. 'Estimating the Distribution of Household Wealth in South Africa'.

11 Minerals Council of South Africa. 2020. 'Facts and Figures'.

12 Department of Statistics, Republic of South Africa. 2021.

13 South African Reserve Bank. 2021.

This study is not advocating for a particular position. It is not setting ambitions around levels and timelines for South Africa's emission reduction. Nor is this study prescribing sector- or company-specific emission reduction targets.

The study does aim to develop the necessary technical and socio-economic pathways research and analysis to support decision-making and bolster a coordinated and coherent effort among national and international stakeholders. This research is anchored around three key questions:

- What is the cost of inaction for South Africa, should it fail to respond to critical global economic drivers stemming from global climate action?
- What would it take, from a technical perspective, to transition each of South Africa's economic sectors to net-zero emissions by 2050?
- What are the social and economic implications for South Africa in reaching net-zero emissions by 2050?

**Approach of this study.** To understand how a transition of the South African economy towards net-zero emissions can be achieved, this study assesses each sector and intersectoral interdependencies in detail (with this report detailing the initial findings of the electricity sector analysis). Our analysis of the South African economy is structured along understanding what the decarbonisation pathways could be for key heavy emitting sectors, namely: electricity, petrochemicals and chemicals, mining, metals and minerals, manufacturing, transport and AFOLU (Agriculture, Forestry and Other Land Use) (Figure 2). Given this is a multi-year project, a preliminary report will be released as each sector is completed. Towards the end of the study, each sector analysis will be further refined on the basis of understanding interlinkages better. For example, insights gained from the transport sector analysis around the impact of electric vehicles on electricity demand will be leveraged for further refinement of the electricity sector analysis.

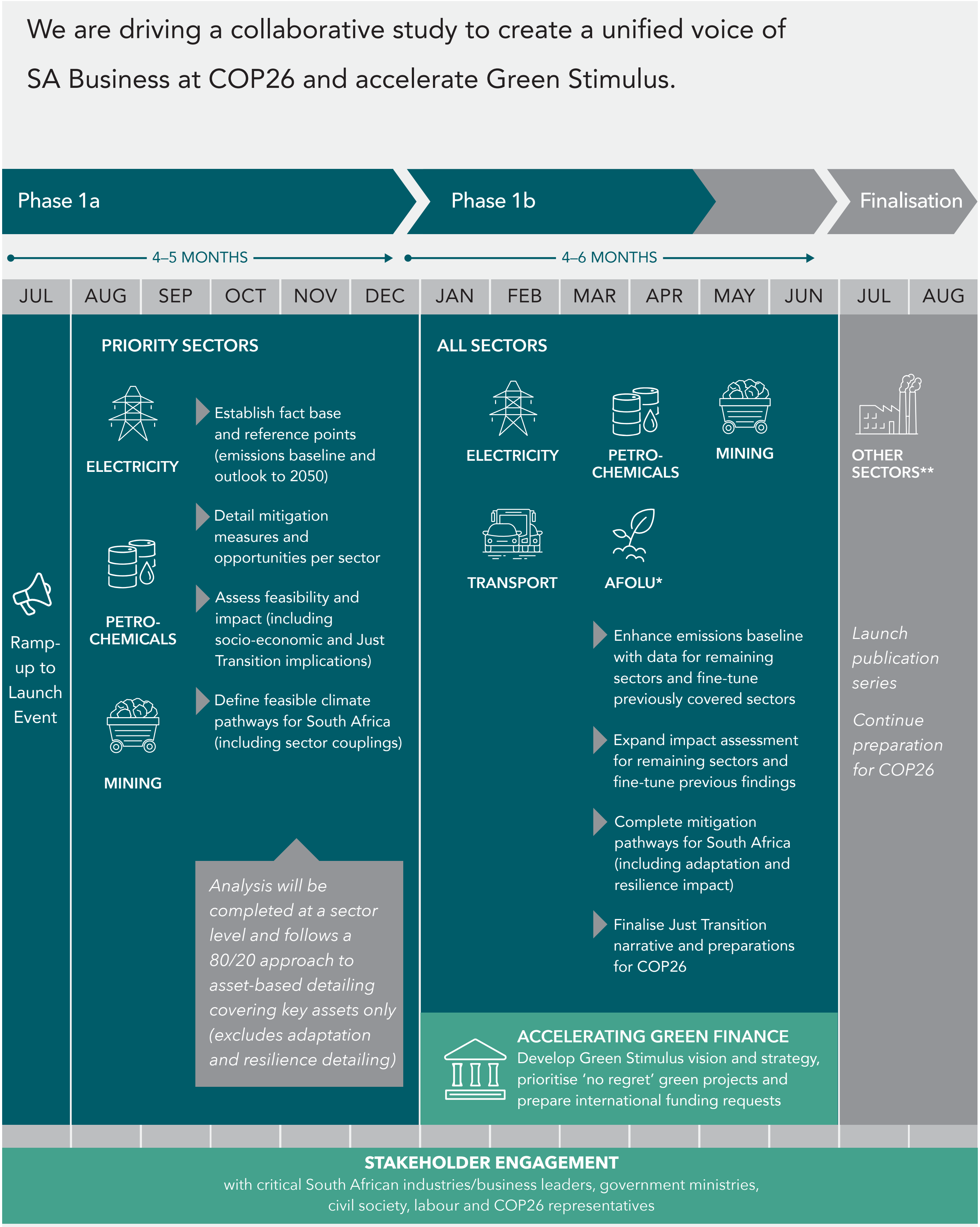
The first phase of the study focuses on today's key drivers of South Africa's emissions: electricity and the petrochemicals and chemicals sectors which make up more than 60% of the country's total emissions. Given the socio-economic implications of decarbonising South Africa's energy landscape, particularly impacting coal mining regions and the mining workforce, the mining sector was assessed as part of the project's first phase. The second phase of the study focuses on the transport and AFOLU sectors. Eventually, the study will provide a comprehensive view of the South African economy, its potential future net-zero economy and the pathways that can lead to this future economy as informed by various key stakeholders (see Figure 2).

The study is a collaborative effort, aiming to create a 'unified voice of South African business' on the country's needs, opportunities, and challenges in achieving a net-zero economy, involving multiple stakeholders from all sectors. The governance arrangement that has overseen this work is key to enabling this collaborative, multi-stakeholder approach: across multiple levels, key stakeholders are involved in the content development.

The sector assessments are conducted within technical committees which include South African and international experts and stakeholders from private and public sectors, as well as civil society and academia. An advisory board consisting of high-profile representatives from various sectors including industry, government, labour, civil society, and academia; and a steering committee consisting of selected private and public sector representatives provided continuous direction on content development. In addition, a group of 27 Chief Executive Officers (CEOs) from across the private sector endorsed and guided the study development (see Figure 3).

This report is the first in a series being released to illustrate the findings of this study. These reports are intended as consultation material to leverage further engagement with sector experts and key stakeholders, beyond the extensive stakeholder engagement that was already undertaken from August 2020 to June 2021 within the respective technical working groups of this project. We hope this will foster continued dialogue during the project as we work towards a final report that will collate the individual sector findings and provide collective insight. The first report is focused on the decarbonisation of the electricity sector in South Africa.

**Figure 2: Approach of this study**




* AFOLU: Agriculture, Forestry, and Other Land Use

**Other sectors include Minerals and Metals as well as Manufacturing and Construction

Source: NBI-BCG project team.

Figure 3: Governance set-up of the study

To ensure representative, balanced and fact-based content, a comprehensive governance structure is in place.

| CEO champions | Advisory boards | Steering committee |
|---|---|---|
| CEOs | Industry, government and civil society representatives | Company representatives |

**Core project team**

NBI, BCG, IDDRI

**Technical committees and expert meetings**

| | | |
|---|---|---|
| Energy sector | Chemicals and Petrochemicals sector | Mining sector |
| Transport sector | AFOLU sector | Other sectors |

**Socio-economic modelling for a Just Transition**

**Four key objectives of governance structure**

- Enable multi-stakeholder inputs through an inclusive consultation process
- Create a platform for collaboration and alignment on key assumptions and methodology
- Ensure that the final output is fact-based and balanced in its recommendations
- Provide a fact-based business perspective into national consultations and planning processes hosted by government


Photo: Shutterstock.com

# 3. DECARBONISING POWER IN SOUTH AFRICA

## Key findings of the sector analysis

The future of the power sector in South Africa in 10 key findings

1. *By leveraging its world class renewable energy sources, South Africa can fully decarbonise its power sector, while unlocking the opportunity to stimulate economic growth and job creation.*

2. *South Africa's complementary wind and solar resources are among the best renewable energy resources in the world, available on vast amounts of unused land.*

3. *By 2050, a renewables-dominated power system is the most cost-competitive system for South Africa.*

4. *Transitioning South Africa's power system to net-zero would require the deployment of ~150GW wind and solar capacity by 2050 – this is almost four times the total capacity of South Africa's coal power plants today – and an investment of ~ZAR3 trillion within the next 30 years, requiring significant expansion and upgrade to the transmission and distribution infrastructure.*

5. *To reach net-zero by 2050, South Africa would need to speed up deployment of renewable energy capacity; at least 4GW of renewables will need to be installed every year – roughly ten times the current pace of new-build.*

6. *Natural gas as a transition fuel will be critical in this journey – initially growing as an enabler to the integration of wind and solar into the power system at scale, gas will then be gradually replaced by other technologies to reach net-zero emissions.*

7. *The transformation of South Africa's power system can result in net-positive job creation, if South Africa can successfully localise elements of the renewable energy value chain and effectively re-skill the workforce.*

8. *South Africa's world class renewable energy resources also allows a highly competitive production cost of $H_2$ below 1.60 \$/kg by 2030, putting South Africa as potentially one of the largest global exporters of green $H_2$ and green fuels.*

9. *To help fund this journey and ensure competitive cost of capital, access to international green finance will be required to succeed.*

10. *To enable this pathway, cross-sector collaboration and a conducive policy environment will be critical.*

## 3.1 SCOPE AND APPROACH OF THE POWER SECTOR ANALYSIS

The aim of the power sector modelling is to identify potential pathways that could lead to a just, net-zero transition of South Africa's power sector by 2050. The modelling provides a comprehensive fact-base of what it would take to decarbonise the sector while improving overall energy security for the country. As such, this fact-base attempts to quantify the techno-economic and socio-economic trade-offs between the different electricity supply system options, each based on a 'dominant' technology set. These findings are intended to serve as inputs for aligning broad, diverse stakeholder views and for strategic decision-making in the power sector.

The power sector modelling is **not intended** to:

1. Quantify the exact power sector price path or make a recommendation on what is required to achieve a cost reflective tariff (the absolute price that various end consumers will pay for electricity over time, see side bar 'Real relative costs versus cost reflective tariffs')
2. Detail the exact power supply mix per year and replace national power system planning
3. Provide detailed, system-level solutions for complex technical challenges like grid stability or system inertia.

The power sector modelling **is intended** to:

1. Quantify the 'book-end scenarios' of real relative costs between different strategic choices around supply technologies for South Africa's power system
2. Provide sufficient resolution to quantify key metrics that will influence strategic decision-making, for example:
   - Supply capacity and generation
   - Cumulative emissions
   - Real relative costs between different supply system options.

### Real relative costs versus cost reflective tariffs

The need for cost reflective tariffs is a critical enabler to the implementation of the proposed pathways. However, conclusions on cost reflective prices cannot be drawn from this study. This study models the real, relative costs which include:

- Incremental Capital Expenditure (CAPEX), Operating Expenses (OPEX), and fuel cost for the supply mix (gigawatt [GW] and terawatt-hours [TWh])
- Grid upgrade costs for increased Renewable Energy (RE) generation (ZAR 3 billion/GW of wind or solar energy)
- Transmission and distribution costs (20c/kWh)
- Other costs: carbon sequestration costs for Direct Air Carbon Capture and Storage (DACCS) (ZAR 270/tonne for sequestration, over and above operational costs of ~ZAR 2000–3000/tonne), demand-side response costs (ZAR 3000/kilowatt [kW]).

These real costs exclude:

- Inflation (all costs are real)
- Cost premium of committed Independent Power Producers (IPPs) for the next 10–15 years (e.g., early Renewable Energy Independent Power Producer Procurement Programme [REIPPPP] rounds)
- Cost of servicing historical Eskom debt
- Last-mile distribution costs (1–2c/kWh)
- Cost of other grid investments like smart grid upgrades.

**Figure 4: Six-step approach to power sector analysis**

## Analytical approach to power sector modelling.

**1 Assess the starting point**

**Assess the current power sector context globally and locally**

Assess the challenges and opportunities from a socio-economic and environmental perspective

**2 Identify the supply gap**

**Quantify the 2050 supply-demand gap for South Africa**

Identify the supply-demand gap driven by:

- Growth in electricity demand
- Coal plant decommissioning

**3 Identify optimal 2050 system archetype**

**Identify the cost optimal net-zero power system for the country in 2050**

Quantify the cost and emissions of three baseline tech dominant system archetypes:

- RE dominant
- Coal and CCUS dominant
- Conventional nuclear dominant

Assess broader trade-offs qualitatively (e.g. environmental and socio-economic impacts)

**4 Assess last-mile decarbonisation options**

**Assess cost-optimal tech options for last-mile decarbonisation**

Identify various last-mile decarbonisation options available to reduce residual emissions in the RE dominant system to zero/net-zero

**5 Define net-zero pathways**

**Develop potential net-zero pathways for the power sector**

Map two book-end pathways to reach the optimal net-zero 2050 supply mix

- *Low emissions path*: accelerated decommissioning of coal with all coal off by ~2042
- *IRP aligned path*: coal ramp-down in line with the IRP with the cost of higher emissions

**6 Identify key trade-offs and enablers**

**Identify key trade-offs of the net-zero pathways**

Identify and compare trade-offs along two dimensions:

- *Techno-economic*: cost, emissions, new-build CAPEX and abatement cost
- *Socio-economic*: jobs, GDP

Identify critical enablers and no-regret desicions to transition the power sector

In addition, the CAPEX profiles arising from the techno-economic modelling conducted in this phase of the project will also serve as the basis for a more detailed socio-economic impact assessment that will quantify key socio-economic trade-offs in selecting an optimal pathway. This modelling will include jobs created (indirect, direct, and induced), GDP impact, affordability of required CAPEX profiles and resilience of the South African economy to specific price shocks arising from the techno-economic modelling of various pathways. Although some preliminary job numbers are referenced in this report, these numbers will be updated once more granular socio-economic modelling has been completed leveraging Social Accounting Matrices (SAMs) that have been developed for this project to test the impact of pathways for different economic structures of the economy.

The power sector modelling is conducted along six steps (Figure 4).

1. **Assessing the starting point**: Assessment of the current power sector context, including challenges and opportunities from a socio-economic, technical, and environmental perspective.
2. **Identifying the supply gap**: As a starting point for the assessment of the least-cost electricity system supply option, the 2050 supply-demand gap was first quantified. This supply-demand gap was calculated using the Integrated Resource Plan (IRP) low-demand profile[14] as a basis for how electricity demand will evolve from 2020 to 2050 and mapping this against available supply. Available supply was quantified by decommissioning existing infrastructure in line with the decommissioning dates outlined in the 2019 IRP.[15] To account for the potential impact of demand-side management on supply requirements, a demand-side response of 2.5 GW is assumed (ramping-up linearly from 0.3 GW in 2026 to 2.5 GW from 2035–2050). In subsequent phases, this demand assumption will be updated to reflect key sector insights and findings

14 See section 3.3.2 for additional information on this projection.

15 Coal plants decommissioned according to IRP schedule (Figure 7 and 26 in IRP report).

(e.g., electrification in the transport sector) and also the implications of sector coupling and more granular demand-side management.

3. **Identifying the optimal 2050 system archetype to meet future demand**: Identification of the cost-optimal net-zero power system for 2050 is based on three baseline technology-dominant system archetypes: (i) Renewables dominant; (ii) Coal and Carbon Capture, Utilisation and Storage (CCUS) dominant; (iii) Conventional nuclear dominant. Each of these archetypes comprise a range of supply technologies but are characterised by the supply technology that accounts for the majority of power generation in the system making it the 'dominant' technology. The archetypes do not reflect where the supply is generated (i.e., grid versus embedded or distributed generation), but rather cost-optimally ensures supply meets demand. To assess the cost-optimal 2050 net-zero power system, the real relative cost of the systems is compared rather than narrowly comparing the technology costs of each generation technology in isolation.
4. **Assessing last-mile decarbonisation options**: Identification of technological options that enable last-mile decarbonisation towards a (net) zero emissions power system. These are technologies that take the power sector from the emissions reductions achieved with known technologies implementable today to (net) zero emissions.
5. **Defining net-zero pathways**: Development of potential pathways that enable the transformation of today's power sector into the identified, optimal 2050 (net) zero emissions power system archetype (including last-mile decarbonisation options).
6. **Identification of key trade-offs**: Identification of potential trade-offs that will need to be considered and further assessed to identify the optimal pathway for the country.

## 3.2 KEY FINDINGS OF THE POWER SECTOR ANALYSIS

***By leveraging its world class renewable energy sources, South Africa can fully decarbonise its power sector, while unlocking the opportunity to stimulate economic growth and job creation.***

### 3.2.1 SECTOR CONTEXT: SOUTH AFRICA'S ELECTRICITY SECTOR AND THE NEED FOR A JUST TRANSITION

South Africa's power sector is facing challenges along multiple dimensions. Due to its reliance on a largely aged coal fleet, the sector is unreliable, expensive, accounts for a significant share of the country's emissions, and negatively impacts the environment – particularly water availability, air quality, and consequently, health. The current single buyer market structure is not conducive to appropriate risk allocation. Non-discriminatory access and trading rules, subject to technical constraints, could enable the market to develop in line with the net-zero pathways.

South Africa's power sector is heavily reliant on abundant local coal resources. Today, more than 80% of electricity is generated via coal powered plants, which make up a total generation capacity of ~38 GW. The existing coal fleet is aged, and based on the 50-year decommissioning schedule in the IRP, ~10% of coal power generation capacity will reach end-of-life by 2030, and >60% by 2045. The degradation of this coal fleet, coupled with the delayed commissioning and underperformance of Medupi and Kusile, has been a significant contributor to load shedding in recent years.[16] Energy shed has increased from ~190 GWh in 2018 to ~1350 GWh in 2019 and ~1800 GWh in 2020 (approximately 10% of annual hours). Given the downward trend in the Energy Availability Factor (EAF) from ~72% in 2018 to 65% in 2020, the low reliability of power supply and the need for load shedding is likely to persist.

Despite South Africa's abundant and complementary wind and solar energy resources, less than 6% of electricity is generated via renewables today. Around ~1% of power supply is generated via diesel generators for provision of peaking capacity and power supply in times of supply shortages.[17] As a result of the significant reliance on coal for power generation, South Africa's electricity system has a grid emission factor of ~1.0 $tCO_2e$/MWh – among the most carbon intense in the world. This makes the power sector a key contributor to the country's overall emissions: it accounts for ~40% (~225Mt $CO_2e$) of the overall national emissions baseline (Figure 5, 2017 data).

***South Africa's complementary wind and solar resources are among the best renewable energy resources in the world, available on vast amounts of unused land.***

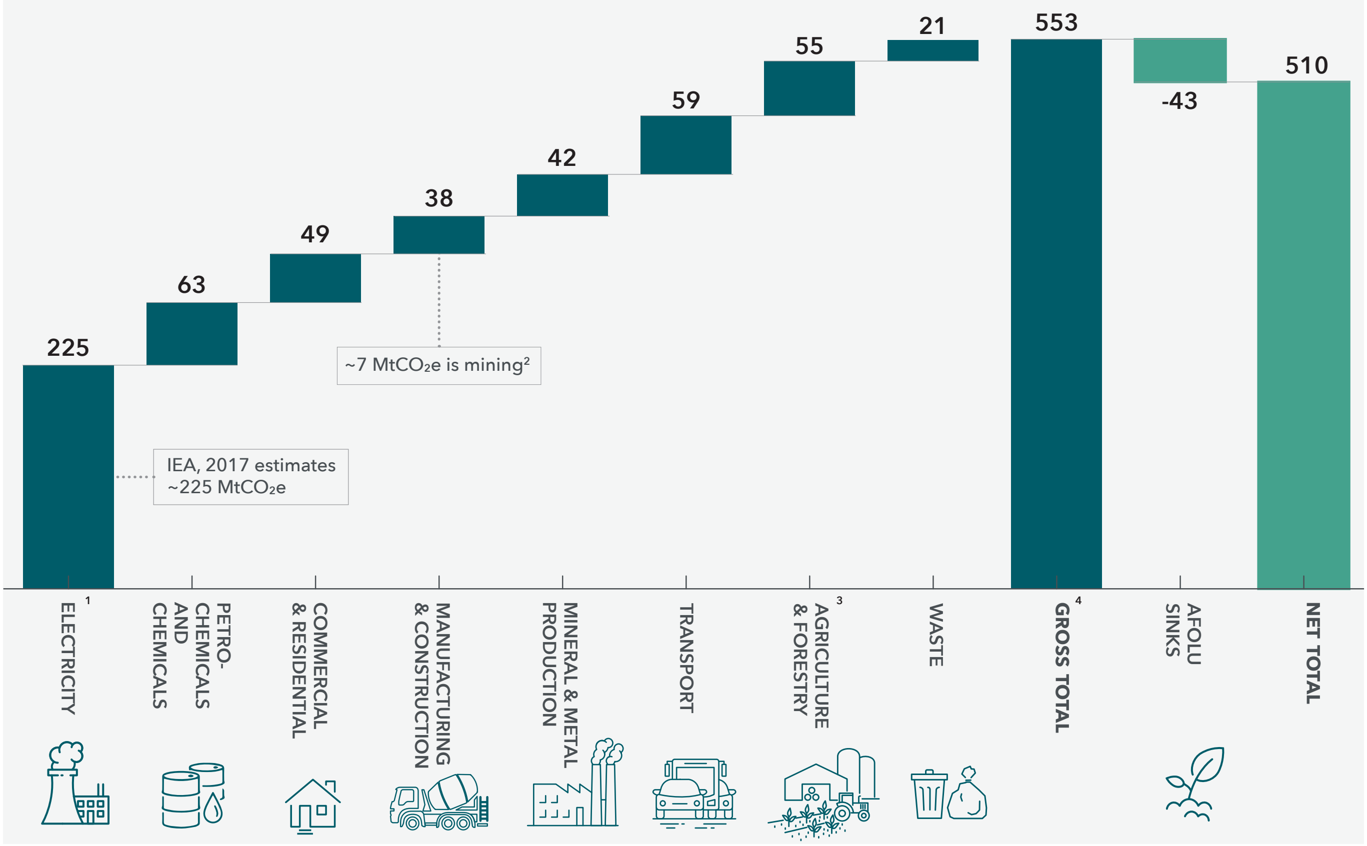
16 Wright, JG., & Calitz, JR. 2020. 'Systems analysis to support increasingly ambitious $CO_2$ emissions scenarios in the South African electricity system'. CSIR ResearchSpace.

17 Wright, JG., & Calitz, JR. 2021. 'Statistics of utility-scale power generation in South Africa in 2020'. CSIR ResearchSpace.

**Figure 5: South Africa's emission baseline**

Sectors in scope for the first phase of this project account for ~55% of national emissions and are key to ensuring a Just Transition.

OVERVIEW OF EMISSIONS IN SOUTH AFRICA ($MtCO_2e$)




1. Emission figures based on view of electricity and heat production of which electricity production contributes >97% of emissions.

2. GHGI does not explicitly state estimate for mining emissions so this has been estimated. Assumed Scope 1 emissions share of top 12 companies is same as their market share (80%) and use this to gross up to 100%.

3. Includes fossil fuel combustion for both agriculture and forestry.

4. Gross total excludes categories 1A5 as it is not linked to any sectors and 1B1 to avoid the double counting of fugitive emissions from coal mining which are included in the mining sector emissions approximation.

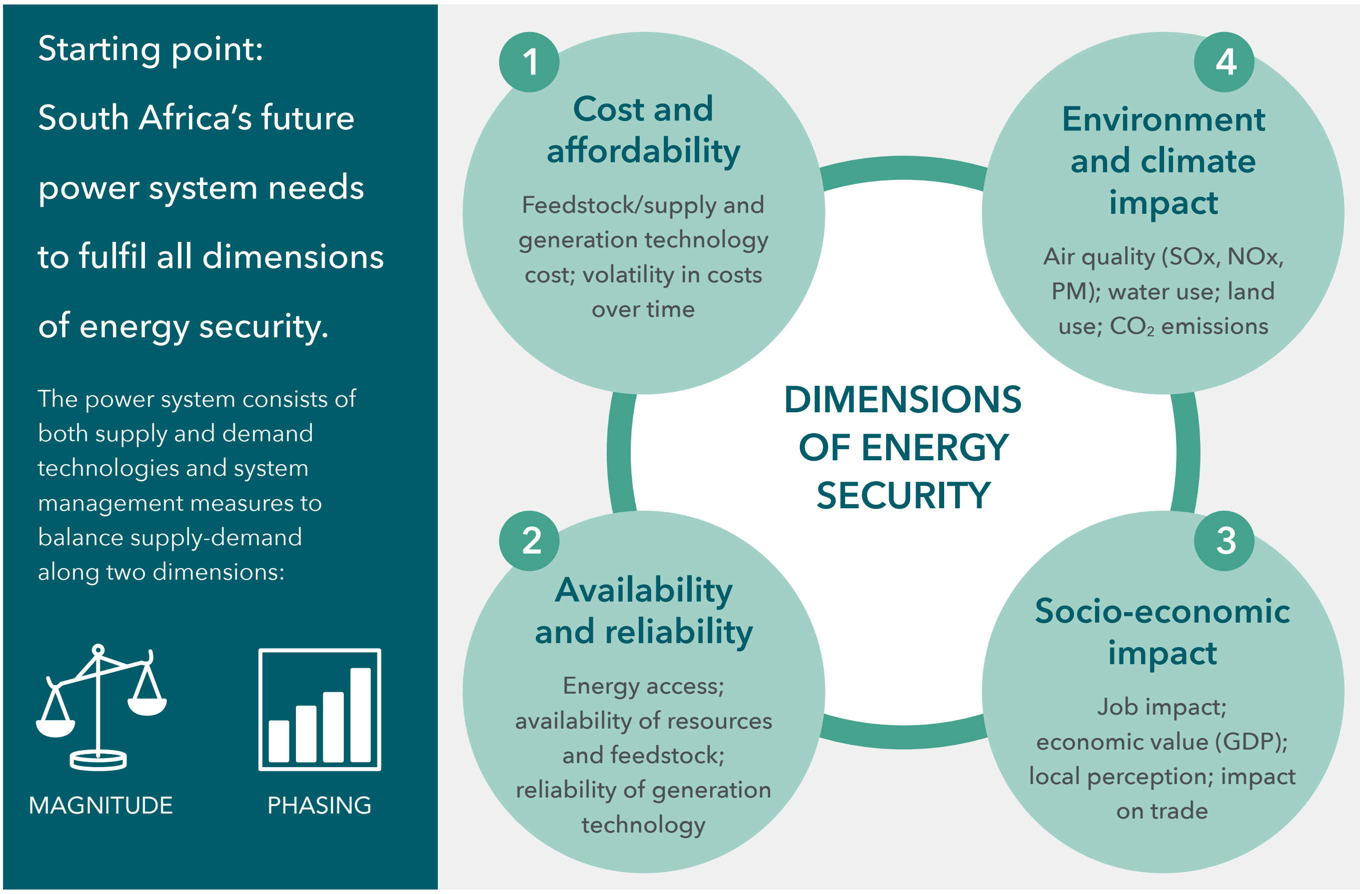
Sources: GHGI. 2017; IEA. 2015; WEO. 2019; CDP. 2015; GHGI. 2015; CAT; NBI-BCG project team.

In addition to its significantly large emissions footprint, the sector also has a significant environmental footprint. South Africa's power sector accounts for 2% to 3% of water consumed – an immense water footprint in a country suffering from increasing water insecurity.[18] In addition, the coal fleet releases high levels of Nitrogen Oxides ($NO_x$), Sulphur Oxides ($SO_x$), and Particulate Matter (PM) – driving air pollution and impacting air quality and community health.[19]

18 Eskom. 2016/17. 'Annual Report'.

19 The technical model quantifies the cost and emissions trade-offs. Broader trade-offs (water use, environmental impact, system inertia) are not quantified. These trade-offs are rather used to pressure-test the least-cost findings by: 1) qualitatively comparing RE to alternatives against these dimensions; 2) where RE scores less favourably, identifying at a high level if the solutions required would materially impact cost.

Figure 6: Energy security needs of South Africa's future power system




Given these broad-ranging challenges, South Africa's future power system requires a fundamental shift forthwith. The system needs to fulfil all dimensions of energy security (Figure 6). The demand and supply side technologies and system management mechanisms need to be anchored on:

- **Low-cost and affordable** feedstocks and generation technology, with cost improvements over time
- **Available and reliable** resources, feedstocks, and generation technology
- **Positive socio-economic impact** though job creation, GDP potential, and trade impacts
- **Positive environmental impact** through a reduction in water use, improved air quality, and climate impact through the reduction in $CO_2e$ emissions.

### 3.2.2 FUTURE DEMAND OUTLOOK

The 2019 Integrated Resource Plan (IRP) low-demand scenario projects a total demand of ~370 TWh in 2050 (see side bar on page 25 for additional details on this projection). Assuming Medupi and Kusile are the only remaining operational coal plants in 2050, with other coal plants decommissioned according to their dead-stop dates, a supply gap of ~310 TWh will exist in 2050. This supply gap is the starting point for assessing the least-cost 2050 power system, as the quantum of combined supply from various generation sources in the system should be sufficient to meet this supply gap.

Based on the 2017 load profile, inputs received from the University of Cape Town's Energy Research Centre were scaled and used to model hourly load demand in 2050 in line with the projected ~370 TWh of demand mentioned above. Supply profiles modelled for the 2050 power system were set up to meet this hourly demand profile with a 10% to 15% reserve margin in 2050, assuming that wind is reliably available 6% and solar 0% to meet firm capacity.

## The IRP

The IRP is an electricity supply development plan based on a least-cost electricity supply and demand balance, taking into account security of supply and environment issues, such as emissions and water usage. A draft IRP was issued in 2018, and then finalised as the promulgated IRP 2019. In reaching the final IRP, several key decisions were made, including:

- Retention of the current annual build limits on renewables (wind and solar PV) pending the finalisation of a Just Transition plan
- Stipulation that all new coal power projects must be based on high efficiency, low emission technologies and other cleaner coal technologies[20]
- Expression of support for gas-to-power, and the replacement of diesel peakers with gas peakers
- Extension of the life of the Koeberg nuclear plant by 20 years, and launch of nuclear build programme, with the aim to deploy an additional 2500 MW of nuclear energy.

Together with the planned decommissioning of the existing coal fleet, all these decisions resulted in a reduction in the grid emission factor from around 1.0 t $CO_2e$/MWh in 2020 to around an estimated 0.4 t $CO_2e$/MWh in 2050. With an anticipated demand of around ~370TWh in 2050, this amounts to estimated emissions in 2050 of 150–160 Mt $CO_2e$.

### 3.2.3 MEETING FUTURE DEMAND: THE LEAST-COST 2050 POWER SYSTEM

***By 2050, a renewables-dominated power system is the most cost-competitive system for South Africa.***

Three energy sources are potentially available at scale to close this supply gap in 2050 and fulfil the energy security needs of the country: (i) renewable energy; (ii) coal with CCUS; (iii) conventional nuclear energy. These energy sources form the basis of the archetypes to assess the least-cost 2050 power system. As mentioned, each of these archetypes comprise a range of supply technologies but are characterised by the supply technology that

**Figure 7: Comparing the real cost of three technology dominant archetypes in 2050**

| Renewables archetype – the least-cost solution with $CO_2$ price of R127/tonne | Renewables dominant electricity system | Coal + CCUS power electricity system | Nuclear energy dominant electricity system |
|---|---|---|---|
| DOMINANT TECHNOLOGY | Wind and Solar 52 GW + 78 GW | Coal-CCUS 35 GW | Nuclear 20 GW |
| REAL COST (CENTS/kWh) | 100 | 129 | 116 |
| $CO_2$ EMISSIONS (Mt) | 70 | 70 | 69 |
| LEAST-COST PEAK-LOAD TECHNOLOGY | Gas turbine + CCGT 29 GW | Gas turbine 21 GW | Gas turbine + CCGT 20 GW |
| ADDITIONAL KEY SYSTEMS FEATURES | Storage 15 GW, Network investments | Carbon transport and storage | N/A |
| HIGH SENSITIVITY OF COST TO ... | Network cost, Peak-load management | Carbon price and CCUS cost | Build delays/CAPEX |

Source: Plexos model, NBI-BCG project team.

20 According to the latest IRP, new coal powered generation of 1500 MW is supposed to be deployed in the period from 2023 to 2027, over and above the ~5700 MW required to complete Medupi and Kusile from 2019 to 2022.

accounts for the majority of power generation in that system making it the 'dominant' technology.

The renewable energy archetype's primary supply technology is a combination of wind and solar. However, it also leverages battery storage for short-term variability management, uses gas for peaking and mid-merit and has Medupi and Kusile still operational in 2050. The cost optimisation of this archetype yields ~130 GW of RE (52 GW wind and 78 GW solar), 29 GW gas (Open Cycle Gas Turbine [OCGT] and Combined Cycle Gas Turbine [CCGT]), and 15 GW of battery storage. This supply mix costs ~100 cents per kilowatt hour (c/kWh) in 2050 in real 2020 terms,[21] and produces ~70 Mt of $CO_2e$ emissions. This RE dominant system is significantly cheaper than the comparable 70 Mt coal and nuclear systems which cost 129 c/kWh and 116 c/kWh respectively.

The coal and CCUS system consists predominantly of coal (~35 GW), with gas for peaking (~21 GW) and limited RE (~32 GW wind and solar combined). The nuclear dominant system consists of 20 GW of nuclear, supported by 10 GW coal, peaking and mid-merit gas (~20 GW) and ~50 GW of wind and solar (Figure 7).

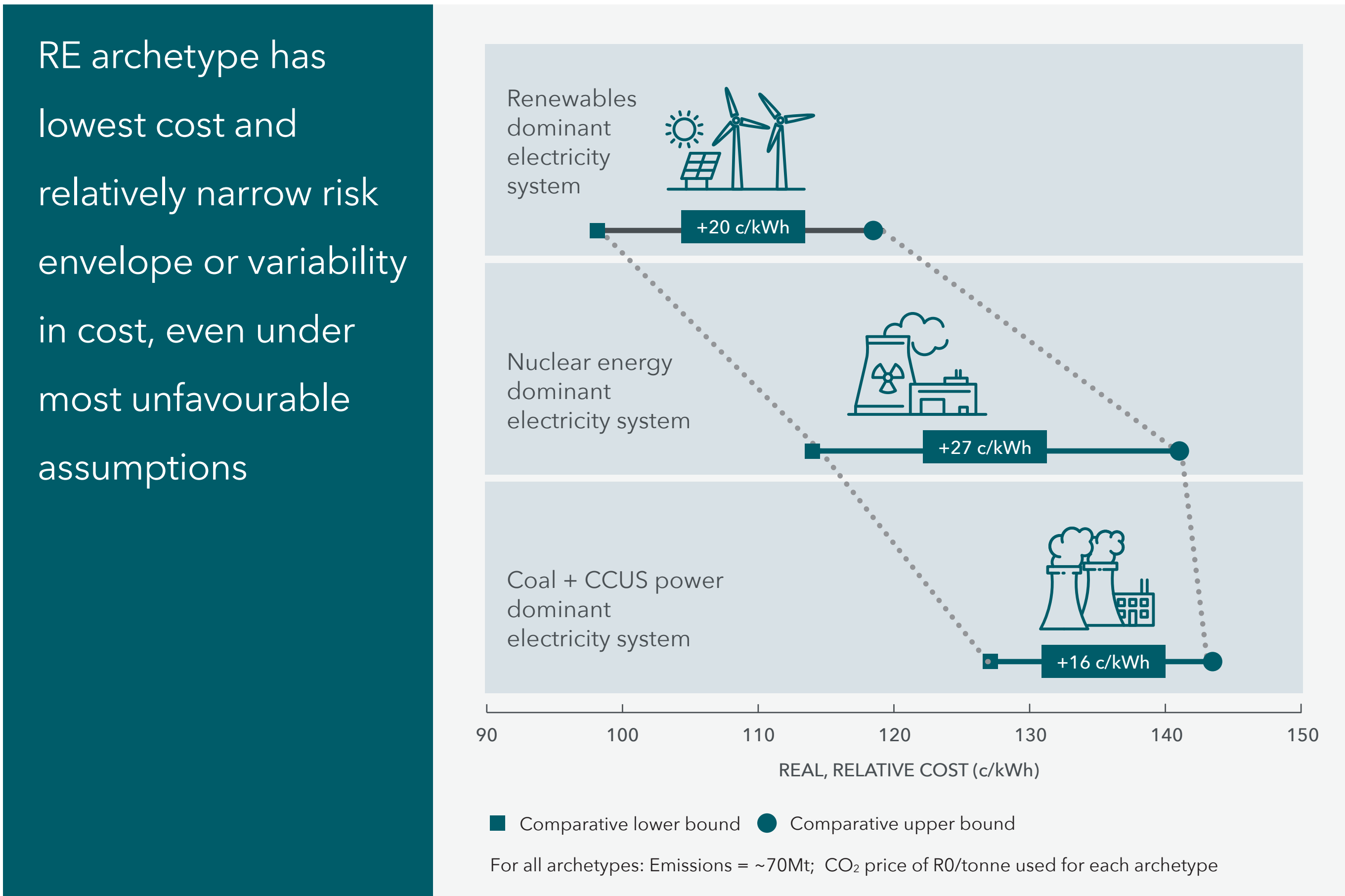
***Transitioning South Africa's power system to net-zero would require the deployment of ~150GW wind and solar capacity by 2050 – this is almost four times the total capacity of South Africa's coal power plants today – and an investment of ~ZAR3 trillion within the next 30 years, requiring significant expansion and upgrade to the transmission and distribution infrastructure.***

These cost findings are pressure tested with a range of sensitivities:

1. $CO_2$ price
2. Sub-optimal RE locations: assuming 5 percentage point lower load factors on renewables if placed in sub-optimal locations
3. Technical solutions and cost to address system inertia
4. Transmission losses: assuming transmission losses double with RE generation further from the load centres
5. Water use
6. CAPEX assumptions and grid upgrade costs.

This sensitivity analysis allows for comparison of lower bound costs, upper bound costs, and the variability in

**Figure 8: Risk envelope of system archetypes**




Source: Plexos model, NBI-BCG project team.

21 With carbon price = ZAR 127/tonne as a starting point.

## The role of gas in the power sector transition and South Africa's decarbonisation journey in general

Decarbonising South Africa's power sector will require a transformation of today's coal power dominated into a renewable energy dominated electricity system. Deployment of solar and wind generation capacity at scale will increase the need for energy storage and peaking capacity as a means to address variability of renewable energy sources. Gas is a proxy for the flexibility requirements of the RE dominant system, in line with the findings on the role of gas in the recent IEA Net Zero report.

Leveraging natural gas as part of the energy mix in gas power plants for peaking will be key to managing seasonal variability and to lowering system cost in early years when battery storage is still expensive. As a result, gas-to-power (GTP) plants are expected to become a key demand anchor for natural gas in South Africa, with ~218PJ/a by 2030, for peaking and mid-merit load. GTP natural gas demand is quite resilient to gas price and remains constant for price ranges of $7-9/GJ. Even at $9/GJ, this is the most cost-competitive technology option for peaking and long-term seasonal variability management. Hence, in the mid-term, natural gas will play a critical role in enabling the decarbonisation of South Africa's electricity sector.

In the long-term, last-mile decarbonisation of power could either be reached by a complete phase out of gas (e.g., via substitution of natural gas with green $H_2$; reduced need for flexibility due to advanced demand-side management) or via equipping GTP peakers with negative emissions technology, such as CCUS and DACCS, if suitable storage sites are identified.

> *Natural gas as a transition fuel will be critical in this journey – initially growing as an enabler to the integration of wind and solar into the power system at scale, gas will then be gradually replaced by other technologies to reach net-zero emissions.*

**However, further questions related to the role of natural gas in South Africa's net-zero pathway still need to be addressed:**

- First, what role does natural gas play in decarbonising the remaining South African economy, particularly the domestic petrochemicals sector which is currently heavily reliant on coal feedstock, and in enabling future economic growth?
- Second, what are likely demand scenarios for natural gas in South Africa, from a sectoral and geographic perspective?
- Third, what are natural gas supply options for South Africa's power sector – and potential other sectors – and what are infrastructure requirements?
- Fourth, if South Africa leverages natural gas for the power sector and potentially also the decarbonisation in other sectors, how can a gas lock-in be avoided and ensured, that gas only serves as a 'transitional fuel'?

Those questions will be addressed in detail in the forthcoming publication, 'The role of gas in South Africa's net-zero pathway'.

costs or the risk envelope. The RE lower bound cost of 98 c/kWh is significantly lower than the coal and nuclear costs of 127 c/kWh and 114 c/kWh respectively. Similarly, the upper bound RE cost of ~118 c/kWh is 23 to 25 c/kWh lower than the coal and nuclear archetypes. The variability in cost of the RE archetype, reflecting a broad range of sensitivities is ~20 c/kWh, marginally higher than the coal envelope of 16 c/kWh, but lower than the nuclear envelope of ~27 c/kWh. Therefore, the RE dominant archetype is the least-cost power system to meet the 2050 supply gap (Figure 8). This finding that coal is not part of the least-cost power system for South Africa, is consistent with the IEA Net Zero pathways which phase out all coal capacity and have no new coal capacity investments.

> *To reach net-zero by 2050, South Africa would need to speed up deployment of renewable energy capacity; at least 4GW of renewables will need to be installed every year – roughly ten times the current pace of new-build.*


Photo: Shutterstock.com

### 3.2.4 LAST-MILE DECARBONISATION: HOW TO ACHIEVE A NET-ZERO EMISSIONS POWER SYSTEM

By deploying renewable energy with a combination of gas and batteries for flexibility the energy system is able to reduce emissions and supply electricity at least-cost. Achieving a net-zero or zero emissions renewable energy dominant power system would require the elimination of or compensation for the ~70 Mt $CO_2e$ residual emissions, predominantly driven by the remaining coal capacity. Four options are considered to remove these emissions:

- Retrofitting coal plants with CCUS
- Replacing coal with baseload gas
- Overbuilding RE and storage
- Replacing coal with flexible nuclear like Small Modular Reactors (SMR).

Of these options, the RE overbuild is the cheapest with a cost of 101 c/kWh, compared to 110 c/kWh for retrofitting the coal, 107 c/kWh for baseload gas, and 109 c/kWh for SMR (Figure 9).

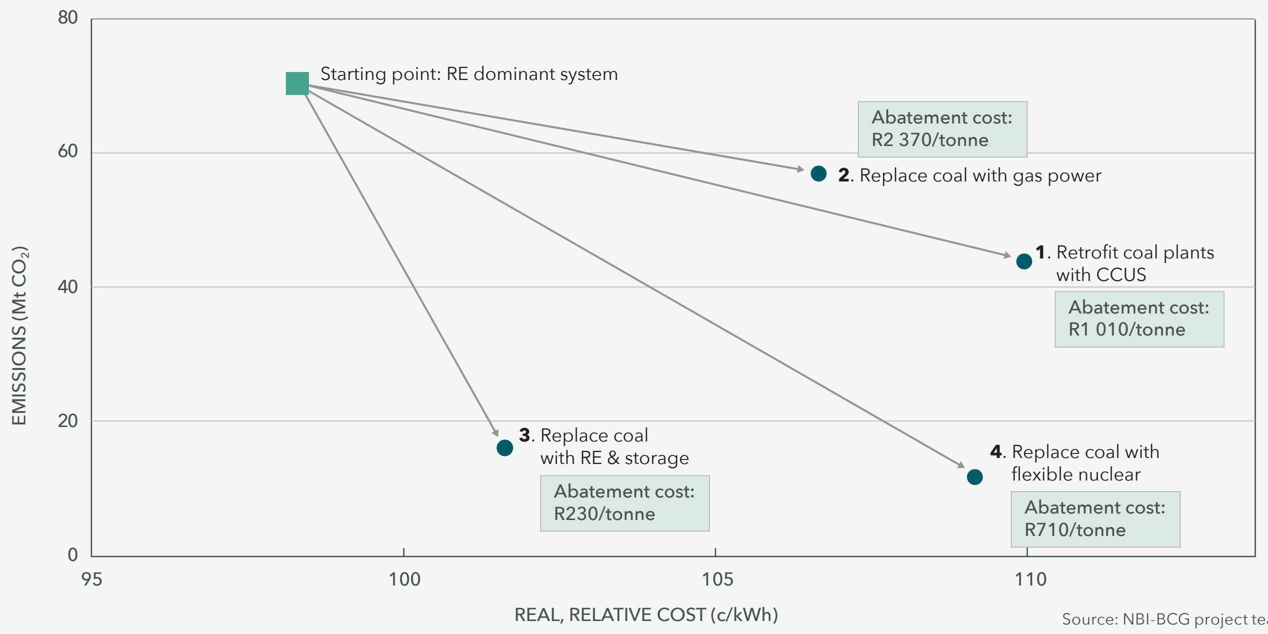
This RE overbuild option is the cheapest option to reduce the system emissions down to ~16 Mt $CO_2e$. Beyond this point, the utilisation of additional battery storage reaches zero as the system needs more mid-term variability management for which the short-term storage is ill-suited. Two decarbonisation options are considered for this last-mile 16 Mt: one option is the compensation of residual emissions from GTP plants via the deployment of DACCS technology. The second option is the deployment of green $H_2$ as a substitute for natural gas in GTP plants.[22]

Last-mile decarbonisation via deployment of DACCS or by switching from gas to green $H_2$ for peaking costs up to 30 c/kWh more and ~ZAR 1640 to 1670/tonne in abatement cost,[23] relative to the 16 Mt $CO_2e$ RE system. Regardless of which technological solution is pursued, improved demand-side management should be considered to reduce the need for peaking capacity in general. Furthermore, SMR could play a role in last-mile decarbonisation and providing grid flexibility if the techno-economic feasibility of the technology significantly improves. Given the technological uncertainty linked to DACCS, green $H_2$, and SMR, a decision on the optimal last-mile decarbonisation strategy will likely only be made a decade prior to deployment, between 2030 and 2040 (Figure 10).

22 CCUS less suited due to a) the ramp-up/ramp-down of the turbines; and b) the low emissions intensity of the turbines. DACCS, like CCUS, requires suitable storage sites, which are yet to be identified or confirmed in South Africa.

23 Gas and DACCS abatement cost: ZAR 1640/tonne, green $H_2$ abatement cost: ZAR 1670/tonne.

**Figure 9: Decarbonisation options for residual emissions**




Source: NBI-BCG project team.

**Gas price of R140/GJ assumed for all cases**

Abatement cost = difference in total cost / difference in total emissions (static 2050 view)

*In the R0/tonne $CO_2$ price case:

For comparability **starting point RE system optimised for ~70 Mt**, not purely cost-optimised.
RE system **emissions can be significantly reduced to ~16 Mt** with **negligible cost (~3 c/kWh)** of abating additional emissions **(R230/tonne)**.

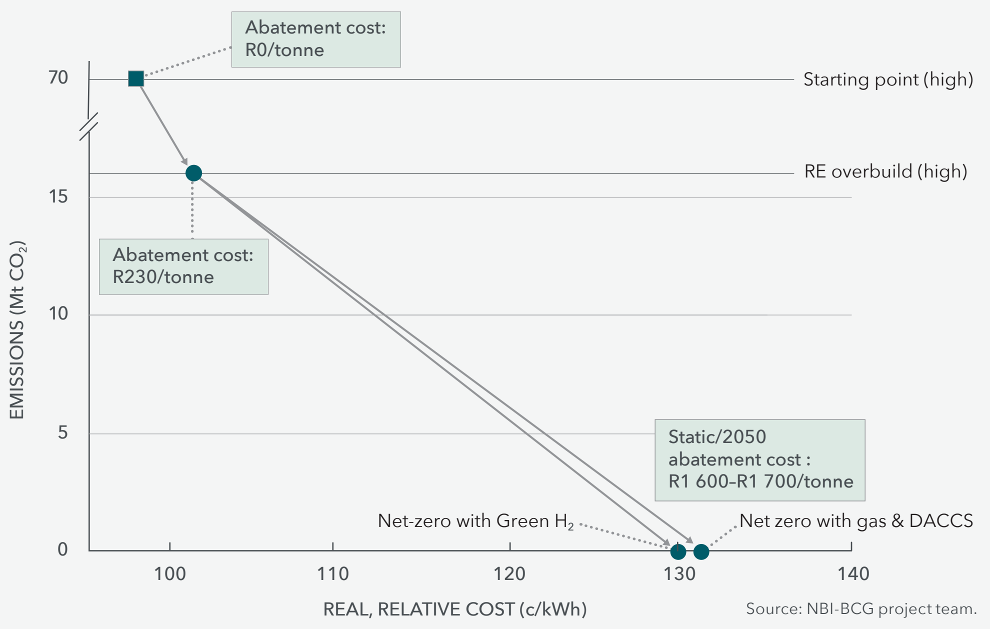
Other options to reduce **70Mt emissions come with much higher costs**:

- Retrofit coal with CCUS: **R1 010/tonne**
- Replace coal with gas: **R2 370/ tonne**
- Replace coal with flexible nuclear: **R710/tonne**

**Figure 10: Last-mile decarbonisation of the RE dominant system**

Getting to net-zero may add up to 30 c/kWh to the real relative cost

(from 16 Mt anchor point)




Source: NBI-BCG project team.

## South Africa's green $H_2$ opportunity – enabling economy wide decarbonisation, in power and beyond

Presently, $H_2$ is used primarily by refineries to produce ammonia and methanol and the $H_2$ is mainly carbon intense: black, or grey. However, lower or zero-carbon $H_2$, particularly green $H_2$, will play an important role in decarbonisation across sectors. In its net-zero study, the International Energy Agency (IEA) expects global $H_2$ use to expand from less than 90 Mt in 2020 to more than 200 Mt in 2030 – whereby the share of low-carbon $H_2$ is projected to rise from 10% to 70% in 2030, half of which is expected to be produced via electrolysis, the other half is expected to be blue $H_2$. By 2050, the IEA projects a potential $H_2$ demand of ~530 Mt of which ~60% is electrolysis-based and ~40% fossil fuel-based in combination with CCUS[24] (Figure 11).

> *South Africa's world class renewable energy resources also allows a highly competitive production cost of $H_2$ below 1.60 \$/kg by 2030, putting South Africa as potentially one of the largest global exporters of green $H_2$ and green fuels.*

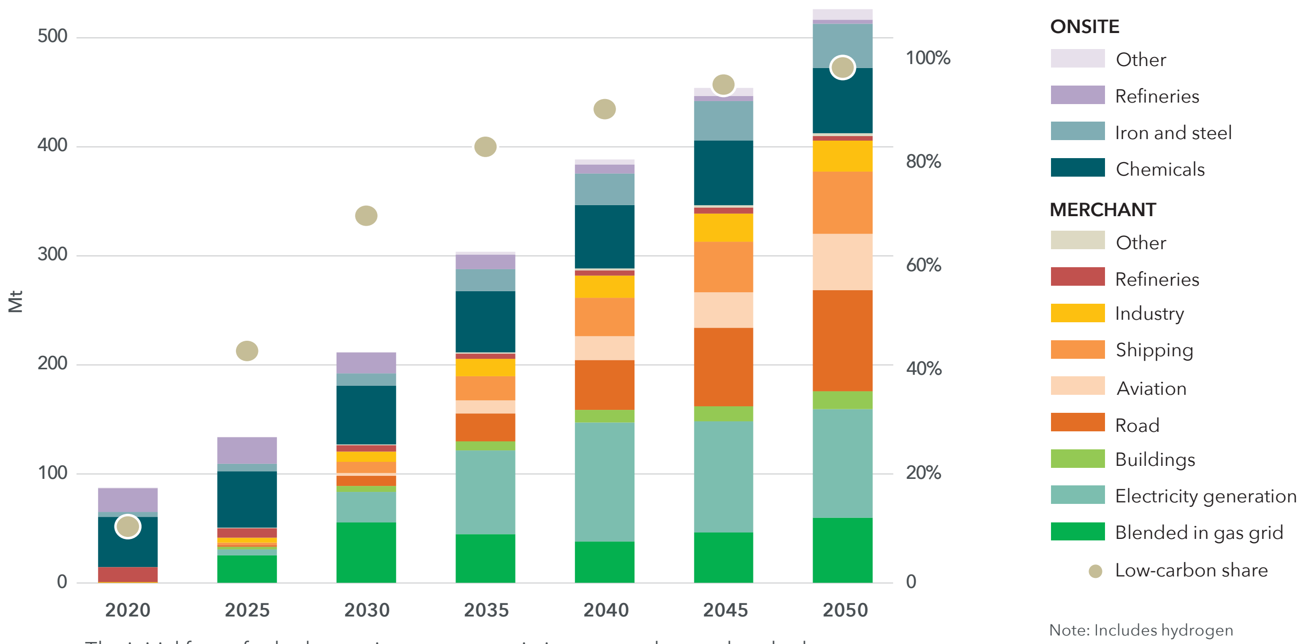
In South Africa's power sector, green $H_2$ could play a role in enabling last-mile decarbonisation of electricity by replacing natural gas in gas plants leveraged for providing peaking capacity, and for energy storage purposes, which could result in ~1,4 Mt green $H_2$ demand by 2050.

## South Africa's competitive advantage in green $H_2$ production

South Africa is well positioned to produce green $H_2$ and green $H_2$ products at scale in the future. This includes Power-to-X products such as green hydrocarbons via conversion of green $H_2$. This competitive advantage in the production of green $H_2$ and related products is anchored in three factors.

Firstly, South Africa is endowed with a unique, high quality renewable energy potential, with complementary wind and solar energy resources across the country. Load factors for wind and solar reach up to 44% and 23% respectively in some parts of the country – among the highest in the world. The dedicated Renewable Energy Development Zones (REDZ) alone can hold ~922 GW capacity.[25] To put this into perspective, the decarbonisation of South Africa's power sector would require the roll-out of ~84 GW and 64 GW solar PV and wind by 2050 respectively.[26]

**Figure 11: Global $H_2$ and $H_2$-based fuel demand in IEA Net-zero Scenario (IEA, 2021)**




The initial focus for hydrogen is to convert existing uses to low-carbon hydrogen: hydrogen and hydrogen-based fuels then expand across all end-uses.

Note: Includes hydrogen and hydrogen contained in ammonia and synthetic fuels.

Source: IEA. 'Net Zero by 2050: A Roadmap for the Global Energy Sector'.

24 IEA. 2021.
25 Assuming 60% (~550 GW) solar PV and 40% (~370 GW) wind, at an average load factor of 22% and 38% for solar PV and wind respectively.
26 BCG-NBI analysis.


## Different production pathways for $H_2$

$H_2$ can be produced and deployed in various ways. Depending on which production pathway is chosen, the carbon intensity of the produced $H_2$ varies greatly. Conventional, carbon intense $H_2$ includes black and grey $H_2$, low-carbon $H_2$ includes blue and turquoise $H_2$, and zero-carbon $H_2$ includes pink and green $H_2$:

- **Carbon intense $H_2$** (black and grey $H_2$): Fossil fuel-based $H_2$, produced through steam reforming of mineral oil (black $H_2$) or natural gas (grey $H_2$), which results in the emissions of $CO_2$. Today, this is the dominant and most cost-effective production method. Therefore, most of $H_2$ used today is carbon intense black or grey $H_2$ – whereby black $H_2$ is more carbon intense than grey $H_2$.
- **Low-carbon $H_2$** (blue and turquoise $H_2$): Blue $H_2$ is produced via steam reforming, in combination with Carbon Capture, Utilisation and Storage (CCUS) technology – which results in the capture of 80% to 90% of the $CO_2$ emissions produced. Since the process related carbon emissions are substantially reduced, but not fully reduced, blue $H_2$ can be considered 'low-carbon' $H_2$. Turquoise $H_2$ is produced as a by-product of methane pyrolysis, which splits methane into solid carbon and $H_2$. The carbon intensity of the produced $H_2$ is potentially still high, given upstream methane emissions. However, the technology is currently still in its early stages and not techno-economically feasible yet.
- **Zero-carbon $H_2$** (green and pink $H_2$): Green $H_2$ is produced via water electrolysis – which splits water into hydrogen and oxygen – via renewable energy. No emissions are produced during the production process. Therefore, green $H_2$ is completely emission free in its production. Pink $H_2$ is also produced via water electrolysis, however, the power is supplied from nuclear energy. This makes pink $H_2$ a zero emission $H_2$, like green $H_2$.

The high renewable energy potential allows for competitive Levelised Cost of $H_2$ (LCOH) by the early 2030s: LCOH of ~USD 1.6/kg (~USD 13.3/GJ) can be achieved in South Africa by 2030 – close to or at par with expected 2030 LCOHs in emerging future $H_2$ and $H_2$ products export countries, such as Australia (~USD 1.6/kg) and Saudi Arabia (~USD 1.5/kg).[27]

Secondly, South Africa is endowed with significant amounts of unused land which could be leveraged for green $H_2$ production infrastructure. Water supply is deemed to be sufficient to meet the water demand of large-scale green $H_2$ production. REDZ alone account for ~5.45 million hectares (Mha)[28] – in comparison, producing a hypothetical 10 Mt of green $H_2$ (~1330 PJ) would require ~1 Mha of land which represents ~1% of land in South Africa, and ~20% of land allocated to REDZ. The water requirement for the hypothetical 10 Mt $H_2$ would represent around a third of water consumed by the South African power sector today. However, this water requirement would not be met by leveraging potable water sources, but via water desalination plants – leveraging industrial or urban wastewater, sea water, and other non-potable water resources. The deployment of desalination plants would only add marginal cost to the overall LCOH (~0.005-0.01 USD/kg green $H_2$).

Third, South Africa's green $H_2$ opportunity is also anchored in the existence of relevant expertise and technology for the production of Power-to-X products like $H_2$-based chemicals and fuels, and local use cases for green $H_2$ and $H_2$ products. South Africa has a unique expertise in the Fischer-Tropsch technology, including existing assets. The Fischer-Tropsch process is critical in the production of synthetic hydrocarbons like green jet fuel. This expertise and physical infrastructure gives South Africa a first-mover advantage. It allows for local beneficiation of green $H_2$ and enhances the potential for large-scale local demand. Furthermore, given the existing local expertise and production capabilities, and the existing trade relationships and infrastructure, an opportunity exists around the export of green $H_2$ products such as green ammonia, methanol, and jet fuel into a growing global market for green fuels and green chemicals.

**However, further questions need to be addressed to assess South Africa's green $H_2$ opportunity:**

- What is the role of green $H_2$ in the decarbonisation of other sectors in South Africa, and what economic opportunities emerge? For instance, how can South Africa seize a potential opportunity to become an exporter of green $H_2$ products in a growing global $H_2$ market?
- How could the demand for local green $H_2$ and green $H_2$-based products be linked to exports, so it evolves over time in South Africa?
- What are green $H_2$ production and delivery options and implied infrastructure requirements in light of potential demand scenarios?
- What are the key policy decisions and frameworks needed to enable the development of a successful local green $H_2$ economy in South Africa?

A detailed assessment of the potential role of green $H_2$ for South Africa's decarbonisation and future economic growth along these key questions will be featured in the forthcoming publication 'South Africa's Green $H_2$ Opportunity'.

27 Port Elizabeth weather data used, with near optimal wind and solar conditions: 44% wind load factor and 23% solar load factor. Weighted Average Cost of Capital (WACC) assumed to be 2%. Resulting Levelised Cost of Energy (LCOE) are USD 16.6/MWh for wind, and USD 14.8/MWh for solar PV. Assumes overbuild of renewables (1.5 times electrolyser capacity). Electrolyser efficiency assumed to be 65%. Calculated via BCG's $H_2$ cost model.

28 The land allocated to REDZ is not in competition with other land use options such as agriculture or settlements.

Kalkbult, Northern Cape. Photo: scatec.com/locations/south-africa

### 3.2.5 NET-ZERO PATHWAYS: PATHWAYS TOWARDS THE OPTIMAL SYSTEM ARCHETYPE

The renewable energy dominant system is the cheapest energy archetype with the lowest decarbonisation cost towards a net-zero emissions system. Two book-end renewable energy dominated electricity system pathways were assessed to quantify what the supply mix could look like over time in migrating to this net-zero emissions archetype in 2050:

1. The 'IRP constrained pathway', with coal ramp-down in line with the IRP at the cost of higher emissions.
2. The 'low emissions pathway' with accelerated decommissioning of coal with all coal off by ~2042 (a modelled least emissions outcome).

The 'IRP constrained pathway' is anchored in a coal decommissioning schedule in line with the timeline presented in the IRP 2019. However, the pathway features a linear ramp-down of Medupi, Kusile, and any new-build coal plants between 2049 and 2050 to reach net-zero emissions in the power sector mid-century. The 'low emissions pathway' eliminates all coal by 2042, including Medupi and Kusile.

Both pathways include two last-mile decarbonisation 'branches' towards net-zero emissions (via deployment of DACCS to compensate for residual emissions from use of gas in GTP peakers), and zero emissions (via substitution of natural gas with green $H_2$) in GTP plants. Both last-mile decarbonisation options are deployed in the 2040s.

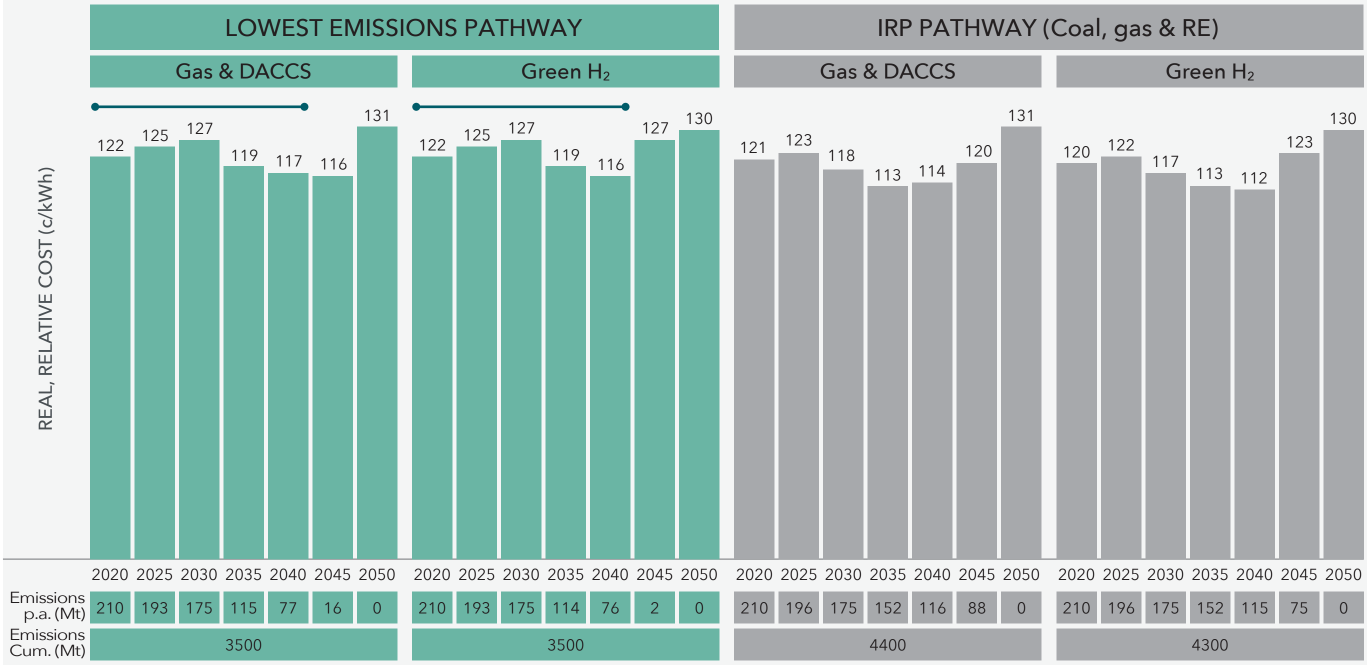
By ramping-up renewables and ramping-down coal earlier, the low emissions pathway yields around ~1 Gt $CO_2e$ lower cumulative emissions than the IRP constrained pathway with ~3.5 Gt $CO_2e$ and ~4.4 Gt $CO_2e$ cumulative emissions respectively.[29] This frontloading of investment in the low emissions pathway yields a relatively flat new-build CAPEX profile and also has the potential to create around 1 million net job-years[30] in the first 15 years, around 0.2 million more than the IRP constrained pathway.

29 Low emissions pathway cumulative emissions: ~3.5 Gt; IRP pathways cumulative emissions: ~4.4Gt.

30 Step 1: Quantify jobs at risk in the coal mining value chain up to 2050 (sources for direct coal mining jobs: *StatsSA QES & QLFS; Minerals Council Facts and Figures*. Sources for indirect multipliers: *Oxford Economics SAM for SA*). Jobs at risk in this value chain are quantified through assessment of export, Eskom, synfuels, and industrial demand trends (source: *NBI-BCG analysis*). Step 2: Quantify job potential through construction, installation, operations, and maintenance of the net-zero renewable dominant system up to 2050 (source: *NBI-BCG power sector analysis*; *EPRI job multipliers*).

**Figure 12: Comparison of real, relative cost and emissions in the pathways , leveraging optimal net-zero 2050 end points (see Figure 10)**

## The cost trajectories and trends are similar across the pathways, but the low emissions paths yield 2–8% higher costs in the first 15–20 years.




Increased relative cost from early coal decommissioning of ~2-9 c/kWh up to 2040

Note: CAPEX in relative cost includes new-build CAPEX & sustaining CAPEX.

General cost trends:
Increase in costs: from ~2025/2030
Decrease in costs (RE ramp-up): from ~2030/2035
Increase in costs from last-mile decarbonisation: from ~2040/2045

Source: BCG LCOE model, Plexos model, NBI-BCG project team.

However, the low emissions pathway costs an additional ~2 to 9 c/kWh in the short-term (~2025 to 2040). The additional cost of the lower emissions pathway relative to the IRP constrained pathway is equivalent to a marginal abatement cost of ~ZAR 730 to 900/tonne[31] in the case of last-mile decarbonisation by DACCS and ~ZAR 780 to 850/tonne[32] in the case of last-mile decarbonisation through the substitution of natural gas with green $H_2$.[33]

In delaying the ramp-up of renewables, in line with the IRP, the IRP constrained pathway not only delays job creation but also impacts CAPEX. As a result of this, the CAPEX profile of the IRP constrained pathway peaks in the last decade, with around ZAR 0.3 to 0.4 trillion additional CAPEX required between 2041 and 2050, relative to the low emissions pathway. However, given the scale of change and the convergence to net-zero, both the IRP constrained pathway and low emissions pathway yield similar cumulative net-job years (~2.4 million net-job years for 2020 to 2050) and similar total costs (~ZAR 75.5 trillion total cost for the 30-year period) (Figure 12, Figure 13, Figure 14)

Across both pathways, the costs increase from ~2020 to 2025. The cost increase is higher in the low emissions pathway due to the earlier coal decommissioning and as a result higher per annum coal capital cost, as well as due to earlier build out of renewables when learning curves technology costs are still improving. The real costs subsequently decline from ~2030 or 2035 given the growing share of increasingly cheaper wind and solar energy in the system.

> ***The transformation of South Africa's power system can result in net-positive job creation, if South Africa can successfully localise elements of the renewable energy value chain and effectively re-skill the workforce.***

31 Sensitivity on the DACCS cost (lower bound based on BCG global benchmark for 2050; upper bound ~3x higher worst-case scenario).

32 Sensitivity on whether additional RE capacity to produce green hydrogen is incurred within or beyond the power sector (lower bound: cost of additional RE capacity all incurred in the power sector; upper bound: all additional cost incurred outside the power sector).

33 NBI-BCG analysis.

Figure 13: Comparison of generation per technology in the pathways

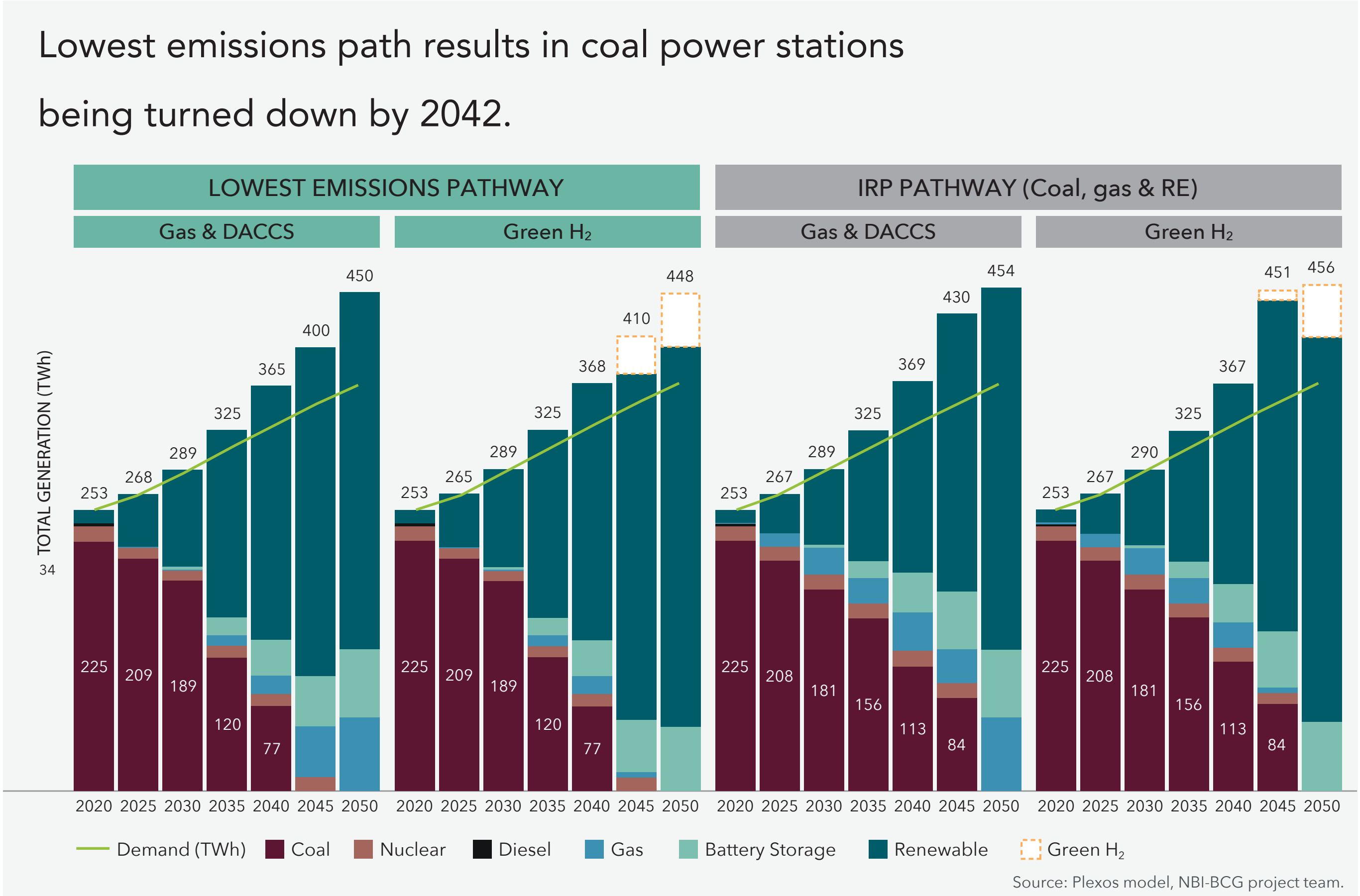
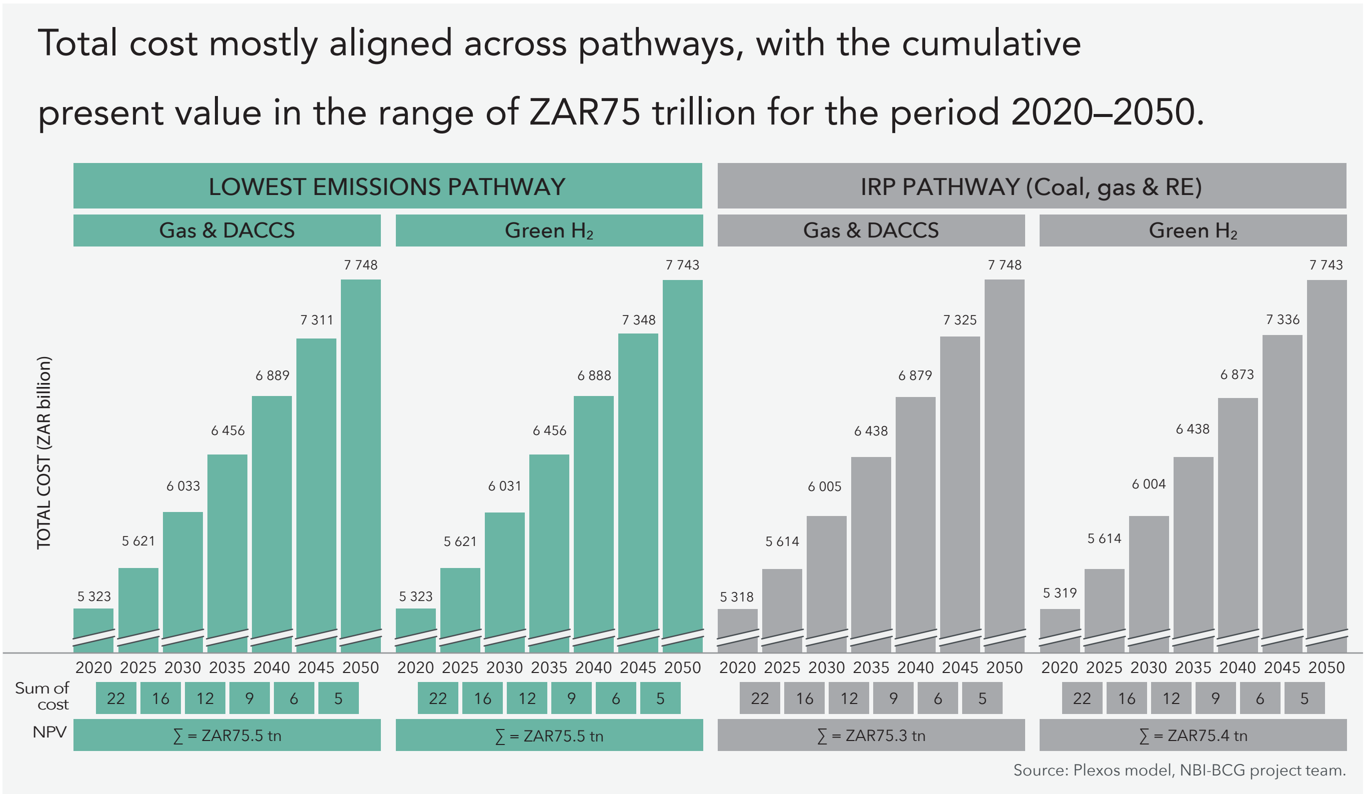



Figure 14: Comparison of total cost of the pathways




34 Total generation (TWh) includes curtailed energy (i.e., curtailment not subtracted out). Average battery storage of ~4 hours used in modelling.

### 3.2.6 KEY TRADE-OFFS OF THE CONSIDERED PATHWAYS

To conclude, identifying the optimal pathway for South Africa in the transition towards a renewable energy dominated, net-zero emissions power system requires a holistic assessment of both techno- and socio-economic trade-offs. Preliminary trade-offs assessed include:

1. Techno-economic impact
   - Cumulative emissions
   - Real, relative cost
   - CAPEX profile of new-build
   - Total cost
   - Marginal $CO_2e$ abatement cost.

2. Socio-economic impact
   - Job creation
   - GDP potential.

See Figure 15 for a summary of these trade-offs. In summary:

- There are two book-end pathways to achieve net-zero by 2050 in South Africa's power sector (each with two technology choices for last-mile decarbonisation – green $H_2$ or DACCS).
- Both pathways create more net-jobs than are lost in the coal value chain. However, the low emissions pathway creates ~200k more net-jobs by 2035 than the IRP aligned pathway.
- The low emissions pathway also saves ~1 Gt $CO_2e$ of cumulative emissions versus the IRP aligned pathway (3.5 Gt $CO_2e$ versus 4.4 Gt $CO_2e$).
- However, the additional jobs and lower cumulative emissions come at a higher relative system cost in the short- to mid-term (2 to 9 c/kWh higher) which equates to marginal abatement cost (relative to the IRP constrained path) of ZAR 730 to ZAR 850/tonne.

This fact-base serves as a starting point to identify the optimal pathway for South Africa's power sector. These insights will be enriched with cross-sector and broader macro trade-offs in subsequent reports. But, irrespective of the pathway the sector follows, there are a set of critical, no-regret decisions that need to be made in the next 24 months to ensure future energy security of the power sector.

**Figure 15: Techno- and socio-economic trade-offs of the net-zero pathways**

Evaluating the trade-off of pathways 1–4.

| TRADE-OFFS | LOWEST EMISSIONS PATHWAY | | IRP PATHWAY (Coal, gas & RE) | |
|---|---|---|---|---|
| | Gas & DACCS | Green $H_2$ | Gas & DACCS | Green $H_2$ |
| SOCIO-ECONOMIC | Almost 1mn net-job years by 2035, with an additional ~1.5 net-job years in last 15 years (~2.4mn net-job years cumulatively) | | Less than 0.8mn net-job years by 2035, with an additional 1.6–1.7mn in last ~15 years (2.4mn net-job years cumulatively) | |
| CUMULATIVE EMISSIONS | Cumulative emissions of ~3.5 Gt | Cumulative emissions of ~3.5 Gt | Cumulative emissions of ~4.4 Gt | Cumulative emissions of ~4.3 Gt |
| REAL RELATIVE COST (c/kWh) | Cost of 131 c/kWh in 2050 with 2-9 c/kWh higher cost in 2025-2040 | Cost of 130 c/kWh in 2050 with 2-9 c/kWh higher cost in 2025-2040 | Cost of 131 c/kWh in 2050 | Cost of 130 c/kWh in 2050 |
| NEW-BUILD CAPEX & TOTAL COST | Total CAPEX of ~R2.9 tn relatively evenly distributed Total cost of ~R75.5 tn | Total CAPEX of ~R3.1 tn relatively evenly distributed Total cost of ~R75.5 tn | Total CAPEX of ~R2.8 tn unevenly distributed Total cost of ~R75.3 tn | Total CAPEX of ~R3.0 tn unevenly distributed Total cost of ~R75.4 tn |
| $CO_2$ ABATEMENT COST | R730–900/ton* | R780–850/ton* | | |

Pro Neutral Con

*Present value (PV) of the additional total cost in the low emissions case compared to the IRP, scaled by the difference in PV of emissions

Source: NBI-BCG project team.

## 3.3 HOW TO ENABLE THE TRANSITION OF SOUTH AFRICA'S POWER SECTOR

The pathway for South Africa's power sector will need to optimally balance these trade-offs. Irrespective of the pathway the country takes, there are a set of critical no-regret decisions that need to be made in the next two years. Integrated policy and planning – from energy, fiscal, environmental and industrial perspectives – coupled with close collaboration and coordination of stakeholders will be critical.

As a starting point for these no-regret decisions, a set of high-level outcomes required for the low-carbon transition of the sector have been defined. These outcomes are based on the findings of the techno-economic modelling. Although the magnitude and phasing of the outcomes vary across pathways, the outlook provided in Figure 16 is intended to serve as the basis for no-regret decisions that hold, irrespective of magnitude and phasing differences.

**Figure 16: Outcomes needed to achieve a just, net-zero transition of South Africa's power sector**

| | 2020–2030 | 2030–2040 | 2040–2050 |
|---|---|---|---|
| **Coal** | Coal plants decommissioned/ repowered/ repurposed according to dead-stop dates | Accelerated decommissioning/repowering/ repurposing of select coal plants | |
| **RE and battery** | Up to ~150 GW solar and wind capacity installed (capacity ramp-up from 2021) with battery storage to manage short-term variability | | |
| **Gas** | 10–25 GW gas capacity installed and utilised for load balancing as coal plants reach end-of-life | | 0–40 GW gas capacity mostly for peaking |
| **Last-mile** | | Last-mile decarbonisation technologies (e.g., gas and DACCS or green $H_2$) deployed | |
| **Broader power sector** | ■ Expanded and upgraded transmission and distribution infrastructure to accommodate increased RE generation (and potential new load centres) and more embedded distribution<br>■ New power market structure with revised tariff structure<br>■ Continued research and technology development to cost effectively meet system inertia requirements | | |
| **Just Transition** | ■ Increased local manufacturing of components for solar PV and wind, leveraging South African Renewable Energy Masterplan (SAREM)<br>■ Access to more affordable green funding, with mechanisms in place to hedge foreign exchange risks<br>■ National Just Transition strategy and roadmap, with an immediate focus on displaced workers in the coal value chain | | |

Source: NBI-BCG project team.

**Figure 17: Recommended no-regret decisions for next 24 months**

| | | |
|---|---|---|
| **Power supply** | **Coal** | ■ Update policy stance to have no new coal and no new conventional nuclear built to 2030 and beyond<br>■ Decide on which power stations will be repowered/repurposed and how (split of gas vs. RE vs. battery vs. decommission) – on decommissioning in particular, there must be clarity and alignment on committed decommissioning amongst key stakeholders<br>■ Identify commercially/financially viable solutions to support early decommissioning of coal plants |
| **Power supply** | **RE** | ■ Increase allocation of RE in IRP from ~20 GW to at least 30 GW by 2030<br>■ Fast-track the procurement of RE power so that at least 30 GW is procured by 2030; ~100 GW by 2040 and ~150 GW by 2050<br>■ Allocate funds to research programmes to investigate solutions to handle system inertia challenges |
| **Power supply** | **Gas**[35] | ■ Assess trade-offs of recent REIPPPP gas procurement announcement and consider feasibility of reducing 20 year term of PPA's being considered for power ships to prevent unnecessary supply infrastructure lock in<br>■ Quantify installed capacity and utilisation factors of gas required beyond 2030 in the IRP (limit load factor to max ~25% post-2040[36]) |
| **Power supply** | **Green $H_2$** | ■ Develop national green $H_2$ strategy that clearly articulates where in the value chain SA should play and where SA has a 'right to win'<br>■ Kick-off green $H_2$ pilot projects in partnership with potential long-term off-take markets e.g., Germany (particularly test appetite for cheaper sources of finance, e.g., at 2% WACC) |
| **Broader power and energy sector** | **Power system** | ■ Set up transparent, predictable commercial process for procurement of future energy needs to improve investor confidence (with transparency on self-generation supply commitments for system planning)<br>■ Draft integrated energy plan, aligned to new procurement process, co-ordinating and aligning all sub-sectors (e.g., power, petrochemicals)<br>■ Kick-off electricity sector market reform study, including target ownership structure and requirements for inclusions and local content<br>■ Define and implement future market structure for power sector (including tariff structure with both capacity and energy charges)<br>■ Set up strategic grid expansion task team to drive the expansion and upgrade of the transmission and distribution infrastructure (including acquisition of servitudes) |
| **Broader power and energy sector** | **Just Transition** | ■ Develop national RE industrialisation and localisation plan ensuring alignment with SAREM research and stakeholder engagement (critical to have a view on where in value chain SA can play and where there is a 'right to win')<br>■ Launch re-skilling and re-deployment programme for displaced workers in coal value chain |

Source: NBI-BCG project team.

35 See "The role of gas in the power sector transition and South Africa's decarbonisation journey in general" on page 22 for more detail.
36 Limit load factors to mid-merit and peaking. Mid-merit load factors typically range from 10-30%; peaking load factors typically < 10%.

Figure 18: Recommended strategic decisions for mid-to-long-term

| | | |
|---|---|---|
| **Mid-term: By 2025** | **Power system** | ■ Refine integrated energy plan and planning process leveraging lessons learnt |
| | **Broader power and energy sector** | ■ Invest in forex hedging for imports of all commodities required for the roll-out of large-scale RE<br>■ Scale up investments in green $H_2$ pilots and bring 1–2 facilities into commercial production |
| | **Just Transition** | ■ Scale up production of RE components locally (starting narrow and capturing more value over time) leveraging lessons learnt from Green Cluster Agency (e.g., in Mpumalanga) |
| **Long-term: Beyond 2025** | **Power system** | ■ 2030–2040: Re-assess feasibility of last-mile decarbonisation technology option space and compare trade-offs (beyond just gas and DACCS and green $H_2$ storage)<br>■ 2040–2050: Deploy last-mile decarbonisation technologies |

Source: NBI-BCG project team.

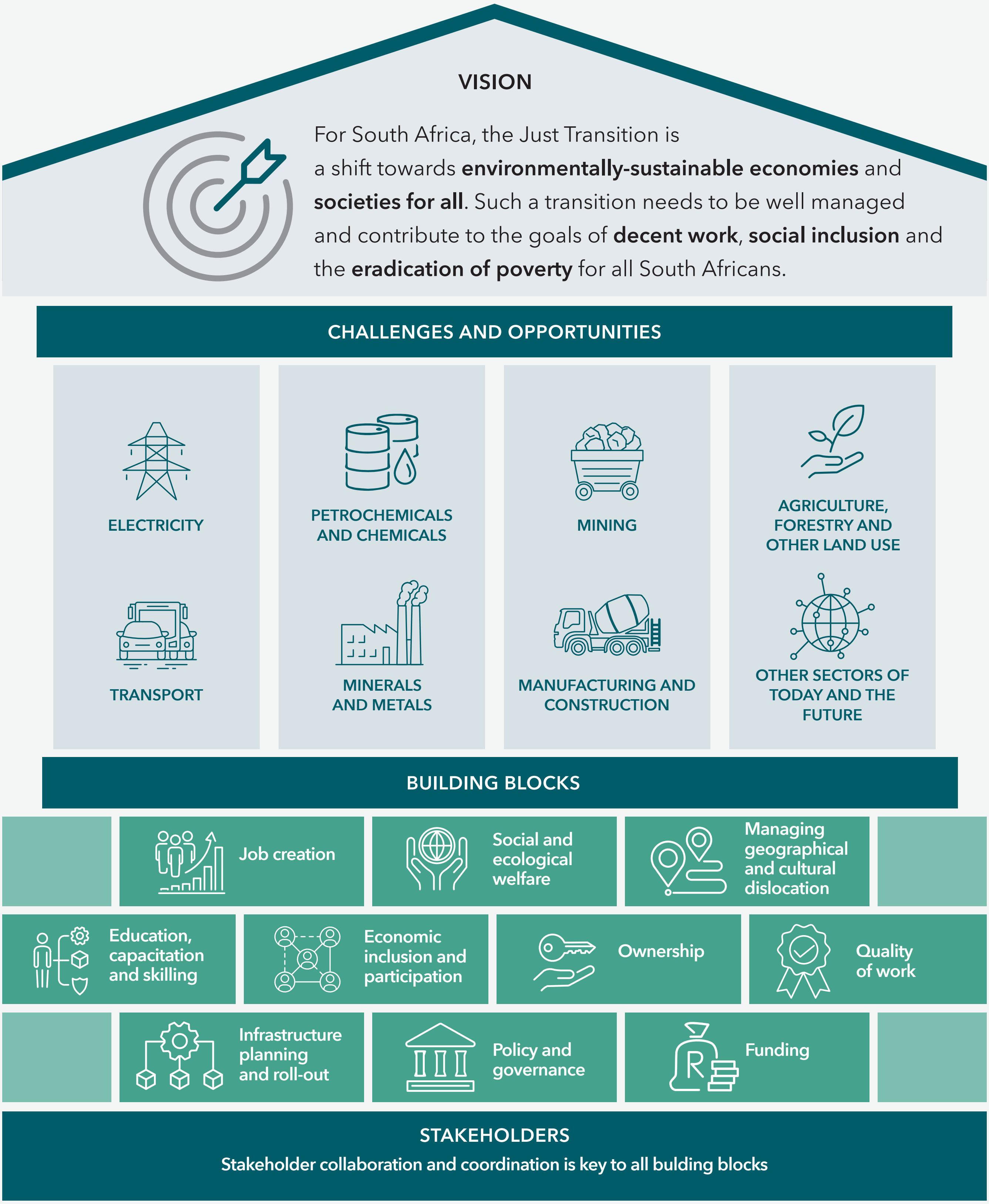
The no-regret decisions outlined in Figure 17 and Figure 18 are the result of rigorous debates held during multiple stakeholder engagement workshops. They are intended to translate the fact-base developed as part of this study into practical actions that can be taken now to realise required outcomes and drive a just energy transition.

This action needs to be taken within the context of South Africa's overall needs. The transition towards a fully decarbonised, renewable energy dominated power system needs to be well managed to contribute to social upliftment and the eradication of poverty and inequality. Several dimensions need to be addressed in ensuring a Just Transition for South Africa's power and other sectors. Along each of these dimensions, the public and private sectors need to act collaboratively and decisively to ensure no-one is left behind (Figure 19).

*To help fund this journey and ensure competitive cost of capital, access to international green finance will be required to succeed.*

**Figure 19: Vision, challenges and opportunities and building blocks for South Africa's Just Transition**

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




Source: NBI-BCG project team.

As stated previously, South Africa's unique triple challenges of inequality (highest Gini coefficient in the world), unemployment (greater than 30%) and youth unemployment (greater than 50%), and poverty (more than half of South Africans living in poverty) provide a key context to the transition. Perspectives on a Just Transition differ, ranging from thinking of a Just Transition as a labour relations exercise, to the more common view of focussing on jobs and skills, to the opportunity to structurally reform the economy to address the underlying causes of poverty, inequality and unemployment. It is certain that South Africa needs to adopt a more ambitious perspective on a Just Transition.

An important epiphany is that many of the physical and trade-based climate risks to which South Africa is exposed are exogenous. There is little that can be done and as a consequence South Africa will transition. It is up to South Africa to make it just. A managed transition gives South Africa the best hope of doing so. South Africa needs to identify the risks to which each sector of the economy is exposed and understand how to convert those risks into opportunities, identifying additional investment opportunities across the economy.

*To enable this pathway, cross-sector collaboration and a conducive policy environment will be critical.*

When investing in those opportunities it is imperative that South Africa considers the broad range of Just Transition elements that include considerations of:

- Job creation
- Social and ecological welfare
- Managing geographic and cultural dislocation of communities
- Education, capacitation and re-skilling
- Economic inclusion and participation (especially of the youth and black women)
- Ownership
- Quality of work
- Infrastructure planning and roll-out
- Policy and governance
- Funding.

A broad and ambitious Just Transition cannot be an afterthought but rather should be the goal for which South Africa aims. While a detailed assessment of South Africa's Just Transition potential will be featured in a companion publication it should be kept in mind that a Just Transition needs to built on a national conversation that includes all stakeholders. Furthermore, the specific costs of social transition is a factor that needs to be included in funding and framework discussions.

# 4. OUTLOOK

As was stated in the foreword of this report, South African business commits unequivocally to supporting South Africa's commitment to find ways to transition to a net-zero emission economy by 2050. Furthermore, business would support an enhanced level of ambition in the NDC that would see the country committing to a range of 440 to 350–370 Mt $CO_2e$ by 2030. However, this enhanced ambition would have to be conditional on the provision of the requisite means of support by the international community. In this light the business community will play its part to work with international and local partners to develop a portfolio of fundable adaptation and mitigation projects that would build resilience and achieve deep decarbonisation.

A managed Just Transition is central and such a transition is impossible without a broad multi-stakeholder effort. National Government, through the Presidential Climate Commission and the National Planning Commission and supported by key government ministries are leading this effort.

In support of this national programme the NBI membership together with BCG and BUSA are running a multi-year project to understand net-zero decarbonisation pathways, sector by sector. This will provide a solid input into national and local dialogues as well as identifying critical investment areas. Furthermore, this level of detail enables policy frameworks and engagement with providers of international support to maximise the potential to leverage concessional finance and trade support to attract local public and private finance.

This work is ongoing and is intended as a basis for further consultation and a foundation for future work. The work on each sector will be released in stages as it is completed and will form a basis on which others can build. Ultimately a final body of work of the combined sector content will be made up of reports on:

- An introduction to the project and to a managed Just Transition, including analysis from our economic modelling
- Electricity
- Petrochemicals and chemicals
- The role of gas
- The role of green hydrogen
- Mining
- Transport
- Agriculture, forestry and other land use
- Construction
- Heavy industry
- A concluding chapter highlighting key investment opportunities and no-regret decisions.

Each of these reports will be published via our Just Transitions Web Hub (http://jthub.nbi.org.za). Please monitor this website for the latest report versions, supporting data and presentation material, as well as news of other Just Transition initiatives and a wide range of current opinion and podcasts on a Just Transition for South Africa.

We invite you to engage with us and to provide comment and critique of any of our publications via info@nbi.org.za.

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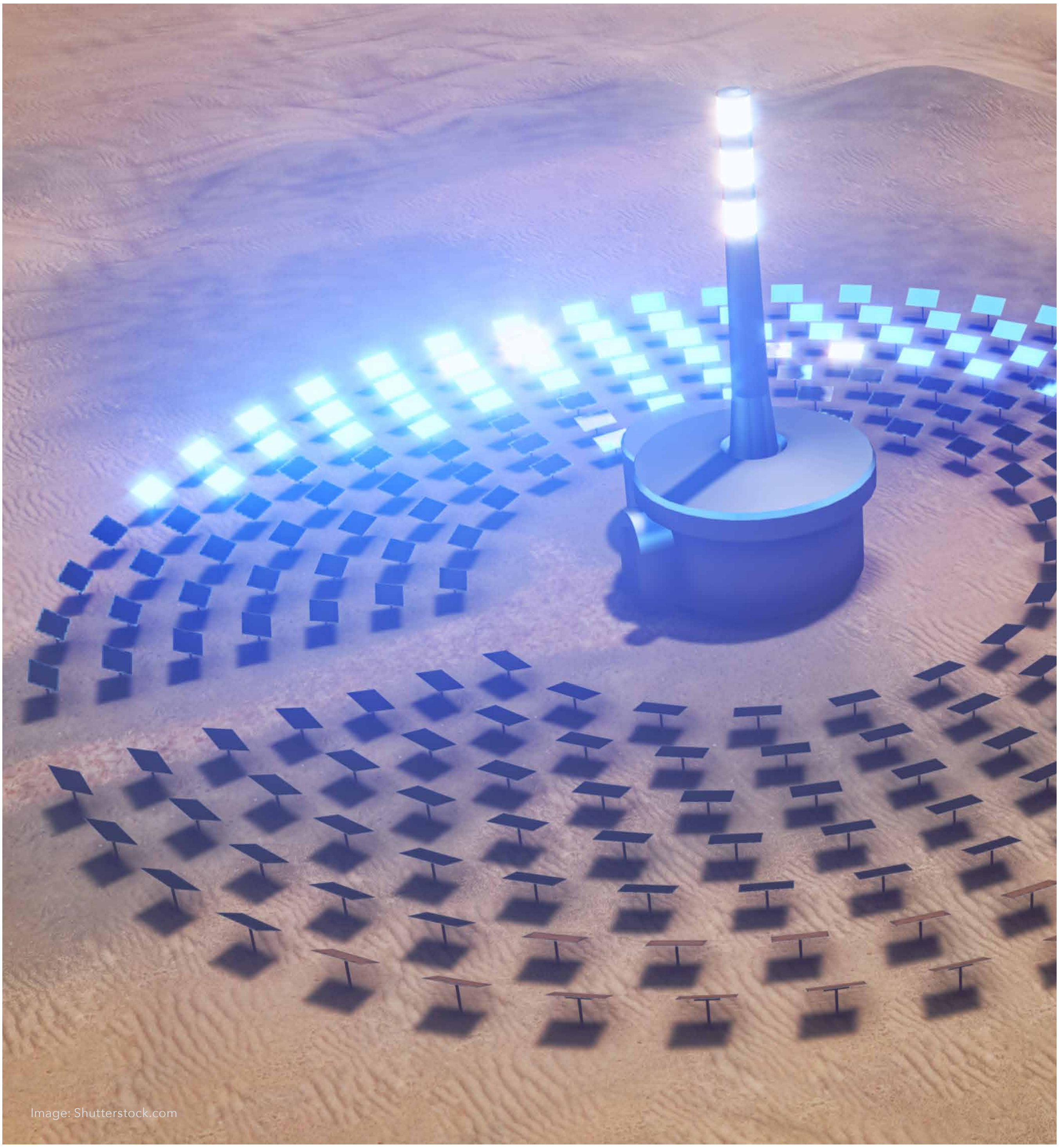



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