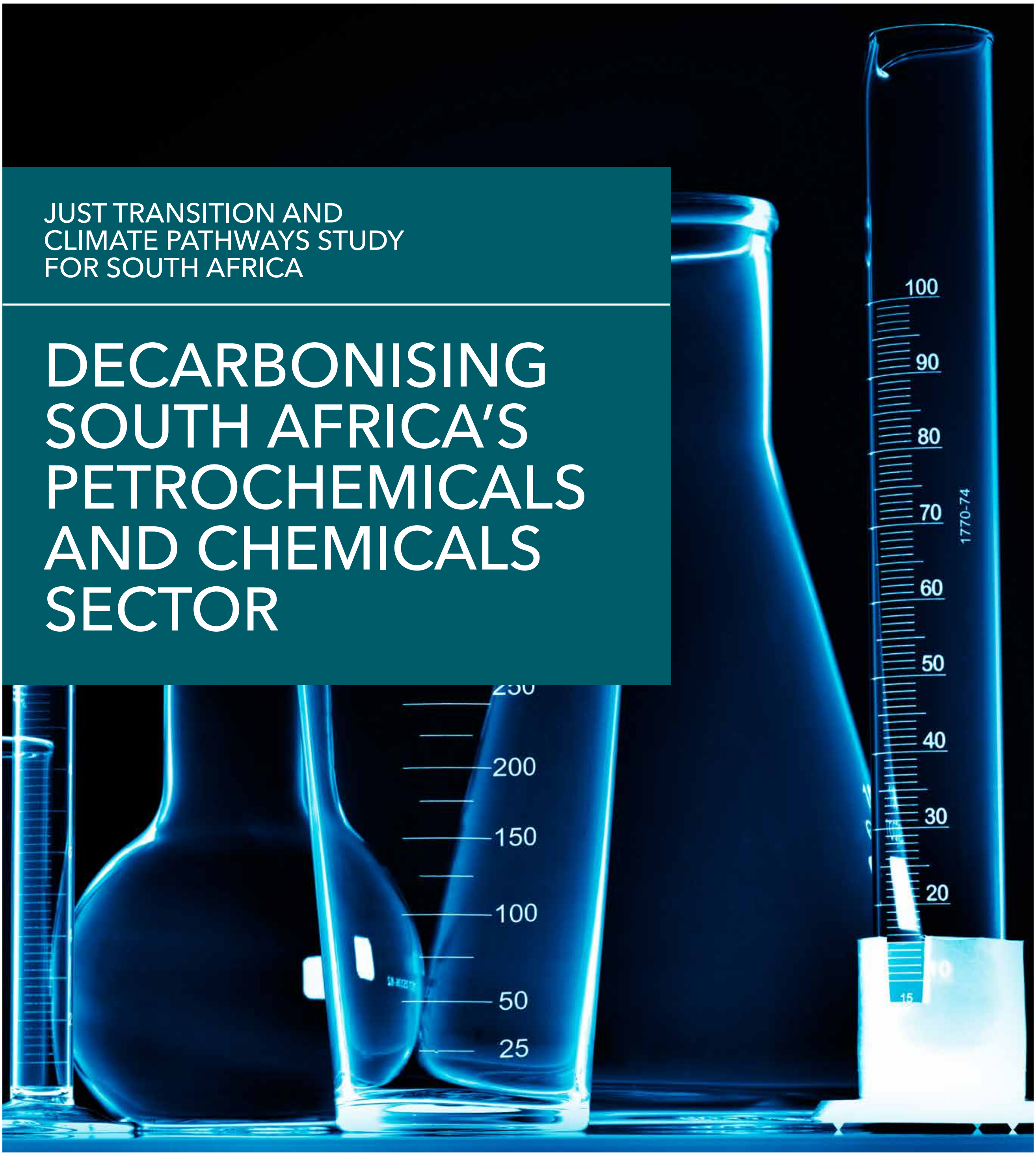
National Business Initiative

CHAPTER 02

JUST TRANSITION AND CLIMATE PATHWAYS STUDY FOR SOUTH AFRICA

DECARBONISING SOUTH AFRICA'S PETROCHEMICALS AND CHEMICALS SECTOR



IN PARTNERSHIP WITH

BUSA BUSINESS UNITY SOUTH AFRICA

BCG BOSTON CONSULTING GROUP

ACKNOWLEDGEMENTS

RESEARCH SUPPORTED BY

SOUTH AFRICA UK PACT

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 COALITION

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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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
BEV	Battery Electric Vehicles
bn	billion
bpd	barrels per day
CAIA	Chemical and Allied Industries' Association
CCS	Carbon Capture and Storage
CCU	Carbon Capture and Utilisation
CCUS	Carbon Capture Utilisation and Storage
CMD	Capital Markets Day
CO_2e	Carbon dioxide equivalent
COP26	United Nations Conference of the Parties 26
CT	Cape Town
CTL	Coal-to-Liquid
DACC	Direct Air Carbon Capture
DACCS	Direct Air Carbon Capture and Storage
DFFE	Department of Forestry, Fisheries and the Environment
DBN	Durban
EU	European Union
FCEV	Fuel Cell Electric Vehicles
GDP	Gross Domestic Product
GHGI	Greenhouse Gas Inventory
Gt	Gigatonne (one thousand million tonnes)
GTC	Gas-to-Chemicals
GTL	Gas-to-Liquid
GW	Gigawatt
H_2	Hydrogen
ICE	Internal Combustion Engine
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JHB	Johannesburg
kt	kilo tonnes (thousand tonnes)
LCOH	Levelised Cost of Hydrogen
LNG	Liquified Natural Gas
Mt	Megatonnes
Mtoe	Million tonnes oil equivalent
Mtpa	Megatonnes per annum
NDC	Nationally Determined Contribution
NZE	IEA Net Zero Emissions Scenario
PE	Port Elizabeth (Gqeberha)
PGMs	Platinum Group Metals
PJ	Petajoule
PtX	Power-to-X
PV	Solar photovoltaic technology
RE	Renewable Energy
REDZ	Renewable Energy Development Zones
RTS	IEA Reference Technology Scenario
SAF	Sustainable Aviation Fuel
SAPIA	South Africa Petroleum Industry Association
Scope 1 emissions	All direct emissions from activities of an organisation under their control, including on-site fuel combustion for fleet vehicles, stationary machinery and heating process, and fugitive emissions from drilling or spontaneous combustion of coal
Scope 2 emissions	Indirect emissions from electricity and steam purchased and used by the organisation. Emissions are created during the production of the electricity and steam that are used by the organisation
Scope 3 emissions	All indirect emissions (not included in Scope 2) that occur in the value chain of the respective organisation, including both upstream and downstream emissions (e.g., emissions linked to use of organisation's products)
SDS	IEA Sustainable Development Scenario
SSA	Sub-Saharan Africa
TWh	Terawatt hours
UNFCCC	United Nations Framework Convention on Climate Change
US$	US Dollar
ZAR	South African Rands
ZEV	Zero Emission Vehicles

CONTENTS

JUST TRANSITION AND CLIMATE PATHWAYS STUDY FOR SOUTH AFRICA

SERIES INCLUDES:

01 Decarbonising South Africa's power system

02 Decarbonising the South African petrochemicals and chemicals sector

03 The role of gas in South Africa's transition

04 Decarbonising the South African mining sector

05 Decarbonising the AFOLU (Agriculture, Forestry and Other Land Use) sector in South Africa

06 Decarbonising the South African transport sector

07 South Africa's green hydrogen opportunity

08 Challenges and opportunities for a Just Transition

OVERVIEW OF CEO CHAMPIONS

Onboarding of additional CEOs ongoing

Joanne Yawitch
NBI CEO

Cas Coovadia
BUSA CEO

André de Ruyter
Eskom CEO

Fleetwood Grobler
Sasol CEO

Mxolisi Mgojo
Exxaro CEO

Leila Fourie
JSE Group CEO

Nolitha Fakude
Anglo American SA Chairperson

Alan Pullinger
First Rand CEO

Hloniphizwe Mtolo
Shell SA CEO

Portia Derby
Transnet 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 Group CEO

Nyimpini Mabunda
GE SA CEO

Mark Dytor
AECI CEO

Alex Thiel
SAPPI CEO

Mohammed Akoojee
CEO Imperial Logistics

Yusa Hassan
Engen MD and CEO

Tshokolo TP Nchocho
IDC 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, AFOLU (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 emissions 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 420–350 Mt CO_2e 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

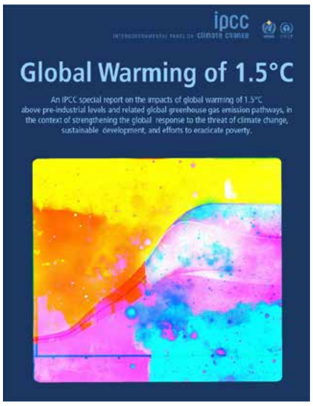
2.1 THE PURPOSE OF THIS REPORT

This report, focusing on the decarbonisation of South Africa's petrochemicals and chemicals sector, is the second 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_2e**.[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

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_2e.

> *"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."*
>
> **Mr António Guterres,**
> **United Nations Secretary-General**

Photo: UN Climate Action Summit

past 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.

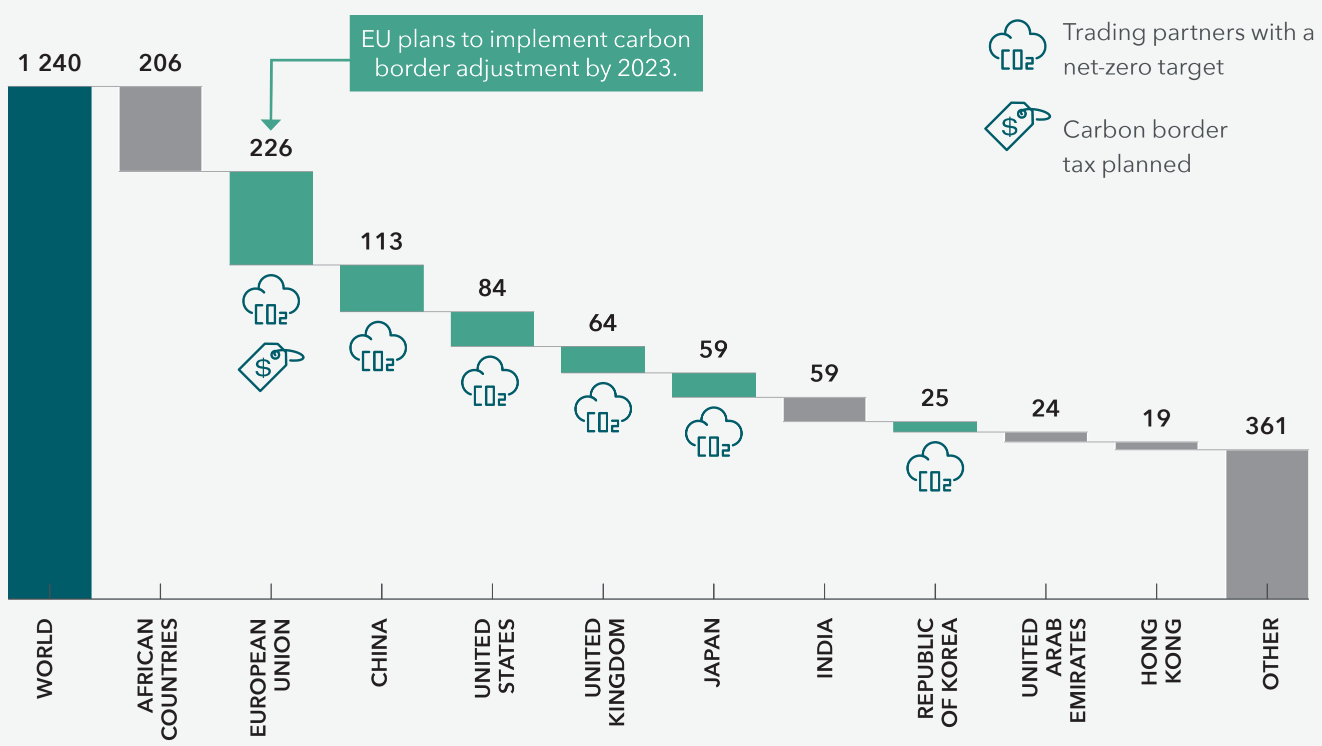
South Africa is also facing a significant trade risk. South Africa ranks in the top 20 most carbon-intensive global economies on an emissions per Gross Domestic Product (GDP) basis, and in the top five amongst countries with GDP in excess of US$100 billion (bn) per annum. The South African economy will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

South Africa has predominantly coal-based power generation, the coal-to-liquid (CTL) 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 Second 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 ~80 k direct jobs and ~200 to 300 k 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 5–10 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 10 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 reskilling 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 enable 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 petrochemicals and chemicals 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).

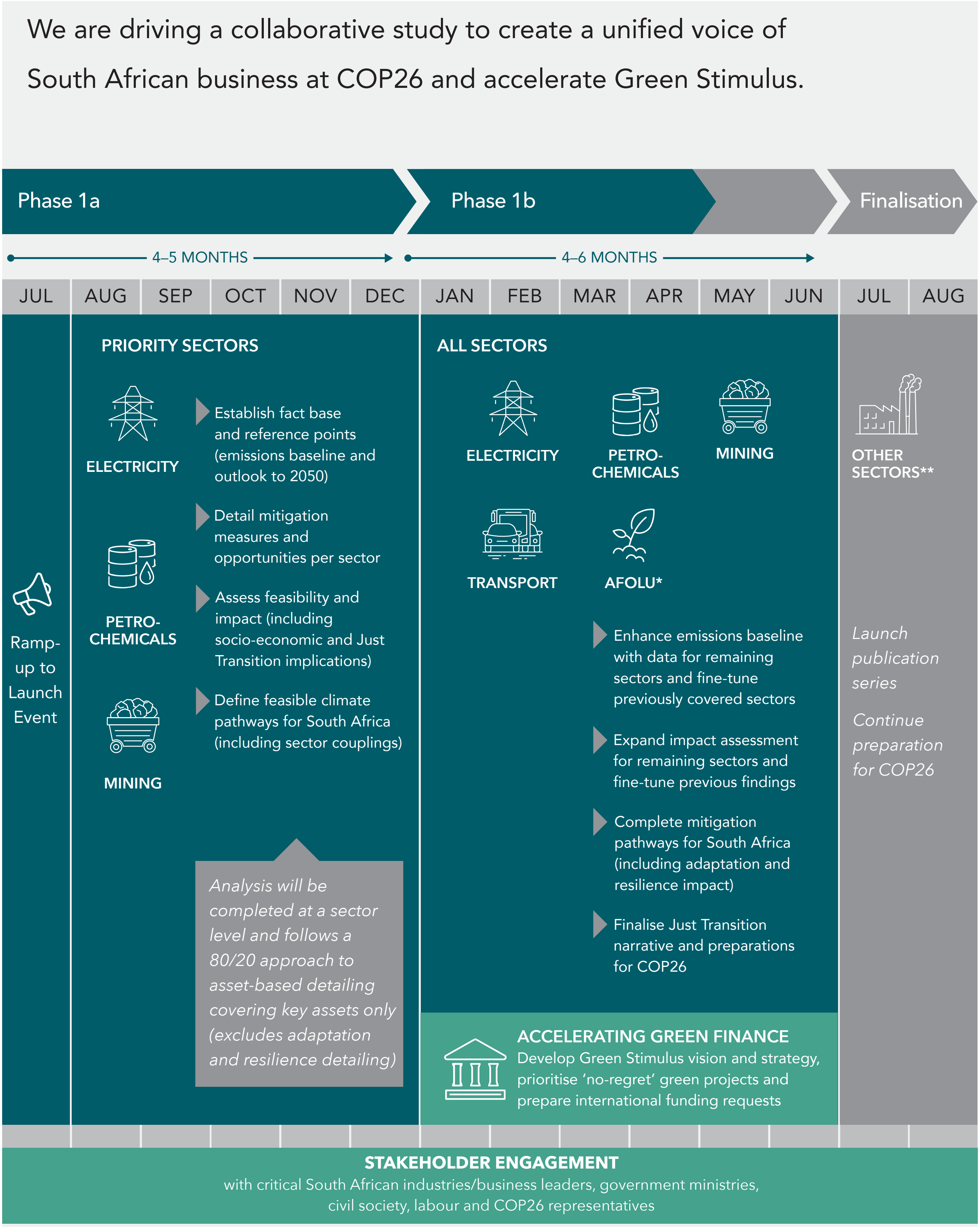
The study is a collaborative effort, aiming to create a 'unified voice of South African business' on the country's needs, opportunities, and challenges in achieving a net-zero economy, involving multiple stakeholders from all sectors. The governance arrangement that has overseen this work is key to enabling 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 second in a series being released to illustrate the findings of this study. The first report is focused on the decarbonisation of the electricity sector in South Africa. 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.

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

3.

KEY FINDINGS OF THE PETROCHEMICALS AND CHEMICALS SECTOR ANALYSIS

Ten key findings of the petrochemicals and chemicals sector analysis

1. *If South Africa can unlock disruptive technology, in particular green hydrogen (H_2) and sustainable sources of carbon,* ***it can fully decarbonise its petrochemicals and chemicals sector****, which today drives 13% of the country's emissions, and* ***become a leading producer of green fuels and chemicals for local demand and export****.*

2. ***South Africa will be faced with different challenges in the petrochemicals and chemicals sector across timelines****: In the 2030s, South Africa could be facing the risk of weakened energy security, given a potential decline in domestic refinery capacity, due to decreasing competitiveness against imports, and regulatory compliance and feedstock supply risks. In the long-term, the sector will need to adapt to a changing demand landscape: Depending on the transport sector decarbonisation scenario, conventional liquid fuels demand could decrease by 50–100%, while conventional chemicals would eventually be substituted by decarbonised alternatives – also as a result of carbon border adjustment mechanisms – globally and in South Africa.*

3. ***While in the mid-term, energy security needs to be maintained and the socio-economic risks associated with declining domestic refinery capacity and a potentially resulting negative balance of payment change managed, the changing demand landscape creates an opportunity for South Africa in the long-term****: South Africa could become a leading producer of green synthetic fuels and green chemicals, particularly e-ammonia and sustainable aviation fuel (SAF), for local demand and export, enabled by decarbonisation and conversion of South Africa's synfuels sector.*

4. ***South Africa's opportunity in the production of green fuels and chemicals is based on a competitive advantage in the production of green H_2 and synthetic fuels****: First, South Africa has some of the best solar and wind resources on the planet; second; it has sufficient land and access to seawater for desalination, which can also serve a dual purpose of improving water security; and third, it has unique Fischer-Tropsch technology for beneficiation of H_2 into hydrocarbons, such as e-methanol and SAF.*

5. ***Decarbonising South Africa's synfuels production will not just support the transition to the production of green fuels and chemicals, it will also be critical to reduce South Africa's overall emissions footprint and the carbon-intensity*** *of locally produced chemicals – given that today's coal-based synfuels sector drives ~90% of the petrochemicals and chemicals sector's emissions and constitutes a key supplier of feedstock for local downstream chemicals production.*

6 ***The ability to decarbonise the petrochemicals and chemicals sector will depend on access to key technologies and feedstocks****: Full decarbonisation of the existing synfuels production requires access to green H_2 at scale below a price of US$2/kg and sustainable carbon feedstocks, supplied via, for example biomass and – potentially in the long-term – Direct Air Carbon Capture (DACC). For gas to support the decarbonisation as a transition feedstock, gas prices would need to be secured at an economically-viable level.*

7 ***Depending on the timing of availability and affordability of disruptive technology and lower emissions feedstock, such as Carbon Capture Utilisation and Storage (CCUS), DACC, green H_2, biomass and gas, different pathways towards net-zero synfuels production exist****; whereby cumulative emissions range between 0.6–1.2 Gt CO_2e, but socio-economic trade-offs differ significantly across pathways with regards to, for example, timing and scale of investment requirements, impact on production cost, job impact across the sector's, and adjacent value chains and the speed at which green production can be achieved.*

8 ***Two per cent of the sector's direct emissions are linked to downstream chemicals production****; removing those emissions will require process, energy and material efficiency improvements, fuel switching, access to sustainable feedstock and negative emission technology, such as CCUS.*

9 ***While the decarbonisation of the petrochemicals and chemicals sector enables local industrialisation and realisation of new export opportunities*** *which help improve South Africa's balance of payment, it will be critical to manage socio-economic risks in the mid-term, in particular the displacement of workers in the coal, refinery and adjacent value chains, which together make up ~140 000 direct jobs today, and the risk of increasing reliance on liquid fuels imports, which would decrease energy security and negatively impact South Africa's balance of payment in the 2030s – accelerating decarbonisation across sectors will be key to mitigate those risks.*

10 ***It will be critical to establish cross-sectoral and international partnerships and pilot projects to drive research and development, off-take agreements to secure cheap financing at an early stage, and a conducive local policy environment*** *to unlock the key technologies and feedstock needed to drive decarbonisation and the establishment of green fuels and chemicals production in South Africa – if this cannot be achieved, the sector is at risk of losing its competitiveness and will eventually come to a demise.*

3.1 SCOPE AND APPROACH OF THE PETROCHEMICALS AND CHEMICALS SECTOR ANALYSIS

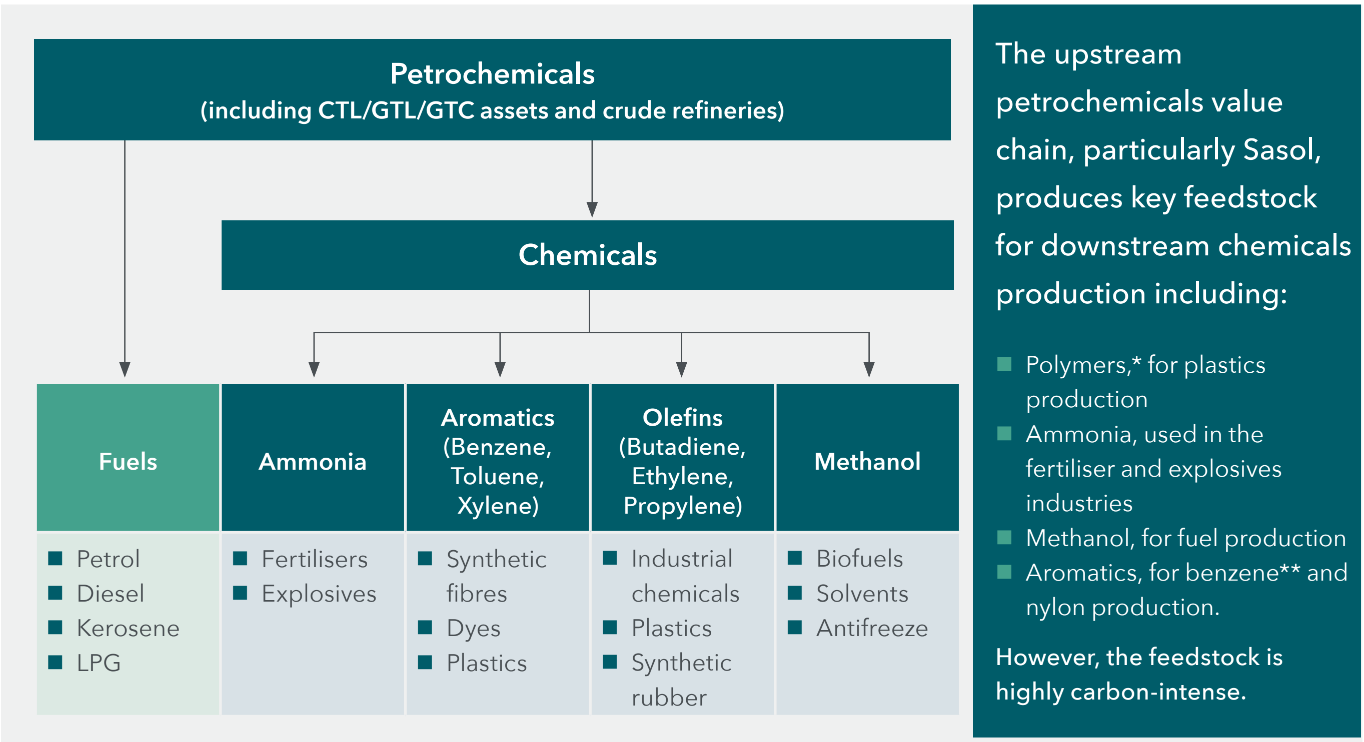
The petrochemicals and chemicals sector is structured as follows (Figure 4): The upstream petrochemicals value chain consists of South Africa's synfuels assets – Sasol's Secunda coal-to-liquid (CTL) and PetroSA's gas-to-liquid (GTL) operations – and the local conventional crude refineries (See Figure 5 and "South Africa's upstream petrochemicals value chain" on page 22). The downstream chemicals value chain consists of various chemical players, whereby upstream and downstream petrochemicals and chemicals are closely intertwined (this also includes Sasol's Gas-to-Chemicals (GTC) plant which receives large portions of its feedstock from the Secunda CTL plant).

The analysis addresses five key questions to understand the future of South Africa's petrochemicals and chemicals sector in the transition towards a net-zero world:

1. How will the petrochemicals and chemicals demand landscape change globally and locally?
2. How can the sector respond to a changing demand landscape and where can South Africa build on existing competitive advantages?
3. What decarbonisation pathways exist for the South African petrochemicals and chemicals sector?
4. What are the socio-economic risks and opportunities that arise with the decarbonisation of the petrochemicals and chemicals sector?
5. What are key enablers for the decarbonisation of South Africa's petrochemicals and chemicals sector and the development of local green fuels and chemicals production?

This analysis focuses on identifying decarbonisation pathways for the upstream petrochemicals sector, given the significant emissions footprint of the local synfuels production which forms part of the upstream value chain: more than 90% of the sector's direct emissions are driven by South Africa's synfuels production. Furthermore, the upstream petrochemicals value chain is an important supplier of – today carbon-intense – feedstock to the downstream, chemicals value chain. Hence, decarbonising the sector's upstream petrochemicals value chain, particularly the synfuels sector, is an important enabler to reducing South Africa's direct emissions and the carbon-intensity of the petrochemicals and chemicals sector's overall product landscape.

Figure 4: Overview of the petrochemicals and chemicals sector



Notes: * Polypropylene/propylene
** Plastics, resins, synthetic fibres, rubber lubricants, dyes, detergents, drugs and pesticides

Source: TIPS, 2019; NBI-BCG analysis.

The analysis was conducted in close collaboration with various relevant private and public stakeholders, including the Chemical and Allied Industries' Association (CAIA), South Africa Petroleum Industry Association (SAPIA) and Sasol. In addition, relevant key insights from other sector analysis – particularly from the transport and power sectors – were leveraged as part of the petrochemicals and chemicals analysis.

3.1.1 THE SOUTH AFRICAN PETROCHEMICALS AND CHEMICALS SECTOR TODAY

If South Africa can unlock disruptive technology, in particular green H_2 and sustainable sources of carbon, ***it can fully decarbonise its petrochemicals and chemicals sector****, which today drives 13% of the country's emissions, and* ***become a leading producer of green fuels and chemicals for local demand and export*** *.*

The upstream petrochemicals sector can be divided into the conventional local crude refineries and South Africa's synfuels assets. The sector not only produces conventional liquid fuels, but also critical feedstock for the downstream chemicals value chain. The upstream value chain is dominated by Sasol, which produces synthetic fuels and feedstock for the downstream chemicals value chain – including for its own GTC operations. This includes, in particular, polymers for the production of plastics, ammonia used in the fertiliser and explosives industries, methanol for fuel production and aromatics for the production of benzene and nylon. South Africa's downstream chemicals value chain produces a range of products, including basic chemicals, rubber products, plastic products, other chemical products and human-made fibres.[14]

The petrochemicals and chemicals sector is with ~13% (~63 Mt CO_2e out of ~500 Mt CO_2e total gross national emissions, as per the latest Department of Forestry, Fisheries and Environment (DFFE) emissions figures) of national emissions, the second largest emission source in the South African economy, second only to the electricity sector (Figure 6). Ninety percent of emissions from the petrochemicals and chemicals sector are driven by Sasol's Secunda and Sasolburg (CTL and GTC) operations. The produced synfuels are on average ~26 times more carbon-intense[15] than conventional liquid fuel (produced in conventional crude refineries). This carbon-intensity is embedded in the locally produced chemicals for which Sasol's products are leveraged as feedstock. The local refineries, which also produce feedstock for the downstream chemicals sector, make up ~6% (~4 Mt CO_2e) of the full petrochemicals and chemicals sector emissions, while the downstream chemicals sector (excluding Sasol's GTC plant) is responsible for only ~2% (~1.5 Mt CO_2e) of direct emissions in the sector (Figure 7).

The sector is an important socio-economic contributor in the country. In 2019, the sector contributed ~ZAR232 bn (~6.22%) to the national Gross Domestic Product (GDP). A large share of this was driven by the top three listed chemicals companies in the country[17] – Sasol, AECI and Omnia, with a ~4.70%, 0.15% and 0.11% contribution to

Petroleum and petrochemical products

Generally, crude oil is the basis of petroleum products (containing several classes of fuels, such as gasoline, diesel, kerosene, fuel oil) and petrochemical products (note: some chemical compounds of the same structure as petrochemicals can also be derived from other carbon sources, such as coal, natural gas or sustainable carbon sources such as biomass. For example, in South Africa's synfuels sector, coal is the key feedstock for the production of synfuels via the Fischer-Tropsch process). Petrochemicals can be divided into three groups:

Olefins: This includes, for example, ethylene and propylene and butadiene, which are important feedstock for the production of plastics and industrial chemicals and synthetic rubber respectively.

Aromatics: These include, for example, toluene, benzene and xylenes, which are used for the production of dyes and synthetic detergents, isocyanates, plastics and synthetic fibres.

Synthesis gas: This is a mix of carbon monoxide and H_2 which serve as the basis for the production of, for example, methanol and diesel- and gasoline-range hydrocarbons.[16]

14 Trade and Industrial Policy Strategies. 2019. *National Employment Vulnerability Assessment: Analysis of potential climate-change related impacts and vulnerable groups*.

15 Based on 2020 carbon-intensity figures: Natref: 0.33 tonne CO_2e/tonne product sold; Secunda: 8.62 tonne CO_2e/tonne product sold.

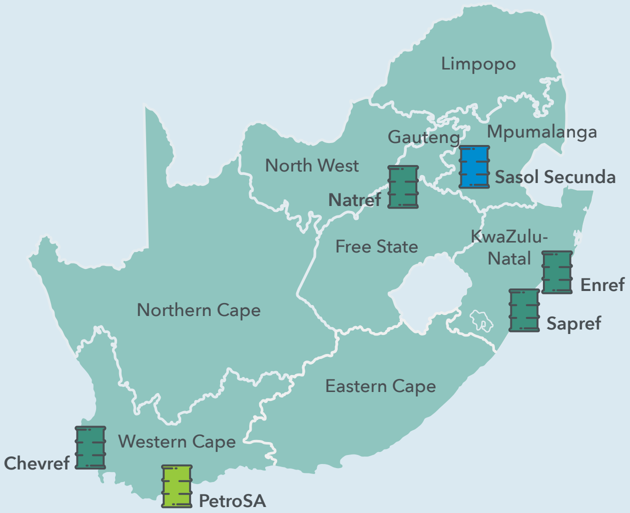
16 James G. Speight, 'Chapter 12 – Petrochemicals'. *Handbook of Industrial Hydrocarbon Processes*. 2011.

17 Note: Top three companies based on revenues of companies listed on Johannesburg Stock Exchange (JSE).

South Africa's upstream petrochemicals value chain

Figure 5: Overview of South Africa's refinery assets

South African refinery ownership and crude throughput



Note: * Crude equivalent average yield

Crude oil refined at the following refineries:		
Astron closed /currently not in operation	**100 000** barrels/day	Chevron South Africa
Enref closed /currently not in operation	**120 000** barrels/day	Engen Petroleum
Natref	**108 000** barrels/day	Sasol (64%) Total South Africa (36%)
Sapref	**180 000** barrels/day	Shell South Africa (50%) BP Southern Africa (50%)
Coal and gas processed and refined at:		
Sasol Secunda	**160 000** barrels/day*	Sasol
Gas processed and refined at:		
PetroSA closed /currently not in operation	**45 000** barrels/day*	PetroSA

Source: South African Petroleum Industry Association.

South Africa's upstream petrochemicals value chain consists of two groups of refinery assets (see Figure 5):

1. **Four conventional refineries** which refine imported crude include Sapref, Enref, Natref and the Astron refinery (formerly Chevref)
2. **Synfuels assets**:
   - PetroSA's GTL plant (45 000 bpd), which processes and refines natural gas. PetroSA is facing the challenge of depleting gas supply and is currently not operational.
   - Sasol's Secunda CTL operations (160 000 bpd), which processes and refines coal and gas. The liquid fuels products are mainly produced via the Fischer-Tropsch process with coal as the key feedstock, resulting in liquid fuel with ~26 times higher carbon-intensity than conventionally refined crude. Sasol's GTC plant at Sasolburg is closely integrated into the synfuels production.

2019 GDP, respectively. Furthermore, in 2017 the sector accounted for ~169 000 direct and ~693 000 indirect jobs, whereby a quarter of the direct jobs are linked to Sasol (28 000), AECI (~8 000) and Omnia (~3 500).[18] Furthermore, the sector also mitigates the dependence on petrochemicals and chemicals imports, hence improving South Africa's balance of payments.

The petrochemicals and chemicals sector is a net importer today, particularly for refined products. For example, in 2019 ~US$14.8 bn and ~US$8.7 bn of liquid fuels were imported and exported respectively. For chemical products, in 2019, ~US$3.7 bn and ~US$1.8 bn of plastics and rubbers; and ~ US$9.3 bn and ~US$5.4 bn of chemicals, were imported and exported respectively.[19]

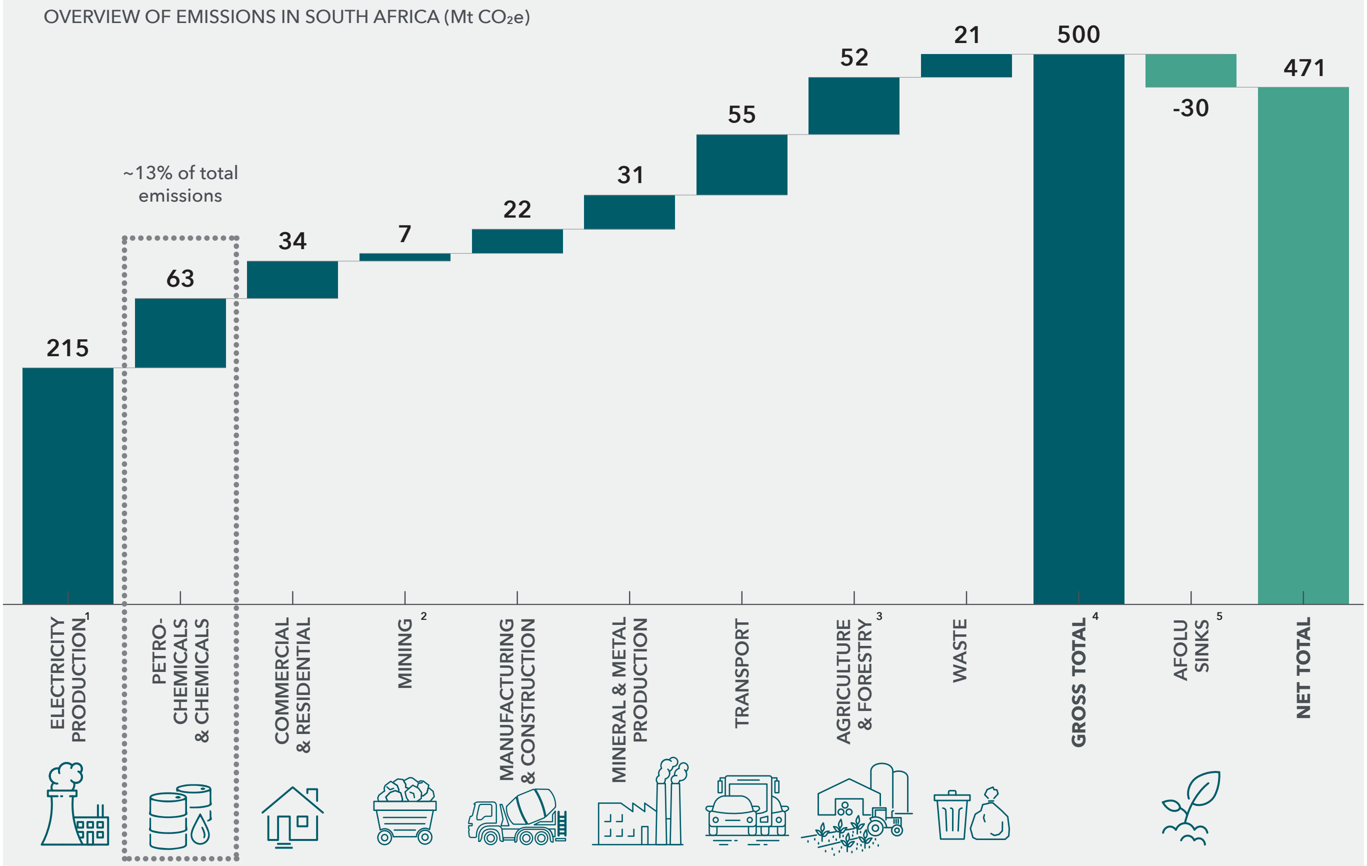
18 Oxford Economics; African Markets; S&P Capital IQ; Sasol; AECI; Omnia, BCG Analysis.
19 World Integrated Trade Solution. 2021.

Photo: Shutterstock.com – Caltex refinery. Milnerton, Western Cape

In 2018, 70% of chemicals, rubbers and plastics were exported to Sub-Saharan Africa (SSA), Europe and Central Asia, whereby SSA and Europe make up the largest destinations for South Africa's chemical products. The large dependence on Europe as a key off-taker of South Africa's chemical products highlights the risks of carbon-intense products in the context of a potential implementation of a European Union (EU) Carbon Border Adjustment Mechanism.

Figure 6: Overview of direct emissions per sector in South Africa (Mt CO_2e)

Direct emissions from the petrochemicals and chemicals sectors are responsible for ~13% South Africa's total gross emissions (as per latest Department of Forestry, Fisheries and the Environment estimate).



Notes:

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

2. The Greenhouse Gas Inventory (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 this was used to gross up to 100%.

3. Agriculture (~47 Mt, labelled as 'AFOLU excluding. FOLU' in GHGI) and energy emissions in Agriculture/Forestry/Fishing (~4 Mt).

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, gold, and PGMs mining, which are included in the mining sector emissions approximation.

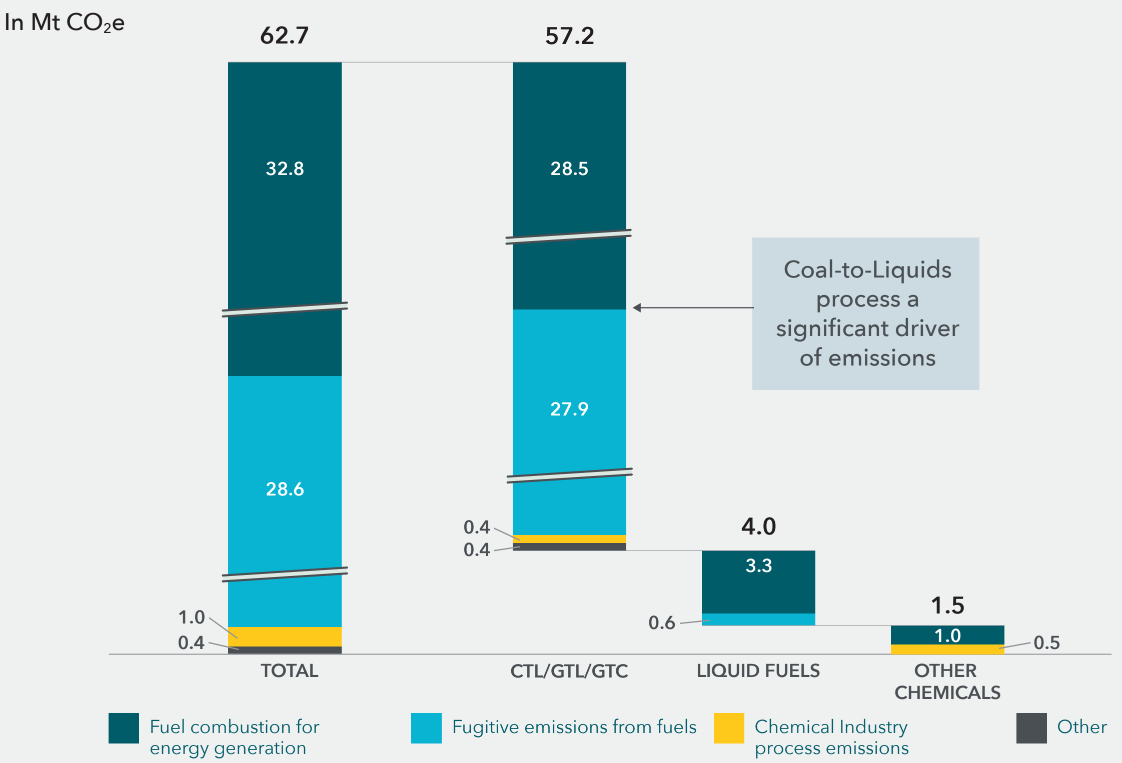
5. AFOLU sinks: FOLU (labelled as 'Land' in GHGI) + Other ('harvested wood products').

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

In the mid-term, the need for petrochemical imports could significantly increase. The reason for this lies in a growing liquid fuel supply and demand gap, caused by a potential shutdown of South Africa's refineries towards 2030. South Africa's four conventional crude refineries are aged and require significant investments of around ~ZAR60–70 bn for upgrades to ensure compliance with the Clean Fuels II Standard which will already be effective from 2023, and further investments to ensure competitiveness with the highly-efficient, large-scale refineries in the Middle East and Indian basin.

Figure 7: Emissions from South Africa's petrochemicals sector are primarily driven by CTL and GTC processes

In 2017, the petrochemicals sector produced ~63 Mt CO_2e, of which synfuels production accounted for ~57 Mt CO_2e.



Note: Other emissions (from wastewater treatment, mining) from CTL/GTL/GTC processes included to keep all of Sasol within petrochemicals.

Source: GHGI, 2017; Sasol Emissions Report, 2017.

***South Africa will be faced with different challenges in the petrochemicals and chemicals sector across timelines**: In the 2030s, South Africa could be facing the risk of weakened energy security, given a potential decline in domestic refinery capacity, due to decreasing competitiveness against imports, and regulatory compliance and feedstock supply risks. In the long-term, the sector will need to adapt to a changing demand landscape: Depending on the transport sector decarbonisation scenario, conventional liquid fuels demand could decrease by 50–100%, while conventional chemicals would eventually be substituted by decarbonised alternatives – also as a result of carbon border adjustment mechanisms – globally and in South Africa.*

The 120 000 barrels per day (bpd) Enref plant – South Africa's second largest crude refinery, contributing to ~20% of South Africa's domestic refining capacity – closed operations in 2020 due to a fire. Earlier in 2021, the decision was made that Enref would not reopen and instead be converted into a storage terminal.[20]

The 100 000 bpd Astron refinery (formerly Chevref) also closed after a fire in 2020 and is expected to stay shut until at least 2022. Whether it will start operating again is still uncertain.

Significant investments would need to be made to upgrade Sapref (180 000 bpd) and Natref (108 000 bpd) to comply with the Clean Fuels II Standard, which is to be implemented in 2023. The investments would be financially unsustainable, particularly in the current global refinery environment. Sasol and Total already voiced the consideration of closing or selling Natref if a repurposing

20 Roelf, W. 2021. South Africa's Engen refinery to be converted into a storage terminal. *Reuters*, 23 April 2021.

is not economically-viable. Royal Dutch Shell is currently reviewing its shareholding in the Sapref refinery, also leaving the future of the refinery uncertain.[21 22]

PetroSA (45 000 bpd) had to close operations due to a depleting gas supply. However, as a synthetic fuels facility, there may be an opportunity to repurpose it to produce green synthetic fuels, such as SAF, in the future.[23]

Hence, with Enref and Astron closed, already today ~43% (220 000 bpd out of 508 000 bpd in total) of South Africa's domestic conventional crude refining capacity is shut. Furthermore, the future of all refineries beyond the introduction of the Clean Fuels II Standard in 2023 is highly uncertain. Those local challenges, paired with the increasingly challenging and competitive global refining environment, could lead to a potential shutdown of all of South Africa's domestic refining capacity before 2030. This would increase the need for fuel imports in the mid-term, while the road transport sector is still dominated by internal combustion engines (ICE) and the main driver of liquid fuel demand in South Africa (see section 3.1.2). As a result, South Africa's energy security is at risk of being weakened in the mid-term.

3.1.2 A CHANGING DEMAND LANDSCAPE

> ***While in the mid-term, energy security needs to be maintained and the socio-economic risks associated with declining domestic refinery capacity and a potentially resulting negative balance of payment change managed, the changing demand landscape creates an opportunity for South Africa in the long-term:*** *South Africa could become a leading producer of green synthetic fuels and green chemicals, particularly e-ammonia and sustainable aviation fuel, for local demand and export, enabled by decarbonisation and conversion of South Africa's synfuels sector.*

Today, consumption of refined oil products[24] represents ~40% of global total energy demand and contributes 34% to global emissions. The global transport sector is the largest consumer. It drives ~60% of demand, where demand is mainly linked to the consumption of diesel and gasoline fuel in the road transport sector.[25]

Definitions of lower emission alternatives to conventional oil products

Low emissions fuels: These include liquid biofuels, biogas and biomethane, hydrogen and hydrogen-based fuels that do not emit any CO_2 from fossil fuels directly when used, and also emit very little when being produced (compared to conventional fossil fuels).

Synthetic methane: Low-carbon synthetic methane is produced through the methanation of low-carbon hydrogen and carbon dioxide from a biogenic or atmospheric source.

Biomethane: This is a near-pure source of methane produced either by upgrading biogas (a process that removes any CO_2 and other contaminants present in the biogas), or through the gasification of solid biomass followed by methanation. It is also known as renewable natural gas.

Liquid biofuels: Fuels derived from biomass or waste feedstocks, and include ethanol and biodiesel. They can be classified as conventional and advanced liquid biofuels according to the bioenergy feedstocks and technologies used to produce them and their respective maturity.

Hydrogen-based fuels/green synthetic fuels: Liquid fuels that include ammonia and synthetic hydrocarbons (both gases and liquids).

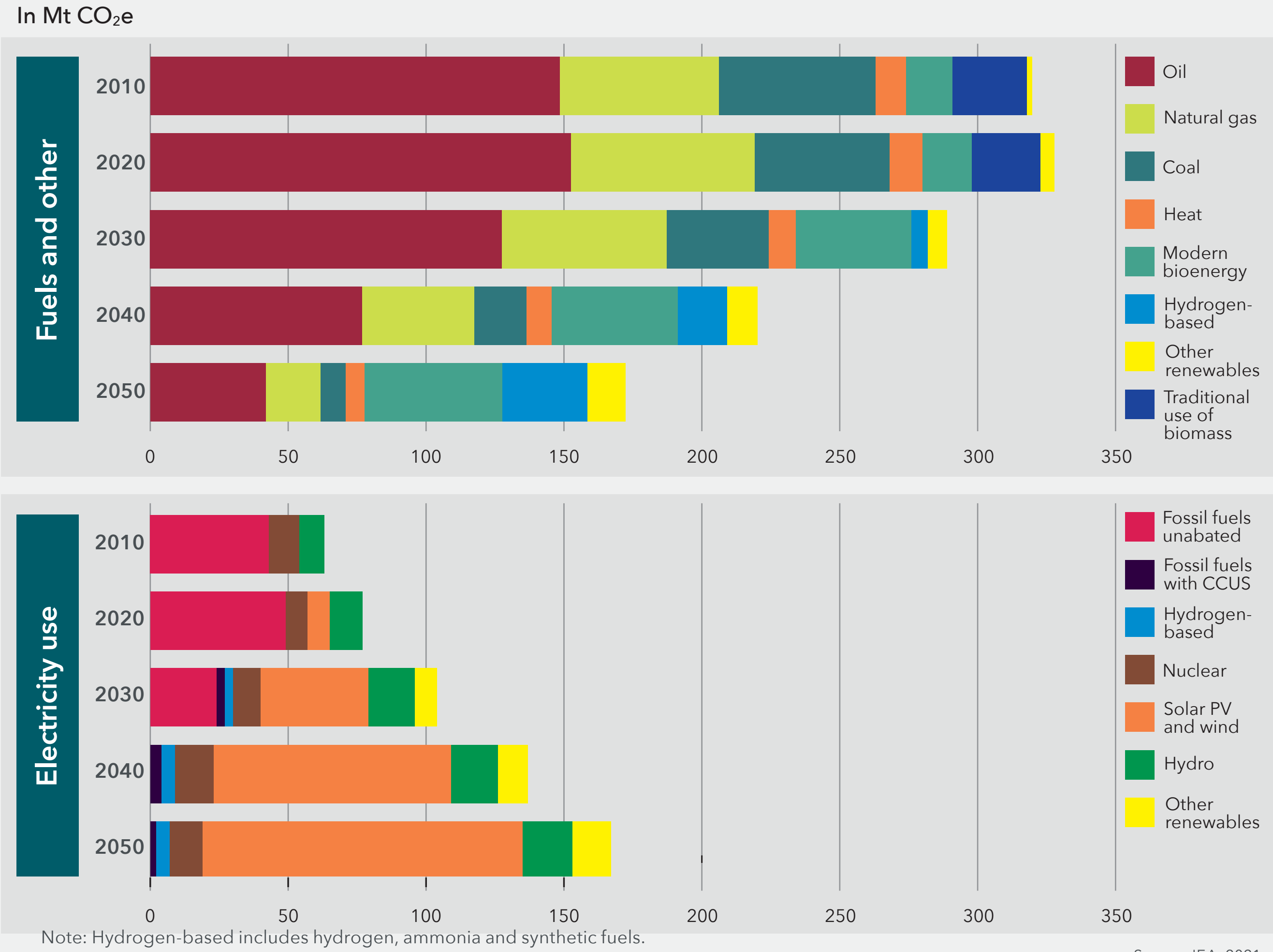
(Source: IEA.)

A similar picture exists in South Africa. South Africa's refined oil product demand was around 27 million tonnes oil equivalent (Mtoe) in 2018, with 75% of this demand being driven by diesel and gasoline consumption, mainly in the road transport sector. Consumption of refined oil products for non-energy use (e.g., as a feedstock in the petrochemicals sector) and in industry, were responsible for 14% and 7% of demand, respectively.[26 27] In 2020, consumption of refined oil products contributed to 15% of national emissions in South Africa, exceeded only by the consumption of coal, which drove ~82% of national emissions. Approximately 80% of this is driven by the transport sector alone. Achieving net-zero emissions in

21 Mills, E. 2021. South Africa's Sasol mulls Natref refinery's future. *Argus Media group*, 17 August 2021.
22 Bloomberg. 2021. Almost Half of South Africa's Oil Refining Seen Shut Until 2022, *Bloomberg*.
23 Roos and Wright. 2021. *EU-South Africa Partners for Growth – Powerfuels and Green Hydrogen*.
24 This includes, e.g., gasoline, diesel fuel, jet fuel, liquid petroleum gases, asphalt and asphalt products, other refined petroleum products.
25 IEA. 2021. *Data & Statistics*.
26 IEA. 2020. *World Energy Balances*.
27 SAPIA. 2020.

Figure 8: Global total final consumption by fuel in the IEA NZE scenario

The share of electricity in final use jumps from 20% in 2020 to 50% in 2050.



Note: Hydrogen-based includes hydrogen, ammonia and synthetic fuels.

Source: IEA, 2021.

2050 in South Africa, would require a shift away from conventional refined oil products particularly in the transport sector, towards carbon-neutral alternatives.

In its *Net Zero by 2050* report, the International Energy Agency (IEA) paints a picture of how global total final fuel consumption would change, if the world pursues an ambitious decarbonisation path to achieve net-zero emissions by 2050. In this scenario, fossil fuels only meet a small share of energy demand and are used predominantly in non-emitting processes or in facilities equipped with CCUS (Figure 8, it is important to note, that CCUS does not prove a viable option for carbon sequestration in South Africa yet (see "Deep dive: The feasibility of Carbon Capture Utilisation and Storage in South Africa" on page 40). In the IEA Net Zero Emissions Scenario (NZE) , global energy demand would mostly be met via 'net-zero compatible' energy carriers – such as renewable energy used to generate electricity, green synthetic fuels in vehicles (H_2, SAF, e-ammonia) and alternate vehicle technologies (e.g.,batteries).

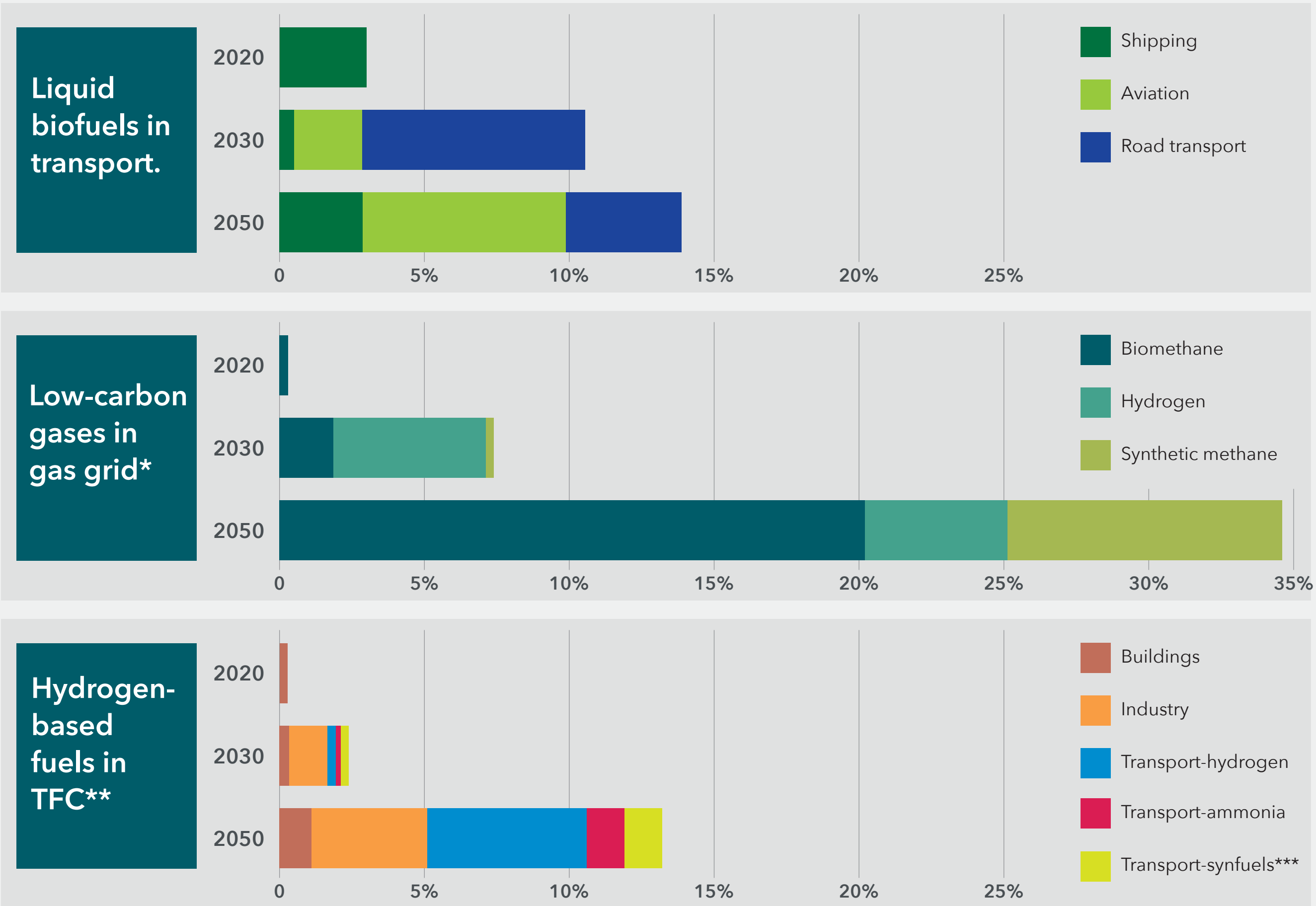
The IEA expects the demand for lower emission fuels as alternatives to conventional liquid fuels to increase in the mid- to longer-term. Lower emission fuels would help to achieve decarbonisation across sectors where direct electrification is not feasible. This includes for example, a significant uptake of liquid biofuels in the shipping and aviation space, hydrogen-based fuels particularly in the transport (including shipping and aviation) and industry sectors and bio- and synthetic methane and hydrogen for heating purposes in gas grids (Figure 9).

While the demand for chemicals – particularly methanol, ammonia and high-value chemicals – is expected to increase, life cycle emissions linked to chemicals will need to be reduced. This will also require a significant decrease of the use of conventional refined oil products

Figure 9: In a global net-zero scenario, demand for low- and zero-carbon fuels grows significantly across sectors

Low emissions fuels in the form of liquid biofuels, biomethane, hydrogen-based fuels help to decarbonise sectors where direct electrification is challenging.

Global supply of low emissions fuels by sector in the NZE



Notes: * Low-carbon gases in the grid refers to the blending of biomethane, hydrogen and synthetic methane with natural gas in a gas network for use in buildings, industry, transport and electricity generation.
** TFC: Total Final Consumption.
*** Synfuels refer to synthetic hydrocarbon fuels produced from hydrogen and CO_2.
Final energy consumption includes, in addition to the final energy consumption of hydrogen, ammonia and synthetic hydrocarbon fuels, the on-site hydrogen production in the industry sector.

Source: IEA, 2021.

as a feedstock for the production of chemicals in a transition towards net-zero. While conventional liquid fuel consumption reduces drastically in the IEA NZE, some oil consumption remains in a net-zero 2050 world. The IEA sees most of the remaining oil consumption linked to the use as feedstock in the production of non-energy goods, such as lubricants, paraffin waxes, bitumen and asphalt which 'seal' the carbon and do not lead to direct emissions in their use. The production of those products does not require combustion, hence does not create direct process emissions.[28]

In South Africa, the change in the demand landscape is expected to look similar – albeit at a potentially different pace. While in the mid-term, driven by potential shutdowns of the local refining capacity, demand for import of conventional liquid fuels could grow – mainly linked to conventional liquid fuel demand in the road transport

28 IEA. 2021. *Net Zero by 2050 – A Roadmap for the Global Energy Sector.*

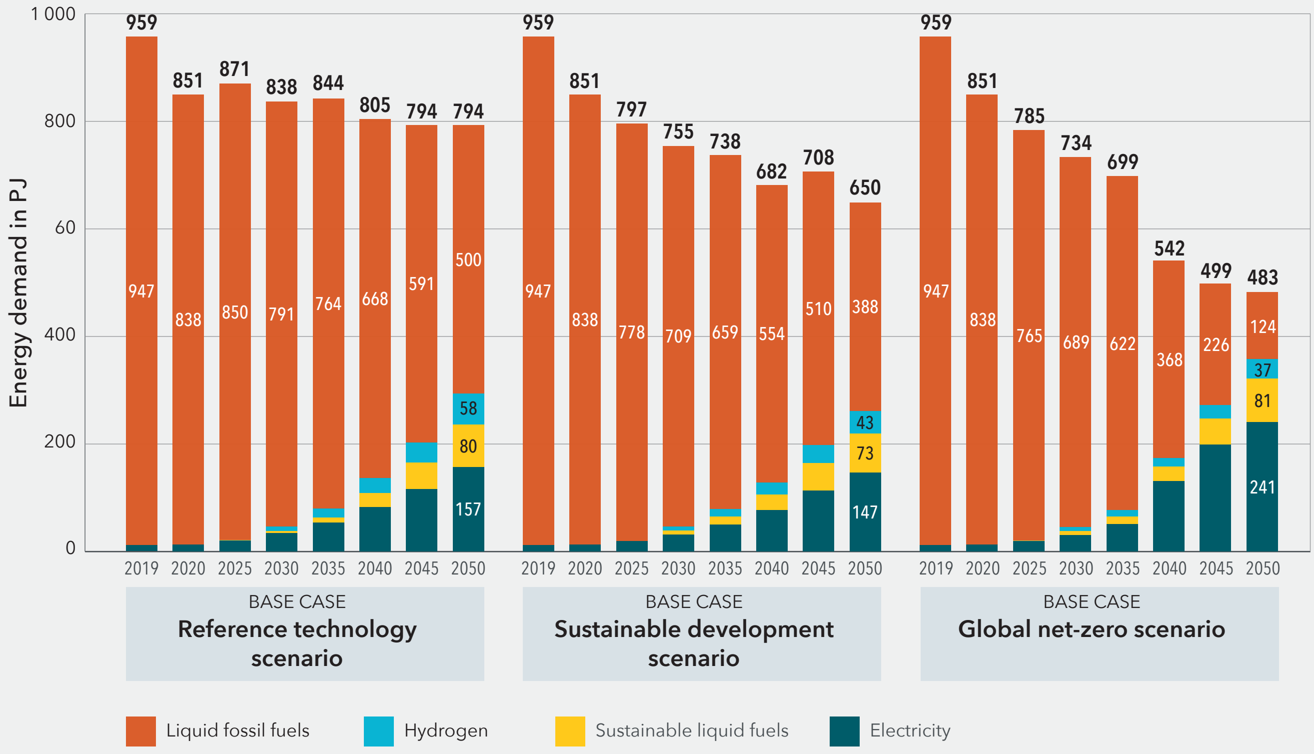
sector, the long-term trend is away from conventional liquid fuels towards greener, sustainable alternatives, mainly driven by the decarbonisation of South Africa's transport sector, which currently drives 75% of South Africa's liquid fuel demand.

Considering a less ambitious transport decarbonisation scenario: In 2050, South African demand for conventional liquid fuels could have declined by at least 50%, assuming South Africa is not driving decarbonisation actively and change is driven by a moderate global decarbonisation scenario (anchored in the IEA's Reference Technology Scenario (RTS) – compatible with a global temperature increase of 3 °C). In this less ambitious decarbonisation scenario linked to the IEA RTS, zero emission vehicles (ZEV)[29] reach ~60% of the passenger and commercial vehicle parc in South Africa by 2050. This is driven by, for example, global techno-economic improvements in ZEV technology and increasingly ZEV-favouring regulation in major markets, such as the United States (US) and the European Union (EU). In this less ambitious decarbonisation scenario, only 5 million ICE and hybrid vehicles remain by 2050, despite a vehicle parc growing from 11 million to 16 million vehicles. The effect on the conventional liquid fuels demand is a 50% decline to 13 billion litres (500 petajoules (PJ)). In comparison, the annual electricity demand in transport increases by more than four times, from 10 TWh to 45 TWh per year by 2050, while H_2 demand picks up to at least 60 000 tonnes – driven by 10 million ZEVs on the road by 2050 (Figure 10).

Figure 10: Liquid fuels demand in South Africa after the transport sector's decarbonisation

Liquid fuels demand will decrease by at least 50% by 2050 in South Africa due to the transport sector's decarbonisation.

This analysis includes energy demand from domestic aviation, rail, and road transport.



Note: Liquid fossil fuels refers to conventional diesel, petrol, LNG and jet-kerosene; Sustainable liquid fuels or sustainable aviation fuel (SAF) refers to synthetic jet-kerosene.

Source: eNatis; ICCT; IEA; IHS Markit; Marklines; NAAMSA; BCG battery model; NBI-BCG project team.

29 ZEV include battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEVs) – hence vehicles which do not produce any emissions (direct emissions) when used. (Parc refers to total number of vehicles registered at a point in time in a country.)

Considering the most ambitious transport decarbonisation scenario: In a most ambitious, global net-zero scenario (anchored in the IEA's NZE), where South Africa also pushes decarbonisation actively across sectors, conventional liquid fuels demand could decrease by close to 100%. This despite growing demand for passenger and commercial transport linked to a growing population and economy – given that in this future scenario increased transport demand is met via decarbonised technologies and fuels.

In this scenario, South Africa's conventional liquid fuels demand drops to 3 billion litres (120 PJ) by 2050 – which is a ~90% reduction based on today's liquid fuel consumption in the sector. This is driven by two factors:

- Firstly, a decreased demand in road transport, linked to lasting global behavioural changes in mobility, increased modal shifts, and efficiency gains in transport, inhibit further vehicle parc growth.
- Secondly, higher uptake of ZEVs across passenger and commercial vehicles, linked to earlier techno-economic competitiveness of the technology, reducing the ICE vehicle parc further, with only 1 million ICE and hybrid vehicles remaining by 2050 as adoption of ZEVs accelerates, with 10 million ZEVs by 2050 (only 0.7 million ZEVs by 2030).

On top of global decarbonisation trends, South Africa's transport sector will require a combination of extensive local policy and incentives with private sector action to fully decarbonise. If South Africa actively drives 100% ZEV adoption by 2050, the decline of conventional liquid fuels demand could well reach 100% by 2050.

Therefore, both globally and in South Africa, the demand landscape for petrochemicals and chemicals will significantly change, if ambitious decarbonisation efforts are pursued across sectors. In this move away from conventional to lower and zero emissions petrochemicals and chemicals, H_2 will play a critical role. Lower emissions and zero emissions (green) H_2 will serve as the basis for lower emissions petrochemicals and chemicals, such as e-ammonia, SAF and e-methanol. The global H_2 demand could reach 300–500 Mt by 2050, and the IEA estimates that ~62% of this demand would be met via green H_2, the remainder via H_2 production equipped with CCUS.[30]

The role of lower and zero emissions H_2 and hydrogen-based products in sector-wide decarbonisation becomes evident in the growing global momentum around H_2.

Several countries have already developed national H_2 strategies. Some countries are emphasising the need for imports of hydrogen-based products due to limited and costly local production in their strategies. This includes, in particular, the EU and its member states and Japan. Today, Germany, the Netherlands and Japan emerge as the first markets, with concrete import targets of around ~25–30 Mt of H_2 by 2050.[31] On the other hand, countries such as Australia, Chile and Saudi Arabia are positioning themselves as future, leading suppliers of H_2 products, given their competitive advantage in the production of low-cost lower and zero emissions H_2.

Furthermore, South Africa's neighbours are also positioning themselves as potential future green H_2 product suppliers. For example, Namibia has already established a partnership with the German government with the intent to jointly build up Namibia's renewables and green H_2 production potential.[32] In this context and in the context of climate impacts on balance of payments it is critical that the South African chemicals sector strongly considers investment in H_2 infrastructure.

3.1.3 SOUTH AFRICA'S GREEN FUELS AND GREEN CHEMICALS OPPORTUNITY

> ***South Africa's opportunity in the production of green fuels and chemicals is based on a competitive advantage in the production of green H_2 and synthetic fuels****: First, South Africa has some of the best solar and wind resources on the planet; second; it has sufficient land and access to seawater for desalination, which can also serve a dual purpose of improving water security; and third, it has unique Fischer-Tropsch technology for beneficiation of H_2 into hydrocarbons, such as e-methanol and SAF.*

As the world pursues decarbonisation efforts across sectors, demand for conventional petrochemicals and chemicals will decline and demand for lower and zero emissions alternatives will increase. As discussed, the same development is expected in South Africa. The pace will largely depend on how much South Africa will actively drive decarbonisation efforts. The global, but also local, move towards hydrogen-based products in particular, opens up an opportunity for South Africa: South Africa is well-positioned to produce green H_2 and hydrogen-based products at scale in the future. This includes, Power-to-X (PtX) products, such as green hydrocarbons (e.g., SAF, e-methanol) and e-ammonia. This competitive advantage

30 300 Mt and 500 Mt correspond to the IEA Sustainable Development Scenario (SDS) and IEA Net Zero Scenario (NZE), respectively.

31 See countries' hydrogen strategies.

32 German Federal Ministry of Education and Research. 2021. Press Briefing.

in the production of green H_2 and related products is anchored in three aspects.

Firstly, South Africa is endowed with a distinctive, 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. South Africa's dedicated Renewable Energy Development Zones (REDZ) alone can hold ~922 GW capacity. 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.[33] The high renewable energy potential allows for competitive Levelised Cost of H_2 (LCOH) by the early 2030s: LCOH of ~US$1.6/kg (~US$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 (~US$1.6/kg) and Saudi Arabia (~US$1.5/kg).

Secondly, South Africa is endowed with significant amounts of unused land which could be leveraged for green H2 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). In comparison, producing a hypothetical 10 Mt of green H_2 (~1 330 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, seawater and other non-potable water resources. The deployment of desalination plants would only add marginal cost to the overall LCOH (~0.005–0.01 US$/kg green H_2).[34]

Thirdly, 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 hydrogen-based chemicals and fuels, and local use cases for green H_2 and H_2-products. South Africa has a globally unique expertise in the Fischer-Tropsch technology, including existing assets, such as Sasol's Secunda facility and the PetroSA GTL plant. The Fischer-Tropsch process is critical in the production of synthetic hydrocarbons like SAF. The expertise and physical infrastructure give 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 e-ammonia, e-methanol and SAF, into a growing global market for green fuels and green chemicals.

Green fuels and chemicals

The production of green fuels, i.e., fuels which do not effectively increase CO_2 in the atmosphere when produced and combusted, requires the substitution of fossil fuel feedstock with sustainable sources of carbon and decarbonisation of the production process. For example, synthetic hydrocarbons which are produced via leveraging green H_2 and sustainable sources of carbon (e.g., biomass, carbon captured from the atmosphere via direct air carbon capture), where production is powered via renewables, would result in a fuel which – when produced and combusted – does not effectively increase CO_2 in the atmosphere. Another example is green ammonia (e-ammonia), which could be used as an alternative, sustainable fuel for shipping. However, the production of ammonia would require the use of green H_2 and a move away from the conventional, carbon-intense ammonia production process.

As laid out in the IEA report, *Net Zero by 2050 – A Roadmap for the Global Energy Sector*, for the production of chemicals in a net-zero scenario, fossil fuel feedstock could still play a role, where the produced chemicals 'seal' the CO_2. This includes, for example, products such as asphalt, bitumen, paraffin waxes and lubricants. The production of those chemicals does not include the combustion of fossil fuel and hence does not generate direct process emissions (if appropriate end-of-product life measures are taken, e.g., no incineration).

33 Not including storage, however, the installed wind and solar capacity provide excess electricity at some points, which is stored.

34 Note: Assumes that desalination plant and end user are near the source of the water being processed. Water could be desalinated at the coast and then piped inland (however, infrastructure adequacy and availability are uncertain and costs would need to be analysed), or inland industrial and mining wastewater (and water currently used for coal power plants) could be treated at/near the site of the inland end user, reducing the water transmission cost but potentially requiring more treatment steps.

In the light of the changing demand landscape, globally and in South Africa, the country should explore its opportunity in the production of green hydrogen and related products and ensure long-term competitiveness of its petrochemicals and chemicals sector by transforming it into a green fuels and green chemicals hub for local and international markets. This would entail production of green H_2 for local consumption and as a feedstock for the production of H_2 products, such as e-ammonia, SAF, e-methanol, and other hydrogen-based chemicals – both for local consumption and for export.

Key trade partners and future global demand nodes for H_2 products are already considering South Africa as a potential supplier. For example, Germany, which has recently launched its 'H_2Global' programme with the aim to secure future H_2 product supply, has already demonstrated clear interest in partnering with South Africa in that space. In June 2021, German development bank KfW launched a programme on behalf of the German government of EUR200 million to support the development of green H_2 projects in South Africa.[35 36]

> ***Decarbonising South Africa's synfuels production will not just support the transition to the production of green fuels and chemicals, it will also be critical to reduce South Africa's overall emissions footprint and the carbon intensity*** *of locally produced chemicals – given that today's coal-based synfuels sector drives ~90% of the petrochemicals and chemicals sector's emissions, and constitutes a key supplier of feedstock for local downstream chemicals production.*

3.1.4 DECARBONISING THE SOUTH AFRICAN PETROCHEMICALS AND CHEMICALS SECTOR

> ***The ability to decarbonise the petrochemicals and chemicals sector will depend on access to key technologies and feedstocks****: Full decarbonisation of the existing synfuels production requires access to green H_2 at scale below a price of US\$2/kg and sustainable carbon feedstocks, supplied via, for example biomass and – potentially in the long-term – DACC. For gas to support the decarbonisation as a transition feedstock, gas prices would need to be secured at an economically-viable level.*

The conventional local crude refineries could have shut down beyond 2030. As argued before, already by 2023 South Africa could see all its local crude refineries shut down, if alternative, lower emissions operations and production are not realisable. If the local refineries – including the PetroSA GTL asset – would shut down, almost 80% of South Africa's domestic refining capacity would have disappeared, but only ~6% of the sector's emissions. Roughly 2% of emissions would remain from the downstream chemicals sector. However, the bulk of the remaining emissions is linked to South Africa's synfuels production, which drives ~90% of the sector's overall emissions baseline. The full decarbonisation of the sector would hence either require full decarbonisation of the synfuels assets, or – while emission reduction measures are implemented – their eventual closure by 2050, if a net-zero 2050 target is pursued.

Decarbonising the upstream petrochemicals sector

Decarbonisation of South Africa's synfuels production removes ~90% of the petrochemicals and chemicals sector emissions while decarbonising feedstock for downstream chemicals production. However, it also opens up the opportunity for South Africa to establish production capacity for green fuels and green chemicals, by repurposing and converting existing synfuels assets, and to become a leading supplier for green fuels and green chemicals for local and global demand. In this way, South Africa's petrochemicals and chemicals sector could support the country's transition towards a net-zero economy while realising a significant economic opportunity.

In this context, the following analysis focuses on the decarbonisation and conversion of South Africa's existing synfuels assets, aiming to leverage South Africa's existing unique expertise and technology in the production of synfuels, and to protect the synfuels sector's significant socio-economic contribution to South Africa. While the analysis focuses on the conversion of Sasol's synfuels operations, it is important to note that PetroSA, located near the port of Mossel Bay, could also play a role in the production of green synfuels. If proven techno-economically feasible, the plant could be revived and converted to a synfuels production asset, with production primarily destined for export via Mossel Bay port. To determine the role PetroSA could play, further analysis around the feasibility of conversion needs to be conducted.

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35 Federal Ministry of Economic Affairs and Energy. 2021. *Weiterer Baustein der Nationalen Wasserstoffstrategie umgesetzt: Neues Instrument H2Global geht an den Start.*

36 CSIR. 2021.

Disruptive technologies, which are currently either at early maturity stages, and feedstock – for which availability, accessibility and affordability is at present uncertain – will need to be unlocked to enable the conversion of the existing synfuels assets and for the decarbonisation of the downstream chemicals value chain:

1. **Deployment of renewable energy, including energy storage at large scale** will need to be enabled already within the 2020s, to drive early decarbonisation of electricity consumption. In addition to renewable energy deployment, **energy- and process-efficiency improvement** will need to be enabled to support and further drive early emissions reduction.

2. **Access to green H_2 and sustainable sources of carbon at scale** will be critical to enable the phase-out of fossil fuel feedstock. Biomass could serve as the major sustainable source of carbon particularly in the mid-term (see "Deep dive: Biomass as a sustainable source of carbon in South Africa" on page 34). CO_2 captured from industrial applications via CCU could also be leveraged as an interim solution to acquiring carbon feedstock and supporting the phase-out of coal.

   In addition, sustainable carbon could also be sourced via DACC. However, DACC is still in its early development stages (in 2021 variable OPEX is estimated at ~ZAR2 900/t CO_2e and projected to be ~ZAR1 600/t CO_2e in 2050) and would need to further mature to become techno-economically viable – therefore, it is only considered as an additional sustainable source of carbon in the distant future.

3. **Availability of CCUS** will be important to achieve further emission reduction over the course of the transition towards net-zero operations, hence for the periods where fossil fuel feedstock is not yet completely phased-out.

4. **Introduction of gas for the phase-out of coal feedstock** could support the decarbonisation of the sector. However, towards 2050, gas use would need to ramp-down to zero, or the remaining usage limited to the production of non-combustible products. Furthermore, while gas feedstock is still used on a large scale, process emissions would need to be captured via CCUS technology.

   It is important to note, that the current gas supply from Pande-Temane into the sector will start to decline from the mid to late 2020s. Hence, if no new gas supply can be secured at affordable prices, gas will phase-out of the sector in the 2030s. However, Sasol announced its net-zero commitment at its 2021 Capital Markets Day, stating the role of gas in the phase-out of its coal feedstock. This would require the unlocking of new gas supply in the 2030s.

It is important to mention, that South Africa has updated its Nationally Determined Contributions (NDC) and now aims to reach a peak and following decline in national emissions by 2025 – earlier than in its initial NDC. Hence, to reach this ambition, particularly the synfuels sector – alongside the power sector – would need to drive first emission reductions by that time.

Deep dive: Biomass as a sustainable source of carbon in South Africa

Production of low- and zero-carbon fuels and chemicals will require sustainable sources of carbon. Biomass, alongside captured carbon via CCU and DACC, could serve as a sustainable source of carbon. Three types of biomass are usually considered:

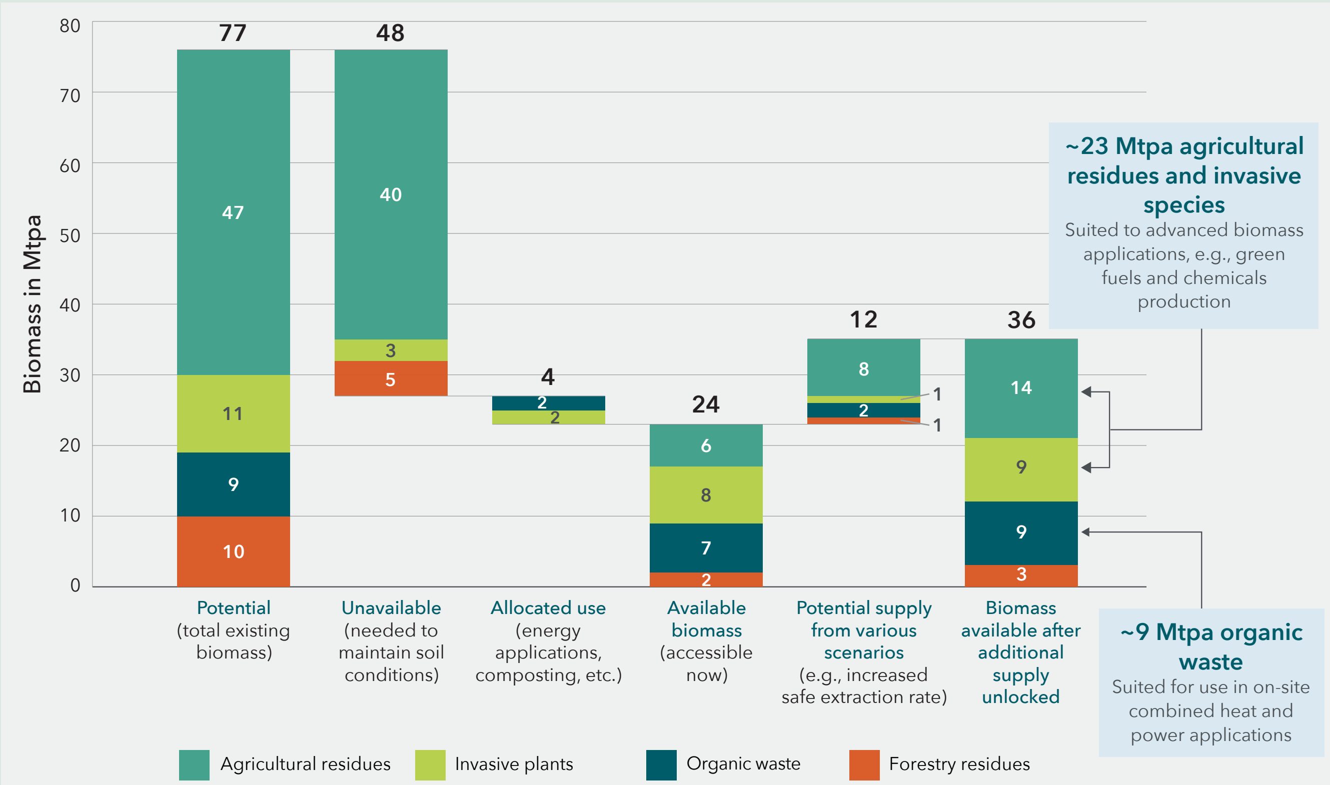
- **First generation biomass**: Agricultural crops grown on arable land (e.g., corn, soybeans, sugar cane).
- **Second generation biomass**: Sustainable biomass sources that do not result in land use change or compete with food crops. This includes non-edible agricultural waste (e.g., maize, sugar cane); invasive alien plants (e.g., prickly pear, eucalyptus); organic waste (e.g., sewerage, wastewater, solid waste); and forestry waste (e.g., sawmill, plantation, pulp and paper waste.
- **Third generation biomass**: Algae engineered to harvest oil, produced in ponds, tanks or the sea.

While **first generation biomass** has previously played a large role in the production of lower-carbon fuels, it is no longer seen as the main source of biomass, given that it poses a risk to food security and food prices due to direct competition with food crops. The EU for example, emphasises in its Renewable Energy Directive II and certification bodies requirements, that the use of biomass should 'maintain food security', which would already exclude a large scope of first-generation biomass – particularly in a future where populations and hence food demand grow. **Third generation biomass** is currently still techno-economically unfeasible and questioned with regards to its sustainability. Therefore, **second generation biomass** is the most promising and relevant biomass source today and in the short- and mid-term future.

It is important to note, that if biomass is used in synthetic processes, the carbon content of biomass will be an important metric, which determines how much biomass will be actually required to meet the carbon demand of the respective industrial process. Hence, the higher the carbon content of the considered biomass, the less biomass will be required if compared to biomass with very low-carbon content.

Currently, there is a significant lack of data and analysis around the availability of second generation biomass in South Africa. Based on currently available data, second

Figure 11: In South Africa, main sources of second generation biomass are organic waste, agricultural residue and invasive species



Source: The BioEnergy Atlas for South Africa.

generation biomass in South Africa is mainly anchored in organic waste, agricultural residue and invasive species amounting to ~77 Mtpa accessible biomass. Hence, biomass that is not yet used on-site or needed to maintain soil conditions, is estimated to be around ~24–36 Mtpa (Figure 11). Agricultural residue is predominantly maize residue within a ~500 km region in the eastern Highveld, whereby only ~15% of those are estimated to be available for collection. Invasive species are primarily located in sparsely populated areas in KwaZulu-Natal, the Eastern Cape and Mpumalanga. Organic waste is mostly produced in major urban regions in Johannesburg, Pretoria, Durban and Cape Town. Forestry residue is mainly concentrated in KwaZulu-Natal and eastern Mpumalanga. Regional, cross-border availability of second generation biomass is uncertain given lack of data (Figure 12).

Alone, ~15–20 Mtpa of biomass would be needed to decarbonise the existing CTL synfuels plant – provided CCU (e.g., use of carbon from other industrial emission sources) and green H_2 are introduced at scale. Without CCU (or other, alternative carbon sources, such as atmospheric carbon via DACC) and green H_2, the biomass demand would increase to ~40–45 Mtpa biomass (assuming a 30% carbon content of biomass). Hence, the current 24–36 Mtpa accessible biomass potential could serve this demand, but only if additional, alternative sources of carbon (e.g., via CCU, DACC) and green H_2 are unlocked.

Three key challenges need to be addressed to leverage second generation biomass as a sustainable carbon source in South Africa:

- First, there is a lack of data and analysis around the availability and accessibility (e.g., how much biomass can be extracted from the soil without causing soil degradation or reducing the soils capacity to capture carbon) of second generation biomass in South Africa and regionally. Further studies need to be conducted to close the current data gap.
- Second, the local impact of climate change needs to be considered in the continued assessment of second generation biomass availability and measures taken to ensure sufficient second biomass availability. Policy measures which unlock further biomass supply should also be considered to expand the scale of biomass available for industrial use.
- Third, if better certainty around the availability and accessibility of second generation biomass is established, infrastructure and services need to be established which collect, process and transport the biomass to the respective end users. It will be important to assess the carbon footprint associated with the required logistics. Collection of biomass will be a challenge, given the multiple, dispersed locations of biomass sources. Processing biomass will be critical, given that it is not in a form where it can be fed directly into the respective industrial processes. However, collection, processing and transport of biomass could also create new job opportunities.

Figure 12: Location of second generation biomass in South Africa based on available data

Agricultural residue

- Predominantly maize residues within ~500 km region on the eastern Highveld
- Only ~15% of residue available for collection

Invasive species

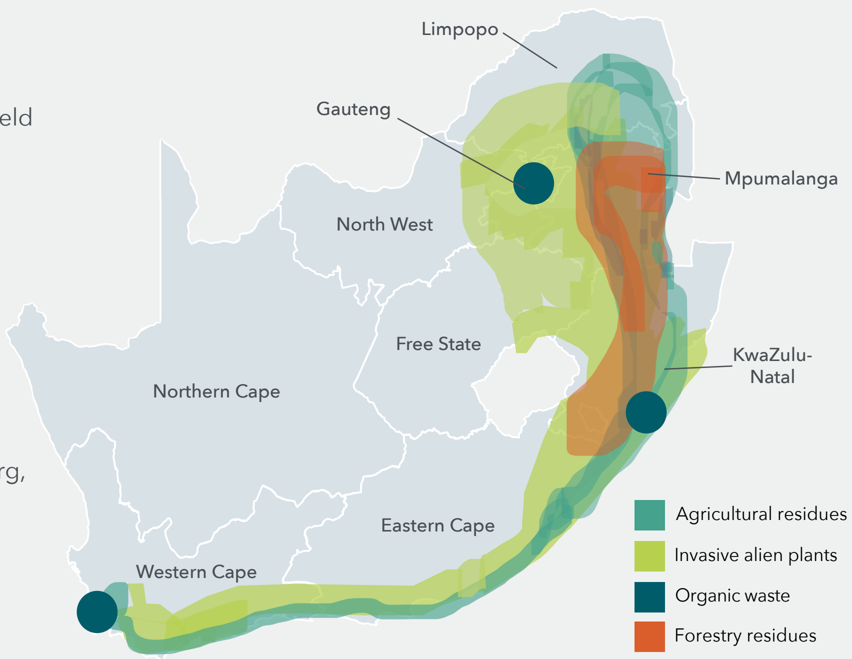
- Primarily in sparsely populated rural areas in KwaZulu-Natal, Eastern Cape and eastern Mpumalanga

Organic waste

- Mostly in urban regions (Johannesburg, Pretoria, Durban and Cape Town)

Forestry residues

- Largely in KwaZulu-Natal and eastern Mpumalanga



Source: The BioEnergy Atlas for South Africa; Department of Forestry, Fisheries and Environment; StatsSA census of commercial agriculture, 2017.

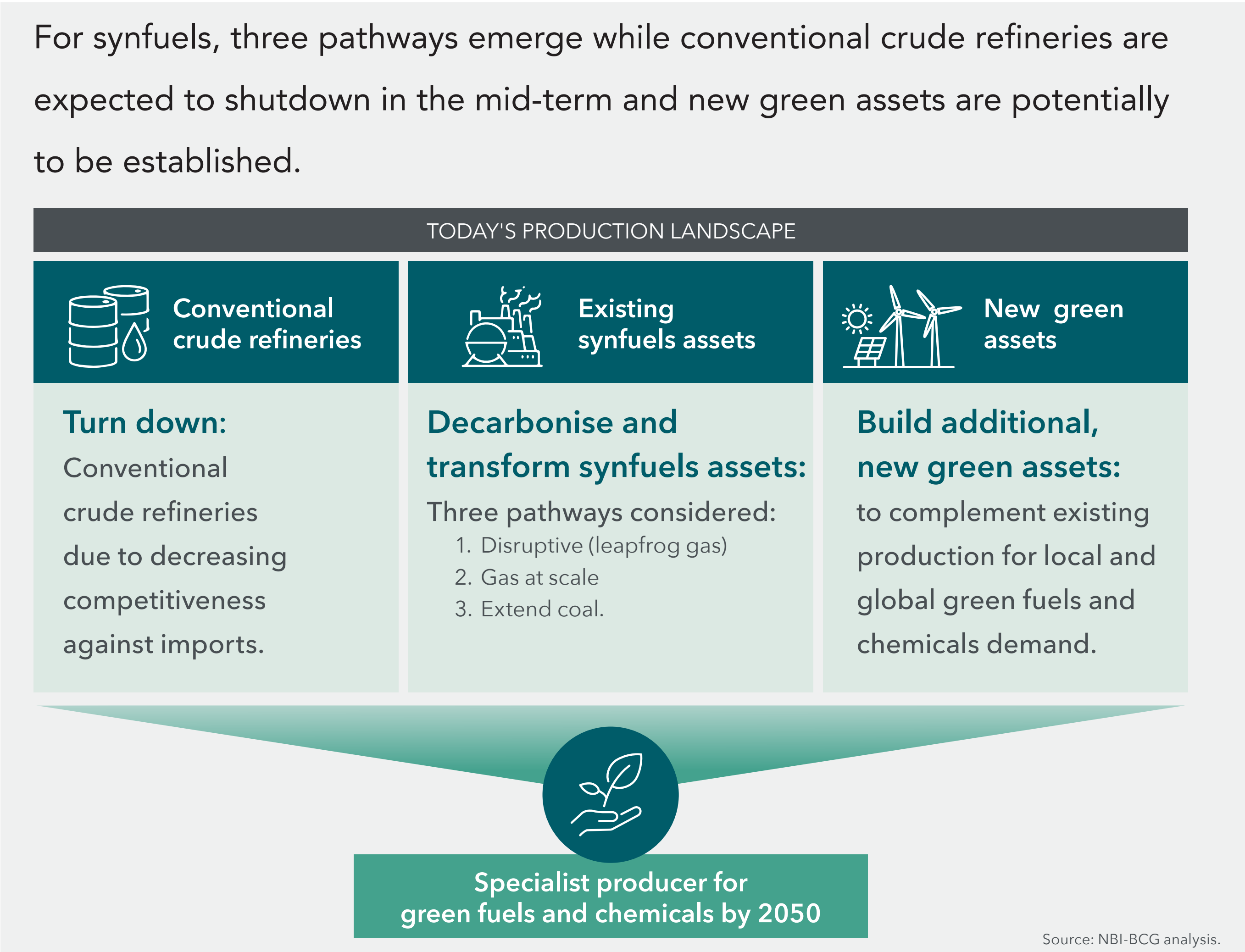
High uncertainty exists around the feasibility of unlocking green H_2, sustainable sources of carbon, CCUS and DACC and affordable gas supply. Disruptive technology, such as green H_2, CCUS and DACC are still in their early development phases and need to further mature from a techno-economic perspective.

Green H_2 would need to be unlocked at US$2/kg for it to be an economically-feasible alternative feedstock in South Africa's synfuels sector.[37] By 2030, LCOH of ~US$1.6/kg (~US$13.3/GJ) could already be realised – however, unlocking this green H_2 production potential requires cheap financing and a conducive policy framework informed by a national green H_2 strategy.

Sustainable sources of carbon need to be identified and unlocked – locally and regionally available second generation biomass could play an important role. Alone ~15–20 Mtpa of biomass would be needed to decarbonise the existing CTL synfuels plant – provided CCU (e.g., use of carbon from other industrial emission sources) and H_2 are introduced at scale. Without CCU (or other, alternative carbon sources, such as atmospheric carbon via DACC) and green H_2, the biomass demand would increase to ~40–45 Mtpa biomass (assuming a 30% carbon content of biomass). As mentioned earlier, for gas to play a role in decarbonising the sector, gas supply would need to be secured at the required affordability threshold.

Therefore, various decarbonisation pathways could emerge for the sector, depending on whether and when those technologies and feedstock become accessible. In this analysis, three pathways were considered, which assume different scenarios regarding the availability of the relevant technologies and feedstock. All three synfuels

Figure 13: Considered pathways for the upstream petrochemicals sector



Source: NBI-BCG analysis.

37 To put this into perspective, today's green H_2 prices are significantly higher. Depending on the considered location, today's green H_2 LCOH are for example: ~US$3.80/kg in Gqeberha (formerly Port Elizabeth), in ~US$3.90/kg in the Renewable Energy Development Zone 4, in an optimal part of Namibia it is ~US$3.10/kg, in Secunda it is ~US$5/kg. But these costs are projected to decrease rapidly over the next couple years, mainly due to sharp learning curves for renewable energy and electrolysers.

decarbonisation pathways are similar in the 2020s, where the focus lies on large-scale renewables deployment and energy and process efficiency improvements. However, beyond 2030, the pathways differ – based on different assumptions around the availability of the required technologies and feedstock. All pathways converge again in the 2050s, where net-zero compatible operations need to have been established and remaining carbon-intense, emitting operations closed. In addition to converting existing assets, new, green assets could be built in the interim to increase local production capacity, based on the growing local and global demand (Figure 13).

> ***Depending on the timing of availability and affordability of disruptive technology and lower emissions feedstock, such as CCUS, DACC, green H_2, biomass and gas, different pathways towards net-zero synfuels production exist****; whereby cumulative emissions range between 0.6–1.2 Gt CO_2e, but socio-economic trade-offs differ significantly across pathways with regards to, for example, timing and scale of investment requirements, impact on production cost, job impact across the sector's and adjacent value chains, and the speed at which green production can be achieved.*

Green H_2 and sustainable sources of carbon unlocked at scale in the early 2030s: The 'disruptive' pathway would require large-scale renewable energy deployment and efficiency improvements in the 2020s, followed by a shift to green production in the 2030s.

- To enable an early move to complete decarbonisation of synfuels production and products, green H_2 and sustainable carbon sources – for example, via biomass and DACC – would need to be unlocked at scale in the early 2030s, while coal feedstock would be phased out in parallel and completely removed by latest 2040.
- This pathway would not require the introduction of gas at scale to replace coal. Gas, which is currently used as feedstock on a relatively small scale (compared to coal), would have phased out by 2030, due to the uptake of green technology and feedstock and a depletion of the currently leveraged gas supply sources.
- Overall, the pathway could result in ~0.6–1.0 Gt CO_2e cumulative emissions, assuming that gas is completely phased out by the 2030s coal by latest 2040, and green feedstock (green H_2 and biomass) is ramped up from mid-2030 onwards.

Green H_2 and sustainable sources of carbon will only be unlocked towards the 2040s and gas can be secured at contract term rates: A coal phase-out could be achieved via substitution with gas – implying a significant ramp-up of gas intake should it be at an affordable rate. If not, volume uptake is constrained. This pathway would also require large-scale renewable energy deployment and efficiency improvements in the 2020s, followed by the introduction of 'gas at scale' by the early 2030s, which would enable a gradual, but eventually complete phase-out of coal.

- Green H_2 and sustainable carbon sources would need to be introduced along the way to enable further emissions reduction and further scaled-up towards 2050, to eventually achieve fully decarbonised production.
- This 'gas at scale' pathway would result in significant decarbonisation in the mid-term and the production of lower-carbon products. To achieve fully decarbonised production, gas would need to be completely phased out by 2050. This pathway could result in a gradual decline of process emissions in the 2030s–2040s, driven by a phase-out of coal and the scale-up of gas as a feedstock – this in combination with renewables deployment, process and energy-efficiency improvements and potential deployment of CCUS. However, further significant process emissions reduction and a shift to green production would only be achieved post–2040s, where gas is eventually phased out (or remaining gas feedstock used exclusively in the production of non-energy goods and non-emitting processes) and the use of green H_2 and sustainable sources of carbon scaled-up.
- A 'gas at scale' pathway could result in ~1.0–1.2 Gt CO_2e cumulative emissions until 2050, assuming that gas is introduced at scale from the early 2030s onwards, halving coal consumption by the mid-2030s and completely phasing coal out by the late 2040s, while green feedstock ramps up from the mid-2040s onwards.

Green H_2, sustainable sources of carbon or gas cannot be unlocked before 2040: A third pathway exists in theory, which implies an extended use of coal, if the 'disruptive' and 'gas at scale' pathways cannot be pursued due to techno-economic and supply challenges. This pathway is a delayed move towards decarbonised operations and green products.

- While this pathway would also require large-scale renewable energy deployment and efficiency improvements in the 2020s, it would only move to the deployment of green H_2 and sustainable carbon by the 2040s, when techno-economic feasibility of those technologies is expected to have improved significantly.
- Furthermore, the current gas supply would have depleted around the early 2030s, if no new affordable gas supply can be secured – hence, gas would have phased out in early 2030. As a result, the use of coal as a primary feedstock could theoretically be extended and even if measures, such as renewables deployment,

process and energy-efficiency and CCUS deployment (if proven feasible in South Africa) are driven – relatively highly carbon-intense products would still be produced in the mid-term, until the 2040s. Significant emissions reduction would therefore only be achieved from the 2040s onwards, where coal is phased out – or operations closed by 2050 if a conversion to green production is not possible.

- Overall, extending coal use would not only lead to the highest cumulative emissions footprint (1.2–1.3 Gt CO_2e) among the three pathways, but also risk the respective plant's 'license to operate', a significant and increasing carbon tax liability and market access in the context of a decarbonising world and decarbonising South Africa. Therefore, an extension of the use of coal as the primary feedstock in the production of synfuels is highly unlikely.

In all three pathways, renewable energy deployment, process- and energy-efficiency improvements and CCUS, play a critical role. CCUS could help with emission reduction while fossil fuel feedstock gradually phases out – but is still used as a feedstock and hence producing process emissions. However, the feasibility of carbon storage in South Africa is still uncertain, given the lack of proven suitability of potential storage sites (see "Deep dive: The feasibility of Carbon Capture Utilisation and Storage in South Africa" on page 40). However, utilisation of carbon (via CCU) could play the role of a more sustainable carbon source: carbon captured from still emitting processes could be utilised as feedstock for the production of lower emissions synthetic hydrocarbons – or, as discussed earlier, in chemical products which 'seal' the carbon (e.g., lubricants, bitumen).

Decarbonising the downstream chemicals sector

> ***Two per cent of the sector's direct emissions are linked to downstream chemicals production****; removing those emissions will require process, energy and material efficiency improvements, fuel switching, access to sustainable feedstock and negative emission technology, such as CCUS.*

The downstream chemicals value chain is dominated by the production of plastics, pharmaceuticals and inorganics.[38] It is responsible for ~2% of the sector's direct emissions. To reduce those process emissions, various mitigation levers need to be deployed. Those include:

- Process and energy-efficiency
- Fuel switching (e.g., electrification of machinery with renewable energy as the power source)
- The move to lower and zero emissions feedstock (e.g., sustainable sources of carbon from DACC and biomass, green H_2)
- Improved material efficiency (e.g., improved recyclability of products)
- Negative emissions technology such as CCUS for potentially remaining process emissions, in the case of remaining fossil fuel feedstock, particularly in the mid-term where fossil fuel is phased out but still present as a feedstock.[39]

Particularly plastics and rubber production and consumption drive significant emissions. To reduce the overall emissions footprint of those products, a full life cycle approach would need to be taken. This starts with the reduction of emissions in the production of plastics and rubbers (e.g., requiring the use of decarbonised feedstock, the limitation of fossil fuel feedstock to production of non-energy goods via non-emitting processes); responsible consumption; as well as material efficiency via increased reuse, and mechanical and chemical recycling of plastic and rubber materials, which would avoid landfilling and incineration, but most importantly reduce the demand for primary petrochemicals.[40 41]

38 A broad class of substances encompassing all those that do not include carbon and its derivatives as their principal elements.

39 TIPS. 2019. *Petrochemical value chain: Background, problem identification and possible options.*

40 EEA. 2021. *Plastics, a growing environmental and climate concern: How can Europe revert that trend?*

41 IEA. 2021. *Net Zero by 2050 – A Roadmap for the Global Energy Sector.*

Photo: Shutterstock.com

Deep dive: The feasibility of Carbon Capture Utilisation and Storage in South Africa

CCUS refers to the capture of CO_2 from large point, stationary sources, such as power plants or industrial production facilities, followed either by utilisation (CCU – Carbon Capture Utilisation) of the captured CO_2 in a range of applications, or the injection in deep geological formations for permanent storage (CCS – Carbon Capture Storage). Relevant geological formations include for example, saline formations and depleted oil and gas reservoirs.

To enable deployment of CCS in South Africa, the following criteria need to be fulfilled:

- Firstly, geological formations which are suitable for the permanent storage of CO_2 must be identified in South Africa. The considered geological formations need to ensure safe and permanent storage of CO_2, provide sufficient storage capacity, and need to be located near enough to key emissions sources to avoid high transport costs.
- Secondly, the technology needs to further mature, the cost associated with the capture of CO_2 needs to be reduced, and transport and storage costs need to be optimised.
- Thirdly, a conducive policy environment that creates the necessary regulatory framework that ensures effective, safe and sustainable deployment of CCS over the long-term, and which incentivises investments in CCS technology and drives research and development, needs to be in place.

Preliminary studies have indicated that the Durban basin, along the KwaZulu-Natal coast, could serve for CO_2 storage. However, significant uncertainty exists regarding the suitability of the geological formations in the Durban basin for permanent CO_2 storage and further research is required.

If further research proves that the Durban basin is suited for permanent storage of CO_2, it would be the largest CO_2 storage site in South Africa. It is estimated that it could store ~5 Gt of CO_2. To put this into perspective, if the petrochemicals and chemicals sector continues to emit ~63 Mt CO_2 per year, cumulative emissions of ~1.9 Gt CO_2 would be generated between 2021 and 2050.

CCS scenarios in South Africa

To assess the potential cost of CCS for several emissions hubs in South Africa, the overall capture, connection, transport and storage costs were compared for six CCS deployment scenarios, leveraging the Durban basin as a potential storage site (Figure 14).

Each scenario includes a different set of emissions sources. These sources range from the highest concentration (easier-to-capture) emissions sources in Scenario 1 (covering ~17 Mt CO_2e/a), to the full range of national emissions sources in Scenario 5B (covering 72.8 Mt CO_2e/a), hence with on average less concentrated CO_2 streams:[42]

Secunda and Sasolburg Scenarios

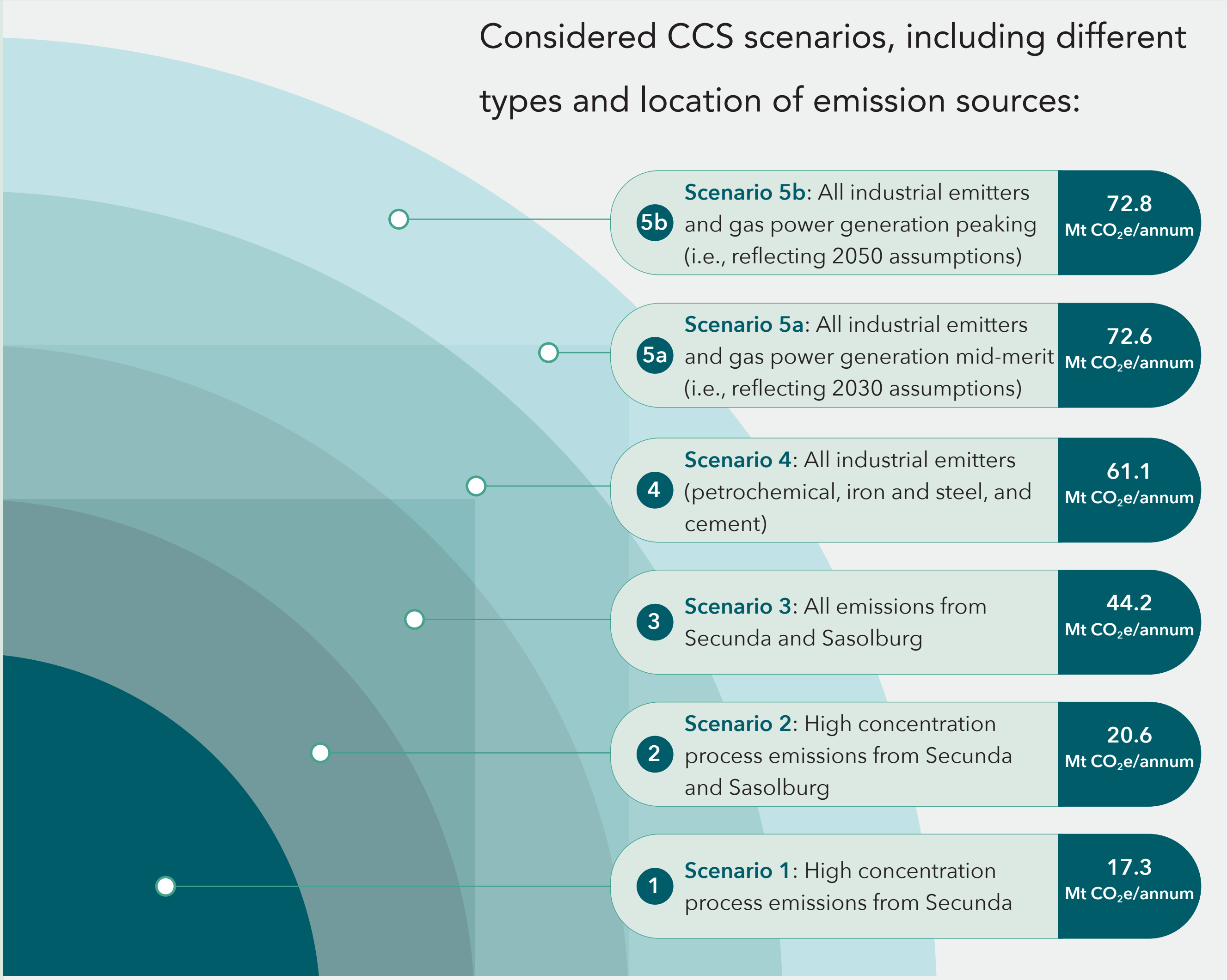
- Scenarios 1 to 3 focus exclusively on CO_2 sources related to Sasol's synfuels operations:
  - Scenario 1 only includes high-concentration CO_2 streams from Secunda.
  - Scenario 2 includes high-concentration CO_2 streams from Secunda and Sasolburg.
  - Scenario 3 includes all CO_2 streams, high- and low-concentration, from Secunda and Sasolburg.

Cross-sectoral and regional scenarios

- Scenario 4 considers CCS use for CO_2 emissions from all industrial emitter (including the petrochemical, iron and steel and cement sectors).
- Scenarios 5A and 5B consider use of CCS for the combined CO_2 emissions from industrial emitters and power generation, whereby scenario 5B assumes higher (mid-merit) use of gas peakers.
- Furthermore, the cost of CCS on a regional level was assessed for Scenarios 4 and 5B. The additional dimension of regional clusters for the industrial and power sector emitters were considered. Those regional clusters included Johannesburg (JHB), Durban (DBN), Gqeberha (PE) and Cape Town (CT). The JHB cluster includes all emitters within the Gauteng, Free State and Mpumalanga provinces and accounts for ~80% of total emissions captured in Scenario 5B. The DBN, Gqeberha (PE) and CT clusters include all emitters from their respective provinces.

42 Emissions for individual cement, iron and steel, petrochemicals and chemicals, and power sector assets gathered from reporting and disaggregated into process and combustion emissions. Process and combustion emissions were further split into high- and low-concentration emissions streams based on standard factors for each process type. It was assumed, that CCS captures 90% of the emissions of the considered emissions stream.

Figure 14: Considered CCS scenarios for cost analysis



Note: Includes emissions from all clusters (JHB, DBN, CT, PE – if on-line).

Source: NBI-BCG analysis.

Cost of CCS scenarios in South Africa

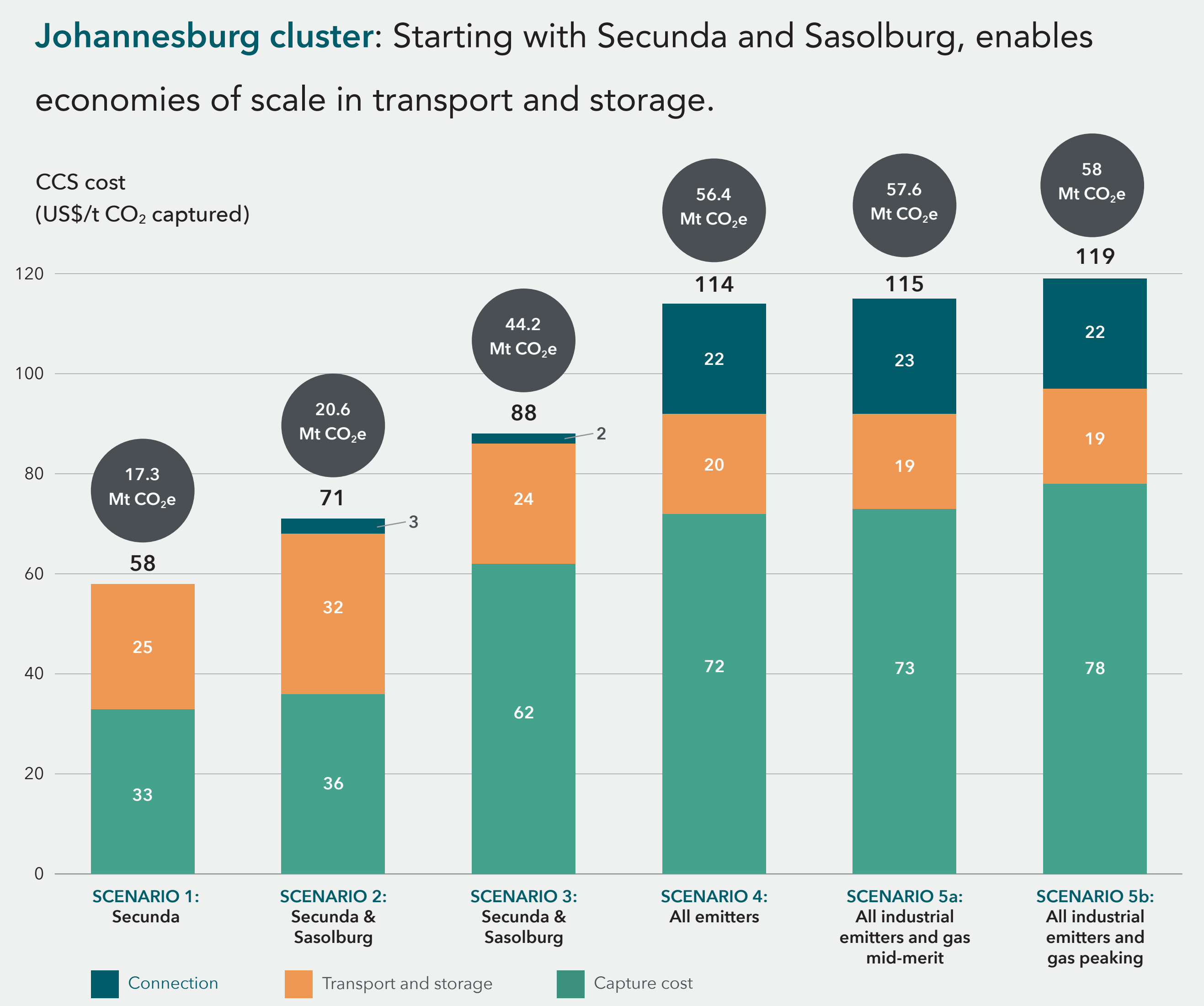
Cost of CCS is driven by the cost of capturing CO_2, the cost of connecting CO_2 streams (in case of multiple CO_2 sources that are then transported via a joint network), and transport (to the respective storage site) and storage cost.

The CO_2 capture cost is the biggest driver of total cost of CCS and makes up ~50–65% of total cost across the considered scenarios (Figure 15). Capture cost is lowest for highly-concentrated and highest for low-concentrated CO_2 streams. As a result, the lowest total cost of CCS is ~US$58/tonne CO_2 and is associated with Scenario 1, which captures CO_2 from the highly-concentrated Secunda CO_2 streams. Capture cost increase by ~140% between Scenario 1 and 5B (Scenario 5B has CO_2 a capture cost of ~US$78 due to the various, on average lower-concentrated CO_2 streams) with Scenario 5B resulting in the highest total cost for CCS.

Additionally, the connection cost is almost negligible in Scenarios 1 to 3, given that all emissions sources are located at Sasol, but increases to ~20% of the total CCS cost in Scenarios 4 to 5B, given the need to bring together various CO_2 streams from geographically spread-out CO_2 emitters.

However, transport and storage costs decrease with scale of CO_2 transported. Therefore, the scenarios with the largest amount of CO_2 captured (Scenario 5B) results in the lowest transport and storage cost. For example, transport and storage cost are US$19/tonne CO_2 in Scenario 5B, which covers ~60 Mt CO_2, while they are US$25/tonne CO_2 in Scenario 1, where only highly-concentrated CO_2 from Secunda is captured (~17 Mt CO_2).

Figure 15: CCS cost in the JHB cluster lowest when only high-concentration, process emissions from Sasol considered

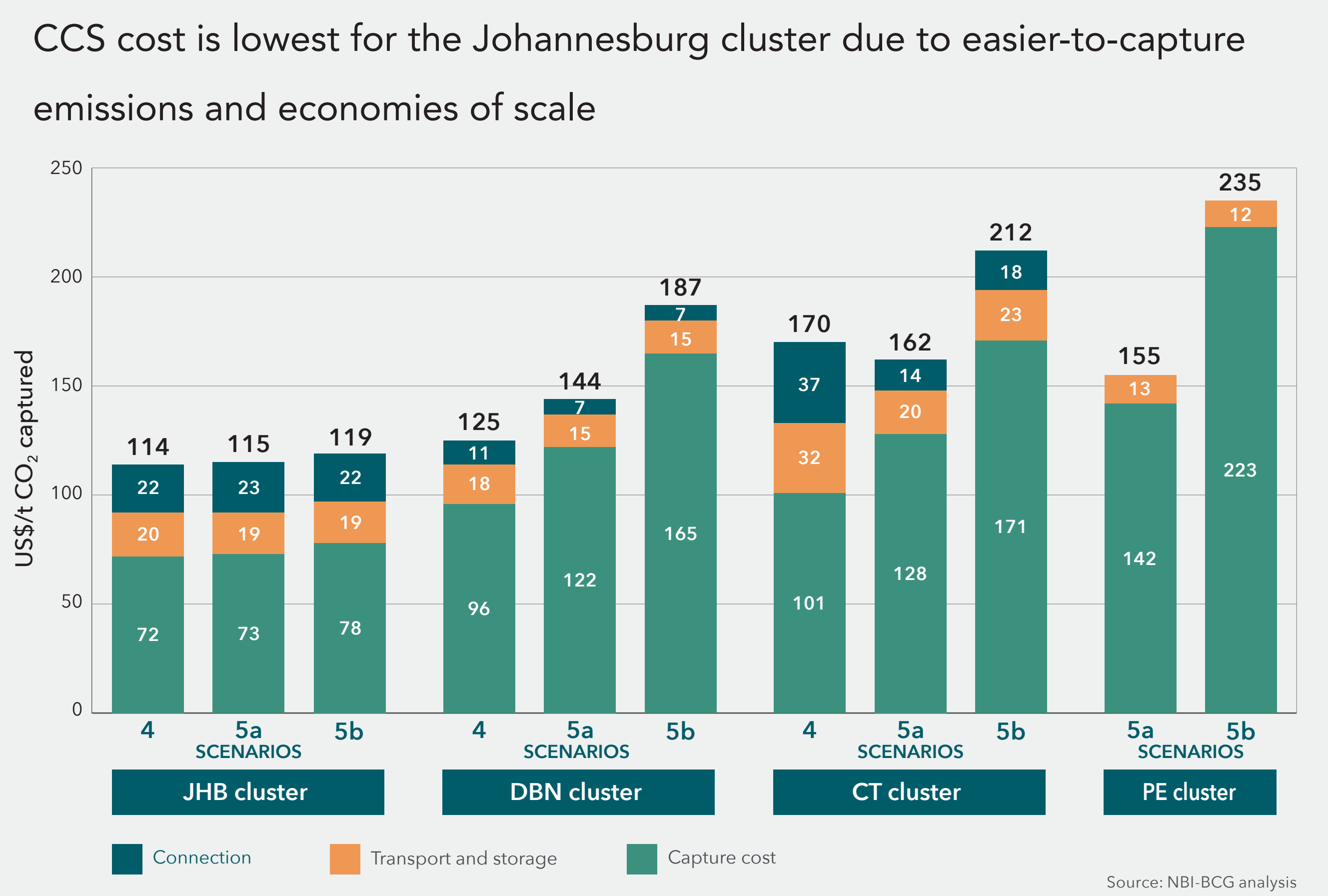


Source: NBI-BCG analysis.

When comparing the costs of different regional clusters, the JHB cluster is able to achieve the lowest total CCS cost in all scenarios, with the PE and CT clusters being the most expensive CCS deployment scenarios (Figure 16). As before, the key cost differentiator is the capture cost, driven by the concentrations and types of emissions sources in each cluster. For example, even though the transportation and storage costs of the JHB cluster are generally higher than that of the Durban and PE clusters (given their closer proximity to the Durban basin), the capture cost of the JHB cluster is almost three times less than that of the PE cluster in Scenario 5B – resulting in double the total CCS cost per tonne for the PE cluster. This is because the relatively low-concentration, combustion emissions from gas turbines that will likely drive emissions in the Eastern Cape are more costly to capture than the higher-concentration, process emissions that drive emissions in the JHB cluster.

To conclude, this analysis shows the significant cost challenge faced by emitters in the Durban, Cape Town and Gqeberha clusters due to the nature of their emissions, and the technological development that will therefore be required to reduce capture costs to more competitive levels. However, it also highlights an opportunity for Sasol's Secunda and Sasolburg operations to develop large-scale CCS capabilities and, as a result, lay a pathway to lower-cost CCS for the entire JHB cluster, which accounts for over 80% of national emissions eligible for capture. Specifically, high concentration emissions sources at Secunda and Sasolburg could be captured, transported and stored for less than US$75/tonne CO_2 captured.

Figure 16: Comparison of CCS cost of different clusters in South Africa



Once carbon budgets are exceeded, carbon taxes of US\$40/tonne CO_2 are expected and may increase, making CCS a potentially competitive option. Furthermore, by rolling out CCS at scale, Sasol would reduce transportation and storage costs for the JHB cluster from ~US\$30/tonne CO_2 captured to less than US\$20/tonne CO_2 captured.

However, as highlighted initially, the feasibility of CCS in South Africa hinges primarily on the availability of a suitable storage site in the region – such as the Durban basin. To enable the roll-out of CCS in South Africa, further analysis that assesses the suitability of the considered site needs to be conducted.

3.1.5 KEY CHALLENGES AND OPPORTUNITIES ASSOCIATED WITH THE DECARBONISATION OF SOUTH AFRICA'S PETROCHEMICALS AND CHEMICALS SECTOR – AND RISK OF FAILING TO DECARBONISE

> ***While the decarbonisation of the petrochemicals and chemicals sector enables local industrialisation and realisation of new export opportunities*** *which help improve South Africa's balance of payment, it will be critical to manage socio-economic risks in the mid-term, in particular the displacement of workers in the coal, refinery and adjacent value chains, which together make up ~140 000 direct jobs today, and the risk of increasing reliance on liquid fuels imports, which would decrease energy security and negatively impact South Africa's balance of payment, in the 2030s – accelerating decarbonisation across sectors will be key to mitigate those risks.*

From an emissions perspective, the considered synfuels decarbonisation pathways range between 0.6 and 1.2 Gt CO_2e cumulative emissions. The 'disruptive' pathway results in the lowest and the 'extend coal' pathway in the highest cumulative emissions. While the 'disruptive' pathway is evidently the lowest emissions pathway, it also represents the potentially most expensive pathway, given the required early deployment of technology and feedstock – particularly green H_2 – which in the 2020s and early 2030s will still be expensive and early in their technical maturation. However, the difference in cost increases between the considered pathways could shrink, if the impact of, for example, a carbon tax is considered as well – particularly with regards to the 'extend coal' pathway. Therefore, the 'extend coal' pathway and the 'gas at scale' pathway could result in similar high production cost increases as the 'disruptive' pathway. A significant production cost increase could create socio-economic challenges if the affordability of the products to the South African economy and South African population is not maintained.

The 'disruptive' and 'gas at scale' pathways would result in a phase-out of coal as key feedstock by the early 2030s. Given that the synfuels sector consumes ~20% of locally produced coal, this feedstock switch would further impact coal mining jobs in addition to the coal phase-out driven by the power sector. However, both pathways would drive large-scale investments and job creation related to, for example, green H_2 production and pave the way towards earlier production of low and zero emissions products, hence the establishment of a more competitive petrochemicals and chemicals sector. While the 'extend coal' pathway would result in a later phase-out of coal and hence in a later impact on the coal mining sector, it would not just present a significant carbon tax liability but also an overall 'license to operate' risk, given the continued environmental and climate impact coal-based production would still have.

All pathways require large-scale deployment of renewables and energy storage already in the 2020s to drive substantial decarbonisation at the early stages. In total, around ~1.2 GW of renewable energy – including large-scale energy storage solutions – would need to be deployed to decarbonise electricity consumption in the CTL synfuels sector alone, not yet accounting for the renewable energy capacity required for the production of the required green H_2 feedstock. Negative emission, technology, such as CCUS and DACC, will be critical for further emissions reduction towards 2050. However, suitable storage still needs to be identified in the case of CCS and direct air capture technology would need to be further developed to improve its techno-economic feasibility.

Hence, each of the considered synfuels pathways hinge on the availability of technologies and feedstock which are currently either highly uncertain or techno-economically not feasible yet. The decarbonisation of the downstream chemicals production will equally be reliant on those levers, albeit on a different scale.

As mentioned earlier, Sasol's commitment to net-zero emissions by 2050 includes the plan to phase-out coal by leveraging gas as an alternative, lower carbon feedstock, while green production is established and ramped-up. This would place the synfuels sector in between the 'disruptive' and 'gas at scale' pathways. Hence, an 'extend coal' pathway is not realistic.

To conclude, the decarbonisation of South Africa's synfuels and downstream chemicals value chain hinges on the availability of disruptive technologies and sustainable feedstock. Shifting to lower and eventually net-zero operations and products will require a combination of renewable energy, efficiency improvements, green H_2, sustainable sources of carbon and gas and, in the long-term, additional deployment of even more disruptive technologies, namely CCUS and DACC. It will be critical for South Africa to unlock those technologies and feedstock. A failure to decarbonise the sector would result in an increasingly uncompetitive petrochemicals and chemicals sector, which would eventually come to a demise. This poses a critical socio-economic and energy security risk to South Africa and the loss of a unique, future-oriented industrialisation opportunity. It will be critical for South Africa to enable a successful transition of the local petrochemicals and chemicals sector towards decarbonised production.

Key to enable this will be to:

1. Facilitate the shutdowns or potential conversions of South Africa's conventional crude refineries in the mid-term.
2. Enable the decarbonisation and conversion of South Africa's synfuels assets in the mid- to long-term.
3. Accelerate the decarbonisation of the transport sector to speed up the move away from conventional liquid fuels demand – which would otherwise need to be increasingly imported – hence reducing the risk of a weakened energy and fuel security.
4. Mitigate the negative socio-economic impact linked to the decarbonisation of the sector – in particular with regards to the job losses along the refinery, fuel retail and coal value chains which make up ~ 5 000, ~130 000[43] and ~7 500[44] direct jobs respectively.

All those actions have to be managed against the need to ensure energy security for South Africa.

43 TIPS. 2020. *The petroleum-based transport value chain: A just transition approach*.

44 Employment listed under Sasol's Mining Business Unit.

Photo: Shutterstock.com

3.2 ENABLING THE DECARBONISATION OF SOUTH AFRICA'S PETROCHEMICALS AND CHEMICALS SECTOR

***It will be critical to establish cross-sectoral and international partnerships and pilot projects to drive research and development, off-take agreements to secure cheap financing at an early stage, and a conducive local policy environment** to unlock the key technologies and feedstock needed to drive decarbonisation and the establishment of green fuels and chemicals production in South Africa - if this cannot be achieved, the sector is at risk of losing its competitiveness and will eventually come to a demise.*

3.2.1 KEY ENABLERS

To realise the sector's decarbonisation potential, critical enablers need to be put in place. This includes, in particular:

- **Ensuring a Just Transition and maintaining energy security.** Mitigation of the socio-economic risks associated with the sector's decarbonisation will be critical. This requires addressing the displacement of workers in the coal, refinery and fuel retail value chain in particular. Ensuring the sector's decarbonisation creates socio-economic value for the country will furthermore require the realisation of localisation opportunities and with that job creation in the new emerging green fuels and chemicals sector. It will also be critical to mitigate the socio-economic risk arising from the expected decline in local refinery capacity which could lead to an increasing reliance on liquid fuels imports, hence weakened energy security, in the 2030s. Mitigating this risk does not just imply an acceleration of the shift towards the production of green fuels, but even more so the need to enable an accelerated road transport sector decarbonisation and hence move away from the reliance on conventional liquid fuel.
- **Renewable energy and energy storage technology (e.g., gas or battery technology to manage for intermittency) deployment at large scale, starting already within the 2020s.** To put this into perspective, 1.2 GW of renewable energy alone will be needed to meet the energy demand of the existing CTL plant.

  Deployment of large-scale energy storage will require a supporting policy framework and access to cheap finance – particularly in light of uncertainties around the techno-economic viability of large-scale energy storage in the 2020s. It is important to note, that in this timeframe gas – if it becomes available – is likely to be more cost effective to manage intermittency than battery technology, which still needs to further mature.
- **Access to green H_2 and sustainable sources of carbon at scale**. Green H_2 would need to be unlocked at below US$2/kg. Sufficient supply of sustainable carbon would need to be made accessible, whereby second generation biomass – and potentially in the long-term carbon supplied via direct air carbon capture – will play an important role.
- **Feasibility of CCUS in South Africa.** In the mid-term, CCUS will be important to achieve further emissions reduction while fossil fuel feedstock is still used in emitting production processes. However, a key enabler for carbon storage to become feasible, is the identification of suitable storage sites. Furthermore, pilot projects will be required that support the development of a CCUS commercialisation strategy for South Africa.
- **Gas as a transition fuel.** For gas to support the decarbonisation of the sector, it will be critical to secure gas supply at prices disconnected from the spot price, otherwise, it would not be affordable to the sector. A 'gas at scale' pathway would require supply of gas at the right affordability threshold and at large scale. Sourcing the required volumes affordably for a 'gas at scale' pathway is highly complex. This does not rule out gas as a transition fuel on a smaller scale, as announced by Sasol at its 2021 Capital Markets Day (CMD), where Sasol committed to increase gas consumption by 40–60 PJ.

To eventually achieve net-zero production by 2050, gas use will either need to be phased out by 2050, or restricted to application equipped with negative emission technology, and non-emitting processes and products (e.g., non-energy goods).

3.2.2 NO-REGRET ACTION

Key actions need to be pursued to enable the sector's decarbonisation, while ensuring that the objectives of South Africa's Just Transition are met.

First, it will be critical to assess the socio-economic impact of a shutdown of South Africa's refinery landscape, which would result in increased reliance on liquid fuels imports at least in the 2030s–2040s, and to identify potential counter measures that could be taken to mitigate the socio-economic risk, particularly linked to jobs in the refinery sector that would disappear, and a potentially negatively impacted trade balance. This includes the assessment and planning around the opportunities of localisation of new value chains, including job creation (e.g., related to a local green H_2 economy). Furthermore, the techno-economic feasibility of reconverting PetroSA to a green synfuels production asset, primarily for export, should be assessed.

Second, with regards to the decarbonisation of South Africa's remaining upstream petrochemicals sector, represented by Sasol's synfuels assets, it will be critical to kick-off the establishment of local production capacity for green H_2. The development of a national green H_2 vision and commercialisation strategy will be a critical part of this, alongside the launch of a public-private green H_2 consortium. In addition, it will be important to secure off-take agreements with key trade partners (e.g., for the supply of sustainable aviation and shipping fuels), which enable cheap financing and the launch of pilot projects in the near-time, which drives learning and capacity-building. It will be critical to develop the conducive policy frameworks needed to enable large scale deployment of renewable energy capacity and energy storage. Most importantly, strategies to secure the required financing will need to be developed.

Third, further research needs to be conducted with regards to the existence of suitable carbon storage sites. Without suitable storage, carbon storage will not be feasible in South Africa. The feasibility of storage in the Durban basin should be assessed in particular, given that it currently represents the most promising storage site in South Africa. In addition, a cross-sectoral, public-private CCS consortium should be established, which determines the approach and requirements for the development of potential CCS clusters in the Johannesburg region, including assessing the feasibility of the cost of US$115–120 per tonne CO_2.

Fourth, making biomass available at scale will be important to unlock sustainable sources of carbon for industrial use. In this context, it will be important to develop a national biomass strategy which focuses on the availability, accessibility and affordability of biomass. The use of biomass in the synfuels space will be an important first use case, reaching a potential scale of ~15–45 Mtpa demand (depending on the availability of alternative, sustainable sources of carbon and scale of uptake of green H_2 as a feedstock) for decarbonisation of the synfuels sector. Furthermore, DACC can in the long-term also be a source of sustainable carbon supply. Given the technology is currently in its early development stages, it will be important to drive further research and collaboration around the deployment of DACC technology in South Africa.

Fifth, given the expected increasing local and global demand for green fuels and chemicals, understanding the potential need for the development of additional, new green fuels and chemicals production assets is crucial and needs to be further assessed as part of the development of a South African green fuels and chemicals industrialisation plan. This plan should form part of South Africa's overall industrialisation vision and strategy.

Sixth, it will be critical to establish the required gas policy frameworks and make timely decisions on potential gas import plays. In this context of no-regret action, it will be important to first, establish an interdisciplinary task team to fast-track the gas masterplan and the development of a market aggregation mechanism; and second, to finalise local content requirements for upstream participation as part of the Upstream Petroleum Resources Development Bill.[45]

Supporting a Just Transition

Today, the synfuels sector alone consumes ~20% of the locally produced coal. Sasol operates five coal mines which supply its Secunda plant – around 7 500 employees are linked to Sasol's coal mining operations.[46] Decarbonisation of the sector would imply a phase-out of coal. This would lead to the closure of further mining sites and a loss of related jobs, in addition to coal mining closures and job loss resulting from the phase-out of coal in the power sector. Furthermore, the expected closure of most, if not all, of South Africa's refineries towards the beginning of the 2030s, will lead to further job loss. A national Just Transition strategy and roadmap will need to be developed to manage the loss of jobs along the coal mining and refinery value chain. This includes, in particular, the launch of a reskilling and redeployment programme for displaced workers.

45 See more details in our report "The role of gas in South Africa's decarbonisation"

46 Sasol. 2021. Company website.

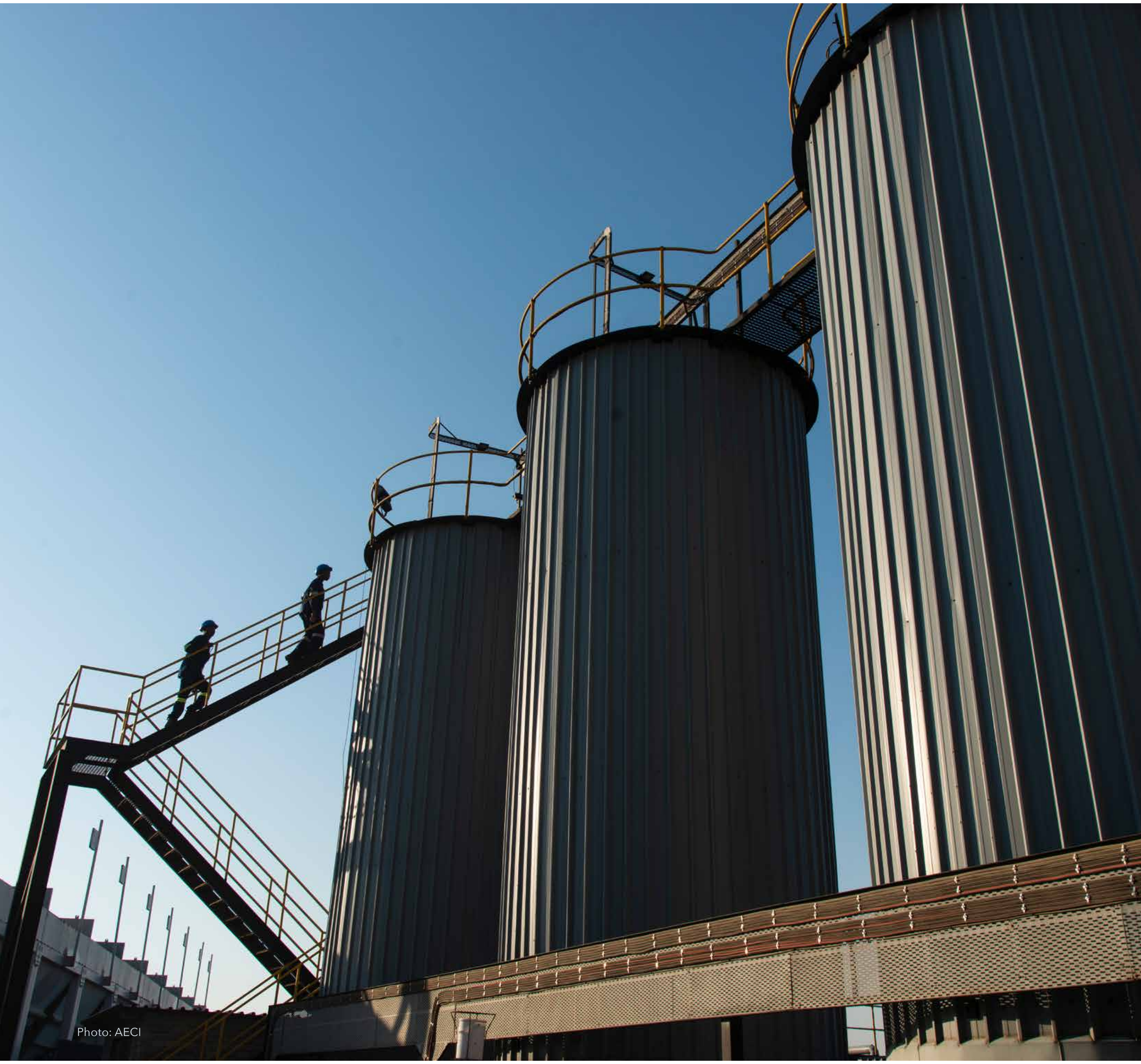


Photo: AECI

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 420–350 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 important, 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 identify 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 H_2
- 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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