IRENA
International Renewable Energy Agency

Socio-economic footprint of the energy transition

SOUTH AFRICA

ISBN: 978-92-9260-556-8

Citation: IRENA (2023), *Socio-economic footprint of the energy transition: South Africa*, International Renewable Energy Agency, Abu Dhabi.

About IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. An intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity.
www.irena.org

Acknowledgements

This report was developed under the guidance of Rabia Ferroukhi (ex-Director – Knowledge Policy and Finance Centre) and Michael Renner (Head – Policy and Socio-economics), and was authored by Bishal Parajuli and Gondia Sokhna Seck (IRENA), Xavier Casals and Álvaro López-Peña (consultants). The modelling results were provided by Alistair Smith, Ha Bui, Jamie Pirie and Jon Stenning (E3ME, Cambridge Econometrics).

The report benefited from the reviews and inputs from internal and external experts: Asami Miketa, Jarred McCarthy, Larissa Pinheiro Pupo Nogueira, Nolwazi Khumalo and Omar Marzouk (IRENA), Prof. Richard Calland (University of Cape Town). The report was copy-edited by Erin Crum.

IRENA would like to thank the Government of Denmark for supporting IRENA with the work that formed the basis of this report.

For further information or to provide feedback: **publications@irena.org**

Disclaimer

Contents

Figures

Tables

Boxes

Abbreviations

BECCS	bioenergy with carbon capture and storage
CAGR	compound annual growth rate
CCS	carbon capture and storage
CO_2	carbon dioxide
CO_2eq	carbon dioxide equivalent
CSP	concentrated solar power
EMP	Electrification Master Plan
EU-27	economies of the European Union
EV	electric vehicle
FISIM	financial intermediary services indirectly measured
G20	Group of 20
GDP	gross domestic product
GHG	greenhouse gas
Gt CO_2	gigatonne of carbon dioxide
GW	gigawatt
INEP	Integrated National Electrification Programme
IPP	independent power producer
IRENA	International Renewable Energy Agency
IRP	Integrated Resource Plan
JET	Just Energy Transition
JET IP	JET Investment Plan
kWh	kilowatt hour
LULUCF	land use, land-use change and forestry
Mt	million tonnes
MW	megawatt
NDC	Nationally Determined Contribution
OECD	Organisation for Economic Co-operation and Development
P2X	power-to-X
PES	Planned Energy Scenario
PJ	petajoule
PPP	purchasing power parity
PV	photovoltaic
RDP	Reconstruction and Development Programme
REIPPP	Renewable Independent Power Producer Programme
SACREEE	SADC Centre for Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SAREM	South African Renewable Energy Masterplan
SMEs	small-and medium-sized enterprises
t	tonne
TES	total energy supply
TFEC	total final energy consumption
USD	United States dollar
ZAR	South African rand

Unless otherwise stated, the exchange rate from US dollars (USD) to South African rand (ZAR) used throughout this report is that given by the 1 August 2023 UN operational rates of exchange – *i.e.* USD 1 = ZAR 17.644; unless otherwise stated, all USD figures are at USD 2019 values.

Executive summary

Over the last ten years, the Republic of South Africa's economy has experienced a growth rate of approximately 1% annually. The country is still faced with the lingering effects of apartheid and an uneven socio-economic transition, resulting in it being the most unequal nation globally according to the Gini coefficient (World Bank, n.d.). The unemployment rate reached 34.9% at the end of September 2021. As a result, poverty rates have risen to levels not seen for more than a decade, reversing years of progress.

The impacts of climate change exacerbate existing poverty and inequality in South Africa. Low-income households are disproportionately affected, as they are more exposed to pollution and extreme weather events, have limited access to quality public health services, and possess fewer financial resources to cope with related damage. South Africa is highly vulnerable to the physical impacts of climate change, experiencing warming at twice the global average. The country faces increasing risks of aridity, droughts and extreme storms, which already manifest in events such as the water emergency in Cape Town and unprecedented floods in Durban. Transitioning to a low-carbon and climate-resilient energy sector is essential for protecting the environment, human health and the economy, while also addressing social inequities.

South Africa has adopted several policies and initiatives to achieve the energy transition. In September 2021, the country updated its 2015 Nationally Determined Contribution (NDC). In this update, the country chose a bolder decarbonisation pathway, reducing the target emissions upper range by 17% for 2025 and 32% for 2030. South Africa demonstrates its commitment to international co-operation on a just energy transition by actively participating in a newly formed Just Energy Transition (JET) Partnership. This ambitious and long-term collaboration involves the governments of South Africa, France, Germany, the United Kingdom and the United States, as well as the European Union. The partnership's primary objective is to expedite the decarbonisation of South Africa's economy, placing particular emphasis on its electricity system. Carbon pricing has been part of the country's energy policy since the introduction of the Carbon Tax Act in May 2019.

To support transition planning and informed policy making, IRENA analyses the transition's socio-economic footprint using a macro-econometric model to measure impacts on gross domestic product (GDP), employment and human welfare. This process provides insights into how the transition can be planned to maximise benefits.

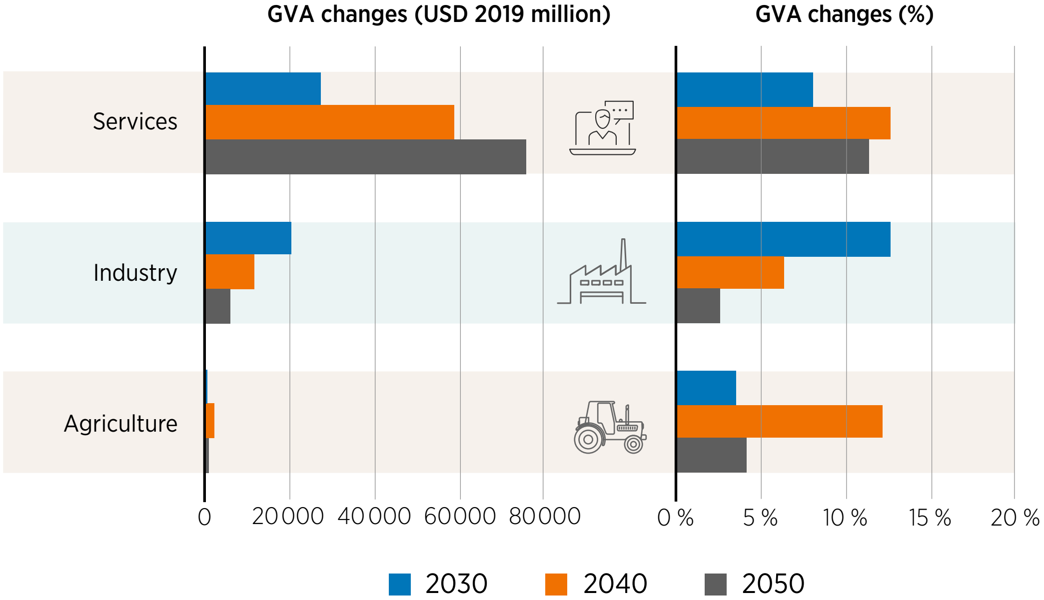
In IRENA's Planned Energy Scenario (PES),[1] **South Africa is expected to experience significant economic growth between 2021 and 2050 as envisioned in the baseline assumption of the E3ME model.**[2] Real GDP in the PES is assumed to grow with a compound annual growth rate of 2.7% per year between 2021 and 2030, by 3.0% per year in the 2031-2040 period and by 3.5% per year from 2041-2050. This is in-line with the national Integrated Resource Plan (IRP) upper forecast of 3.2% annual GDP growth to 2050 (Ministry of Energy, 2019).

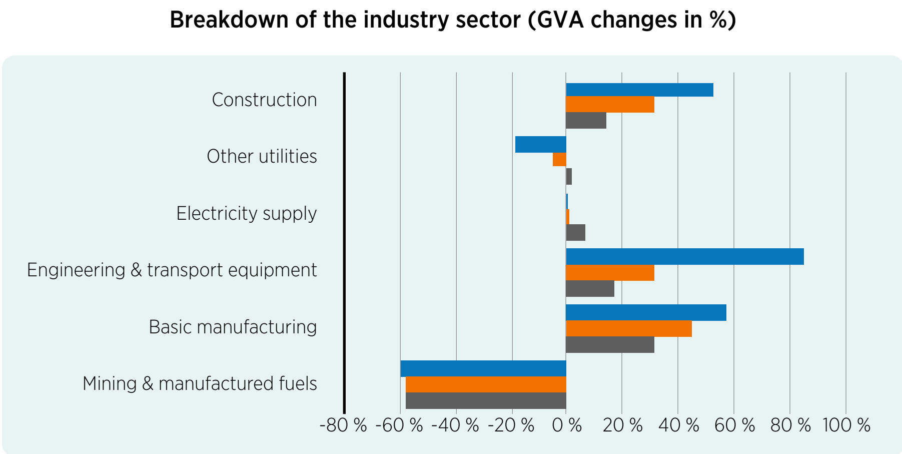
Under the 1.5°C Scenario, South Africa is expected to improve its GDP by an additional 7.8% on average over the 202150 period compared with the PES, resulting in substantial economic gains. The industries sector demonstrates notable improvements when compared with the PES, with percentage increases of 14.5% in 2030, 6.7% in 2040 and 2.7% in 2050 (Figure S 1). This growth can be attributed to private sector investment in energy efficiency and electrification, increased global demand, and an improved trade position. The sector plays a crucial role as a supplier of basic inputs to other sectors, both domestically and internationally. Private sector investment in energy efficiency and renewables, along with increased export values driven by global demand and improved trade performance, contribute to the positive performance of engineering and basic manufacturing sectors, surpassing the projected outcomes under the PES. When compared with the PES, the services sector overall shows the highest percentage changes, with 8.8% in 2030, 14.4% in 2040 and 12.9% in 2050 (Figure S 1)

[1] *"Current plans and policies" means those in place before 2020.*

[2] *Baseline forecasts are constructed using a comprehensive set of international data sources. The main source for population data is the United Nations (World Population Prospects). The main source for GDP forecasts is the International Energy Agency (World Energy Outlook). These data are supplemented with data from the International Labour Organization, the Organisation for Economic Co-operation and Development (OECD) (STAN database), the World Bank, the Asian Development Bank and the European Commission (AMECO, Eurostat, EC annual ageing report, EU Reference Scenario reports). E3ME is a global, macro-econometric model owned and maintained by Cambridge Econometrics: www.e3me.com.*

Figure S1: Gross value added (GVA) evolution between PES and 1.5°C Scenario in USD 2019 million (left panel), in percentage (right panel), by sector.



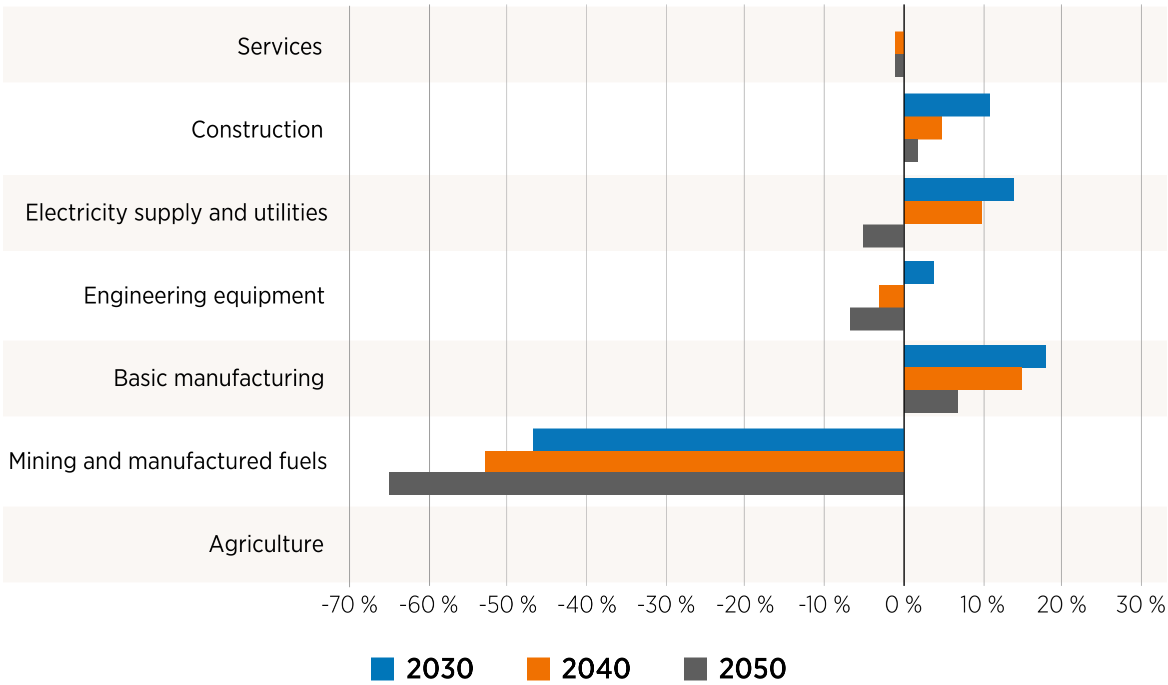


Note: GVA=Gross value added; PES=Planned Energy Scenario.

In terms of employment, South Africa's labour market has historically been marked by an unemployment rate consistently above 20%. This persistent issue was further aggravated by the COVID-19 crisis, which exposed the labour market's limited resilience.

Under the 1.5°C Scenario, employment is, on average, 0.2% higher than in the PES over the 2021-2050 period. Sectors such as basic manufacturing, engineering equipment, electricity supply and utilities, and construction exhibit varying degrees of job growth, albeit with a decreasing trend (Figure S2).

Figure S2: Percentage change in employment, 1.5°C Scenario compared with the PES, by sector, 2030, 2040 and 2050



In the energy sector, the number of jobs in the energy sector remains steady at around 1 million under the 1.5°C Scenario (Figure S 3). However, this figure is 0.1 million lower than the projected jobs under the PES. This outcome is a result not only of front-loaded construction of new transition-related technologies, particularly energy efficiency, but also an overall increase in labour productivity throughout the sector, as more output is achieved with less input and human resources, thanks to automation and advanced technologies.

Under the PES, approximately 70% of total energy sector employment (0.75 million jobs) will still depend on fossil fuels. However, under the 1.5°C Scenario, this percentage is significantly reduced to 20% (0.2 million jobs), indicating a substantial shift towards cleaner energy sources. While the share of energy efficiency jobs remains relatively stable at around 13-14% (equivalent to 0.14 million jobs), there is a notable uptick in the proportion of jobs related to power grids and flexibility. This category experiences a significant increase from 5% (or 0.06 million jobs) in the PES to 12% (0.11 million jobs) under the 1.5°C Scenario. Under the 1.5°C Scenario, renewables represent 51% of energy sector jobs in 2050 – the highest share – amounting to 0.5 million positions. This compares with a 12% share (0.13 million jobs) in the PES, demonstrating a substantial growth in renewable energy job opportunities.

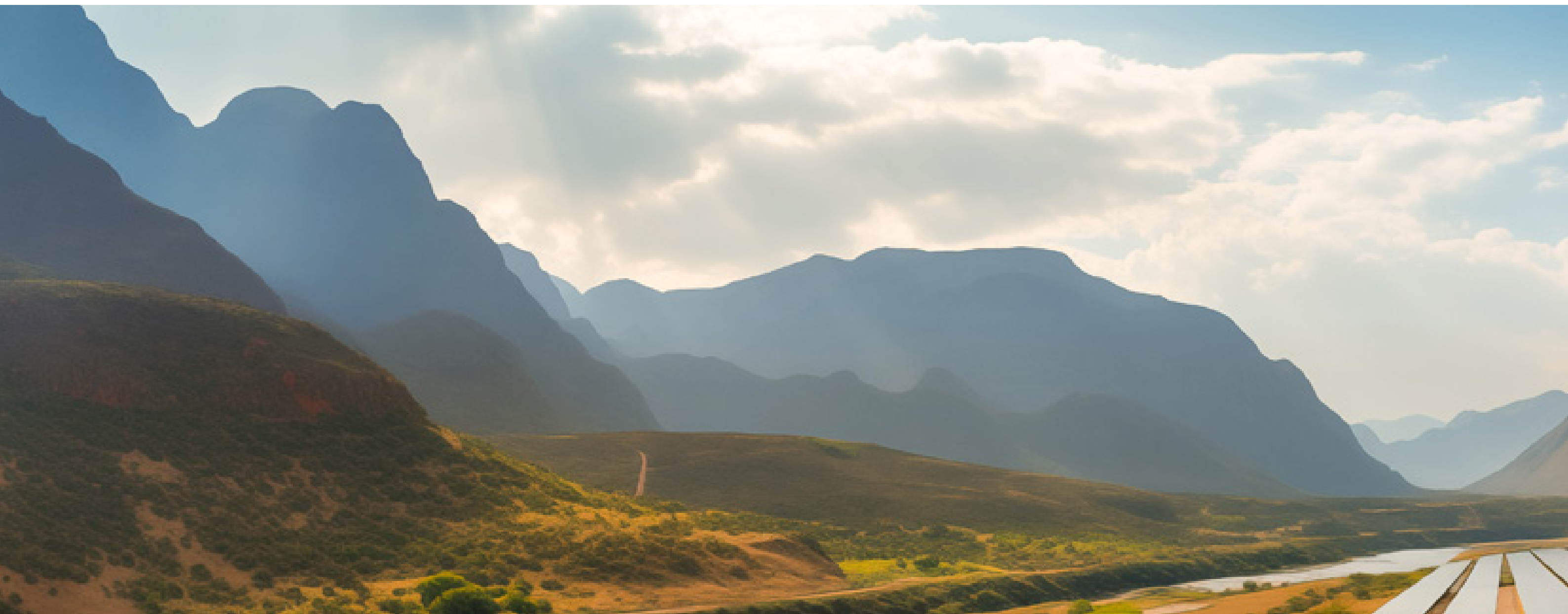
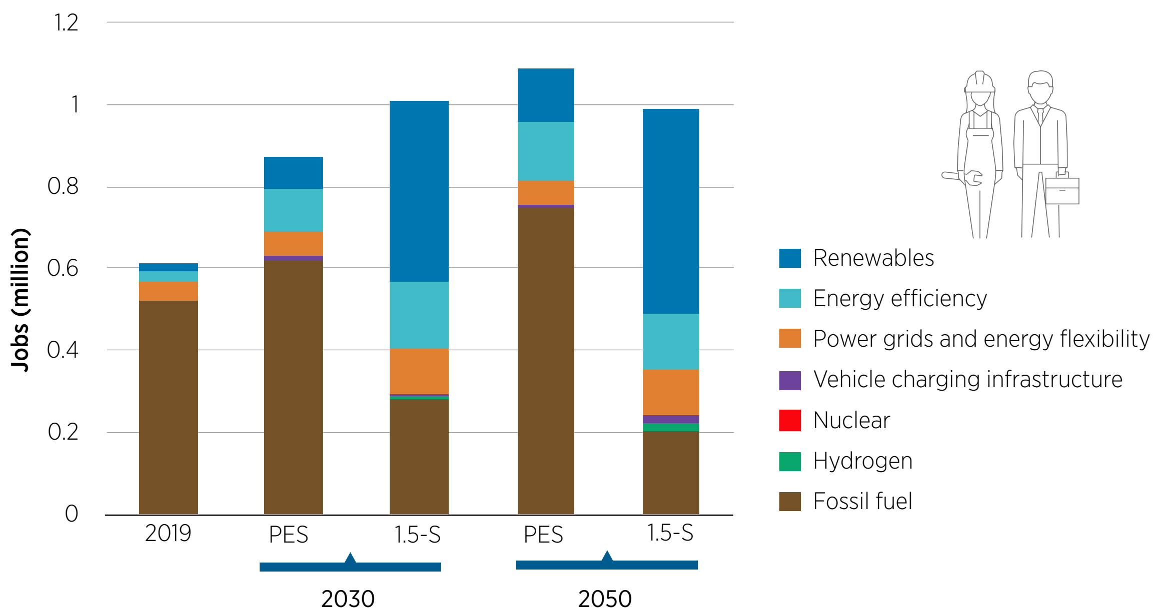


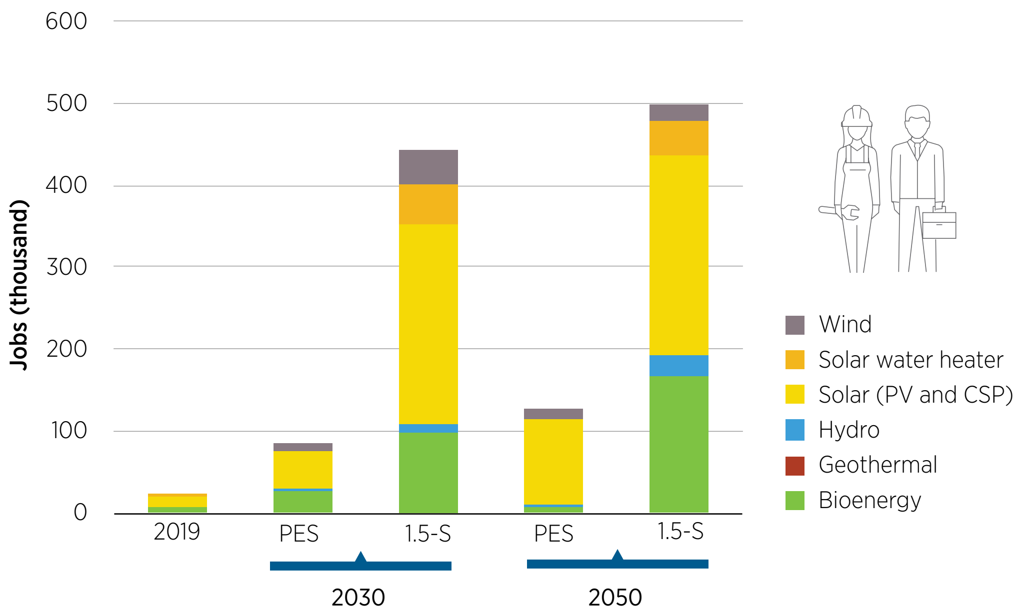
Figure S3: Overview of energy sector jobs in South Africa under 1.5°C Scenario and PES, by sector, 201950



Note: 1.5-S = 1.5°C Scenario; PES = planned energy scenario.

The growth in renewable energy jobs is more pronounced under the 1.5°C Scenario, surpassing the PES projections (Figure S 4). An estimated 500 000 jobs are expected in the renewable energy sector by 2050 under the 1.5°C Scenario. Solar technologies (*i.e.* photovoltaic [PV] and concentrated solar power [CSP] are expected to dominate the renewable energy job market in South Africa, with approximately 245 000 jobs in both 2030 and 2050. Bioenergy also plays a significant role, creating nearly 100 000 jobs in 2030 under the 1.5°C Scenario, increasing to 166 000 by 2050. Additionally, solar water heaters contribute around 45 000 jobs in 2050, hydro another 25 000 jobs, and wind over 21 000 jobs.

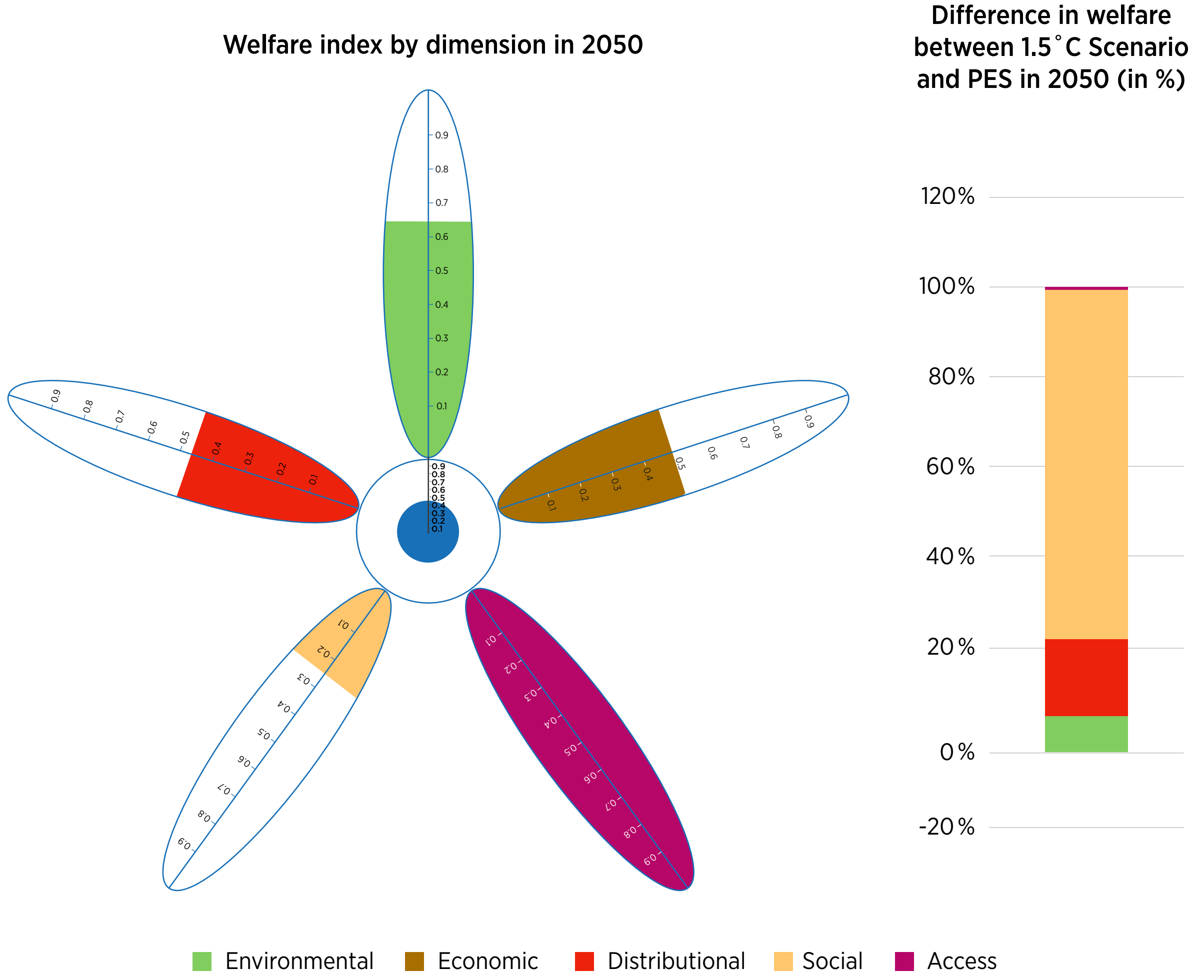
Figure S4: Renewable energy jobs in South Africa in the PES and 1.5°C Scenario, 2019, 2030 and 2050



Notes: PES = Planned Energy Scenario; 1.5-S = 1.5°C Scenario.

Welfare improves by over 99.8% under the 1.5°C Scenario by 2050 compared with the PES led by the social and distributional dimensions (right panel in Figure S 5). Further measures have the potential to bring about even greater increases in welfare in South Africa. The detailed results provide clear indications of where to focus policy action to improve welfare (left panel in Figure S 5). The greatest potential for improvement exists in the social dimension, with a focus on the introduction of measures to raise funding for social programmes.

Figure S5: Welfare Index by dimension for the 1.5°C Scenario (left) and difference in welfare between the 1.5°C Scenario and the PES (right), 2050



Notes: Left panel: The five petals are on a scale from 0 to 1 and represent the absolute values of the five dimensions of the Welfare Index. The number in the centre is also on a scale from 0 to 1 and represents the absolute value of the overall Welfare Index. PES = Planned Energy Scenario.

To achieve and maximise those socio-economic benefits in the country, bringing energy justice to all, the energy transition policy framework should be holistic. The energy transition is a gradual process, and policy makers will need to strive for harmony between energy policy and other areas of national policy over an extended period to ensure an inclusive and just transition. An inclusive and just energy transition must keep people at its heart and embrace diversity and inclusion across several populations (*e.g.* women, youth, older workers, people with disabilities, migrant workers, indigenous people, unemployed people, vulnerable workers). As the energy transition advances, the world is beginning to see the benefits of basing future energy supplies on renewables and limiting energy demand through greater efficiency. A country like South Africa, where high inequality and a fossil fuel-based economy are key challenges – will benefit immensely from the opportunities created by the energy transition given support from the international community and supportive policies.

01 Introduction

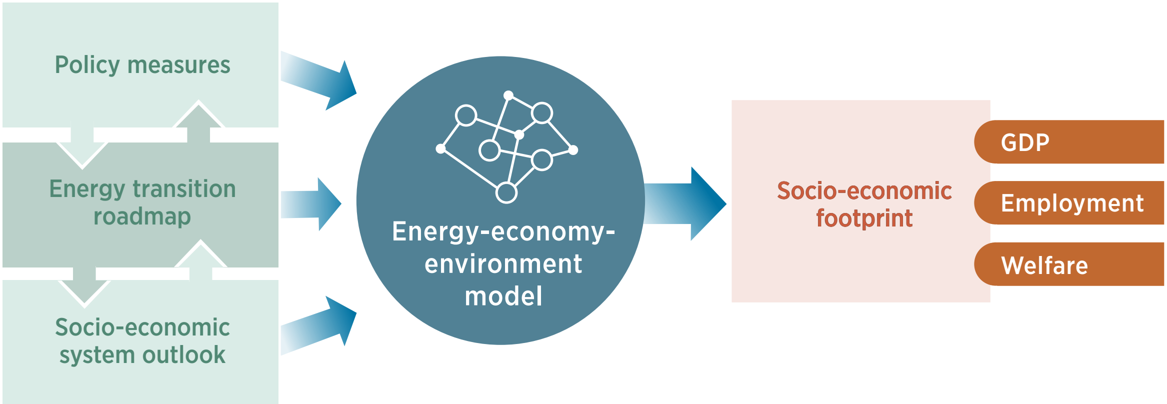
South Africa aims for significant development advances but grapples with ongoing economic and social issues, which are worsened by recent events, including the COVID-19 pandemic and the energy crisis over and above the threats posed by climate change. Over the last ten years, the economy has experienced a growth rate of approximately 1% annually. South Africa is still faced with the lingering effects of apartheid and an uneven socio-economic transition, resulting in it being the most unequal nation globally according to the Gini index (World Bank, n.d.). The unemployment rate reached 34.9% at the end of September 2021. As a result, poverty rates have remarkably risen to levels not seen for more than a decade, reversing years of progress and leading to calls for the introduction of basic income support. This has also caused social exclusion, inequality, crime and social instability, and their influence on the economy has the biggest impact. The global pandemic's effects are still being seen in certain sectors, including the tourism industry, which is not expected to return to pre-pandemic levels until 2024 (although a better recovery was recorded in 2022) (OECD, 2022). Additionally, the country must confront escalating climate change risks.

South Africa's economic recovery has been highly uneven. It has largely been driven by the global economic environment, particularly favourable commodity prices which have supported growth in the gross domestic product (GDP) and fiscal revenues. Although household consumption growth has bounced back since the recession of 2020 (World Bank, n.d.), the deteriorating labour market may hinder a more dynamic and sustainable growth trajectory. Investment remains weak due to ongoing structural issues such as power outages which destabilise the entire economy.

The government has implemented numerous bold strategies and legislative measures to tackle these challenges. In August 2022, South Africa introduced a Just Transition Framework to align its development and climate objectives. To expedite the alignment of the nation's ambitious development and climate targets and their implementation, several critical questions need further examination. These include South Africa's vulnerability to climate change, the intensity of its adaptation efforts, the feasibility of achieving net-zero emissions by 2050, and associated costs. Other considerations involve mobilising public, private and external resources to support climate goals; managing trade-offs between economic prosperity, poverty reduction, and the distributional impacts of climate change.

This report will delve into these complex issues, evaluating the socio-economic consequences of transition pathways at different levels of ambition. Through its analysis of key drivers and impacts, the International Renewable Energy Agency (IRENA) has offered insights that support energy transition planning and implementation at the global, regional, and national levels since 2016 (IRENA, 2016, 2018, 2019a, 2019b, 2020, 2021, 2022a, 2022b, 2023a, 2023b). For the energy transition to be effective and broadly beneficial, IRENA has stressed the importance of a holistic global policy framework (Figure 1). To hasten the transition, ensure its advantages are widely shared and minimise its difficulties, several policy aspects complement and support one another, spanning a wide range of technological, social and economic challenges.

Figure 1: Socio-economic assessment framework



The socio-economic analysis is conducted using a macro-econometric model (E3ME)[3] that integrates the energy system and global economies into a single quantitative framework. The model sheds light on the trade-offs between economic prosperity and employment, while examining welfare aspects, including the distributional implications of these policy choices. Policy makers need to be aware of how such choices will affect people's well-being and overall welfare and of the potential gaps and hurdles that could affect progress. This report aims to provide valuable insights and recommendations to South African policy makers, ensuring that the nation's transition to a low-carbon economy is both just and equitable, fostering job creation and reducing inequalities.

At the global level, IRENA explored these issues in its flagship report, the *World Energy Transitions Outlook: 1.5°C Scenario Pathway* (IRENA, 2021, 2022b, 2023c) (Box 1). Two energy roadmaps for the period to 2050 are analysed: 1) a scenario based on current plans, the Planned Energy Scenario (PES);[4] and 2) an ambitious energy transition scenario (1.5°C Scenario)[5] that aims to achieve the 1.5°C goal consistent with the Paris Agreement. The analysis finds that transforming the energy sector can yield widespread benefits: GDP growth under the 1.5°C Scenario averages an additional 0.5% over the PES through 2030, and energy sector employment reaches 139 million, which is 33 million more than in the PES. Of those 139 million jobs, 38 million would be in renewable energy. Global welfare would be around 20% higher than in the PES. However, these global impacts will be unevenly distributed across countries and regions, depending on local socio-economic structures, the degree of reliance on fossil fuels and other commodities, and the depth and length of the renewables supply chain, among other factors.

[3] *The E3ME global macro-econometric model (www.e3me.com) is used for the assessment of socio-economic impacts. Energy mixes and related investment, based on the World Energy Transitions Outlook 2022 (IRENA, 2022b), are used as exogenous inputs for each scenario, as well as climate- and transition-related policies.*

[4] *It is the reference case for this study, providing a perspective on energy system developments based on governments' energy plans, as well as other planned targets and policies before 2020 including Nationally Determined Contributions (NDCs) under the Paris Agreement. This report considers policy targets and developments before 2020. Policy changes and targets announced since then are not considered in the modelling exercise but are mentioned in the chapters to provide insights on latest developments.*

[5] *This scenario describes an energy transition pathway by which the increase in global average temperature by the end of the present century is limited to 1.5°C, relative to pre-industrial levels. It prioritises readily available technology solutions including all sources of renewable energy, electrification measures and energy efficiency, which can be scaled up at the necessary pace for the 1.5°C goal.*

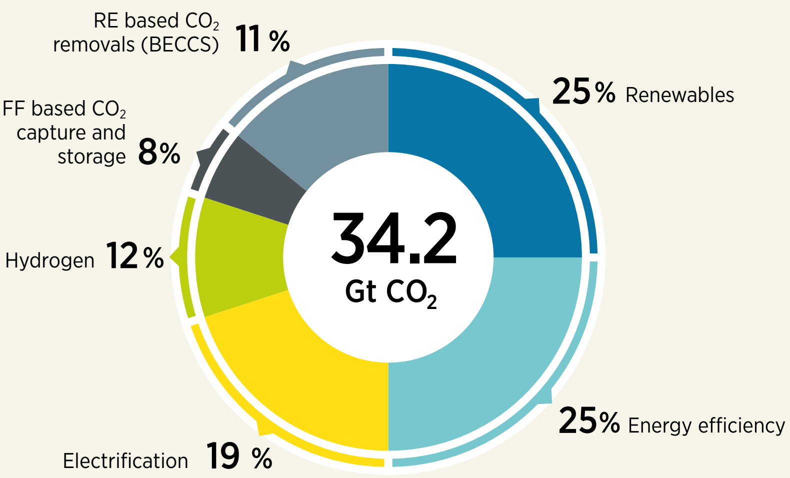
BOX 1: WORLD ENERGY TRANSITIONS OUTLOOK: 1.5°C PATHWAY

The *World Energy Transitions Outlook* outlines a pathway for the world to achieve the goals of the Paris Agreement and halt the pace of climate change by transforming the global energy landscape. The report presents options to limit global temperature rise to 1.5°C and to bring carbon dioxide (CO_2) emissions closer to net zero by mid-century at the global level. They offer high-level insights on technology choices, investment needs, accompanying policy needs and the socio-economic implications to achieve a sustainable, resilient and inclusive energy future.

IRENA's 1.5°C Scenario considers today's proven technologies, as well as innovative technologies that are under development but that could play a significant role by 2050. Figure 2 shows the six main components of the CO_2 emissions abatement based on the most recent edition of the *World Energy Transitions Outlook*. Renewable energy plays a key role in the decarbonisation effort. Over 90% of the solutions in 2050 involve renewable energy through direct supply, electrification, energy efficiency, green hydrogen, and bioenergy with carbon capture and storage (BECCS) (Figure 2). Fossil-based carbon capture and storage (CCS) has a limited role to play, and the contribution of nuclear remains at the same levels as today.

The report presents analysis at a globally aggregated level.

Figure 2: Reducing emissions by 2050 through six technological avenues



Source: (IRENA, 2023c).

Note: FF = fossil fuels; Gt CO_2 = gigatonnes of carbon dioxide; RE = renewable energy.

This report discusses the socio-economic differences between the PES and 1.5°C Scenario in South Africa, using the same inputs and assumptions as the 2022 edition of the *World Energy Transitions Outlook*. Under the PES, South Africa's economy is expected to experience strong economic growth, as envisioned in the baseline assumption of the E3ME model.[6] Under this baseline trend, the country's real GDP would increase with a compound annual growth rate (CAGR) of around 3.0% per year between 2021 and 2050. The South African population is projected to grow at a CAGR of 0.5% over the 2021-2050 period, reaching over 68.4 million in 2050 (Table 1). Economy-wide employment is also expected to rise, by an average of around 0.8% per year, over the same period.

Table 1: GDP, labour force and population growth projections under the PES

Variable	2021-2030 (CAGR %)	2031-2040 (CAGR %)	2041-2050 (CAGR %)
Real GDP	2.7	3.0	3.5
Economy-wide employment	1.0	0.8	0.6
Total population	0.6	0.4	0.4

Note: CAGR = compound annual growth rate.

IRENA's analysis explores the socio-economic footprint outcomes resulting from various assumptions incorporated under the climate policy basket. The climate policy baskets include a range of measures – carbon pricing, international collaboration, subsidies, progressive fiscal regimes (Box 2, and see Appendix for more details) to address distributional aspects, investments in public infrastructure and spending on social initiatives – to support a just and inclusive transition. The baskets also include policies that encourage the deployment, integration and promotion of energy transition technologies.

[6] *Baseline forecasts are constructed using a comprehensive set of international data sources. The main source for population data is the United Nations (World Population Prospects), and for GDP forecasts, the main sources are the International Monetary Fund (for short-term forecasts), European Commission (annual ageing report) and International Energy Agency (World Energy Outlook) (for long-term forecasts). These are applied to historical data from the World Bank, International Monetary Fund and European Commission (AMECO, Eurostat).*

BOX 2: IRENA'S CLIMATE POLICY BASKETS

IRENA's socio-economic footprint analysis includes in its modelling a very diverse set of policies to enable and support a sustainable energy transition. Holistic planning and synergistic implementation can address the multiple angles of the interactions among the energy, economy and social systems more successfully than an approach that relies on a limited number of disconnected interventions.

It should be noted that the level of carbon pricing needed to bring about an energy transition roadmap depends on the effective implementation of accompanying policies. Since IRENA's analysis includes a diverse policy basket, the transition goals can be achieved with significantly lower carbon prices than might otherwise be required.

IRENA's socio-economic analysis assesses the following comprehensive set of policies:

- international co-operation, supporting enabling social policies in all countries and addressing the international justice and equity dimensions
- domestic progressive redistributive policies
- carbon pricing, evolving over time with carbon prices differentiated by each country's income level and special treatment of sectors with high direct impacts on people (households and road transport)
- fossil fuel phaseout mandates in all sectors
- phaseout of all fossil fuel subsidies
- regulations and mandates to deploy transition-related technologies and strategies, including renewables, electric vehicles (EVs), hydrogen, and system integration through electrification and P2X (Power-to-X)
- mandates and programmes for energy efficiency deployment in all sectors
- policies to adapt organisational structures to the needs of renewable-based energy systems (such as in the power sector)
- subsidies for transition-related technologies, including for households and road transport
- direct public investment and spending to support the transition, with participation in all transition-related investments, but with special focus on enabling infrastructure deployment (electric vehicle (EV) charging stations, hydrogen infrastructure, smart meters, *etc.*), energy efficiency deployment and policy expenditure
- policies to align international co-operation with transition requirements: earmarking of funds to transition-related investments, increasing social spending
- public involvement in addressing stranded assets, both domestically and internationally
- policies to align government fiscal balances with transition requirements, addressing domestic distributional issues and aligning deficit spending with transition requirements.

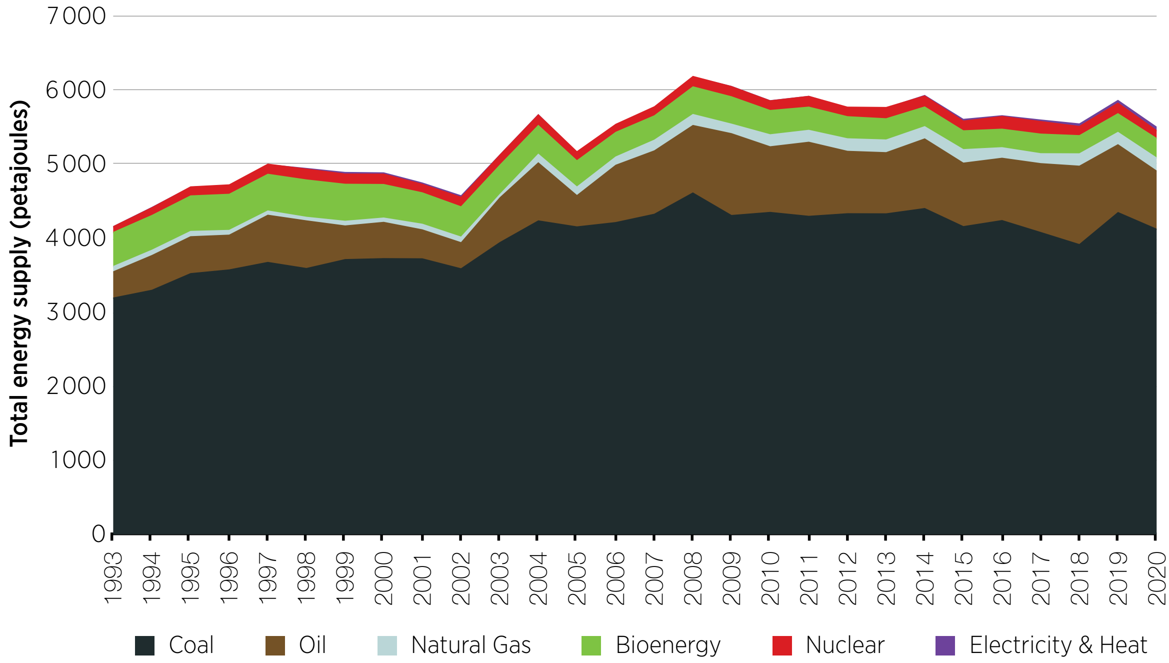
The report is structured as follows: Chapter 2 provides the energy sector trends and the associated policies in the context of climate change and energy transition. Chapter 3 delves into the macroeconomic findings to analyse the socio-economic impacts of policy baskets on the energy transition in South Africa until 2050. An analysis of how this change might affect GDP, job creation and people's welfare is provided. The section not only explores the socio-economic impacts of the energy transition but also highlights its connection to prevailing trends, providing a comprehensive analysis of the subject matter. Chapter 4 provides the summary of the results and policy recommendations for ensuring a just and inclusive energy transition. Additionally, it presents a way forward to achieve it.

02 Contextualising South Africa's energy sector and the need for energy transition

2.1 ENERGY SECTOR TRENDS

South Africa is highly dependent on fossil fuels. Compared with 1993, the Total energy supply (TES) in 2020 had increased by over 30%, reaching 5 510 petajoules (PJ) (UNSD, n.d.) (Figure 3).

Figure 3: South Africa's total energy supply by energy source



Source: (UNSD, n.d.).

In 2020, coal remained the dominant fuel with a 75% share, followed by oil at 14%, biofuels and waste-to-energy at 5%, and natural gas at 3%. Nuclear energy accounted for a smaller portion of the energy mix at 2%. It is worth noting that the renewable energy sector, including bioenergy, accounted for around 324 PJ (equivalent to around 6% of the TES), which is a decrease of around 26% compared with 1990 (UNSD, n.d.). This is due to the replacement of traditional biomass with modern fuels. Bioenergy share in the TES in South Africa is much lower than in other countries/regions of sub-Saharan Africa, where it can exceed 70% (IRENA and AfDB, 2022; UNSD, n.d.). This is potentially due to higher adoption of modern energy sources than other countries of the region.

On the other hand, total final energy consumption (TFEC) reached around 2 253 PJ in 2020, growing 13% from 1990 levels (UNSD, n.d.). Industry (40% of TFEC) and transport (28%) were the sectors with the highest energy consumption in 2020, followed by residential (18.5%) and services (8%). By source, oil products (36%) and coal (22%) together accounted for more than half of TFEC (UNSD, n.d.). Around one-third (30%) of the final energy consumption was from electricity, largely generated from fossil fuels (*i.e.* around 88% in 2020) (IRENA, n.d.).

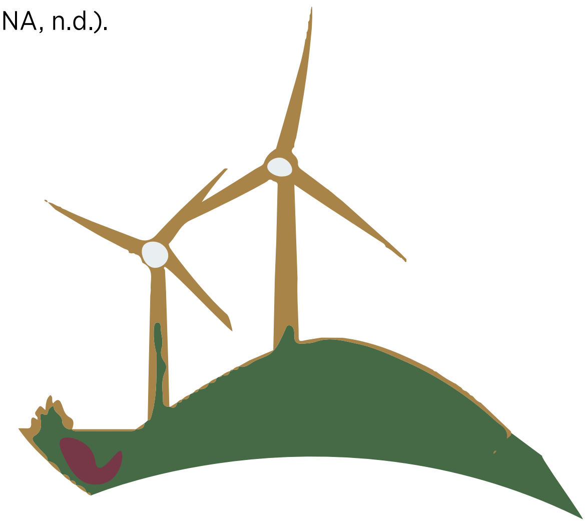
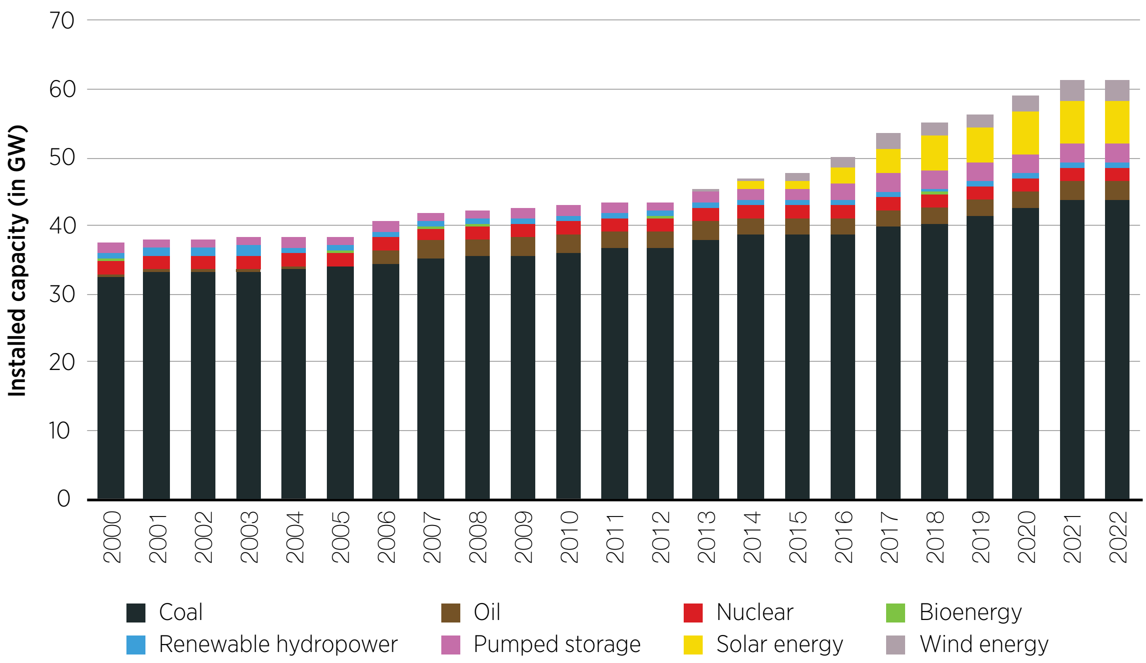


Figure 4: Power capacity (GW) in South Africa, 2000-2022



Source: (IRENA, 2023d).

Notes: GW = gigawatt: Renewable hydropower is hydropower excluding pumped storage.

South Africa's power installed capacity had a stable structure during the 2000s, with coal predominant (71.5% of the total power installed capacity in 2022) (Figure 4). Renewables still make a relatively small contribution to the total power installed capacity, although South Africa has made some notable progress in developing policies around the diversification of the energy mix through the incorporation of renewables. Since 2011, public sector programmes to attract private capital into new renewable capacity helped increase the share of clean capacity to 17% in 2022.[7] Still, 75.4% of the total 61.6 GW of South Africa's generation capacity was fossil fuels in 2022. Nuclear represented 3.2% of installed capacity (IRENA, 2023d).

2.2 SOUTH AFRICA'S ENERGY TRANSITION CHALLENGES AND INITIATIVES

Challenges

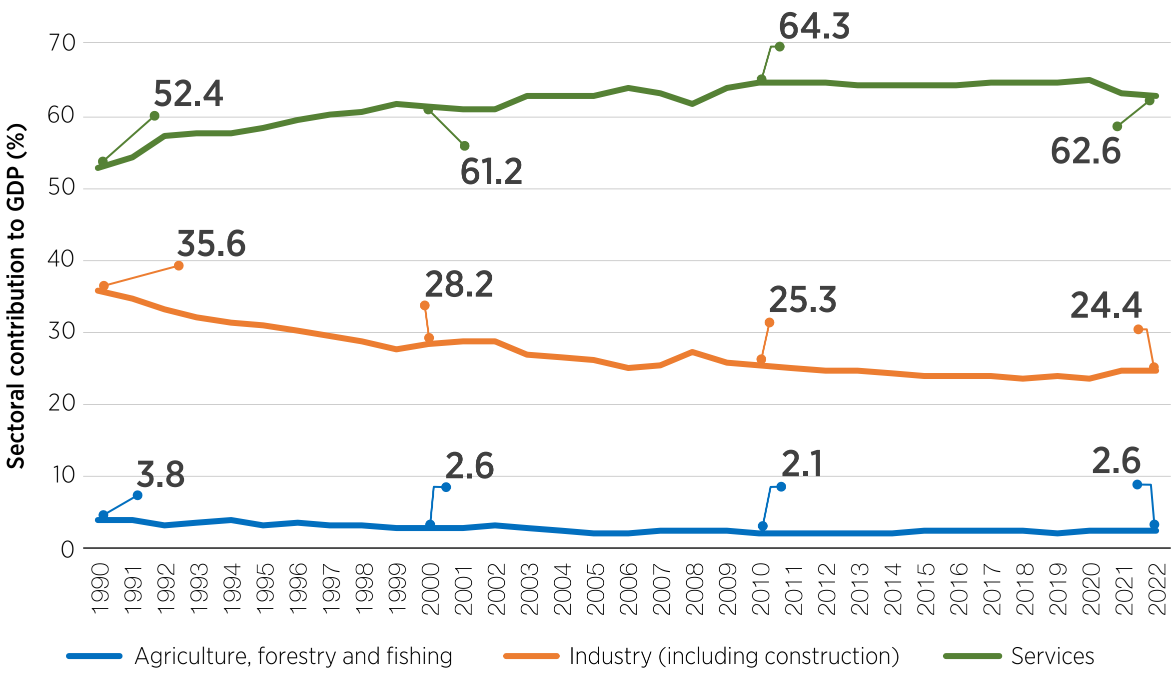
The South African economy has faced significant challenges, leading to a stagnant growth rate over the past two decades. In the early 2000s, fuelled by the commodities price boom, gross domestic product (GDP) experienced an average growth of 4.2% (2001-2008). However, the global financial crisis of 2008 caused a slowdown, with the economic growth averaging 1.4% in the following decade (2009-2019). The COVID-19 pandemic further exacerbated the situation, resulting in a sharp contraction of -6.3% in 2020 due to trade disruptions and lockdown measures. Fortunately, since 2021, the economy has shown signs of recovery, with GDP growth rebounding to 4.9% in 2021 and 2.0% in 2022. Eased lockdowns increased global demand, and government stimulus measures played a role in this positive trend. The country's GDP stood at USD 353 billion in 2021 and USD 360 billion[8] in 2022, making it the second-largest economy in Africa after Nigeria. However, in terms of per capita GDP, South Africa lags behind five African countries, indicating the need for further development (World Bank, n.d.).

[7] *Including onshore wind, solar photovoltaic (PV) and concentrated solar power (CSP), and hydropower.*

[8] *In 2015 USD.*

One key factor contributing to South Africa's economic challenges is the early de-industrialisation. Extensive liberalisation and international integration have led to a decline in the industry sector's contribution to GDP, falling from 35.6% in 1990 to approximately 24.4% in 2022 (Andreoni *et al.*, 2021; World Bank, n.d.) (Figure 5). This is due to structural changes within the manufacturing sector, which has proven to be regressive, as growth primarily concentrated in mineral- and resource-based subsectors. Diversified manufacturing, including metal products, plastic products, and food and beverages, has experienced a decline over the years (Andreoni *et al.*, 2021). Trade liberalisation, which initially had a positive impact on GDP in the late 1990s, has not met expectations in the past two decades. The overemphasis on international competition has hindered development, as the government struggled to enforce conditions that limit rent-seeking and promote reinvestment in broader economic capabilities (Andreoni *et al.*, 2021). Figure 5 illustrates the evolution of the different sectors in GDP between 1990 and 2022, highlighting the need for structural adjustments to stimulate sustainable growth.

Figure 5: Sector contribution to the GDP, 1990-2022



Source: (World Bank, n.d.).

Note: The value-added shares presented in the World Development Indicators for agriculture, industry, and services may not always add up to 100% due to financial intermediary services indirectly measured (FISIM) and net indirect taxes.

The energy sector plays a crucial role in South Africa's development. The country has been grappling with energy challenges such as ageing infrastructure leading to load-shedding, which is expected to persist at least until 2024. This situation has disrupted retail operations and supply chains, and increased costs, which impacted businesses and placed consumers under a lot of financial strain (Marais and Ntsoane, 2023). In addition to energy issues, South Africa has faced other significant disruptions, including slowing global growth, geopolitical tensions, inefficiencies in state-owned firms, and the impact of climate change. The COVID-19 lockdowns imposed stringent measures, resulting in reduced mining and industrial activity, and halting sectors such as tourism, transport and entertainment. Addressing the existing problems is vital for South Africa's economic outlook. Urgent action is required to overcome supply-side barriers, such as ensuring steady electricity access and improving goods and logistics. These measures are crucial to mitigate further deterioration and set the stage for future progress (Marais *et al.*, 2023).

South Africa considers universal access to electricity a top priority, but has not yet achieved it (World Bank, n.d.). In large part due to the Integrated National Electrification Programme (INEP), in place since 2001, the country was able to connect more than 7.4 million households to the grid between 1994[9] and 2018, bringing the electrification rate from 36% to today's 86%[10] (IRENA *et al.*, 2020). Although the initial target was to reach 92% of households by 2014, the policy was revised in 2013. The current New Household Electrification Strategy expects to reach universal access for all households by 2025. Its implementation mostly lies with Eskom and municipalities owning distribution grids, although 10% of households are expected to be provided with off-grid solutions.

Eskom, South Africa's state-owned vertically integrated monopoly utility, is in severe financial distress, while also struggling to keep the lights on. The company survived on bailouts from government, amounting to around ZAR 263.4 billion (South African rand) (around USD 14.9 billion) since 2008/2009, with an additional ZAR 254 billion (around USD 14.4 billion) debt-relief arrangement announced in 2023. In addition, it is facing growing payment arrears from municipalities, which was around ZAR 56.3 billion (USD 3.2 billion) as of the end of December 2022 (Kumwenda-mtambo, Roelf and Gumbi, 2023).

Unreliable electricity access remains at the heart of many socio-economic challenges. Power outages have affected working hours in services, mining, manufacturing and agriculture (Business Tech, 2023). Some 200 days of load-shedding occurred in 2022 alone, with the fourth quarter of 2022 being the worst on record (only 2 load-shedding-free days in 92 days). In the first quarter of 2023, there was only one day without load-shedding, and disruptions lasted longer. This resulted in reduced mining (-1.9%) and manufacturing production (-3.7%) in January 2023 when compared with January 2022. In the meantime, domestic freight and logistics constraints and declining commodity prices have added to the woes.

The country's economy is highly energy-intensive. Nearly half of industrial final energy consumption in 2020 came from energy-intensive industries such as iron and steel (19%), chemicals and petrochemicals (12%) and mining (19%) (UNSD, n.d.). It is worth pointing out that the automotive and iron and steel industries are important components of South Africa's export basket (OEC, n.d.).

South Africa's need for an energy transition is critical due to the heavy reliance of its economy on coal-based power, which results in significant health issues leading to reduced labour productivity. High levels of air pollution from the coal industry contribute to over 25 000 premature deaths annually, with the most severe impacts occurring in the eastern coal belt region of the Highveld (Centre for Research on Energy and Clean Air, 2023). The country's high carbon intensity also threatens its competitiveness in international markets, making it vulnerable to carbon-related penalties.

Over 70% of South Africa's total greenhouse gas (GHG) emissions come from fuel combustion, with the energy sector being the major contributor. Coal-fired power plants account for over 90% of all electricity production (IRENA, 2023d). The need for a green transition is complicated by the spatial concentration of the coal industry. Coal mining and most of Eskom's power plants are concentrated in Mpumalanga province, thus there are a lot of related industries there. There is also the coal-to-liquids facilities at Secunda, which accounts for more carbon dioxide (CO_2) emissions than any other single facility on earth (IMF, 2022). Yet to date only minimal renewable energy capacity has been installed in Mpumalanga, limiting socio-economic alternatives to coal.

---

[9] *Also considering progress made by previous programmes, namely the Reconstruction and Development Programme (RDP).*

[10] *This rate is below only Northern African countries, which, with the exception of Libya, all stand above 99%, and Gabon, which stood above 92% in 2020.*

Moreover, the impacts of climate change exacerbate existing poverty and inequality in South Africa. Low-income households are disproportionately affected, as they are more exposed to pollution and extreme weather events, have limited access to quality public health services, and possess fewer financial resources to cope with damages. Transitioning to a low-carbon and climate-resilient energy sector is essential for protecting the environment, human health and the economy, while also addressing social inequities.

South Africa is highly vulnerable to the physical impacts of climate change, experiencing warming at twice the global average. The country faces increasing risks of aridity, droughts and extreme storms, which already manifest in events such as the water emergency in Cape Town and unprecedented floods in Durban. Climate change threatens labour productivity, biodiversity, human and livestock health, and agriculture, particularly given the nation's reliance on rain-fed agriculture and scarce water resources. Droughts, floods and storms impacted over 22 million people in South Africa between 1980 and 2020 (World Bank CCKP, n.d.). The Intergovernmental Panel on Climate Change predicts that the current trend of increasing extreme heat stress in the region will continue, along with increasing aridity and droughts, increasing the intensity and frequency of heavy precipitation, and increasing coastal and ocean-related hazards, including increased coastal flooding in low-lying areas. In tandem with the rise in average global temperature, these occurrences are becoming more common and more intense, posing risks to the economy through their effects on things such as water and food supplies, human health, and physical infrastructure (World Bank, 2021; IMF, 2022).

Initiatives

The country has adopted several policies and initiatives to achieve the energy transition. In September 2021, the country updated its 2015 Nationally Determined Contribution (NDC). In this update, the country chose a bolder decarbonisation pathway, reducing the target emissions upper range by 17% for 2025 and 32% for 2030.[11] South Africa's 2016 NDC maintains its commitment to a "peak-plateau-decline" trajectory,[12] targeting a GHG emissions range of between 398 million tonnes equivalent carbon dioxide (Mt CO_2eq) and 614 Mt CO_2eq by 2025 – 2030. The new lower and upper ends are consistent with the 1.5°C and 2°C pathways respectively, with targets of 398 Mt CO_2eq to 510 Mt CO_2eq by 2025, and 350 Mt CO_2eq to 420 Mt CO_2eq by 2030 (UNFCCC, 2021). According to the NDC, the country will first focus on the decarbonisation of the electricity sector during the 2020s, then shift the attention to the transport sector. From 2040 onwards, the hard-to-abate sectors would be addressed (UNFCCC, 2021). To achieve these targets, significant investment in new renewable energy capacity is required.

Renewable energy targets are now contained in the country's 2019 Integrated Resource Plan (IRP) – a power system expansion plan that forms the legal basis for any new public (and possibly private) procurement of power generation capacity. The IRP was meant to be updated at least every two years, but the 2010 version was replaced only in 2019. The 2019 IRP also contains allocations for new coal and nuclear plants that were forced in through a "policy adjustment process" that artificially limits the amount of capacity awarded to other technologies. Nevertheless, the 2019 IRP projects that at least 41% of South Africa's installed capacity in 2030 will come from renewable energy (17% of the total power installed capacity in 2022), consisting of 17 742 megawatts (MW) onshore wind (3 102 MW installed in 2022), 8 288 MW solar PV (5 826 MW installed in 2022), 4 600 MW hydro (752 MW installed in 2022) and 600 MW CSP (500 MW installed in 2022) (Ministry of Energy, 2019).[13]

---

[11] *New mitigation targets are 398 million tonnes (Mt) of CO_2 equivalent (CO_2eq) to 510 Mt CO_2eq for 2025 and 350 Mt CO_2eq to 420 Mt CO_2eq for 2030, down from the 398 Mt CO_2eq to 614 Mt CO_2eq range for the period 2025 to 2030 stated in the country's first NDC.*

[12] *Taking the form of a peak, plateau and decline of GHG emissions trajectory range.*

[13] *The CSP plants were already contracted by the time the IRP was promulgated but had not yet been built. Also, the large hydro allocation assumes that the Grand Inga hydro scheme will be developed and sell power to South Africa through the Southern African Power Pool – a prospect that remains deeply unlikely.*

South Africa demonstrates its commitment to international co-operation on a just energy transition by actively participating in a newly formed Just Energy Transition (JET) Partnership. This ambitious and long-term collaboration involves the governments of South Africa, France, Germany, the United Kingdom and the United States, as well as the European Union. The partnership's primary objective is to expedite the decarbonisation of South Africa's economy, placing particular emphasis on its electricity system. This collaborative effort will enable the country to achieve the ambitious targets outlined in its updated NDC emissions goals. The country has also approved JET Investment Plan (JET IP), which focuses on sustainable development and a fair transition for impacted workers and communities, adopting a comprehensive approach that involves all sectors of society. The JET IP lays out needs and shows plans for USD 8.5 billion that will be disbursed through various mechanisms, such as grants, concessional loans, investments and risk-sharing instruments, all aimed at mobilising the private sector's involvement (The Presidency Republic of South Africa, 2022).

Carbon pricing is already a piece of the country's energy policy since the introduction of the Carbon Tax Act in May 2019. The policy leans on the National Greenhouse Gas Emission Reporting Regulations that require companies engaging in polluting activities to measure and report their GHG emissions if they surpass certain thresholds (normally referring to the activity output). The carbon price starts at ZAR 120 per tonne of CO_2 (USD 7.13[14]) and was to be raised annually by an inflation adjustment plus 2% until 2022, and only by inflation thereafter (SARS, 2022). Also, in its first implementation phase (until December 2022), all polluters enjoy a basic tax allowance of 60%, which may be increased up to 95%. For example, electricity generation and manufacturing industries will initially have allowances of 90% (Government of South Africa, 2019). These aim to give emitters slack to transition to cleaner technologies and to reduce the carbon tax's impact on electricity prices, whose affordability is a key policy objective. South Africa's post-apartheid constitution of 1996 establishes a right to a safe environment and environmental protection (Cooper, 2019).

The policy is of relevance as emissions from fuel combustion account for over 70% of total GHG emissions in South Africa, and the energy sector is the largest contributor to climate change. The bill has been extended to 2025. However, it has come in for significant criticism given the low price it imposes, as well as the significant exemptions it offers for the biggest emitters (including Sasol and Eskom). A recent challenge to the tax by organised business was dismissed by National Treasury as well as by studies (Calland, 2023), which pointed out that South African exports will be severely disadvantaged by the Carbon Border Adjustment Mechanism of the European Union – the country's biggest trading partner – given the high level of embedded carbon in the country's products. At this stage, the carbon tax revenue is not earmarked for any specific purpose since the main objective seems to be changing economic behaviour. South Africa also has a draft climate change bill before parliament that would bolster the integration of climate change considerations across sectors. The Presidential Climate Commission has already been established under the bill to chart a just transition pathway to net zero by 2050 and is chaired by the president.

In South Africa, the concept of a "just transition" to a greener economy has gained traction over the past decade. Despite shifts in the governing bodies, the idea remains central to policy dialogue, especially given concerns about job losses amid high unemployment. South Africa uniquely included "just transition" in its initial NDC, reflecting a decade-long public policy focus (Calland, 2023).

[14] *Exchange rate 0.059 USD/ZAR (as of 10 July 2022).*

The South African Renewable Energy Masterplan (SAREM) outlines a strategy to capitalise on the growing demand for renewable energy and storage technologies, particularly solar and wind energy, as well as lithium-ion and vanadium-based batteries. The plan focuses on four main pillars:

- stimulating local demand for renewable energy by ensuring market and system readiness
- promoting industrial growth through local supply chains and supportive policies
- ensuring inclusive development by transforming the industry and aiding emerging suppliers
- enhancing local skills and innovation to facilitate the deployment of renewable technologies.

SAREM aims to drive both industrial and inclusive growth while contributing to a just energy transition. In this context, the country has local content policies (though it has met serious criticism over time[15]). Local content requirements have been increased over time, with the aim to develop industrial and economic conditions. The Department of Trade, Industry and Competition is also working to drive the overall renewable energy industrialisation process for the country through SAREM (Naidoo, 2023; Paton, 2023).

[15] *When the Renewable Energy Independent Power Producer Procurement Programme (REI4P) process was halted in 2015, this saw the financial collapse of the few manufacturing companies that had managed to be set up to service the programme. As a result, preferred bidders have been unable to meet local content requirements in the latest rounds due to a lack of local manufacturing capacity. Temporary local content exemptions have therefore been granted for these latest windows.*

03 Socio-economic impact of the energy transition

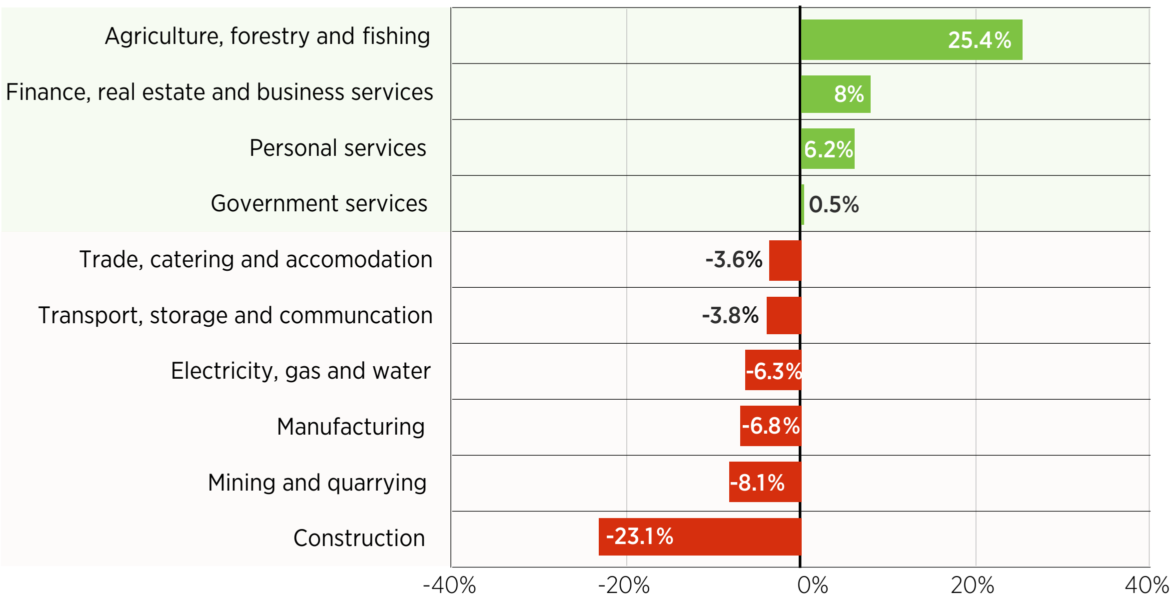
This section presents the key findings of IRENA's socio-economic analysis for South Africa's energy transition, outlining potential impacts on aggregated economic activity (GDP), employment and welfare. These findings delineate the difference between the 1.5°C Scenario and the PES.

3.1 ECONOMIC IMPACTS, AS MEASURED BY GDP

From a sector perspective, South Africa's GDP structure has undergone a progressive transition to a service economy, driven primarily by the growth of financial services (African Development Bank, n.d.). Services contributed to 63% of the country's GDP in 2022, which is significantly higher than the sub-Saharan African average of 46.9% (World Bank, n.d.). In contrast, the contribution of agriculture to GDP has steadily declined over the last half of the 20th century, mainly due to severe droughts in the 1980s. This decline resulted in a reduction of its weight in GDP from 3.8% in 1990 to its current level of 2.6% with agriculture, forestry and fishing (see Figure 5) (World Bank, n.d.). Similarly, the industry sector's contribution decreased from 35.6% in 1990 to 24.4% in 2022. Notably, these figures for industry and agriculture in South Africa are lower than the sub-Saharan African averages of 28.0% and 17.3%, respectively, in 2022 (World Bank, n.d.).

Despite improvements in 2021, only four of the ten sectors performed positively relative to the pre-pandemic period (Figure 6). This again points to some of the structural constraints that were discussed in the earlier section.

Figure 6: Value added by sectors in in the 4th quarter of 2022, when compared with 2019/pre-pandemic levels



Source: (Statistics South Africa, 2023a).

Agriculture, forestry and fishing value-added more than doubled in real terms between 2002 and 2022, growing at an annual compound rate of 3.1%. Notably, the agriculture sector experienced a remarkable 25.4% growth in the second quarter of 2022 compared with pre-pandemic levels. The main crops contributing to this growth include maize, wheat, sugar cane, potatoes, groundnuts, citrus and grapes (FAO, 2023). Additionally, South Africa is a relevant exporter of citrus fruits, wine and animal products. Moving on to the industry sector, it encompasses various sectors such as mining, manufacturing, construction, electricity, water and gas/other utilities. South Africa's industrial performance has been relatively low compared with its peer group of upper-middle-income countries such as Brazil. The country has low average investment rates and a relatively low share of manufactured goods in total merchandise exports, with minimal high-tech exports. When compared with middle-income and upper-middle-income countries (excluding the People's Republic of China [hereafter, "China"]), South Africa's average growth rate for GDP has been lower at 2.2%, and for industry has been lower at 0.8%, during the last two decades (*i.e.* 2002-2022). These challenges, such as low industrial performance, low investment levels and weak exports of sophisticated products, are shared by several other countries to varying degrees.

Despite the current challenges such as the premature deindustrialisation and the energy crisis as seen in previous sections, the long-term outlook for South Africa's economy presents more promising prospects. In IRENA's PES, South Africa is expected to experience significant economic growth between 2021 and 2050 as envisioned in the baseline assumption of the E3ME model. Real GDP in the PES is assumed to grow with a compound annual growth rate of 2.7% per year between 2021 and 2030, by 3.0% per year in the 2031-2040 period and by 3.5% per year from 2041-2050. This is in-line with the national Integrated Resource Plan (IRP) upper forecast of 3.2% annual GDP growth to 2050 (Ministry of Energy, 2019). Under the 1.5°C Scenario, South Africa is expected to improve its GDP by an additional 7.8% on average over the 2021-2050 period compared with the PES, resulting in substantial economic gains. In cumulative terms, the country would be adding around USD 1.4 trillion[16] to the GDP already anticipated under the PES over the same period. GDP would slow down after the initial boost from front-loaded investments, but it would still be 4.5% greater in the 1.5°C Scenario in 2050 than in the PES. Investment, and indirect and induced effects, and trade to a lesser extent, are the main macroeconomic factors that have key impacts on GDP difference depending on the period analysed. The difference in GDP is driven mostly by investment in the transition's first decade (2021-2030), and then by indirect and induced effects from 2030 onwards. Nevertheless, trade also has an impact in driving differences in GDP in the second decade of the transition (*i.e.* 2031-2040), but to a lesser extent in comparison to the indirect and induced effects driver. The different components of the drivers are presented in Box 3.

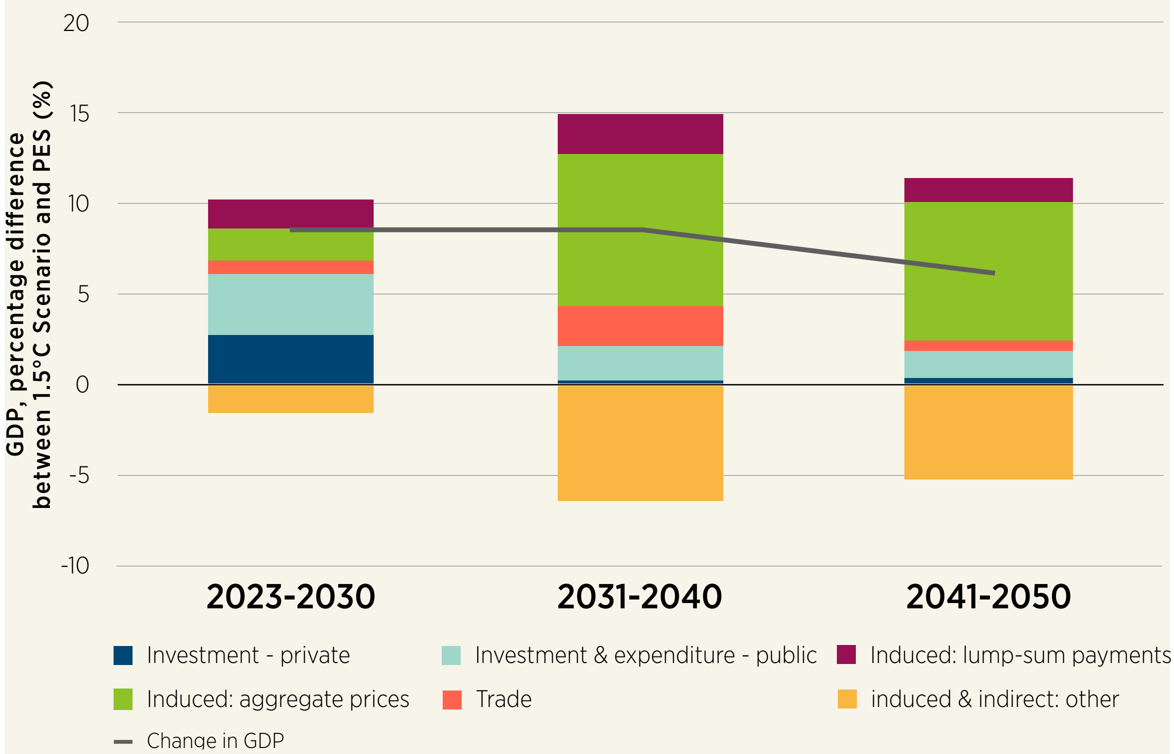
By addressing the existing challenges and leveraging the potential of the energy sector, South Africa has an opportunity to drive sustainable economic growth and improve its long-term prospects. However, it requires concerted efforts and effective policy measures to overcome the current hurdles and create an enabling environment for development.

[16] *In 2019 USD.*

BOX 3: DRIVERS OF GDP GROWTH

To gain a better understanding of the structural elements underlying the socio-economic footprint, IRENA's macroeconomic analysis disaggregates the outcomes by drivers and sectors.* The main macroeconomic drivers that have key impacts on GDP difference are investment, and indirect and induced effects, and trade to a lesser extent, depending on the considered period in the transition.

Figure 7: South Africa's GDP, percentage difference between the 1.5°C Scenario and the PES by driver, 2021-2050



The **investment** driver, which has two components (private investment, and public investment and expenditure), most influences the differential GDP results between the two transition scenarios and does so mainly in the first decade of the transition (*i.e.* 2021-2030).

- The public investment and expenditure driver plays a significant role in the first decade of the transition, before decreasing in the following decades (Figure 7). This is primarily due to the front-loaded investment. Under the 1.5°C Scenario, government social spending in South Africa increases by more than USD 4.9 billion compared with the PES in 2050 (and over USD 99.2 billion in cumulative money throughout the whole transition period), benefiting from the global transition flows. This leads to increased spending on non-defence services predominantly provided by the government, including public administration, healthcare and education, therefore mainly benefiting public and personal services. Nevertheless, the increase in government social spending is modest because, while benefiting from the global transition flows across all three pillars of support (enabling and social, international justice, and international equity), it is also assumed to make a notable contribution (equivalent to the share of some European member states) in return.
- Private investment has a positive impact throughout the transition. Over the first decade of the transition, it is significantly higher under the 1.5°C Scenario than the PES, with a cumulative differential of over USD 118 billion (equivalent to an average impact of around 3.1% per year in GDP during the 2021-2030 period). However, in the second decade, the impact stabilises before declining in the last decade.

Despite the negative impact of fossil fuel investment in the power sector on other sectors and the loss of investment in the fossil fuel supply, private transition-related investments (energy efficiency and other end uses, grids and energy flexibility, and mainly renewables) play an important role in offsetting these trends. Investment in the power sector initially crowds out investment in other sectors, such as construction, metals and engineering. This trend affects these industries the most. But soon after the first decade, this effect dissipates as the relative impact of front-loaded investment tapers off.

Induced and indirect effects have different components (aggregate prices, lump-sum payments and others). Together, they form the second-strongest factor in driving differences in GDP (Figure 7).

- Domestic responses to shifts in carbon prices, technology prices, power sector capacity, fossil fuel subsidies and investment expenditures are all reflected in the positive role of induced-aggregate prices. An increase in price levels is expected, driven by higher electricity prices during the first decade with the front-loaded investment in renewables and the substantial role of coal in power generation where the cost is higher due to increased carbon prices. The complete phaseout of coal by 2050 and the rapid deployment of renewables throughout the transition, as well as the substantial decrease in their costs in the 1.5°C Scenario, lowers electricity costs in the following two decades compared with the first. This reduces production costs for industries and lowers the financial strain due to energy expenditure for households.
- The negative impact of induced and indirect effects (other**) on South Africa's economy is small in the first decade, is at a larger magnitude in the second decade (*i.e.* 2030-2040), and starts diminishing from 2040, mainly driven by consumer expenditure. Between 2021 and 2030, household consumption remains under financial strain although benefiting from investment stimulus and international climate co-operation flows that provide financial support to low-income households, due to increased level of prices with carbon taxes and an energy sector that is still coal-based. After the first decade of the transition, the previous negative effect increases with larger relative reductions in household expenditure than in real disposable income, implying that saving rates increase in the long term in the 1.5°C Scenario compared with the PES. Given South Africa's relatively high debt-to-income ratio and low saving rates, many consumers may use the additional income to pay off debts or build up savings rather than spend. However, after 2040, the reduction in total household expenditure is much smaller than the reduction in real household disposable income. That is, average saving rates are lower in the 1.5°C Scenario. This is a delayed effect of large lump-sum payments being paid in earlier years. In addition, there is an increasing positive impact on the GDP difference of the changes in income tax rates, which is a part of the induced and indirect effects (other) driver.

  Differences in revenue and spending between the 1.5°C Scenario and the PES throughout the transition period require decreases of income taxes under the 1.5°C Scenario. Carbon pricing and international co-operation receipts increase revenues in the 1.5°C Scenario compared with the PES. As the carbon tax rate and the support from the global transition collaboration flows increase, income tax decreases.
- A revenue recycling treatment assumes that lump-sum payments are paid directly to households in the 1.5°C Scenario when the government accumulates excess tax revenues after paying for transition-related investment and other policy costs. Thus, the induced lump-sum payments driver has a positive impact throughout the whole transition period. This effect peaks in the years to 2030 and wears off over time as carbon tax receipts fall in line with emissions. Those additional revenues will be important to enable the investments needed for the transition and to support a just transition.

Given that South Africa is a major exporter of coal and minerals, the **trade** driver also plays a positive role for its economy over the whole transition period, but to a lesser extent than investment and induced and indirect effects. The country benefits mainly from a continued diversification of its economy and from the endogenous investment response to expand productive capacity and increase participation in the global supply chain of raw materials to support global transition-related technology development. In the 1.5°C

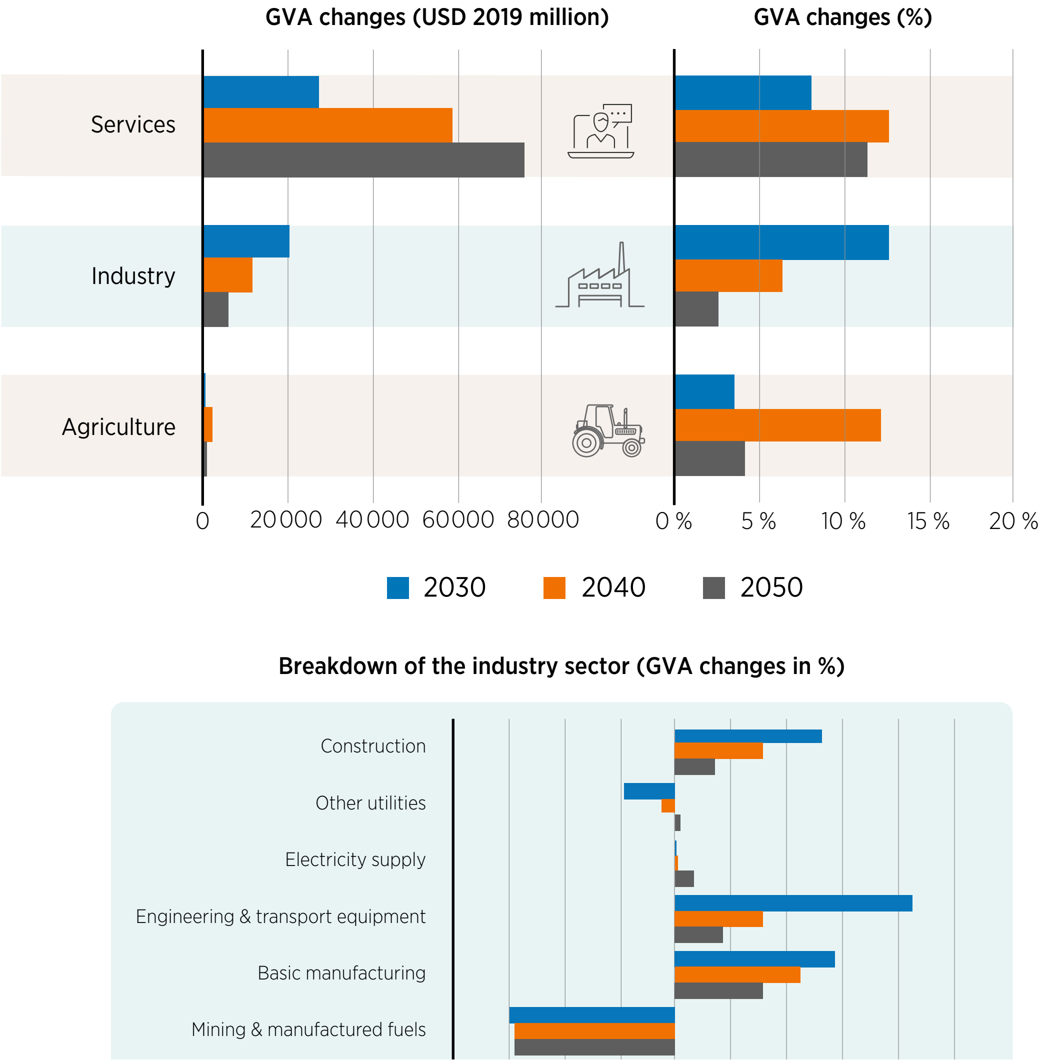
Scenario, the consumption of all fossil fuels reduces dramatically. As an importer of oil and petroleum products, the trade balance improves and reduces the country's burden of import dependence. The improvement in the energy trade balance contributes positively to GDP, amounting to around USD 6 billion[17] in 2050 (equivalent to around 13.6% of the GDP difference between the 1.5°C Scenario and PES in 2050).

* More details available at www.e3me.com and IRENA (2016, 2021).

** This component acts as a "catch-all" for remaining consumption effects; that is, it captures all remaining indirect and induced effects of the scenario inputs, and also the changes in spending due to income tax rate responses.

Under the 1.5°C Scenario, the agriculture sector is expected to continue improving over time. While the agriculture sector exhibits more moderate percentage changes compared with the PES, it still experiences a 3.6% increase in 2030, followed by a higher increase of 13.9% in 2040, and a 4.3% increase in 2050 (Figure 8). These changes are primarily driven by higher investment in biofuel supply.

Figure 8: Gross value added (GVA) evolution between PES and 1.5˚C Scenario in USD 2019 million (left panel), in percentage (right panel), by sector.



Notes: GVA=Gross value added; PES=Planned Energy Scenario.

[17] In 2019 USD

The industries sector demonstrates notable improvements when compared with the PES, with percentage increases of 14.5% in 2030, 6.7% in 2040 and 2.7% in 2050 (Figure 8). This growth can be attributed to private sector investment in energy efficiency and electrification, increased global demand, and an improved trade position. The sector plays a crucial role as a supplier of basic inputs to other sectors, both domestically and internationally. Private sector investment in energy efficiency and renewables, along with increased export values driven by global demand and improved trade performance, contribute to the positive performance of engineering and basic manufacturing sectors, surpassing the projected outcomes under the PES. When compared with the PES, the services sector overall shows the highest percentage changes, with 8.8% in 2030, 14.4% in 2040 and 12.9% in 2050 (Figure 8).

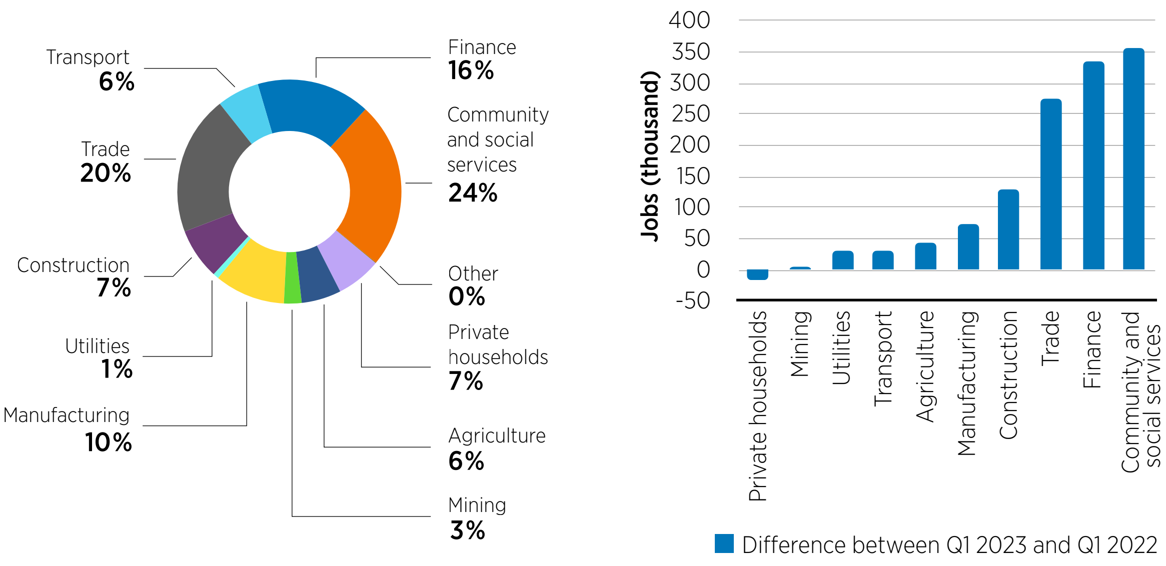
Focusing on the industrial sector, and in particular the manufacturing sector, the data show South Africa is a clear winner. Figure 8 shows significant decline in mining and manufactured fuels under the 1.5°C Scenario (59% reduction compared with the PES), which can be attributed to a strategic shift towards cleaner energy sources and driving industries away from fossil fuels. What could be of particular interest in the South African context is the growth in the basic manufacturing sector. Basic manufacturing and the engineering and transport equipment soar by 2030, with 56.8% growth for basic manufacturing and 84.4% growth for engineering and transport. Electricity supply and construction also witness positive shifts. The sector benefits from innovations and technological advancements that make processes not only more sustainable but also more efficient. Additionally, there is a growing global demand for green and sustainable products. Companies adapting to this trend are likely to experience increased market share and profitability. Other utilities and construction also witness growth to 2050.

3.2 EMPLOYMENT

Economy-wide employment

South Africa's labour market has historically been marked by an unemployment rate consistently above 20%. This persistent issue was further aggravated by the COVID-19 crisis, which exposed the labour market's limited resilience. In the first quarter of 2023, South Africa's unemployment rate of 32.9% positioned it among the countries with the highest global unemployment rates (Statistics South Africa, 2023b). However, there are also encouraging signs of economic recovery as the number of employed persons increased by 258 000, reaching 16.2 million in the first quarter of 2023. Analysing Figure 9 (right panel) reveals that employment rose in nine out of ten sectors from the first quarter of 2022 to the first quarter of 2023. Sectors such as community and social services (357 000), finance (335 000), trade (275 000), and construction (128 000) contributed to an overall rise of 1.3 million in employment compared with the same period last year. The only sector that experienced a decline in employment was private households, with a decrease of 16 000 jobs (Statistics South Africa, n.d.).

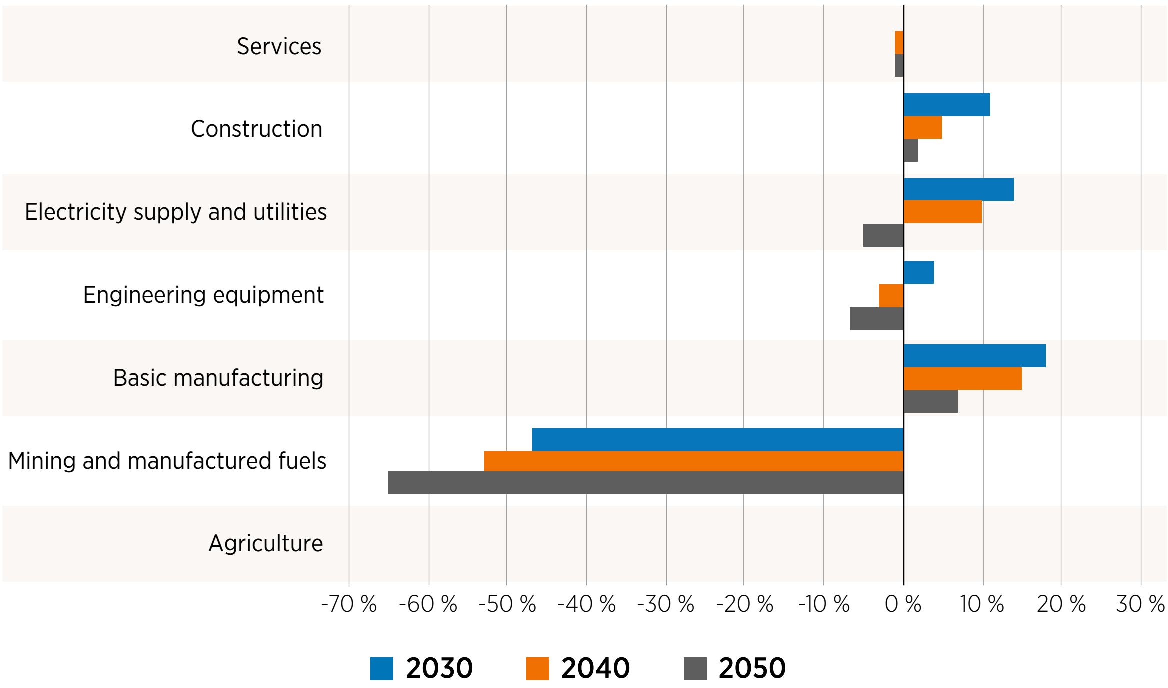
Figure 9: Jobs by sector in South Africa (left), and difference in employment between the 1st quarter of 2022 and the 1st quarter of 2023 (right)



Source: (Statistics South Africa, n.d.).

Even as South Africa's population is projected to reach 75.5 million by 2050 (UNDESA, 2022), the country is expected to continue grappling with the persistent challenge of high unemployment. Under the 1.5°C Scenario, employment is, on average, 0.2% higher than in the PES over the 2021-2050 period, but lower by -2.4% in 2050 (520 000 jobs). This result is influenced by various drivers. Sectors such as basic manufacturing, engineering equipment, electricity supply and utilities, and construction exhibit varying degrees of job growth, albeit with a decreasing trend. The services sector, on the other hand, experiences minimal changes overall. These trends signify a shift in employment patterns, with reduced reliance on mining and manufactured fuels, and a growing emphasis on sectors associated with manufacturing, engineering and renewable energy. Notably, the mining and manufactured fuels sectors are anticipated to witness substantial job reductions of 47% in 2030, 53% in 2040, and 65% in 2050, due to its strong interlinkages with the energy sector and the expected energy transition (Figure 10). Box 4 discusses the role of different drivers.

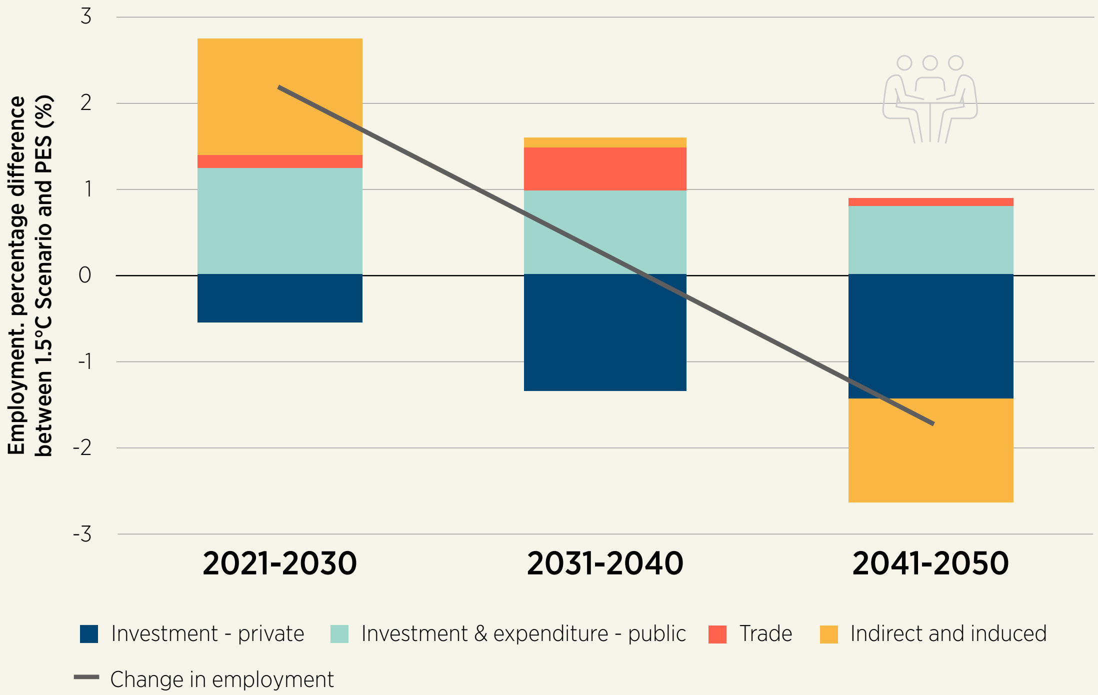
Figure 10: Percentage change in employment, 1.5°C Scenario compared with the PES, by sector, 2030, 2040 and 2050



BOX 4: DRIVERS OF EMPLOYMENT GROWTH

As is the case for GDP, employment is also driven by a set of factors including trade, investment, and indirect and induced effects. This box provides a brief explanation of the impacts observed in Figure 11.

Figure 11: Employment in South Africa, percentage difference between the 1.5°C Scenario and the PES by driver, 2021-2050



The difference in the economy-wide employment outcomes between the 1.5°C Scenario and the PES is mainly explained by trade. The effects of the drivers, namely **investment**, and **indirect and induced effects**, almost cancel each other out due to their opposite impacts on employment over the whole transition period (*i.e.* 2021-2050).

Trade has a positive impact on job creation (around +0.3% per year on average between 2021 and 2050). This is mainly because of the positive effect from changes in net trade in non-energy sectors under the 1.5°C Scenario. This result is broadly consistent with the GDP driver result, but the positive effect on employment is lagging due to employment being a second-order effect. On the other hand, the changes in net trade in fuels do not provide any effect. Although the energy sector trade balance improves, it does not lead to job growth due to a decline in global fossil fuel demand and imports rather than any increase in exports.

Public investment and expenditure lead to more jobs throughout the transition period. Since the government is investing more in transition-related expenditures (energy efficiency and end uses, electrification,renewables, *etc.*), the benefits will be greater in the years leading up to 2030. More service-oriented sectors, including redesign of building spaces, energy management system upgrades and retrofits, are receiving more investments. In addition, throughout the transition, increased social spending is seen compared with the PES, which yields a net positive effect due to strongly positive influences from lump-sum payments financed by international climate co-operation flows.

On the other hand, the impact of **private investment** on the employment differential turns increasingly negative during the transition period, primarily due to the impact on large-scale fuel extraction, particularly the phaseout of coal, which leads to the loss of around 537 000 jobs, equivalent to the entire current workforce, by 2050. Some of the skills in the coal industry could be reoriented towards emerging industries (such as renewable power generation), but others will likely be lost permanently. Government action is needed to retrain workers for alternative occupations and offer social protection in order to prevent severe economic disruptions.

The **indirect and induced effects** of the transition have mixed impacts on employment. In the initial years to 2030, they lead to more jobs, but later in the transition, they result in job losses. These effects are mainly driven by positive contributions from consumer expenditure in the first decade. Household consumption has a net positive effect due to lump-sum payments and price effects. Changes in the sectors, such as food, drink and tobacco within the basic manufacturing aggregate, distribution and retail, and public and personal services, that support consumer spending are a direct result of shifting consumption habits. However, the positive effect from consumer expenditure is offset by the negative impacts from wage effects and lower investment stimulus, mainly in the last decade (*i.e.* 2041-2050 period). The negative impact is mainly attributable to the loss in fossil fuel supply and is most visible in the basic manufacturing, engineering and transport equipment, business services, distribution and retail, and public and personal services aggregates. In addition, the motor vehicles sector (within the engineering and transport equipment aggregate) experiences noticeable demand reductions due to accelerated deployment of electric vehicles, which involve a less labour-intensive production than combustion engines.

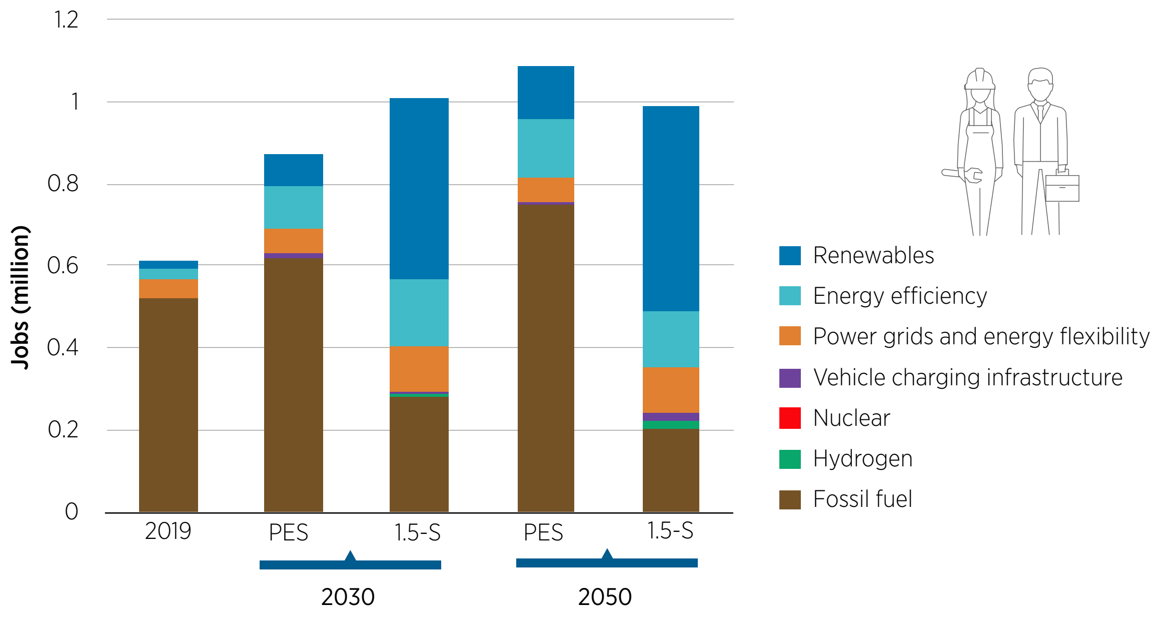
Energy sector jobs

By 2030, the number of people employed in the South African energy sector could potentially reach 1 million under the 1.5°C Scenario, compared with the current 0.6 million (Figure 12). The substantial job losses in conventional energy (fossil fuels and nuclear) of about 0.3 million between the 1.5°C Scenario and the PES are nearly offset by gains of about 0.5 million in renewables and other energy transition-related technologies (energy efficiency, power grids and flexibility, vehicle charging infrastructure, and hydrogen) by 2030. But retraining and recertification, active labour market measures, and social protection programmes are a must to address the misalignments that are likely to emerge throughout the transition period.

Looking ahead to 2050, the number of jobs in the energy sector remains steady at around 1 million under the 1.5°C Scenario. However, this figure is 0.1 million lower than the projected jobs under the PES. This outcome is a result not only of front-loaded construction of new transition-related technologies, particularly energy efficiency, but also an overall increase in labour productivity throughout the sector, as more output is achieved with less input and human resources, thanks to automation and advanced technologies.

Under the PES, approximately 70% of total energy sector employment (0.75 million jobs) will still depend on fossil fuels. However, under the 1.5°C Scenario, this percentage is significantly reduced to 20% (0.2 million jobs), indicating a substantial shift towards cleaner energy sources. While the share of energy efficiency jobs remains relatively stable at around 13-14% (equivalent to 0.14 million jobs), there is a notable uptick in the proportion of jobs related to power grids and flexibility. This category experiences a significant increase from 5% (or 0.06 million jobs) in the PES to 12% (0.11 million jobs) under the 1.5°C Scenario, in line with the investment driver in Box 3. Under the 1.5°C Scenario, renewables represent 51% of energy sector jobs in 2050 – the highest share – amounting to 0.5 million positions. This compares with a 12% share (0.13 million jobs) in the PES, demonstrating a substantial growth in renewable energy job opportunities.

Figure 12: Overview of energy sector jobs in South Africa under 1.5°C Scenario and PES, by sector, 2019-50



Note: PES=Planned Energy Scenario; 1.5-S = 1.5°C Scenario.

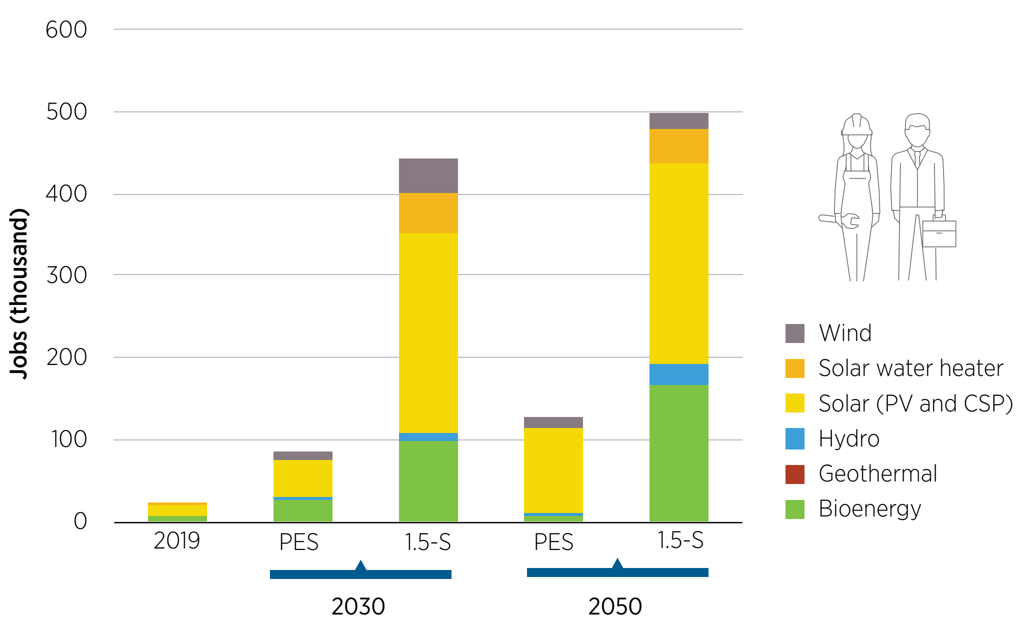
Renewables jobs

The number of jobs in the renewable energy sector is expected to increase significantly from around 23 900 jobs at present to 83 700 by 2030 and 128 400 jobs by 2050 under the PES. However, the growth in renewable energy jobs is even more pronounced under the 1.5°C Scenario, surpassing the PES projections. Figure 13 illustrates this trend, with an estimated 500 000 jobs in the renewable energy sector by 2050 under the 1.5°C Scenario.

In the 1.5°C Scenario, solar technologies, including photovoltaic and CSP, are expected to dominate the renewable energy job market in South Africa, with approximately 245 000 jobs in both 2030 and 2050. Bioenergy also plays a significant role, creating nearly 100 000 jobs in 2030 under the 1.5°C Scenario, increasing to 166 000 by 2050. Additionally, solar water heaters contribute around 45 000 jobs in 2050, hydro another 25 000 jobs, and wind over 21 000 jobs.

Overall, these figures highlight the substantial growth potential and the increasing significance of renewable energy in South Africa's job market, particularly under the 1.5°C Scenario, where solar technologies play a pivotal role in job creation.

Figure 13: Renewable energy jobs in South Africa in PES and 1.5°C Scenario, 2019, 2030 and 2050



Note: PES=Planned Energy Scenario; 1.5-S = 1.5°C Scenario.

Despite these promising prospects, the country faces several challenges. For example, over 80% of the country's coal-fired power plants and coal mines are in one province (Mpumalanga), which will face disproportionate impacts during the low-carbon transition (Bohlmann *et al.*, 2023). Other vulnerable occupations concern the formal and informal service sectors, including several that have historically been held predominantly by women. Municipality incomes and services will be impacted as well, not only their employment rates. In the Malahleni, for instance, coal revenues are covering about half of its income. Communities living near Eskom plants and coal mining operations benefit from essential public amenities such as water and electricity. It may be difficult for these communities to maintain these services without new funding.

In addition, more than 98% of enterprises in South Africa are classified as small-and-medium-sized enterprises (SMEs), which account for between 50% and 60% of total employment and 25% of private sector job growth. SMEs contribute 39% of GDP. Starting out in the low-carbon economy is difficult for small businesses for many reasons, including a lack of resources, reliance on a select clientele and inexperience in the sector. The slow economy has been hard for SMEs, and the economic impact of COVID-19 has only made things worse. In spite of this, the renewable energy value chain presents a number of exciting new prospects for SMEs, in logistics, installation and maintenance of embedded generation systems on a small scale (Androeni *et al.*, 2021; World Bank, 2022). Developing local businesses into viable suppliers for surrounding independent power producers (IPPs) is critical for local economic inclusion and can be facilitated by providing operational business support and skills transfer. Historically, shifting fossil fuel-based regions to new economic models takes time and isn't always successful. Learning new skills can be costly, and new jobs in renewables might not align with where fossil fuel jobs are lost. This highlights the need for social support for affected communities.

In South Africa, IPPs operating within the framework of the Renewable Independent Power Producer Programme (REIPPP) are incentivised to procure from South African businesses. Field interviews showed that commitments are made by IPPs in terms of the value and ratio of revenue that will be procured from national enterprises, as well as a set of targets for value procured from businesses of minority ownership. Key components are itemised in the commitments, as well as a narrative provided on enterprise development strategies that can be supported during the operations and maintenance phase.

Local supplier development works well within an area where there is more than one IPP to diversify the business opportunity and to supply the demand. Developing local business for one-off transactions will not be feasible or will only be created superficially. Therefore, support for local supplier development needs to be strategic and integrated into the larger economic activity or be supported by a longer continuous implementation horizon (the REIPPPP was designed this way to ensure a continuity of job creation and avoid booms and busts of economic activity). Box 5 offers two experiences of efforts at SME development in the South African context, indicating that renewable energy projects do not automatically generate long-lasting structures, skill building and other socio-economic benefits without a comprehensive and holistic policy framework – such as the ones presented in Box 2. Another example is the SADC Renewable Energy Entrepreneurship Support Facility, initiated by the SADC Centre for Renewable Energy and Energy Efficiency (SACREEE) and IRENA, which empowers SMEs in the 16 countries of the Southern African Development Community (SADC), focusing on sustainable energy business development. The facility also bridges the gap between entrepreneurs and financial institutions, enhancing the latter's confidence in sustainable energy initiatives (IRENA, 2022c; SACREEE, 2022).

BOX 5: LOCAL SMALL AND MEDIUM ENTERPRISE DEVELOPMENT: TWO CASE STUDIES

CSP project in South Africa: Local supplier development

At a CSP plant in South Africa, a supplier development initiative aims to develop local SMEs and transfer business management and technical skills. It is partially funded by REIPPPP-mandated enterprise development funds. While the quantitative impact of local procurement is marginal relative to the full value chain, it can represent significant opportunities for local businesses. This IPP utilises joint venture partnerships between established businesses and community-based entrepreneurs (owned and operated by previously disadvantaged black citizens) to increase the inclusion of local contractors in their operations. Local companies are contracted to provide seven types of goods and services:

- office and facilities cleaning
- industrial and solar cleaning
- horticulture on-site
- project site security
- catering for project staff
- scaffolding during construction
- provision of bottled water for consumption on-site.

The business plan foresees that the community-based entrepreneurs should be able to operate independently after three years.

Wind project in South Africa: Bird monitoring SME

This wind IPP supports previously disadvantaged individuals from the project host community to develop professional environmental bird monitoring services. Five unemployed youth trained with a joint venture partner, an environmental specialist firm, throughout the IPP construction and into the operational phase.

Bird monitoring focuses on endangered species such as eagles and vultures. Two rotating teams monitor bird migration paths and document presence of species as well as deaths and injuries of species within the vicinity of the wind farm. Per week, the teams search 40 turbines for carcasses on foot. Reporting includes eagle collision risk and QGIS tracking data. The uniquely proactive approach to bird monitoring includes autonomy for teams to stop turbines until a bird has left the area.

This joint venture eventually gave way to a community-based bird monitoring firm fully owned by its employees. It contracts directly with the wind farm for the 20-year duration of the power purchase agreement. The wind IPP invested some of its REIPPP mandated Socio-economic Development (SED) funds to increase the team's skills for business management and occupational health and safety issues, including snake handling. In the future, the company is looking to extend its business to other wind farms.

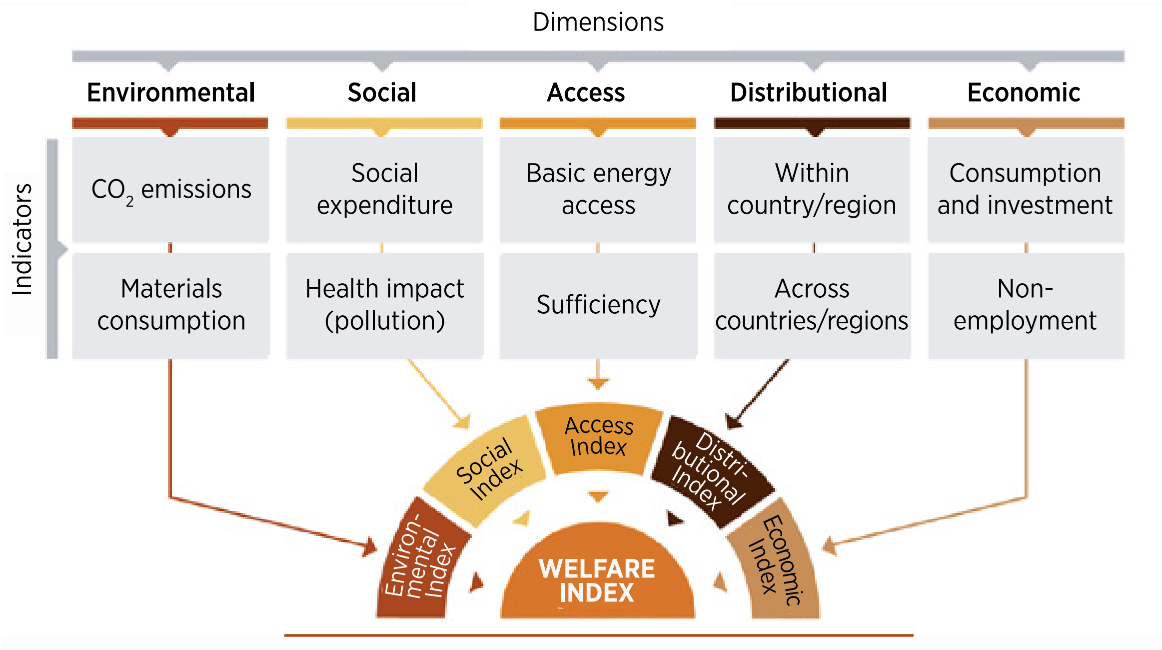
Projects can foster local economic transformation by prioritising community participation, skills development, employment creation and gender equality. The potential for socio-economic development lies in the implementation design. The typical 20-year duration of a project means that renewable energy projects have a long-term presence and are thus lasting development partners of host communities. The context of the social licence to operate provides the business case for providing meaningful and sustainable social welfare.

As South Africa has historically faced high unemployment, it is unlikely that the energy transition will be a silver bullet. However, careful planning can help mitigate some of the existing and future risks. Adaptation strategies include leveraging local strengths to boost renewables and energy efficiency, reskilling workers, and implementing policies to support job loss. Ensuring a fair transition, especially in fossil fuel-centric economies, requires social safety nets and public work programmes. The shift is complex and necessitates substantial social support, as acquiring new skills can be costly and job creation in renewables may not coincide with areas where fossil fuel jobs are lost.

3.3 WELFARE

GDP is the standard measure of economic output. The concerns of citizens, however, go beyond GDP, which does not include or value factors that are not priced into the market, such as human health, fulfilling jobs and environmental quality. And while climate change will likely have negative impacts on future GDP, it also will have significant impacts on societies, nature and economies that no measure of GDP captures. Conventional indicators such as GDP are thus incomplete and potentially misleading, as they do not consider future constraints of natural resources and climate. To incorporate some of the aspects of social well-being, IRENA has developed and upgraded a Welfare Index (IRENA, 2016, 2019a, 2020, 2021, 2022b; Ferroukhi, Casals and Parajuli, 2020) for use in its benefits analyses. The indicator has five dimensions relating to the energy transition: economic, social, environmental, distributional and access. Each dimension is composed of two indicators (Figure 14).

Figure 14: Structure of IRENA's Energy Transition Welfare Index



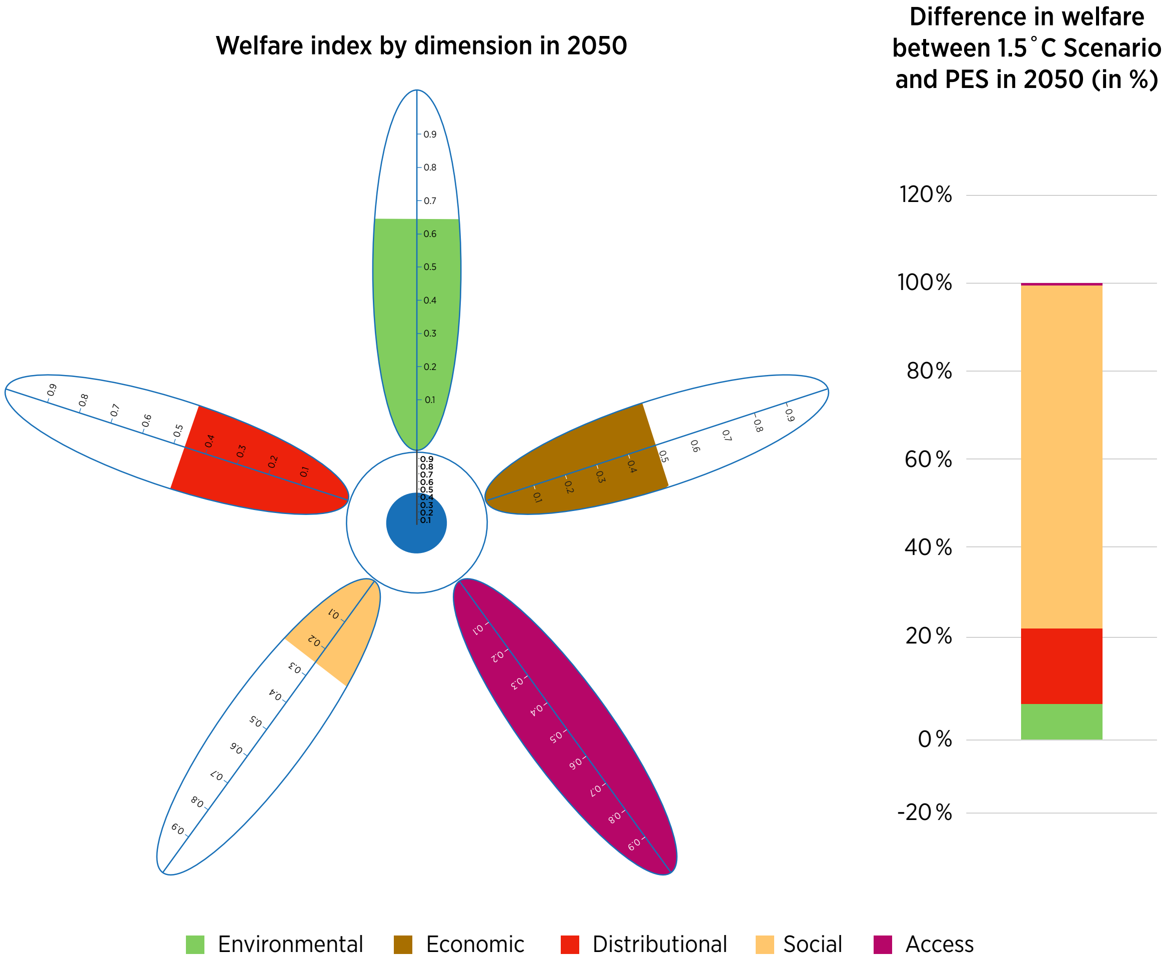
Source: IRENA (2022a).

Note: CO_2 = carbon dioxide.

The welfare Index in the 1.5°C Scenario by 2050 for South Africa, and the difference between PES and 1.5°C Scenario outcomes, broken down by dimensional contributions, are presented in Figure 15. The welfare improvement for South Africa under the 1.5°C Scenario over the PES reaches 99.8% by 2050 (right panel in Figure 15).

The welfare index and its dimensional indexes (left panel of Figure 15) provide an indication of where to focus policy action to improve welfare in South Africa. Under the 1.5°C Scenario, an overall welfare index of 0.52 by 2050 on a scale from 0 to 1 highlights the energy transition benefits to the population of South Africa, yet there is also significant potential for additional measures to deliver further improvements in welfare.

Figure 15: Welfare Index by dimension for the 1.5°C Scenario (left) and difference in welfare between the 1.5°C Scenario and the PES in 2050 (right), 2050



Note: Left panel: The five petals are on a scale from 0 to 1 and represent the absolute values of the five dimensions of the Welfare Index. The number in the centre is also on a scale from 0 to 1 and represents the absolute value of the overall Welfare Index.

Social dimension

The social dimension is informed by two indicators: social expenditure per capita and health costs per person linked to energy system-related air pollution. Overall, social spending per capita in South Africa is below that of most of Group of 20 (G20) countries. In 2020 and in per capita terms, South Africa was at USD 1149.2, significantly below that of EU-27[18] plus the United Kingdom, at USD 5 824.2, and of Brazil at USD 1575.7. Nevertheless, it was four times higher than Indonesia, which was USD 257.4 (Cambridge Econometrics, n.d.).[19]

[18] *The EU-27 refers to the Economies of the European Union (EU), which consists of 27 countries (Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain and Sweden), as of 1 February 2020.*

[19] *Social spending per capita are in 2019 USD.*

The coal-intensive nature of South Africa's economy contributes significantly to air pollution, resulting in a mortality rate of 74.9 deaths per 100 000 population (age-standardised) attributed to household and ambient air pollution in 2019, which is lower than in Indonesia at 96.1 or even Nigeria, the largest African economy, which is at 165.2, but significantly higher than in Brazil at 28.9 (WHO, n.d.). Access to clean cooking has increased from 56% to 87% in the last two decades (*i.e.* 2000-2020) (WHO, Global Health Observatory, 2022). South Africa's average life expectancy currently stands at 64 years, six years lower than the global average and more than ten years lower than countries such as China or Brazil. Health costs amounted to USD 1 550 per person in South Africa in 2020 – significantly above the Africa average of USD 154, China's average of USD 977, EU-27 plus the United Kingdom average of USD 687, Brazil's average of USD 329 and Indonesia's USD 202 (Cambridge Econometrics, n.d.).[20]

The share of public expenditure on health in South Africa's government expenditure has been increasing since 2000 but did not change between 2016 and 2020 and was around 15.3%. It was much higher than G20 countries such as Brazil (10.8%) and Indonesia (10.1%), but lower than others such as the European Union (15.4%), Australia (17.2%), Canada (18.3%), or the United Kingdom (19.5%). South Africa's health expenditure is equivalent to 5.3% of GDP in 2020, much higher than the sub-Saharan Africa average of 2.1%, or the middle-income countries' average of 3.0% (World Bank, n.d.).

Similarly, South Africa allocates 6.2% of its GDP to public spending on education in 2020, surpassing many OECD countries, in line with the post-apartheid goal of using education to rebuild society (OECD, n.d.; World Bank, n.d.). The education expenditure is equivalent to around 19.5% of the total government expenditure in 2020. However, despite these efforts, the quality of education remains poor, particularly in low-income and rural areas, with inadequate schooling infrastructure and insufficient teacher training. Several sub-Saharan African nations that spend less per learner than South Africa achieve better educational outcomes. In 2015, South African grade 9 learners ranked second-to-last in mathematics and last in science performance among 39 countries evaluated by the International Association for Evaluation of Educational Achievement (IMF, 2019). Approximately half of South Africa's students drop out before completing secondary education, and around a quarter fail their high school examinations. As a result of poor educational quality, South Africa ranks 127th out of 157 countries in the World Bank Human Capital Index, scoring below countries with lower income levels (World Bank, 2019).

Under the 1.5°C Scenario, the largest welfare improvement is in the social dimension in 2050 according to the socio-economic modelling results (right panel of Figure 15). Reduced air pollution leads to large improvements in public health, which greatly raise this dimension under the 1.5°C Scenario, while social expenditure is slightly decreasing between the PES and the 1.5°C Scenario. Due to low levels of social expenditure, the 1.5°C Scenario scores low on the social dimension of IRENA's welfare index (0.25 by 2050 on a scale from 0 to 1) (left panel of Figure 15), showing that there is significant room for additional actions to offer improvements on this dimension.

In the policy scenario discussed in Chapter 1, international collaborations play a crucial role in driving the improved social dimension. The funds received through these collaborations are specifically designed to support government spending on social infrastructure, including for healthcare and education. The pursuit of higher education and the attainment of improved health outcomes are deeply influenced by various socio-economic factors, including gender equality and the equitable treatment of marginalised groups. While health, education and social infrastructures do provide opportunity for development, these transformative opportunities are often hindered by pervasive gender disparities and the unequal treatment faced by marginalised communities. But as indicated above, South Africa's experience indicates that spending more money alone is not a guarantee of improved social outcomes. Financial resources need to be part and parcel of a holistic policy approach to maximise benefits.

---

[20] *Health costs are in 2019 USD.*

Distributional dimension

The distributional dimension measures income and wealth inequalities within and across regions and countries. The indicator used is the quintile[21] ratio, which is the ratio of the highest quintile of income/wealth distributions to the lowest quintile of income/wealth distributions. Based on quintile ratios, income inequality in South Africa has worsened since 1995 (WID, n.d.) as the income quintile ratio increased from 5.6 in 1995 to 18.1 in 2021 (which is still lower than in the European Union at 28.0 or in Brazil at 602.9). Wealth inequalities followed the same trend as the income quintile ratio in South Africa in the same period, being the highest in the world and substantially higher than in Brazil with a wealth quintile ratio of around -36 in 2021, but three times higher than Indonesia (around -79) or four times higher than Western Europe at around -106 in 2021 (WID, n.d.).[22]

The persistently high level of inequality in South Africa, as previously evidenced, underscores the urgent need to address the country's socio-economic disparities. While divisions of race and class have historically been prominent factors in shaping inequality, it is crucial to recognise that gender and locality also play significant roles in determining access to opportunities (National Planning Commission of South Africa, 2014). Unfortunately, the COVID-19 pandemic has further exacerbated the economic challenges, resulting in a delicate fiscal space situation, soaring unemployment rates and reducing investment levels. In this context, addressing inequality requires comprehensive efforts that go beyond social disparities among high-income individuals.

An analysis of the distributional dimension reveals significant positive impacts on welfare when comparing the 1.5° C Scenario and PES. Under the 1.5° C Scenario, substantial improvements in income distribution are observed, due to the availability of higher fiscal space while receiving international climate collaboration flows, that enable increasing the public expenditure (subsidies to support the transition, public transition-related investment). By 2050, the absolute distributional index reaches 0.47 under the 1.5° C Scenario in South Africa (left panel of Figure 15), compared with 0.25 under the PES, indicating progress but also highlighting the scope for further improvement, considering the global index at 0.36 in the 1.5°C Scenario. A more significant effort must be made to reduce the country's structural distributional inequalities in addition to the measures contained in the climate policy basket under the 1.5°C Scenario, which directly target the improvement of income distributions (both intra and inter).

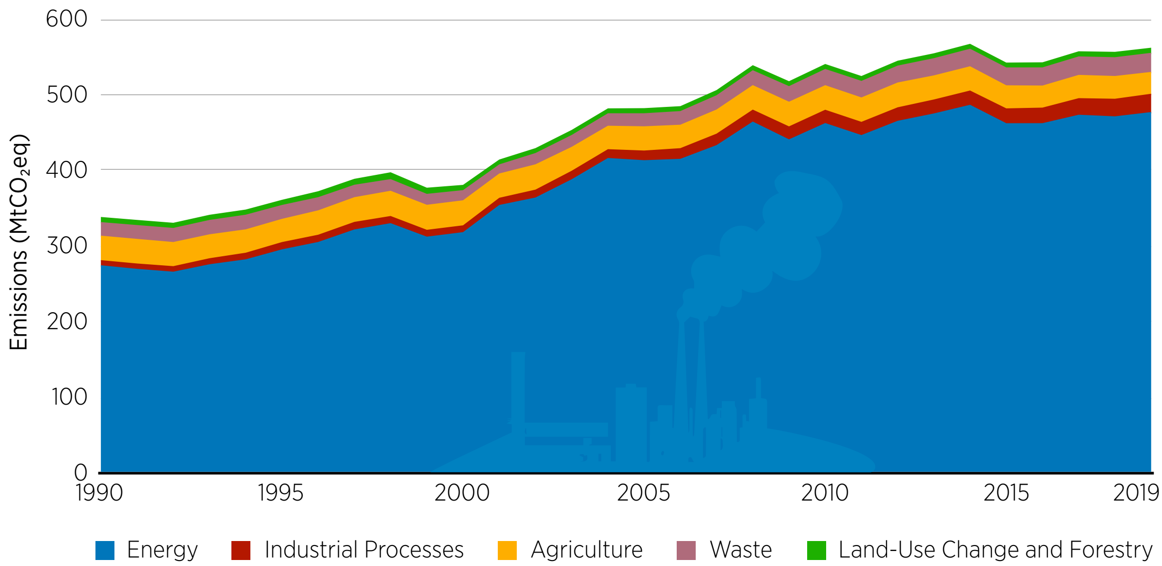
[21] *A quintile refers to any of five equal groups into which a population can be divided according to the distribution of values of a particular variable. Thus, the lowest-income quintile refers to the poorest 20% of a given population, the second quintile encompasses the next 20% moving up the income ladder, and so on.*

[22] *Higher the wealth quintile ratio is higher the wealth inequality.*

Environmental dimension

The environmental dimension considers GHG emissions along with vulnerability towards climate change, and the depletion of natural resources through consumption of materials (measured in domestic material consumption of metal ores, non-metallic minerals, and biomass for food and feed). South Africa's annual GHG emissions stood at 562 Mt CO_2eq (or 555 Mt CO_2eq excluding forestry and land use) in 2019 (World Resources Institute CAIT, 2022). It was the world's 16th-largest emitter of GHG emissions in 2019 with around 48% increase since 2000 (Figure 16). As in many other countries, the energy sector is the largest emitting sector, accounting for around 85% of emissions in 2019. The country is taking important steps towards reversing this trend and lowering the GHG footprint of its economy. For instance, South Africa has recently updated its Nationally Determined Contribution (NDC), choosing a more ambitious decarbonisation pathway in line with the 1.5-2°C pathway established by the Paris Agreement. The country has revised its GHG emissions targets, committing to a fixed range of 398 Mt CO_2eq to 510 Mt CO_2eq by 2025 and 350 Mt CO_2eq to 420 Mt CO_2eq by 2030. This is a significant adjustment from the initial "peak-plateau-decline" trajectory with a target of 398 Mt CO_2eq to 614 Mt CO_2eq by 2025-30 outlined in the first NDC (UNFCCC, 2021).

Figure 16: Total GHG emissions, including LULUCF, 1990-2019



Source: (World Resources Institute CAIT, 2022).

The environmental dimension is the third-largest driver of significant welfare improvements in the 1.5° C Scenario over the PES in South Africa by 2050 (right panel of Figure 15). Mirroring the country's ambition, the 1.5°C Scenario markedly reduces global cumulative CO_2 emissions compared with the PES, therefore helping mitigate climate change and its expected negative impacts on South Africa. By contrast, domestic material consumption, the other indicator of the environmental dimension, continues to grow under both the PES and the 1.5° C Scenario, slightly dragging down the absolute environmental dimension (left panel of Figure 15). This means much more must be done to reduce material consumption in South Africa in the future, with significant room to improve the absolute welfare index. To address this challenge, the country should strategically move away from resource dependence and focus on developing its economy in a sustainable manner, promoting supply chains and practices that prioritise environmental stewardship and resource efficiency. By doing so, South Africa not only can mitigate its environmental impact but also pave the way for long-term economic development and prosperity.

Energy access dimension

The country's Integrated National Electrification Programme (INEP) has been relatively successful. INEP's implementing agencies, namely Eskom, municipalities and non-grid service providers, linked almost 6.7 million South African houses to the power grid, and electricity access has improved from 82% in 1994 to 89% in 2021 (IEA *et al.*, 2023). Since the Non-Grid Electrification Programme began, INEP has installed some 123 379 off-grid systems, mostly in the Eastern Cape, KwaZulu-Natal, Northern Cape and Mpumalanga. INEP also created the first version of the Electrification Master Plan (EMP) to better co-ordinate among the multiple implementing bodies, technologies, and grid and non-grid roll-out in unserved areas to achieve universal access by 2025/26.

Basic energy access improves significantly under the PES, reaching an index value of 0.99 by 2050, and South Africa reaches universal energy access under the 1.5°C Scenario pathway as from 2030, accordingly reaching its maximum value of 1 (left panel in Figure 15). Under both the PES and the 1.5°C Scenario, South Africa's energy consumption has currently reached the sufficiency level[23] assumed at 20 kilowatt hours (kWh) per capita per day in line with literature (Millward-Hopkins *et al.*, 2020).[24] It implies that the energy accessed is not only basic, but also sufficient. It should be noted that IRENA's assumption of 20 kWh/capita/day, which includes the productive uses of energy, is significantly higher than the government's assumption that a typical indigent electrified home will find 50 kWh sufficient for their monthly basic domestic services such as charging of mobile phone, indoor/outdoor illumination, television, radio player and water heating. This assumption was one of the core bases for the design of the INEP.

Economic dimension

The economic dimension is composed of an indicator that measures consumption and investment per capita and another that measures non-employment as the ratio of the share of the working-age population (age group from 15 to 64 years) that is neither employed nor under education while belonging to the 14-24 age group.[25] The country is grappling with high unemployment rates, low labour force participation, and a large number of discouraged job-seekers and non-seekers, as already discussed in section 3.2. The spatial inequalities of the country and the inaccessibility of employment to a large proportion of the working-age population in rural and remote areas have led to a large number of discouraged and non-seeking job-seekers (World Bank, 2018). There are strong proofs of a labour market misalignment which requires a holistic policy framework that allows structural changes in the economy (Habiyaremye *et al.*, 2022; IMF, 2021).

While social, environmental and energy access dimensions significantly improve under the 1.5° C Scenario, the economic dimension of welfare sees no improvement over the PES and becomes mildly negative. Consumption and investment per capita increase under the 1.5°C Scenario over the PES, while the non-employment indicator experiences a decrease, dragging down the absolute environmental dimension (left panel in Figure 15).

[23] *This indicator has been defined as the required level of energy consumption for decent living, but no more.*

[24] *The authors estimated the sufficiency level between 11.6 kWh/capita/day and 30.4 kWh/capita/day across all 119 countries of the Global Trade Analysis Project, www.gtap.agecon.purdue.edu/databases/regions.aspx?version=9.211*

[25] *Non-employment is used instead of unemployment or employment metrics because of its more comprehensive gauging of the social implications of paid work, which is the main goal of a welfare index.*

04 Summary and way forward

The South African economy has faced numerous challenges in recent years, including slowing global growth, geopolitical tensions, inefficiencies in state-owned firms and the impact of climate change. The COVID-19 lockdowns imposed in the country resulted in a severe recession in 2020, with a sharp decline in various sectors.

However, looking ahead to 2050, the outlook for the South African economy appears more positive. Projections indicate significant economic growth, with real gross domestic product (GDP) expected to grow at an average rate of 2.7% per year between 2021 and 2030, with even higher rates in the subsequent periods (*i.e.* 3.0% per year throughout the 2031-2040 period and 3.5% per year in the last decade of the transition period 2041-2050), in line with the national Integrated Resource Plan's moderate forecast of 3.18% annual GDP growth to 2050. IRENA's modelling results suggest that, under the 1.5°C Scenario, South Africa's GDP is expected to be 7.8% higher on average than in the Planned Energy Scenario (PES) over the 2021-2050 period. This would be translated to a cumulative addition of around USD 1.4 trillion[26] to the GDP already anticipated under the PES over the same period. GDP would slow down after the initial boost from front-loaded investments, but it would still be 4.5% higher in the 1.5°C Scenario in 2050 than in the PES. Investment, domestic response to shifts in carbon prices, technology prices, power sector capacity, fossil fuel subsidies, and trade to a lesser extent, are the main macroeconomic factors that have key impacts on GDP difference depending on the period analysed.

Despite these positive economic projections, South Africa continues to grapple with high unemployment rates and energy shortages exacerbated by the COVID-19 crisis. The first quarter of 2023 saw some progress in economic recovery, with an increase in the number of employed persons compared with the previous year. However, the country still faces one of the highest unemployment rates globally. Under the 1.5°C Scenario, employment in South Africa is 0.2% higher on average compared with the PES over the 2021-2050 period but is expected to be lower by -2.4% in 2050. This trend relies on a shift in employment patterns, with reduced reliance on mining and manufactured fuels, and a growing emphasis on sectors associated with manufacturing, engineering and renewable energy. Notably, the mining and manufactured fuels sector is anticipated to witness substantial job reductions throughout the transition period due to its strong interlinkages with the energy sector and the energy transition.

The share of jobs dependent on fossil fuels is significantly reduced in the 1.5°C Scenario, while renewable energy jobs are expected to increase substantially, particularly in solar technologies. Under the 1.5°C Scenario, renewables represent the highest share in energy sector jobs, amounting to 51% (0.5 million jobs) in 2050. Solar technologies, including photovoltaic and concentrated solar power, are expected to dominate the renewable energy job market in South Africa. To navigate these challenges, countries should:

- plan and invest to diversify their economies in line with the energy transition
- recognise local economic strengths and use them to support renewable energy and other key areas such as energy efficiency
- predict the skills needed for renewables and match them with local expertise
- where possible, use skills from the fossil fuel sector in renewables, and offer training for those in fossil fuel jobs to move into renewable roles (IRENA, 2019b).

[26] *In 2019 USD.*

Welfare improves by over 99.8% under the 1.5°C Scenario by 2050 compared with the PES, led by the social and distributional dimensions. Further measures have the potential to bring about even greater increases in welfare in South Africa. The detailed results provide clear indications of where to focus policy action to improve welfare. The greatest potential for improvement exists in the social dimension, with a focus on the introduction of measures to raise funding for social programmes. International climate collaboration flows could play a crucial role in improving the social dimension. The funds received through these collaborations are specifically designed to support government spending on social infrastructures, including healthcare and education. The environmental and distributional dimensions also offer significant room for improvement. Improvements in the environmental dimension would result from policies aiming to reduce material usage. Policies that promote wealth distribution and generate greater fiscal space, which in turn allows improvements in income distribution, should be given more attention to further strengthen the economic and distributional characteristics.

Table 2: Challenge-opportunity framework for South Africa

	Challenges	Opportunities from the energy transition
Economy-wide	Vulnerability to climate change	Lower damages through timely action and adaptation measures
	Climate damage in socio-economic dimensions	Fiscal support (through international collaboration)
	Constrained fiscal budget	International support from climate and social support fund (with aspects related to just transition)
	High inequality	Improved distribution through social measures
	Infrastructure and finance gap	Acceleration of energy infrastructure development
	Declining manufacturing trend	Opportunities to revive high-value industries
Integrated or cross-sectoral	Research and development	Improved research facilities and capabilities to support the transition locally and internationally
	Skills readiness	Empowered local workforce
Energy sector	Heavy reliance on fossil fuels	Less reliance on fossil fuels leading to myriad economic and social welfare benefits
	Unreliable power supply	Availability of reliable and clean power through appropriate long-term planning
	Lack of universal energy access	Clean decentralised solutions for universal energy access
	Lack of access to modern clean cooking fuels	Clean cooking solutions nationwide

The energy transition is a gradual process, and policy makers will need to strive for harmony between energy policy and other areas of national policy over an extended period to ensure an inclusive and just transition. To achieve the central objective of the country, which is to bring energy to all, the energy transition policy framework should be holistic. Some of the key existing challenges and opportunities that can be tapped into through the energy transition are divided into three categories: economy-wide, integrated and energy sector (Table 2).

Economically, South Africa faces vulnerabilities from climate change, constrained fiscal budgets and high inequality. The energy transition offers a pathway to mitigate these issues. Timely action and adaptation measures can reduce climate-related damages, thereby stabilising the economy. International collaboration can provide fiscal support, particularly through climate and social support funds that also address just transition aspects. This can help in bridging the infrastructure and finance gap, and even revive high-value manufacturing industries that have been on a decline.

From an integrated or cross-sector perspective, the transition can significantly boost research and development. Improved research facilities can not only support local transitions but also make South Africa a global player in sustainable technologies. Moreover, the transition can empower the local workforce by enhancing skills readiness, thereby reducing unemployment and improving social equity.

In the energy sector, South Africa's heavy reliance on fossil fuels has caused both economic and environmental strain. Transitioning to renewable energy sources can lead to a myriad of benefits, including a more reliable power supply and less environmental degradation. It opens the door for clean, decentralised solutions that can provide universal energy access, even in the most remote areas. Furthermore, the transition can solve the problem of lack of access to modern clean cooking fuels by introducing clean cooking solutions nationwide.

While South Africa has faced economic challenges in recent times, the long-term outlook suggests the potential for significant economic growth and shifts in employment patterns, particularly towards renewable energy. Addressing high unemployment and ensuring inclusive growth remain key priorities. Emphasising social and environmental dimensions can contribute to overall welfare improvements and sustainable development.

An inclusive and just energy transition must keep people at its heart and embrace diversity and inclusion across several populations (*e.g.* women, youth, older workers, people with disabilities, migrant workers, indigenous people, unemployed people, vulnerable workers). As the energy transition advances, the world is beginning to see the benefits of basing future energy supplies on renewables and limiting energy demand through greater efficiency. A country like South Africa, where high inequality and a fossil fuel-based economy are key challenges, will benefit immensely from the opportunities created by the energy transition with help from the international community and supportive policies.

References

African Development Bank (n.d.), "AFDB Socio Economic Database, 1960-2022 - Africa Information Highway Portal", AFDB Socio Economic Database, 1960-2022, https://dataportal.opendataforafrica.org/nbyenxf/afdb-socio-economic-database-1960-2022 (accessed 21 October 2023).

Andreoni, A. *et al.* (2021), *Structural Transformation in South Africa: The Challenges of Inclusive Industrial Development in a Middle-Income Country,* Oxford University Press, https://doi.org/10.1093/oso/9780192894311.001.0001

Bohlmann et. al, R. B. (2023), "Just Energy Transition of South Africa in a Post-COVID Era", *Sustainability*, Vol 15, N°14, 10854; https://doi.org/10.3390/su151410854, https://www.mdpi.com/2071-1050/15/14/10854 (accessed 7 October 2023).

Business Tech (2023), "South Africa's energy crisis becoming an everything crisis" *BusinessTech*, https://businesstech.co.za/news/business/657403/south-africas-energy-crisis-becoming-an-everything-crisis/ (accessed 7 October 2023).

Calland, R. (2023), "South Africa's "just transition": A whole economy transformation", in Bhattacharya, A., H. Kharas, and J.W. McArthur (Eds.), *Keys to Climate Action: How developing countries could drive global success and local prosperity*, www.brookings.edu/wp-content/uploads/2023/02/Chapter-7.-South-Africas-Just-transition-A-whole-economy-transformation.pdf

Cambridge Econometrics (n.d.), *Welfare database*, Cambridge Econometrics, Cambridge.

Centre for Research on Energy and Clean Air (2023), *Air quality impacts of the New Largo coal mine*, Centre for Research on Energy and Clean Air, https://energyandcleanair.org/wp/wp-content/uploads/2023/07/CREA_Air-quality-impacts-of-the-New-Largo-coal-mine_06.2023.pdf

Cooper, N. J. (2019), "The South African Constitution – Standards of Environmental Protection (Chapter 13) - Environmental Rights", *Environmental rights: The development of Standards,* https://www.cambridge.org/core/books/abs/environmental-rights/south-african-constitution-standards-of-environmental-protection/953351417A223E8A4FDB86FCAD537680 (accessed 7 October 2023).

FAO (2023), "FAO Country Profiles: South Africa", Food and Agriculture Organization of the United Nations, www.fao.org/countryprofiles/index/en/?iso3=ZAF (accessed 7 October 2023).

Government of South Africa (2019), *Carbon Tax Act 15 of 2019*, www.gov.za/documents/carbon-tax-act-15-2019-english-afrikaans-23-may-2019-0000 (accessed 7 October 2023).

Ferroukhi, R., X.G. Casals and B. Parajuli (2020), *Measuring the socio-economics of transition: Focus on jobs*, International Renewable Energy Agency, Abu Dhabi

Habiyaremye, A., *et al.* (2022), "Bridging the labour market skills gap to tackle youth unemployment in South Africa*", The Economic and Labour Relations Review,* Vol. 33, N°4, pp. 786–805.

IEA, *et al.* (2023), *Tracking SDG7: The energy progress report 2023*, International Energy Agency, International Renewable Energy Agency, United Nations Statistics Division, the World Bank and World Health Organization, Geneva, www.irena.org/Publications/2023/Jun/Tracking-SDG7-2023

IMF (2019), "Struggling to Make the Grade: A Review of the Causes and Consequences of the Weak Outcomes of South Africa's Education System", *IMF working paper,* www.imf.org/-/media/Files/Publications/WP/2019/WPIEA2019047.ashx

IMF (2021), *Labor Market Reform Options to Boost Employment in South Africa*, www.imf.org/-/media/Files/Publications/WP/2021/English/wpiea2021165-print-pdf.ashx

IMF (2022), *South Africa: Selected Issues*, https://www.imf.org/-/media/Files/Publications/CR/2022/English/1ZAFEA2022002.ashx (accessed 5 October 2023).

IRENA (2016), *Renewable energy benefits: Decentralised solutions in the agri-food chain*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2016/Sep/Renewable-Energy-Benefits-Decentralised-solutions-in-agri-food-chain

IRENA (2018), *Global transformation: A roadmap to 2050*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2018/Apr/Global-Energy-Transition-A-Roadmap-to-2050

IRENA (2019a), *Global energy transformation: A roadmap to 2050 (2019 edition)*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2019/Apr/Global-energy-transformation-A-roadmap-to-2050-2019Edition

IRENA (2019b), *Renewable energy: A gender perspective*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2019/Jan/Renewable-Energy-A-Gender-Perspective (accessed 31 January 2022).

IRENA (2020), *Global renewables outlook: Energy transformation 2050*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020

IRENA (2021), *World energy transitions outlook: 1.5°C pathway*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2021/Jun/World-Energy-Transitions-Outlook

IRENA (2022a), *Socio-economic footprint of the energy transition: Japan*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2022/Sep/Socio-economic-Footprint-of-the-Energy-Transition-Japan

IRENA (2022b), *World Energy Transitions Outlook 2022: 1.5°C Pathway*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/publications/2022/Mar/World-Energy-Transitions-Outlook-2022

IRENA (2022c), "Women entrepreneurs invited to be in the vanguard of Africas energy transition*",* www.irena.org/News/articles/2022/Oct/Women-entrepreneurs-invited-to-be-in-the-vanguard-of-Africas-energy-transition (accessed 7 October 2023).

IRENA (2022d), *World Energy Transitions Outlook: 1.5°C Pathway*, https://irena.org/publications/2022/Mar/World-Energy-Transitions-Outlook-2022 (accessed 15 July 2022).

IRENA (2023a), *Socio-economic footprint of the energy transition: Indonesia*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jan/Socio-economics-of-the-energy-transition-Indonesia

IRENA (2023b), *Socio-economic footprint of the energy transition: Southeast Asia*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jul/Socio-economic-footprint-of-the-energy-transition-Southeast-Asia

IRENA (2023c), *World Energy Transitions Outlook 2023: 1.5°C Pathway, Vol. 1*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jun/World-Energy-Transitions-Outlook-2023

IRENA (2023d), *Renewable energy statistics 2023*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/Publications/2023/Jul/Renewable-energy-statistics-2023

IRENA (n.d.), "Statistics data", International Renewable Energy Agency, Abu Dhabi, www.irena.org/statistics

IRENA and AfDB (2022), *Renewable Energy Market Analysis: Africa and its Regions*, www.irena.org/publications/2022/Jan/Renewable-Energy-Market-Analysis-Africa (accessed 18 August 2022).

IRENA, *et al.* (2020), *Renewable energy prospects: South Africa*, International Renewable Energy Agency, Abu Dhabi, www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jun/IRENA_REmap_South_Africa_report_2020.pdf

Kumwenda-mtambo, O., *et al.* (2023), *"South Africa govt to take on half of struggling Eskom's debt"*, Reuters, www.reuters.com/world/africa/south-africas-government-take-over-half-eskoms-debt-2023-02-22/ (accessed 5 October 2023).

Marais, H., and Ntsoane, M. (2023), *South Africa economic outlook*, Deloitte Insights, https://www2.deloitte.com/us/en/insights/eco fricamea/africa-economic-outlook.html

Millward-Hopkins, J., *et al.* (2020), "Providing decent living with minimum energy: A global scenario", *Global Environmental Change*, Vol. 65, pp. 102168, https://doi.org/10.1016/j.gloenvcha.2020.102168

Ministry of Energy (2019), *Programmes: Integrated Resource Plan*, www.energy.gov.za/files/irp_frame.html (accessed 7 October 2023).

Naido, P. (2023), "South Africa Relaxes Local-Content Rules to Ease Power Crisis", *Bloomberg,* www.bloomberg.com/news/articles/2023-01-21/south-africa-relaxes-local-content-rules-to-ease-power-crisis?leadSource=uverify%20wall (accessed 7 October 2023).

National Planning Commission of South Africa (2014), Diagnostic Overview, www.gov.za/sites/default/files/gcis_document/201409/npcdiagnosticoverview1.pdf

OEC (n.d.), *South Africa*, Observatory of Economic Complexity, https://oec.world/en/profile/country/zaf

OECD (2022), "Tourism in the economy and outlook for recovery", OECD Tourism Trends and Policies 2022, www.oecd-ilibrary.org/sites/92f6112e-en/index.html?itemId=/content/component/92f6112e-en#section-d1e143728

OECD (n.d.), "Education resources - Public spending on education" OECD Data, Organisation for Economic Co-operation and Development,, http://data.oecd.org/eduresource/public-spending-on-education.htm (accessed 7 October 2023).

Paton, C. (2023), "Local content criteria for SA's first battery storage project scrapped", Business, www.news24.com/fin24/climate_future/local-content-criteria-for-sas-first-battery-storage-project-scrapped-20230515 (accessed 7 October 2023).

SACREEE (2022), "SADC Renewable Energy Entrepreneurship Support Facility", https://www.sacreee.org/content/sadc-renewable-energy-entrepreneurship-support-facility-0 (accessed 7 October 2023).

SARS (2022), *Excise Carbon Tax External Policy*, South African Revenue Service, www.sars.gov.za/wp-content/uploads/Ops/Policies/SE-CBT-02-Carbon-Tax-External-Policy.pdf

Statistics South Africa (2023a), "GDP declines in the fourth quarter" *Statistics South Africa,* https://www.statssa.gov.za/?p=16162 (accessed 7 October 2023).

Statistics South Africa (2023b), "Employment drops in Formal Non-Agricultural Sector in Q1 of 2023" *Statistics South Africa*, https://www.statssa.gov.za/?p=16439 (accessed 7 October 2023).

Statistics South Africa (n.d.), "Time series data – Excel and ASCII format", *Statistics South Africa*, www.statssa.gov.za/?page_id=1847 (accessed 7 October 2023).

The Presidency Republic of South Africa (2022), *South Africa's Just Energy Transition Investment Plan (JET IP) for the initial period 2023-2027,* www.thepresidency.gov.za/content/south-africa%27s-just-energy-transition-investment-plan-jet-ip-2023-2027 (accessed 7 October 2023).

UNDESA (2022), "World Population Prospects 2022", United Nations Department of Economic and Social Affairs, Population Division, https://population.un.org/wpp/Download/Standard/Population/

UNFCCC (2021), *South Africa's Intended Nationally Determined Contribution (INDC)*, https://unfccc.int/sites/default/files/NDC/2022-06/South%20Africa.pdf

UNSD (n.d.), "South Africa - Energy balance visualization", United Nations Statistics Division, https://unstats.un.org/unsd/energystats/dataPortal/

WHO (n.d.), "Air pollution database", www.who.int/data/gho/data/themes/air-pollution (accessed 7 October 2023).

WHO, Global Health Observatory (2022), "Share of the population with access to clean fuels for cooking", *Our World in Data*, https://ourworldindata.org/grapher/access-to-clean-fuels-and-technologies-for-cooking (accessed 7 October 2023).

WID (n.d.), "Data" *World Inequality Database*, https://wid.world/data/ (accessed 7 October 2023).

World Bank (2018), *Overcoming Poverty and Inequality in South Africa: An Assessment of Drivers, Constraints and Opportunities,* World Bank, Washington, D.C., https://elibrary.worldbank.org/doi/abs/10.1596/29614

World Bank (2019), "South Africa Economic Update : Enrollments in Tertiary Education Must Rise", World Bank, Washington, D.C., https://documents.worldbank.org/en/publication/documents-reports/documentdetail/173091547659025030/South-Africa-Economic-Update-Enrollments-in-Tertiary-Education-Must-Rise (accessed 7 October 2023).

World Bank (2021), *Climate Risk Profile: South Africa*, https://climateknowledgeportal.worldbank.org/sites/default/files/country-profiles/15932-WB_South%20Africa%20Country%20Profile-WEB.pdf

World Bank (2022), *South Africa: Country climate and development report*, World Bank Group, Washington, D.C.., https://openknowledge.worldbank.org/server/api/core/bitstreams/52409ffd-96f7-58d4-be7f-c8114abbd4c5/content

World Bank (n.d.), *World Development Indicators,* World Bank, Washington, D.C.,

https://databank.worldbank.org/source/world-development-indicators

World Bank CCKP (n.d.), "South Africa - Vulnerability: Climate Change Knowledge Portal", https://climateknowledgeportal.worldbank.org/country/south-africa/vulnerability (accessed 7 October 2023).

World Resources Institute CAIT (2022), *Climate Watch Historical GHG Emissions. 2022*, https://www.climatewatchdata.org/ghg-emissions

Appendix: Carbon pricing, international collaboration, subsidies, progressive fiscal regimes

Carbon pricing is higher under the 1.5°C Scenario than under the Planned Energy Scenario (PES). However, because of the regressive implications of carbon pricing, levels have been reduced by half compared with previous reports (IRENA, 2020a, 2021a). Under the 1.5°C Scenario, carbon prices are higher for high-income countries than for less wealthy ones. For example, South Africa's carbon price for 2030 (2019 purchasing power parity [PPP]) is set at USD 105 per tonne (t) of carbon dioxide (CO_2), while the price is around USD 150/t CO_2 in high-income economies and USD 30/t CO_2 in low-income countries.

The macroeconomic modelling for most cases assumes revenue neutrality in government fiscal balances. The policies used to implement revenue neutrality depend on the progressiveness of the applied policy basket. In the PES, when government revenues increase (for instance through carbon prices), income taxes decrease, and vice versa. This approach has regressive implications, however, as the wealthiest households generally pay the lion's share of income taxes and benefit accordingly from higher tax cuts. By contrast, in the policy basket used for the 1.5°C Scenario, revenues are recycled through lump-sum payments that target lower-income households progressively: 60% of the payments go to the lowest income quintile, 30% to the second quintile and 10% to the third quintile. Progressive distributional policies help mitigate the regressive effects of the energy transition and climate change itself.

Another key assumption of the climate policy baskets is the level of international collaboration. Whereas no additional collaboration is assumed in the PES, the 1.5°C Scenario policy basket does include enhanced levels to address the climate change challenge and the structural aspects underpinning an unequal distribution of burdens and responsibilities. Within this framework, all countries contribute to a joint effort according to their respective capability and responsibility in terms of climate equity.[27] International collaboration under the 1.5°C Scenario is equivalent to 0.7% of the global gross domestic product between 2021 and 2050. In contrast and given that current commitments and climate finance pledges have not been met, the PES does not consider international climate collaboration flows. Other policies are mentioned in Chapter 2.

---

[27] *Based on the Climate Equity Reference Calculator (https://calculator.climateequityreference.org/).*

IRENA

International Renewable Energy Agency