TECHNICAL ANNEX

September 2022

From coal to renewables in Mpumalanga: Employment effects, opportunities for local value creation, skills requirements, and gender-inclusiveness

Assessing the co-benefits of decarbonising South Africa's power sector

This Technical Annex accompanies the Executive Report to the COBENEFITS study "From coal to renewables in Mpumalanga: Employment effects, opportunities for local value creation, skills requirements, and gender-inclusiveness", presenting background information and further data.

Imprint

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Technical annex: From coal to renewables in Mpumalanga

This technical annex includes background information, modelling assumptions, and other data used in the Executive Report to the study "From coal to renewables in Mpumalanga: Employment effects, opportunities for local value creation, skills requirements, and gender-inclusiveness".

This technical annex was compiled to ensure transparency regarding all modelling assumptions and data used in the Executive Report, and to pave the way for further research on the energy transition in Mpumalanga.
It includes information on:

- Key policy documents and initiatives for the energy transition and green economy initiatives (Sections 1 and 2)
- Descriptions of the detailed research methodology and scenarios (Section 3)
- Input assumptions for local content assessments (Section 4)
- Clean energy potentials in Mpumalanga (Section 5)
- Quantifications of employment, value creation, and skills (Sections 6, 7, and 8)
- Maps of Eskom power plants and mining sites in Mpumalanga (Sections 9 and 10)

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Key findings from the study:

The study analyses and quantifies the socio-economic implications of repurposing coal-fired power plants in Mpumalanga via deployment of renewable energy. The analysis emphasises opportunities related to job creation, necessary skill development with a focus on gender questions, and regional value creation and industrial opportunities in Mpumalanga. The study also highlights important framework conditions necessary for fully harnessing these benefits.

The study employs quantitative and qualitative methods. Quantitative analysis is used to estimate the gross impacts of increased renewable energy deployment arising from each scenario, utilising both the International Jobs and Economic Development Impacts (I-JEDI) modelling tool and desktop literature to estimate the additional jobs/MW associated with distributed solar PV and battery storage. The qualitative analysis included a review of the existing literature

Box 1: Power system pathways for South Africa

The analysis examines potential socio-economic impacts until 2030, via four scenarios depicting an increasingly ambitious and rapid energy transition.

- **Scenario 1 – Current policy: planned repurposing (based on IRP 2019):**
  This scenario assumes the scheduled decommissioning of power stations according to the Integrated Resource Plan (IRP 2019) schedule to 2030 (11 GW), with repurposing of decommissioned plants within the IRP 2019 allocations for renewable energy deployment (28 GW) and related annual build limits (DMRE, 2019). It thereby provides a base case scenario in line with current policy.

- **Scenario 2 – Accelerated repurposing:**
  Compared with the current policy, this scenario assumes quicker decommissioning of additional coal-fired power plants (13 GW) in Mpumalanga and faster deployment of renewables (54 GW) using the *Ambitious renewable energy scenario* from Wright & Calitz (2020)[1].

- **Scenario 3 – Ambitious repurposing:**
  Compared with the current policy, this scenario assumes even quicker decommissioning of additional coal-fired plants (18 GW) as per the *2 GT CO_2 scenario* in Wright & Calitz (2020). These power stations would then be repurposed with renewable energy deployment (65 GW), also making use of land available on old coal mining sites to 2030.[2]

- **Scenario 4 – Super H_2igh Road:**
  This scenario is based on the same assumptions as Scenario 3 (i.e., renewable energy capacity on repurposing sites, plus conversion of coal mining sites) but also assumes additional renewable energy capacity, producing 6 GW of green hydrogen in Mpumalanga by 2030. This scenario draws on the 2 GT CO_2 budget scenario for the decommissioning rate (18 GW) and the roles of other technologies (e.g., gas, nuclear, etc).[3]

[1] Wright, Jarrad, and Joanne Calitz. 2020. "Systems Analysis to Support Increasingly Ambitious CO2 Emissions Scenarios in the South African Electricity System." Tech. Rep. 27 (July): 129.

[2] This study modelled two different local content levels: moderate (representing national-level potential) and high, which is slightly more ambitious. Unless otherwise indicated, the figures shown refer to the moderate level.

[3] Unless otherwise indicated, the figures shown for Scenario 4 – Super H_2igh Road refer to high local content levels.

together with inputs from industry experts, to provide a perspective on resource potential plus transmission capacity-, land-related-, and mining employment considerations. Employee data for Eskom and coal mines were sourced from Eskom and the Mining Quality Authority (MQA), respectively. In addition, interviews were conducted with enterprise development (ED) managers to understand barriers and opportunities for women in the renewables sector.

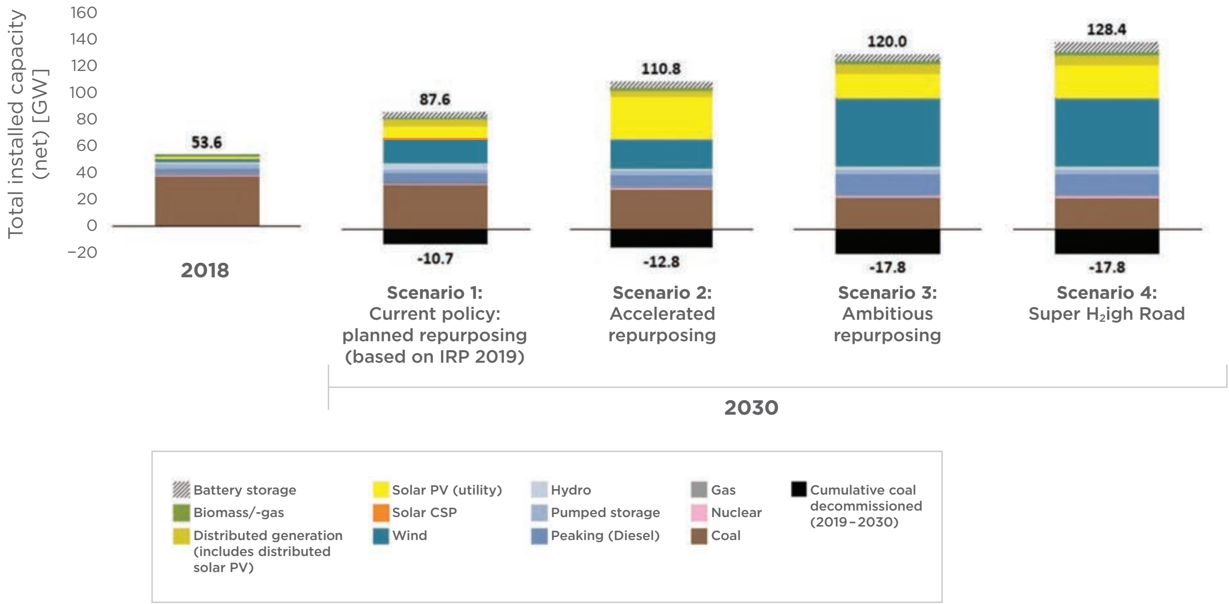


Figure 0-1: Installed capacity (2030) by technology per scenario (source: Wright & Calitz (2020)[4]; own calculation)

Key figures:

Mpumalanga can create up to **79,000** clean energy jobs by **2030**, including **25,000** direct jobs, **26,000** indirect jobs and **28,000** induced jobs. Around **80%** are in construction, with jobs in operations and maintenance accounting for **20%.**

In Mpumalanga, the highest number of clean energy jobs can be can be created under the Super H_2igh Road Scenario in the solar PV industry (**43,000** jobs – **13,900** direct, **13,900** indirect, and **15,200** induced) and the wind industry (**28,900** jobs – **9,000** direct, **9,700** indirect, and **10,200** induced)

Value creation via clean energy technologies in Mpumalanga can reach **R340 billion (USD 22 billion)** for the period **2019 to 2030** at higher local content levels.

[4] From CSIR/Meridian Economics report "Systems analysis to support increasingly ambitious CO_2 emissions scenarios in the South African electricity system" (2020) https://researchspace.csir.co.za/dspace/bitstream/handle/10204/11483/Wright_2020.pdf?sequence=4&isAllowed=y

Key policy opportunities:

- **Policy opportunity 1: Mpumalanga can compensate a large share of jobs[5] lost in the declining coal sector by investing in renewable energies and creating a regional clean energy manufacturing industry.** Under the Super H_2igh Road Scenario with high shares of local content, almost three times more jobs can be created in Mpumalanga in 2030[6] than under the current policy pathway (IRP 2019) (79,000 jobs: 25,000 direct, 26,000 indirect, and 28,000 induced versus 27,000: 8,000 direct, 9,000 indirect, and 10,000 induced). However, not all job losses in the fossil fuel sector can be compensated for by clean energy jobs in Mpumalanga. The decommissioning process is estimated to result in net job losses in the province by 2030. Therefore, a wider strategy for economic growth is needed, including other sectors such as tourism and agriculture.

- **Policy opportunity 2: By deploying renewable and clean energy technologies, Mpumalanga can lay the foundation for becoming the new clean energy hub of South Africa.** Mpumalanga's gross output value[7] can be increased substantially. Between 2019 and 2030, cumulative renewable energy investment in Mpumalanga can reach R320 billion (USD 20.6 billion) in the Super H_2igh Road scenario, a more than 170% increase over the R120 billion (USD 7.7 billion) in the IRP 2019 scenario. By increasing local content requirements (LCR: i.e., the percentage of intermediate goods sourced from domestic supply chains) from 30% at present to 60–80%, gross output value in Mpumalanga can be further increased to R340 billion (USD 22 billion) in the Super H_2igh Road Scenario.

- **Policy opportunity 3: The transition from fossil fuels to clean energy sources is an opportunity for facilitating gender-inclusive careers in the energy sector in Mpumalanga.** Currently, women are under-represented in the energy sector. Mpumalanga has low educational attainment, i.e., 11% of the population hold a post-matriculation qualification. Women could be educated and empowered by establishing dedicated programmes at TVET (technical and vocational education and training) colleges and by providing childcare facilities close to training centres. Existing initiatives to mentor and coach young women in the renewable sector should be further enhanced.

[5] This study defines a 'job' or 'employment opportunity' in terms of full-time equivalent (FTE) units per annum. This approach accounts for part-time and full-time workers in a comparable way. One job is equivalent to one job year, with the total number of jobs indicating the total number of people employed during a specific year. Numbers include direct, indirect, and induced employment.

[6] In this study, operation and maintenance jobs are depicted cumulatively (i.e., over the 10-year time period of 2021 to 2030), whereas all other jobs (manufacturing, installation, etc.) are depicted as occurring in one year only (here, 2030).

[7] Gross output is a measure of total economic activity. It includes payments that industries and businesses make to one another for inputs used in production. Such inputs could include raw materials, services, or anything that a business purchases to produce its goods or services. Gross output also includes value added (definition from NREL). For this study, only the direct and indirect impacts on value creation were considered.

Key Findings:

Employment:

- **In South Africa as a whole, job creation through renewables exceeds anticipated job losses in the coal sector[8].** In Mpumalanga, not all job losses in the fossil fuel sector can be compensated by clean energy jobs; however, under an ambitious decarbonisation scenario, these net losses can be minimised: Under the Super H_2igh Road Scenario with high shares of local content, almost 79,000 clean energy jobs can be created, three times more than under the current policy (IRP 2019) scenario (25,000 direct, 26,000 indirect, and 28,000 induced versus 27,000: 8,000 direct, 9,000 indirect, and 10,000 induced, by 2030).

- **The two most important technologies for the energy transition in South Africa and Mpumalanga will be wind and solar PV energy.** These technologies will also make the largest contributions to job creation, with up to 43,000 jobs in Solar PV (13,900 direct, 13,900 indirect, and 15,200 induced) and 28,900 jobs in wind-energy (9,000 direct, 9,700 indirect, and 10,200 induced) in Mpumalanga by 2030 (Super H_2igh Road Scenario).

- **Biomass creates the most jobs per MW of energy generated. However, the limited potential for sustainably produced biomass, and the competition for biomass use from other sectors, both constrain scalability.** In total, 4,600 jobs (1,400 direct, 1,400 indirect, and 1,800 induced) can be created in the biomass sector under the Super H_2igh Road Scenario by 2030. A detailed analysis is necessary of the sustainable biomass potential in Mpumalanga.

- **The number of jobs lost in the coal sector (operation and maintenance, O&M) jobs) will depend on the number of power plants decommissioned.** Therefore, any accelerated schedule for decommissioning coal needs to be accompanied by faster upscaling of renewable and clean technologies. In the IRP 2019 scenario (10.7 GW decommissioned), 74,000 O&M jobs (22,000 direct, 23,000 indirect, and 29,000 induced) would be lost at coal-fired power stations, compared with 124,000 O&M jobs (36,000 direct, 39,000 indirect, and 49,000 induced) in Scenarios 3 and 4 (17.8 GW decommissioned). The reductions in O&M jobs are cumulative over the period 2019 to 2030. However, not all job losses in Mpumalanga's fossil fuel sector can be compensated by clean energy jobs. The decommissioning results in net job losses in the province by 2030. Therefore, a wider strategy for economic prosperity is needed, including other sectors such as tourism and agriculture.

- **Direct job losses in the Mpumalanga coal sector are lower than total job losses (direct, indirect, and induced).** Direct job losses at Eskom power stations range from 6,500 jobs in the IRP 2019 scenario to 11,000 in Scenarios 3 and 4. Direct job losses in coal mining range from 4,800 in the IRP 2019 to 8,000 in scenarios 3 and 4.

[8] IASS/CSIR/IET (2019). Future skills and job creation through renewable energy in South Africa. Assessing the co-benefits of decarbonising the power sector. Potsdam/Pretoria: IASS/CSIR/IET. https://www.cobenefits.info/resources/cobenefits-south-africa-jobs-skills/

Value creation with renewables:

- **By deploying renewables, the value of Mpumalanga's gross output can be increased substantially.** Between 2019 and 2030, renewable energy investment in Mpumalanga can reach R320 billion (USD 20.6 billion) in the Super H_2igh Road Scenario, a more than 170 % increase over the R120 billion (USD 7.7 billion) in the IRP 2019 scenario. By increasing the local content from 30 % today to 60 – 80 %, local content within the province can be further increased to a gross output value of R340 billion (USD 22 billion).

- **Value creation in Mpumalanga will primarily be driven by manufacturing, amounting to approximately 20 – 44 % of total value creation in all scenarios.** The other parts of the value chain account for 11 – 19% (construction) and 11 – 28 % (financial, professional & business services) of value creation.

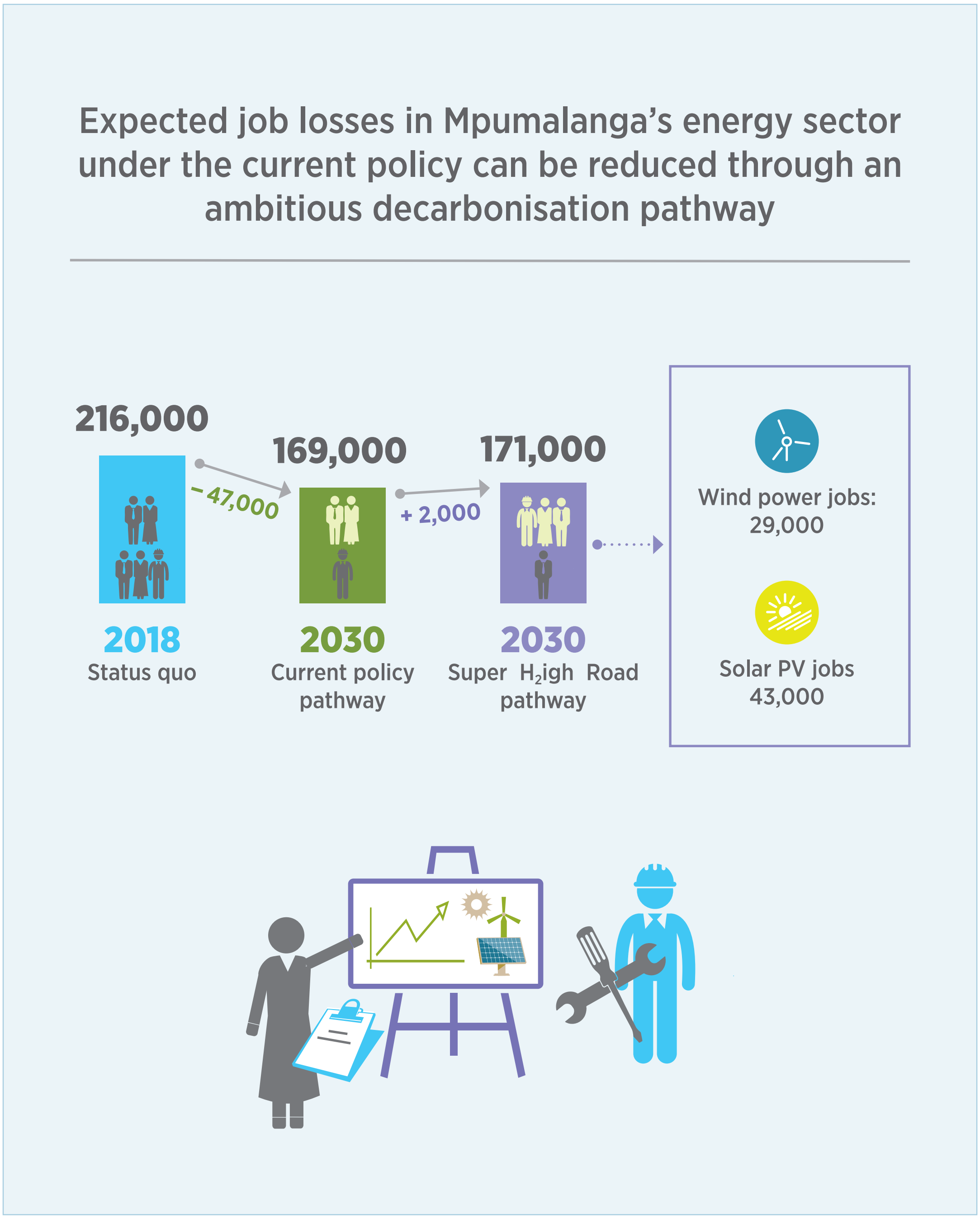
Skills and gender:

- **Upskilling and higher education are pre-requisites for a successful energy transition in Mpumalanga.** The bulk of job creation in renewable energy is within the high-skilled labour group (estimated as 68 – 80 %), although employment is also created in low-skilled roles—especially during project construction phases.

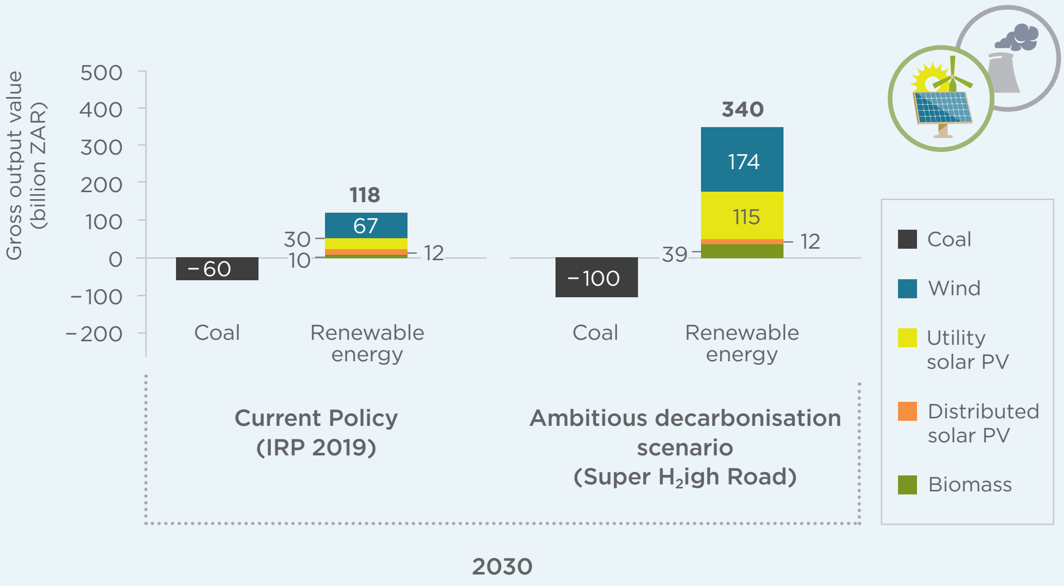
- **The current educational level among coal workers is much higher than the provincial average: 22 % of coal-mining employees and 55 % of Eskom employees have post-matric qualifications, compared with only 11 % among Mpumalanga's working-age population.** Eskom employees often acquire technical skills on the job, as 36 % are technicians and associated professionals. Although coal workers overall have lower educational attainment compared to Eskom employees, they also acquire technical skills on the job (e.g., 43 % are plant and machine operators), and their skills could be utilised in the renewables sector—especially during project construction phases.

- **Women are presently underrepresented in the energy sector. According to Eskom and MQA data sets, Eskom employs 31 % females and coal mines employ 21 % females in Mpumalanga.** However, those female employees are usually better educated than their male colleagues (e.g., 67 % of females compared to 49 % of males at Eskom hold a post-matric qualification), which results in females holding proportionately higher positions despite being numerically underrepresented. Females are currently under-represented in South Africa's renewable energy sector, with women accounting for only 14 % of employees.

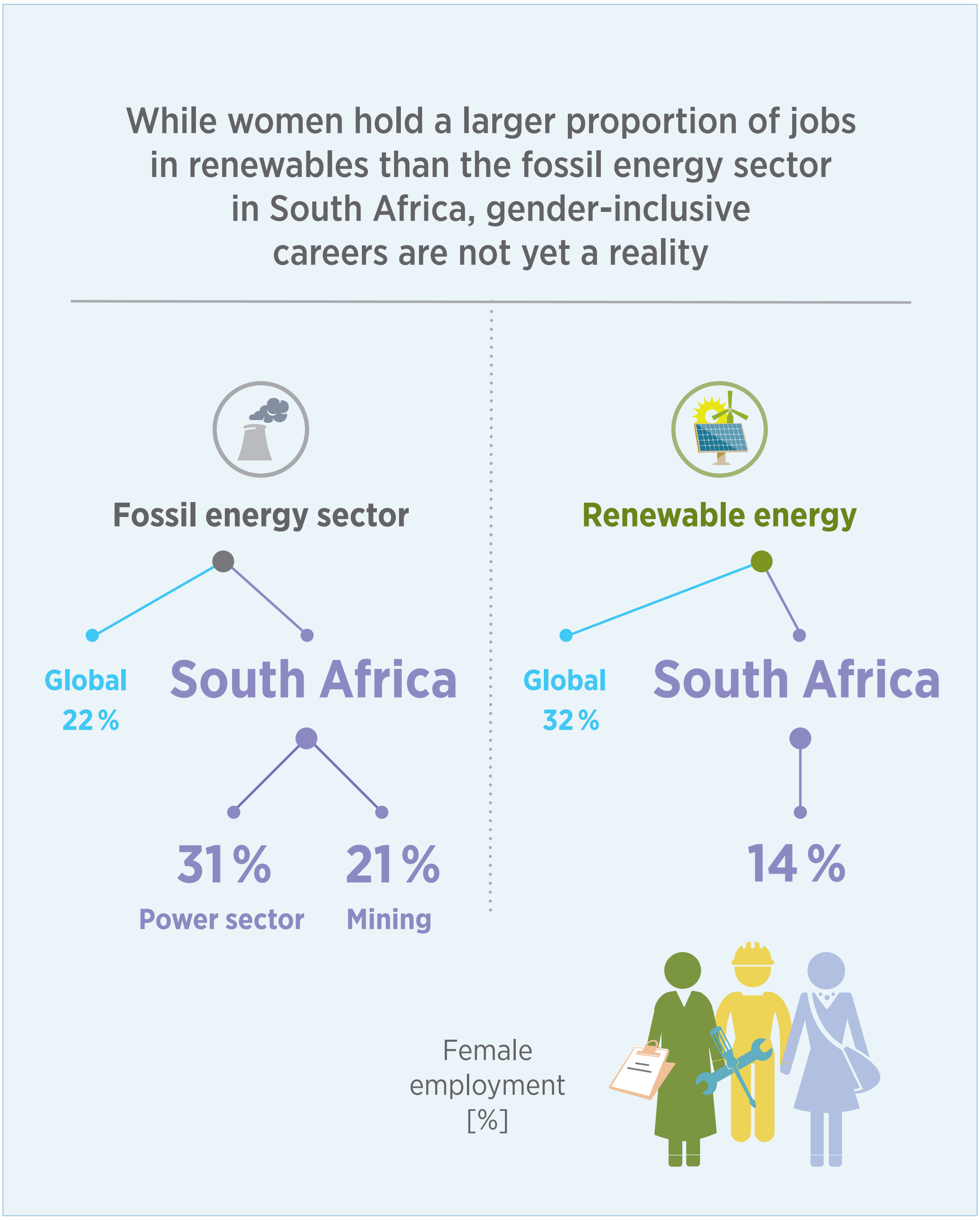
Key Infographics:



Value creation with renewable energy in Mpumalanga can increase from R118 bn to R340 bn in the next ten years by moving from current policy to an ambitious decarbonisation scenario.



Mpumalanga is the centre of the South African coal industry, accounting for approximately 80% of total coal production.



Data sources: IRENA 2019, IASS 2021c, ESKOM 2021, MQA 2021

High-Impact Actions for South Africa:

Building on the study results and the surrounding discussions with political and knowledge partners, we propose to direct the debate in the following areas where policy and regulations could be introduced or enforced to strengthen the socio-economic benefits for Mpumalanga:

- **High-impact action 1:** Implement policies enabling renewable energy development in Mpumalanga to avoid net job losses.
- **High-impact action 2:** Regional procurement with annual build targets to create sustained employment and continuous transfer of skills.
- **High-impact action 3:** Developing and expanding the transmission grid to facilitate renewable energy investments in Mpumalanga and elsewhere.
- **High-impact action 4:** A coordinated approach for localisation and value creation from renewable energies to develop a green provincial economy.
- **High-impact action 5:** Diversification of local content to components in which South Africa has manufacturing strengths.
- **High-impact action 6:** Dedicate Special Economic Zones (SEZs) for the manufacturing of key components to push the clean energy industry in the province.
- **High-impact action 7:** Renewable energy skill-development programmes through TVET colleges to facilitate career opportunities for many.
- **High-impact action 8:** Childcare facilities nearby training centres to reconcile parenting responsibilities and career development
- **High-impact action 9:** Entrepreneurial development for women to open access to markets and networks.

1. Key policy documents and initiatives for the energy transition in South Africa

1.1 National policies

South Africa's energy legislation landscape has been characterised by sensible policy formulation undermined by a combination of regulatory frameworks that are overly bureaucratic and a lack of administrative capacity within government to implement outcomes effectively.

White Paper on the Energy Policy of the Republic of South Africa (DME, 1998)

The 1998 White Paper presented the new democratic government's vision to address the need to reform energy policy in South Africa, to achieve:

a) Redress for past inequities of energy service provision.

b) Promote economic development through energy investments.

c) Manage the environmental and health impacts of energy use in South Africa.

d) Diversify South Africa's energy mix.

National Energy Act (Republic of South Africa, 2008)

The 2008 Energy Act was promulgated to ensure proper energy planning (through an integrated approach), with the establishment of the South African National Energy Development Institute (SANEDI) to support the aims of the White Paper.

Energy Regulation Act (Republic of South Africa, 2006)

The ERA of 2006 intended to:

a) Establish the national regulatory framework for the electricity supply industry.

b) Make the National Energy Regulator the custodian of the national electricity regulatory framework.

c) Regulate the licensing and regulation of generation, transmission, distribution, trading, and the import and export of electricity functions.

National Environment Management Act (Republic of South Africa, 1998)
The 1998 NEMA provides for:

a) Cooperative, environmental governance by establishing principles for decision making on matters affecting the environment.

b) Establishing institutions that promote cooperative governance and procedures for coordinating environmental functions exercised by organs of state.

Whilst NEMA is the apex policy framework, for this study more recent amendments to NEMA are more critical:

a) Air Quality Act (Act no. 39 of 2004).

b) Notices related to the establishment of Renewable Energy Development Zones (REDZs) Phases 1 (Republic of South Africa, 2018) and 2 (Republic of South Africa, 2021).

Mineral & Petroleum Resources Development Act (Republic of South Africa, 2002)

The function of the MPRDA was to make provision for equitable access to sustainable development of South Africa's mineral and petroleum resources. It has subsequently been amended by the Mineral and Petroleum Resources Development Amendment Act (Act no. 49 of 2008).

Preferential Procurement Policy Framework Act (Republic of South Africa, 2000) and Public Management Finance Act (Republic of South Africa, 1999)

The PFMA was established to regulate financial management in the national and provincial government and to ensure that all revenue, expenditure, assets, and liabilities of those sphere are managed efficiently and effectively.

1.2. Policy actors and initiatives

National Planning Commission – Pathways for the Just Transition

In May 2018, the National Planning Commission (NPC) invited representatives from government, business, labour, and community groups to participate in the "Pathways for a Just Transition" project.

The purpose of the project was to review Chapter 5 of the National Development Plan (NDP), to ensure an environmentally sustainable society with an expanded low-carbon economy and reduced emissions, but in a way that addresses the triple threats of poverty, inequality, and unemployment. The NPC wanted the project to interrogate issues that commissioners felt were not addressed in Chapter 5:

a) Who pays for the input costs of the transition and how much will it cost?

b) Will the transition require a restructured economy or new development model?

c) What should the energy mix be, the role of energy efficiency, and the shape and structure of the future energy industry?

d) How is job creation maximised and job losses addressed?

e) How do we continue to build resilience in communities and economic sectors and ensure that the poor are not disproportionately impacted?

The NPC wanted the social dialogue involved to build a collective vision of an end-state and to provide guidance for the development of a Just Transition.

The process involved several workshops with community stakeholders in different provinces, followed by a concluding conference and reports.

NEDLAC

In February 2020, at the behest of President Ramaphosa, the social partners determined to establish a social compact to create a "Framework Agreement for a Social Compact on Supporting Eskom for Inclusive Economic Growth" including a section on the Just Transition.

In the section on a Just Transition, the social partners concurred that:

- Interventions would be undertaken in a manner to reduce carbon emissions, and these interventions should also catalyse support for the transition to clean energy in ways that are inclusive, with particular focus on affected geographical areas.
- Projects that would support worker and community participation and social ownership within the renewable energy sector would be considered.
- Eskom will expand its portfolio of generation to include renewable energy, gas, and other forms of clean energy.
- A study would be conducted to assess options for the repurposing of power station infrastructure for other economic purposes.
- Establishment of a local renewable energy component manufacturing industry will be prioritised. In addition, stimuli should be provided to advance the green hydrogen economy in South Africa.

Presidential Climate Commission

The establishment of the Presidential Climate Coordination Committee, later shortened to the Presidential Climate Commission (PCC)[10] was an outcome of the Job Summit NEDLAC process in 2019 as a commitment by social partners within the Job Summit Framework Agreement signed in October 2018, under the section on Just Transition.

[9] https://www.nationalplanningcommission.org.za/Publication_Documents

[10] https://www.climatecommission.org.za/

The establishment of the PCC was stalled by delays to the Climate Change Bill of June 2018 in which the President made DFFE the responsible department for the PCC and entrenched these powers within the Bill to give the PCC the status of a statutory body. At the end of 2018 NEDLAC partners required the Bill to contain the terms of reference for the PCC, which resulted in the National Climate Change Bill only being gazetted in [May] 2020.

Department of Public Works & Infrastructure/ National Infrastructure Plan 2050

The Department of Public Works & Infrastructure (DPWI) released a draft version of the National Infrastructure Plan 2050 (Republic of South Africa, 2021) that focused on four sectors, including energy, that would be mission-critical to achieving the ambitions of the NDP. The draft recommended the acceleration of structural changes to the energy sector that are well known by stakeholders and underlined the imperative of Just Transition principles informing those processes.

COGTA/District Development Model

President Cyril Ramaphosa's 2019 Presidency Budget Speech recognised the lack of coordination in planning and implementation at local and district municipal levels, and its consequent threats both to government's ability to deliver basic services and to address the triple challenges of poverty, inequality, and unemployment. The District Development Model (DDM) builds on the 1998 White Paper on Local Government (CGTA, 2016) and seeks to more effectively deliver municipal services. In respect to this document, the Nkangala District Municipality (COGTA, 2020) is relevant to how the DDM will have impact.

Eskom Social Plan

In 2017, Eskom commissioned SRK Consulting to produce a report titled "Eskom Generation Fleet Renewal Project: Socio-Economic Study" (SRK Consulting, 2018). Whilst its original purpose was to establish a value proposition for the life extension of Hendrina, Arnot, Komati, Grootvlei, and Camden power stations, the study findings actually highlighted the dependence of the local economies around the power stations.

The later acceptance of the unaffordability of LIFEX and the establishment of the Just Transition office has seen the Eskom Social Plan repurposed as an end-of-life management strategy that is examining options to repower/repurpose old stations (aligned to Eskom's Net Zero 2050 ambitions), in concert with socio-economic mitigations strategies where is no alternative to plant closure.

Eskom's just energy transition strategy is defined as *"the shift towards a low-carbon energy system, without the shift being disruptive to socio-economic development"* (ESKOM, 2021).

The Political Declaration on the Just Transition in South Africa

On 2 November 2021, President Cyril Ramaphosa announced that an agreement had between reached between South Africa and the governments of France, Germany, the EU, UK, and USA, on establishing a partnership to support both the decarbonisation of the South African economy and a Just Transition (COP26, 2021). The agreement pledges that the developed nations will make available some USD 8.5 billion in the form of grants and highly concessional loans to assist the closure of Eskom coal plants, and to support just energy transition initiatives and South Africa's transition to the green hydrogen and electric vehicle sectors.

The Declaration calls for the formation of a Task Team with a set of clear deliverables, over the subsequent 6 to 12 months, to establish an implementable Just Energy Transition Plan for South Africa.

2. Green economy initiatives in Mpumalanga and South Africa

This section covers the current ongoing green economy initiatives in Mpumalanga.

2.1 Green economy: completed and ongoing initiatives

Below is a list of some of the green economy initiatives in South Africa and Mpumalanga, followed by a discussion of the initiatives.

- Mpumalanga Green Economy Roundtable (Mpumalanga DEDT, 2016)
- Strategic plan: 2020–2025 (Mpumalanga DEDT, 2020)
- Mpumalanga Economic Growth & Development Path (Mpumalanga DEDT, 2011)
- Mapping the Green Economy Landscape in South Africa (AFRICEGE, 2015)
- The Green Economy Inventory for South Africa (PAGE, 2017)
- South Africa Green Economy Barometer 2018 (AFRICEGE et al., 2018)

Table 2-1: Green economy initiatives

Project	Project focus and desired output	Project duratio n	Organisation
Mpumalanga Green Economy Roundtable	The roundtable aimed to gather valuable insights on potential provincial priority actions for the green economy, and to start building provincial consensus on the key elements of a Green Economy pathway to be implemented over the next 15 years.	2016	Mpumalanga Province: Department of Economic Development and Tourism
Strategic Plan: 2020–2025	Highlighting interventions that would reduce the carbon footprint; climate change resulting from coal-powered energy.	2020	Mpumalanga Province: Department of Economic Development and Tourism
Mpumalanga Economic Growth & Development Path	Support for clean, renewable energy as opposed to the current intensive utilisation of coal for electricity production and embedding these mechanisms within the manufacturing sector to assist the transition to a green economy. Developing an integrated renewable energy plan for the province. This will include technologies such solar energy, biomass (bagasse, wood-waste, sawdust, wood off-cuts, etc.) and putrescible waste (including municipal solid waste, abattoir waste), and hydropower.	2011	Mpumalanga Province: Department of Economic Development and Tourism
Mapping the Green Economy Landscape in South Africa	This project seeks to identify focus areas for the Green Fund and to develop an understanding of the emerging green economy landscape in South Africa.	2015	African Centre for a Green Economy (AFRICEGE); Development Bank of Southern Africa; Department: Environmental Affairs, Green Fund
The Green Economy Inventory for South Africa	The research objective was to gather data on green economy initiatives implemented in South Africa since 2010 in order to answer the following questions: What are the key sectors in South Africa's green economy? Who are the key actors in South Africa's green economy?	2017	Department of Environmental Affairs
South Africa Green Economy Barometer 2018	The study aims to provide a snapshot of the transition to a fair, green economy. It is drawn from evidence of policy progress as well as the insights of civil society organisations who are tracking the transition on the ground.	2018	African Centre for a Green Economy; Trade & Industrial Policy Strategies; Green Economy Coalition. European Union

Settlement in Mpumalanga © Westewoud via Flickr, CC BY-NC 2.0

South Africa

The realisation of a green economy will need strong policy support that pushes for low-carbon sectors, green cities and towns (AFRICEGE, 2015). The manufacturing sector, with its enormous contribution to sustainable job creation, is encouraged to adopt cleaner and resource-efficient production measures. Public–private partnerships (PPP) between municipalities and the private sector, which could be facilitated by green funding to purposefully invest in renewable energy, could help rural communities to achieve a low-carbon economy. In addition to these renewable energy and energy efficiency solutions, waste management, sustainable transport, biodiversity management, and ecosystem services have a pivotal role to play in the transition to a green economy.

Mpumalanga

Mpumalanga's Green Economy Roundtable aimed to identify key activities to build the green economy. The roundtable outlined the drivers for building the green economy, including the deployment of renewable energy. Localisation of the biopower value chain and development of a bio-refinery could be explored—given that the established sugar industry can help socio-economic development goals while benefitting communities. It is also foreseen that sustainable agriculture could deploy alternative forms of energy in agri-hubs and farms (Mpumalanga DEDT, 2016).

The Mpumalanga 2020–2025 strategic plan promotes the green economy in the province by emphasising the need to implement measures to mitigate climate change, to achieve a low carbon footprint leading to improved human and environmental health. Such interventions include, inter alia, promotion of the bioenergy sector, enforcement of legislation pertaining to pollution control, coordination, and implementation of recycling plants, establishing methods of treating wastewater for re-use in different commercial applications, and the enforcement of rehabilitation and clean-up measures for mining operations. Additionally, the strategic plan identified the need for the manufacturing industry to consider exploring, developing, and using appropriate low-cost renewable energy (Mpumalanga DEDT, 2020).

2.2 Industrialisation in Mpumalanga and South Africa

This section seeks to map out the completed and ongoing industrialisation initiatives and policies that are taking place in Mpumalanga and in South Africa more broadly. The following list summarises industrialisation initiatives and policies. See also Table 2-2.

- Industrial policy action plan: 2018/19–2020/21 (DTI, 2018)
- A summary of the South African national infrastructure plan (PICC, 2012)
- Mpumalanga Industrial Development Plan: Towards the Industrialisation of the Mpumalanga Economy (Mpumalanga DEDT, 2015)
- Strategic plan: 2020–2025 (Mpumalanga DEDT, 2020)
- Strategic plan: 2015–2020 (Mpumalanga DEDT, 2016)

Table 2-2: Summary of industrialisation polices and initiatives

Project	Project focus and desired output	Project duration	Organisation
Industrial Policy Action Plan: 2018/19 – 2020/21	The objective of the industrial policy is to enhance the productive capacity of the economy. Alternatively, industrial policy aims to increase the economy's ability to produce increasingly complex and high value-added products with greater efficiency.	2018	DTIC
A summary of the South African national infrastructure plan	Intends to transform the economic landscape while simultaneously creating significant numbers of new jobs, and to strengthen the delivery of basic services. It sets out the challenges and enablers to which South Africa needs to respond in planning and developing enabling infrastructure that fosters economic growth.	2012	Presidential Infrastructure Coordinating Commission (PICC)
Mpumalanga Industrial Development Plan: Towards the Industrialisation of the Mpumalanga Economy	Establishment of an industrial hub comprising the following centres: Mining and Metals Industrial Centre of Competence; Petrochemicals Industrial Centre of Competence; Agriculture and Forestry Industrial Centre of Competence; Nkomazi Special Economic Zone. Additionally, initiate biomass energy conversion network, which can support the take-off of identified modern biomass conversion opportunities (including conversion into biogas and electricity generation).	2015	Mpumalanga Province: Department of Economic Development and Tourism
Strategic Plan: 2020–2025	Highlights interventions that can contribute towards creating a knowledge -based manufacturing industry within the province.	2020	Mpumalanga Province: Department of Economic Development and Tourism
Strategic Plan: 2015–2020	Seize the potential of greening industries and stimulate manufacturing and beneficiation to achieve job creation. Increase the value of investment in support of all economic infrastructure programmes.	2015	Mpumalanga Province: Department of Economic Development and Tourism

With an ambitious decarbonisation scenario, up to 72,000 people could be employed in construction and O&M in Mpumalanga by 2030. © Shutterstock/sirtravelalot

3. Four regional power system scenarios

3.1 Detailed scenario descriptions

The scenarios explored in this assessment for Mpumalanga depict increasing ambition and speed of the energy transition. Scenario 1 is considered as the base case and is founded on the IRP 2019. Scenarios 2 to 4 are based on frameworks that were applied in previous reports and discussed with key stakeholders in South Africa (e.g., Eskom, DMRE, etc).[11]

Four scenarios were explored in this study, as summarised below.

	Scenario 1: Current Policy: Planned repurposing (IRP)	Scenario 2: Accelerated repurposing	Scenario 3: Ambitious repurposing + RE on old mining sites	Scenario 4: Super H_2igh Road
Description	Scheduled decommissioning of the coal power plants Komati, Camden, Grootvlei, Arnot, Hendrina by 2025. Additional decommissioning of other power stations as per IRP schedule by 2030. Repurposing of these power stations to 2030.	Quicker decommissioning of additional coal-fired power plants in Mpumalanga. Repurposing of these power stations to 2030.	Even quicker decommissioning of additional coal-fired plants. Repurposing of these power stations to 2030. Plus the conversion of old coal mining land via renewable energy deployment	Renewable energy capacity on repurposing sites (see scenarios 1 and 2), plus conversion of coal mining (scenario 3), plus additional renewable energy capacity in Mpumalanga for hydrogen production by 2030.
Renewable energy technology	Renewable energy technologies as per IRP; Battery storage capacity as per IRP	Solar PV+DPV Onshore wind Biomass Battery storage	Solar PV+DPV Onshore wind Biomass Battery storage	Solar PV+DPV Onshore wind Biomass Battery Storage Hydrogen
Renewable energy capacity	As per IRP capacity additions	Based on Wright & Calitz (2020) Ambitious renewable energy Industrialisation Scenario	Based on Wright & Calitz (2020) 2GT CO_2 Scenario	Based on Wright & Calitz (2020) 2GT CO_2 Scenario, plus the opportunity represented by H_2
	Decommissioning as per IRP plan Adherence to VRE build limits as per IRP 20–25 % of planned capacity allocated to MP	Accelerated decommissioning: all coal power plants except Majuba, Medupi, and Kusile No VRE build limits 20–25 % of planned capacity allocated to MP	Accelerated decommissioning: all coal power plants except Majuba, Medupi, and Kusile No VRE build limits 20–25 % of planned capacity allocated to MP	Accelerated decommissioning: all coal power plants except Majuba, Medupi and Kusile No VRE build limits 20–25 % of planned capacity allocated to MP

[11] Scenarios 2 and 3 also take system adequacy concerns into account and grid constraints, as they are mainly based on the results taken from CSIR & Meridian Economics scenarios (see Wright & Calitz, 2020).

Scenario 1 – Current policy: planned repurposing (based on IRP 2019):

This scenario assumes the scheduled decommissioning of power stations according to the Integrated Resource Plan (IRP 2019) schedule to 2030 (11 GW), with repurposing of decommissioned plants within the IRP 2019 allocations for renewable energy deployment (28 GW) and related annual build limits (DMRE, 2019). It thereby provides a base case scenario in line with current policy.

Scenario 2 – Accelerated repurposing:

Compared with the current policy, this scenario assumes quicker decommissioning of additional coal-fired power plants (13 GW) in Mpumalanga and faster deployment of renewables (54 GW) using the Ambitious renewable energy scenario from Wright & Calitz (2020)[12] .

Scenario 3 – Ambitious repurposing:

Compared with the current policy, this scenario assumes even quicker decommissioning of additional *coal-fired plants (18 GW) as per the 2 GT CO_2 scenario in Wright & Calitz (2020).[13] These power stations would then be repurposed with renewable energy deployment (65 GW), also making use of land available on old coal mining sites to 2030.*

Mpumalanga has substantial old coal mining sites that will need to be rehabilitated in the coming decades.[14] In addition, Eskom-owned land in Mpumalanga amounts to <50,000 ha; this reduces to less than 26,000 ha if only the coal power plants are considered (excl. Kusile). Therefore, the old mining land at Eskom sites can be rehabilitated and host additional renewable energy capacity. The ambitious repurposing scenario (3) also foresees establishing new or repurposed wastewater treatment plants on rehabilitated mining land to provide various qualities of water for various purposes (potable, industrial, etc.). The water treatment plants will require electricity, which can be provided by renewable energy plants that will be constructed on the viable and available mining land.

In the 2 GT CO_2 scenario modelled by CSIR and Meridian Economics, there is an increase of 42.6 GW of wind and 13.6 GW of solar PV by 2030 in South Africa. Assuming 15% of allocation of wind capacity and 20% of solar PV capacity to Mpumalanga, then 6,395 MW and 2,724 MW of wind and solar PV respectively would need to be built by 2030, requiring the following real estate:

- *Wind: 6,395*10 = 63,950 hectares (ha) (assuming: 10 ha/MW)*
- *Solar PV = 2,724*2 = 5,488 ha (assuming: 2 ha/MW)*
- *Total land requirement estimate = 69,438 ha*

Scenario 4 – Super H_2igh Road:

This scenario is based on the same assumptions as Scenario 3 (i.e., renewable energy capacity on repurposing sites, plus conversion of coal mining sites) but also assumes additional renewable energy capacity, producing 6 GW of green hydrogen in Mpumalanga by 2030. This scenario draws on the 2 GT CO_2 budget scenario for the decommissioning rate (18 GW) and the roles of other technologies (e.g., gas, nuclear, etc).

The increased role of renewable energy in accommodating hydrogen production, as investigated in the Super H_2igh Road market study by IHS Markit, was considered, including additional biomass to accommodate the ambitions for the Mpumalanga region. This scenario recognises the growing interest and role of green hydrogen in decarbonisation, both in South Africa and globally. It assumes that there is also an export market potential for South Africa to other countries (e.g., European Union, Japan, South Korea).

[12] Wright, Jarrad, and Joanne Calitz. 2020. "Systems Analysis to Support Increasingly Ambitious CO_2 Emissions Scenarios in the South African Electricity System." Tech. Rep. 27 (July): 129.

[13] These scenarios follow the capacity adjustments in the 2 GT CO_2 scenario (Wright & Calitz, 2020), but adjusted for higher levels of biomass.

[14] Other countries have positive experiences of using RE for land rehabilitation purposes e.g., the 5 MW Germany Leipziger Land Solar Plant: 34.5 MW U.S. Casselman wind power project. Therefore, additional renewable energy deployment can be beneficial for Mpumalanga.

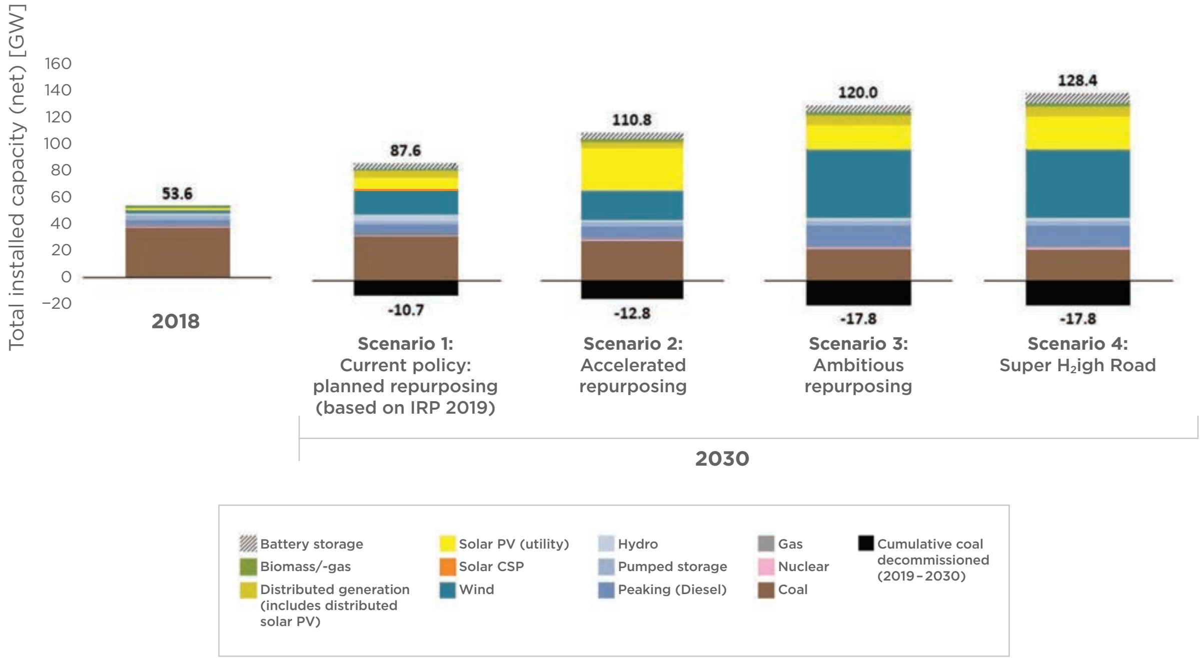


Figure 3-1: COBENEFITS South Africa: Power system reference scenarios Installed capacity (GW) (source: IRP 2019, CSIR Energy Centre analysis)

Scenarios background – Meridian & CSIR

Below is the resulting electricity production from coal for the selected scenarios, taken from the work by Meridian and CSIR, which analysed several different potential scenarios that South Africa could follow on its path to decarbonising the power sector.

Figure 3-3 shows the installed capacity under the selected scenarios from the work by Meridian Economics & CSIR (Wright & Calitz, 2020).

Table 3-1 is the original national-level capacity before adjustments were made to assume greater biomass generation due to Mpumalanga region's resources and ambitions to take advantage of the abundant biomass resources, as used in the final capacity calculations in this study (see Table 3-2).

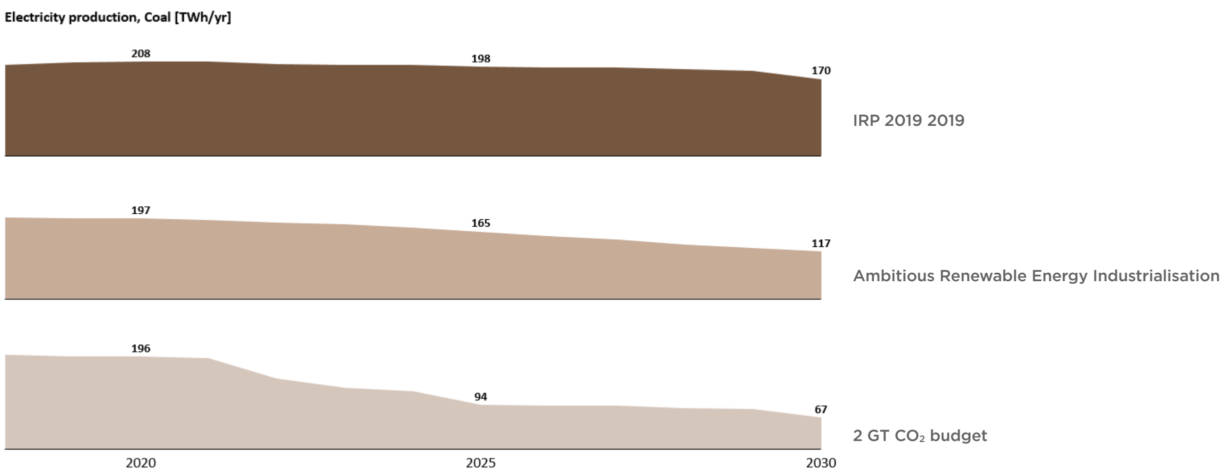


Figure 3-2: Figure 3-2: Electricity production from coal (TWh/yr.) (Wright & Calitz, 2020)

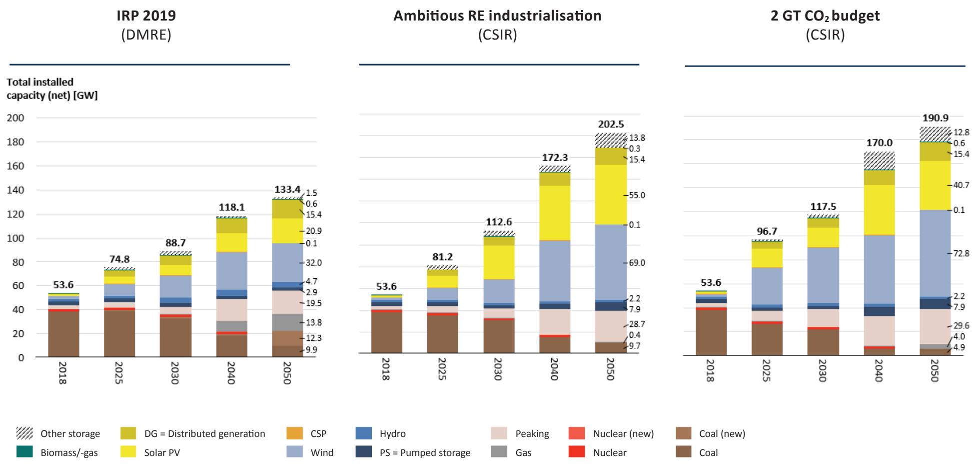


Figure 3-3: National installed capacity, 2030, Meridian & CSIR (Wright & Calitz, 2020)[15]

Table 3-1: National installed capacity, 2030, Meridian & CSIR (source: Wright & Calitz (2020)

	2018 installed capacity	Scenario 1: Planned repurposing (IRP)	Scenario 2: Additional repurposing (Accelerated)	Scenario 3: Ambitious repurposing + RE on old mining sites	Scenario 4: Super H_2igh Road Scenario
Battery storage	0	3 563	4 349	4 349	6 766
Biomass/-gas	282	307	307	557	557
DG	584	7 959	7 959	7 959	7 959
Solar PV	1 479	8 342	30 842	15 962	21 962
Concentraded Solar Power (CSP)	400	600	600	600	600
Wind	2 086	17 998	21 398	46 227	46 227
Hydro	2 192	4 692	2 192	2 192	2 192
PS	2 912	2 912	2 912	2 912	2 912
Peaking (diesel)	3 405	6 231	8 581	14 715	14 715
Gas	425	425	425	425	425
Nuclear (new)	0	0	0	0	0
Nuclear	1 860	1 860	1 860	1 860	1 860
Coal (new)	0	1 500	0	0	0
Coal (existing)	37 935	32 299	30 225	21 291	21 291
Coal decommissioned	0	-10 682	-12 756	-17 815	-17 815

[15] CSP in the key of Figure 3-3 stands for Concentrated Solar Power technology which played a role in the early rounds of REIPPP. It did not receive any allocation in IRP 2019 and CSP technology has only been found to be competitive in the high solar resource areas of the Northern Cape province and therefore has not been considered in this study.

Technology	2018 installe d capacity (MW)	Scenario 1: Planned repurposing (IRP) (MW)	Scenario 2: Additional repurposing (Accelerated) (MW)	Scenario 3: Ambitious repurposing + RE on old mining sites (MW)	Scenario 4: Super H_2igh Road Scenario (MW)
Battery storage	0	3 563	5 271	4 349	6 766
Biomass/-gas	282	682	882	1 482	1 482
Distributed generation	584	6 459	5 659	7 959	7 959
Solar PV	1 479	8 342	30 842	15 962	21 962
Solar CSP	400	600	600	600	600
Wind	2 086	17 998	21 398	46 227	46 227
Hydro	2 192	4 692	2 192	2 192	2 192
Pumped storage (PS)	2 912	2 912	2 912	2 912	2 912
Peaking (diesel)	3 405	6 231	8 581	14 715	14 715
Natural gas	425	425	425	425	425
Nuclear	1 860	1 860	1 860	1 860	1 860
Coal (new)	0	1 500	0	0	0
Coal (existing)	37 935	32 299	30 225	21 291	21 291

Table 3-2: Installed capacity in MW (2030) by technology per scenario (source: Wright & Calitz (2020); own calculation)

Assumptions

- Scenario 1 adhered to constraints on annual build limits provided for in the IRP; the remaining scenarios did not have build limit constraints.
- No nuclear, natural gas, CSP, or diesel provision was modelled as part of this analysis.

3.2 Installed capacity under the four scenarios

Table 3-1 is the national installed capacity per scenario for South Africa in 2030. The capacities for wind, solar PV, distributed solar PV generation, and battery storage were used for the employment analysis, focusing on a specific potential share for Mpumalanga, which was decided based on discussions with industry experts, see Table 3-3. See section 7 for the per annum breakdown per scenario.

Technology	Mpumalanga % of new SA capacity
Wind	15%
Solar PV	20%
Solar DPV	15%
Biomass	Absolute
Battery storage	15%

Table 3-3: Mpumalanga share of national capacity (source: assumptions based on discussions with industry experts)

4. Detailed description of quantitative and qualitive assessments

4.1 Introduction and background

This section provides the context within which the study was conducted, describing insights into key policies and initiatives that were of relevance to the study.

Description of approach and methodology

- Conducted qualitative desktop research into policies, technologies, socioeconomic challenges in Mpumalanga and South Africa more broadly
- Collated relevant policy initiatives and documents and summarised and synthesised the sections relevant to this study
- Conducted a literature review of similar existing initiatives and studies

Assumptions

- IRP 2019, Roadmap for Eskom in a Reformed ESI, and other stated policies and positions by Government are followed.
- South Africa's new NDC is sufficiently ambitious to attract green and transition finance.

4.2 Quantification of employment effects

This section assesses the impact on jobs of the repurposing of decommissioned coal stations and surrounding mines, and how clean technologies could create jobs to compensate for the job losses in the region.

Step 1: Determine the job losses per scenario

[1-1] Based on the described scenarios, a year-on-year breakdown of the decommissioning schedule based on IRP 2019 was established as per Table 4-1.

- The coal capacity to be decommissioned (see Table 4-1) was input to the I-JEDI (International Jobs and Economic Development Impacts) online tool to obtain projected job losses per scenario from the respective power plants. The I-JEDI model is described further in section 7.
- A capacity factor of 60% was assumed for the coal modelling.

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Scenario 1	-756	-739	-1388	-834	0	-370	-372	-1322	-532	0	-1525	-2844
Scenario 2	-756	-739	-1223	-961	-1553	-1490	-1312	-576	-532	-1563	-744	-1307
Scenario 3&4	0	0	-474	-4923	-3952	-1068	-2599	0	0	0	-1216	-3583

Table 4-1: Coal decommissioning per annum per scenario

[1-2] Eskom provided data on current employment at the utility, and these data were used to triangulate and sense-check the modelled numbers. Actual numbers per power plant from Eskom **are not** used.

[1-3] To calculate the number of job losses at the surrounding mines, employment data provided by the Mining Qualifications Authority (MQA) were assessed. Mines that served specific power plants were identified and a jobs-per-MWh ratio was obtained. This ratio was then applied to the annual capacity that would be decommissioned to estimate annual job losses. Data on exact production per mine were outside of the scope of this study.

Table 4-2 shows the relevant power plants and related coal mines as well as the associated mining jobs.

Power station	Name	Company	Eskom supplier	Number of mine employees	Coal production (MTpa)	Power station capacity (MW)	Power station capacity factor	Electricity production (GWh)	Jobs intensity (employees/GWh)
Kendal	Khutala	Seriti	Yes	1634	5.5	3840	69.30%	23 311	0.07
Kriel	Kriel	Seriti	Yes	1068	5	2850	45.70%	11 410	0.09
Tutuka	New Denmark	Seriti	Yes	1668	5	3510	56.20%	17 295	0.1
								Weighted average	**0.086**

Table 4-2: Mining jobs analysis using MQA employment data

[1-4] In addition to the analysis in Table 4-2, a triangulation exercise was conducted with a mining expert to sense-check the results. The insights gained from that discussion are presented below (see Table 4-3).

Mine	Market	Insight	Category *	Run-of-mine (MT)	Yield (%)	To Eskom MT (est.)	Type of operation	Type of coal
Belfast	Export	**Mainly export:** Continue post-Eskom closure Eskom PS closure minimal impact: might lose 10% of employees	3	3.24	50%	0.5	Open cut	Thermal
Dorst	Domestic & export		4	3.4	50%	1–1.5	Open cut & underground	Thermal
Forzando	Domestic & export		4	2.2	50%		Open cut & underground	Thermal
Tumelo	Domestic & export		4	-	50%		Underground	Thermal
Leeuwpan	Domestic & export	Minimal supply to Eskom: Continue post-Eskom closure Domestic market will wane over next	4	6	50%	0.5	Open cut	Thermal
		decade as market moves to other sources, e.g., biomass						
Matla	Eskom	Mining 2 seams, exclusively to Eskom Eskom owns, Exxaro contracts operations Employees will likely lose jobs after Eskom closure, unless the mine is repurposed for beneficiation (keep 80% of employees and hire new employees for beneficiation)	1	6.2	50%	6	Underground. No beneficiation, only crushing and delivery	Thermal

Table 4-3: Coal mine characteristics (expert inputs, 2021)

Mafube	Domestic & export	**Mainly export:** Continue post-Eskom closure **Eskom PS closure minimal impact: might lose 10% of employees**	3	5.4	50%	0.5	Open cut	Thermal
Grootegeluk	Domestic & export	Strategic asset. Fully integrated—if PS closes, mine will also close	2	54.6	50%		Open cut	Thermal & metallurgical

Categorisation of mines*	Description
1	Fully Eskom (Matla)
2	Integrated: Dependent on Eskom PS for continuation
3	Mainly export: Eskom closure has minimal impact
4	Marginal mines: Viable because they can sell to primary market and to Eskom

[1-5] Insights on exports: The challenges to exports are the logistics capacity on the Richards Bay Coal Terminal (RBCT) line to the export market. The RBCT has annual capacity of >110Mt but is presently utilising less than this due to operational challenges.

Coal consumer	Amount (est.) in Mt
Eskom coal	~110
Grootegeluk	30
Lethabo	15
Balance to Eskom	65

[1-6] I-JEDI Model assumptions: Table 4-4 and Table 4-5 show the assumptions that were used in the I-JEDI modelling for the coal jobs impact assessment.

Table 4-4: General I-JEDI assumptions

Rand per USD dollar	**14.0766 (per May 2021)**
Currency year	**2021**
Capacity factor	**60%**

Table 4-5: Local content assumptions on coal

Operations and maintenance (O&M)	% spent in South Africa
Coal (incl. ash disposal) and water	100%
Plant operations (staff, equipment such as trucks)	100%
Civil works (access road maintenance, etc.)	100%

Step 2: Determine job creation potential per scenario

[2-1] For each scenario, job creation potential is modelled in I-JEDI per technology type. To obtain the annual number of jobs, assumptions were required for the construction phasing for each technology. These are detailed in Table 4-6 and are based on industry norms. Table 4-7 depicts the data sources for the model, and Table 4-8 depicts the share per technology of newly installed capacity for Mpumalanga.

Table 4-6: Construction phasing per technology (EPRI, 2016)

Construction phasing				
Year	**1**	**2**	**3**	**4**
Wind	5%	5%	10%	80%
PV	100%			
DPV	100%			
Biomass/-gas	10%	25%	45%	20%

Table 4-7: Data requirement sources for I-JEDI modelling

Input data requirement	Source
Annual megawatts installed (MW)	System modelling (Plexos)/DMRE/IHS Markit
Proportion of labour and materials sourced locally (localisation)	DTI localisation requirements/industry associations/I-JEDI/general web search
Capacity factors per technology type	System modelling (Plexos)
Construction phasing schedule (per technology)	EPRI

Table 4-8: Renewable energy allocation per province (defined by authors)[16]

Province	Wind	Solar PV
Limpopo	0%	5%
North West	0%	10%
Northern Cape	24%	30%
Western Cape	20%	5%
Eastern Cape	30%	5%
Free State	10%	15%
Kwa Zulu Natal	0%	0%
Gauteng	1%	10%
Mpumalanga	15%	20%
Total	100%	100%

[2-2] Renewable energy capacity assumptions per scenario: The following tables present the capacity assumptions per annum for each scenario. The first table beneath each scenario is the national-level capacity. The second table is the Mpumalanga-level capacity and is calculated by multiplying the national level capacity by the share of capacity in Table 4-8 above.

Table 4-9: Scenario 1 – National-level capacity assumptions (MW)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Wind	0	0	0	1600	1600	1600	1600	1600	1600	1600	1600	1600	14400
Solar PV	0	0	0	1000	1000	0	1000	0	0	1000	1000	1000	6000
Solar DPV	0	775	1150	1450	500	500	500	500	500	500	500	500	7375
Biomass/-gas (biopower)	0	0	0	0	50	50	50	50	50	50	50	50	400
Battery storage	0	221	407	1345	0	0	0	0	0	0	1590	0	3563

[16] Defined before GCCA-2024 was issued, which shows further constraints of grid evacuation capacity for primary resource areas – increasing the potential move to Mpumalanga.

Table 4-10: Scenario 1 – Mpumalanga-level capacity assumptions (MW)

	2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**Total**
Wind	0	0	0	240	240	240	240	240	240	240	240	240	2160
Solar PV	0	0	0	200	200	0	200	0	0	200	200	200	1200
Solar DPV	0	116	173	218	75	75	75	75	75	75	75	75	1107
Biomass/-gas (biopower)	0	0	0	0	25	25	25	25	25	25	25	25	200
Battery storage	0	33	61	202	0	0	0	0	0	0	239	0	534

Table 4-11: Scenario 2 – National-level capacity assumptions (MW)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Wind	0	0	0	1600	1800	2000	2000	2000	2000	2000	2000	2400	17800
Solar PV	0	0	0	1000	1500	2500	3500	4000	4000	4000	4000	4000	28500
Solar DPV	0	775	1150	1450	500	500	500	500	500	500	500	500	7375
Biomass/-gas (biopower)	0	0	0	0	75	75	75	75	75	75	75	75	600
Battery storage	0	221	407	2331	0	0	1258	0	0	0	96	957	5 271

Table 4-12: Scenario 2 – Mpumalanga-level capacity assumptions (MW)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Wind	0	0	0	240	270	300	300	300	300	300	300	360	2670
Solar PV	0	0	0	200	300	500	700	800	800	800	800	800	5700
Solar DPV	0	116	173	218	75	75	75	75	75	75	75	75	1107
Biomass/-gas (biopower)	0	0	0	0	50	50	50	50	50	50	50	50	400
Battery storage	0	33	61	350	0	0	189	0	0	0	14	144	791

Table 4-13: Scenario 3 – National-level capacity assumptions (MW)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Wind	0	0	0	14111	7049	771	4842	1765	1056	2379	1557	9100	42630
Solar PV	0	0	0	0	0	0	4042	9578	0	0	0	0	13620
Solar DPV	0	775	1150	1450	500	500	500	500	500	500	500	500	7375
Biomass/-gas (biopower)	0	0	0	0	150	150	150	150	150	150	150	150	1200
Battery storage	0	221	407	835	212	0	0	0	0	795	795	1084	4349

Table 4-14: Scenario 3 – Mpumalanga-level capacity assumptions (MW)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Wind	0	0	0	2117	1057	116	726	265	158	357	234	1365	6395
Solar PV	0	0	0	0	0	0	808	1916	0	0	0	0	2724
Solar DPV	0	116	173	218	75	75	75	75	75	75	75	75	1107
Biomass/-gas (biopower)	0	0	0	0	100	100	100	100	100	100	100	100	800
Battery storage	0	33	61	125	32	0	0	0	0	119	119	163	652

Table 4-15: Scenario 4 – National-level capacity assumptions (MW)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Wind	0	0	0	14111	7049	771	4842	1765	1056	2379	1557	9100	42630
Solar PV	0	0	0	0	1250	1370	1000	1500	1500	3000	5000	5000	19620

Table 4-16: Scenario 4 – Mpumalanga-level capacity assumptions (MW)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Wind	0	0	0	1600	1800	2000	2000	2000	2000	2000	2000	2400	17800
Solar PV	0	0	0	1000	1500	2500	3500	4000	4000	4000	4000	4000	28500
Solar DPV	0	775	1150	1450	500	500	500	500	500	500	500	500	7375
Biomass/-gas (biopower)	0	0	0	0	75	75	75	75	75	75	75	75	600
Battery storage	0	221	407	2331	0	0	1258	0	0	0	96	957	5 271

[2-3] The results are provided along the value chain for each technology, so that the increase in jobs can be seen for construction, versus the operations and maintenance jobs.

[2-4] For scenarios 3 and 4, the land area requirement was calculated, to determine whether the planned renewable energy capacity could be accommodated on the available land.

[2-5] For Scenario 4, a qualitative analysis was conducted to assess potential job creation from other clean technologies, namely hydrogen and battery storage. These data were obtained via a literature review (PwC, IHS Markit, etc.) together with expert interviews. The approach utilises a job-intensity metric that provides an estimate of job creation potential per unit of output. Only limited employment data were available for South Africa.

Step 3: Determine net jobs created/ lost per scenario

The net jobs per scenario were calculated to assess the actual impact of renewable energy power plants in the Mpumalanga region. The results are reported per annum, to see the real change in the number of jobs supported by related technologies in the regions defined.

4.3 Green economy growth and quantification of local value creation

The purpose of this analysis was to assess the localisation and value-creation potentials offered by a green economy in Mpumalanga through a just energy transition.

Step 1: Description of ongoing initiatives related to green economic growth and green economic clusters

a. Desktop research was conducted to compile a list of planned and ongoing initiatives in Mpumalanga, as well as South Africa more widely, to provide examples that Mpumalanga can follow.

b. Organisations engaged in research in this area were approached, as well as leveraging the knowledge of the steering committee (e.g., GreenCape, NBI, TIPS etc.) in order to obtain a comprehensive list of initiatives.

Step 2: High-level analysis of industrial policies for clean energy throughout the value chains of solar PV, wind, storage, and biomass in Mpumalanga and broader South Africa

c. Desktop research was conducted to compile a list of available industrial policies in Mpumalanga and broader South Africa. See Section 2.

Step 3: Quantification of provincial value creation along the renewable energy value chain in line with the four scenarios

[3-1] Localisation and value-creation potentials were quantified for the major renewable energy technologies outlined in the scenarios. A two-part approach was utilised, as follows:

Part One: Establishing the current value chain and supplier network in Mpumalanga for coal and the major renewable energy technologies as defined in the four scenarios:

a. Mapped out the current value chains for the coal power sector and coal mines in Mpumalanga, detailing what manufacturing and services are currently available. See Section 8.1.

b. Mapped out the current value chains for the major renewable energy technologies, detailing what manufacturing and services are currently available. See Section 8.2.

c. Assessed the business case for manufacturers and service providers to establish their businesses in Mpumalanga, thereby increasing localisation of clean technology production in the province. Highlighted which interventions can lead to an improved local business case.

Part Two: Establishing and assessing the potential level of localisation for major renewable energy technologies as defined in the scenarios in Mpumalanga

d. Established the value added by different technologies under the four scenarios, using the national estimate of local content currently in the I-JEDI model and insights from industry (e.g., SAWEA, GreenCape).

[3-2] The I-JEDI model provides estimates of value added to the regional economy at different levels of localisation across the technology value chains.

[3-3] Gross value added will be compared per annum across different economic sectors and scenarios.

a. Assessed the value that can be added into the province with higher levels of localisation.

b. The I-JEDI model provided estimates of gross value added to the regional economy at higher levels of localisation across the technology value chains.

Assumptions

In cases where data for Mpumalanga are scarce, national-level data were used.

4.4 Quantification and description of skills gaps and gender-inclusive career opportunities

The purpose of this analysis is to examine how current employees could be transferred to the renewable energy sector. As the current energy sector is male-dominated, especially in coal mining, this package also looks at gender-inclusive career opportunities.

To complete the analysis, the following approach was undertaken:

- Baseline assessment of the current energy sector (Eskom and coal mining).
- High-level assessment of skill levels in Mpumalanga, with a focus on gender questions.
- Skill-level requirements for all renewable energy technologies throughout the value chain (i.e., manufacturing, development, construction & installation, operations & maintenance), while also looking into opportunities for women to be involved in the sector; and
- With an understanding of the skills gap and outputs of the employment effects, available training facilities in South Africa will be investigated.

The detailed methodology is described in the following sections.

Baseline assessments

A baseline assessment was performed to understand current educational and skill levels attained in the old energy sector, and whether these skills are transferable to the renewable energy sectors; and, where there are skills gaps, what kinds of training will be required to upskill current energy sector employees. The assessment was conducted for:

- Eskom coal-fired power plants
- Coal mining
- Mpumalanga province

Defining education and skill levels

Individuals with an educational level lower than Grade 7 are categorised as functionally illiterate, defined as: Reading and writing skills that are inadequate for an individual to cope with the demands of everyday life, including the demands posed in the workplace. These types of employees tend to perform low-level work, including cleaners, truck drivers, gardeners, and miners. Employees with primary school level or Adult Basic Education Training (ABET) levels 1 to 3 are also regarded as low-skilled (see Table 4-17).

Employees with a secondary qualification but with no matric tend to perform semi-skilled work such as plant operators. Employees with a matric qualification are regarded as skilled, as they tend to perform entry-level technical work and administrative jobs.

Employees with a post-matric qualification such as National Certificates N4–6 (i.e., technical qualification), or a tertiary degree are regarded as highly skilled. This category includes white- and blue-collar professions including artisans, engineers, and lab technicians.

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Employees with a post-matric qualification such as National Certificates N4–6 (i.e., technical qualification), or a tertiary degree are regarded as highly skilled. This category includes white- and blue-collar professions including artisans, engineers, and lab technicians.

Skill level	Education level	Description of education type
High-skilled graduate	Post-matric	Tertiary education
Skilled	Matric (Grade 12)	Secondary education with matric
Semi-skilled	Grades 8–11	Secondary education
Unskilled	<Grade 7	Primary education

Table 4-17: Description of educational and skill attainment levels in South Africa (adopted for this study)

Occupations among Eskom employees were aggregated according to Table 4-18, to better understand their skill levels. The grouping/categorisation was guided by that applied to coal-mining occupations.

Type of occupation	Job description	Skill level
Professionals	Engineers, Environmental scientists	High-skilled
Managers	Site and shift supervisors; senior and mid-level managers, etc	High-skilled
Technicians and associated professionals	Lab technicians	Skilled to high-skilled
Artisans	Electrician, fitter, plumber, motor mechanic, etc.	Skilled to high-skilled
Clerical support workers	Administrative officers and related	Semi-skilled to skilled
Plant and machine operators and assemblers	Controller operator, driver, crane operator, etc.	Semi-skilled to skilled
Elementary occupations	Cleaner, general worker, etc	Low-skilled
Learners	Eskom, coal mining graduates	Unskilled
Other (contractors)	Unspecified contractors	

Table 4-18: Aggregated occupation types at Eskom and coal mines (adopted for this study)

Eskom and coal mining data sources

The employee data obtained from Eskom for this study refer to three power plants in Mpumalanga: Hendrina, Grootvlei, and Komati. The total number of employees investigated was 2,705, which included permanent staff members. The analysis only included staff members that work at the power plants and excluded employees that work in the distribution areas.

Data on coal-mining employees were provided by the Mining Qualification Authority (MQA). The data set included only those coal mining companies operating in Mpumalanga, which have submitted their employee data to the MQA. The total number of employees investigated was 30,067, which included permanently employed staff members.

The data from Eskom and MQA contained the following information per employee:

- Gender
- Age
- Years of service
- Type and level of qualification; and
- Job description

Mpumalanga skill levels

Mpumalanga province comprises three district municipalities, namely: Gert Sibande, Nkangala, and Ehlanzeni. Educational and skill levels for the province were analysed using District Development Model, 2020. The analysis was based on the population aged 20 years and older.

Skill requirements in renewable energy sector

The types of skills required throughout the value chains of wind, solar PV, and biomass were investigated. A detailed study was conducted by the RES4Africa Foundation, 2020, which looked at careers and qualifications required for wind and solar PV. Skills required for the biomass sector were investigated, including agri-energy jobs resulting from biomass planting.

Policy recommendations and outlook for further research

The development of policy recommendations was oriented towards the following objectives:

- **Policy recommendations: Employment and skills development:** Recommendations should be made on the necessary (re)skilling of workers and on localising certain training facilities in Mpumalanga

- **Policy recommendations: Value creation:** Discussion of industry policies suitable for locating emerging clean energy technologies in Mpumalanga

Outputs from the employment effects and value creation were collated to form a series of recommendations. Several workshops and meetings were conducted with different stakeholders and the projects team, to develop definitive recommendations. Similarly, an additional evaluation was done of the work presented on skills and gender considerations.

These recommendations on skills and gender issues considered current skill levels and types; and establish the potential for implementing re-skilling programmes that build on existing skills while supplementing this with adjacent and additional skills required for the renewable energy sector. Skills that are common to roles in both the coal and renewable energy sectors will therefore be an important foundation on which to base the re-skilling requirements.

The policy assessments from chapter 1 were integrated with this analysis, to provide industrial policy recommendations based on both pull and push approaches.

Specific attention was paid to the provincial policy initiatives necessary to build on national initiatives and to ensure that Mpumalanga's localisation policy is specifically aligned to the imperatives of the just energy transition.

I-JEDI model description

The International Jobs and Economic Development Impacts (I-JEDI) model, developed by NREL and adapted by CSIR, was used to estimate job creation and gross output value per scenario.

To assess the gross employment impacts of increased renewable energy deployment, the CSIR adapted the I-JEDI tool for South Africa. I-JEDI has been used in several CSIR projects, namely, the GIZ Just Transition, other COBENEFTS studies, and the IRP comments, to name a few. The I-JEDI model estimates the economic impact of construction and operation of power plants, by characterising these two phases in terms of domestic and international expenditure. Model data are then used in the country-specific input–output (I–O) model to estimate employment, earnings, gross domestic product (GDP), and gross output impacts (IASS/CSIR/IET, 2019). I-JEDI provides estimates of direct, indirect, and induced jobs, as defined below:

- **Direct jobs** are those directly related to a power plant. For example, workers employed during plant construction or operation.

- **Indirect jobs** are associated with activities related to the power plant. Examples include the manufacturing of power plant components, or construction-related activities such as cement manufacturing or transport of components to construction sites.

- **Induced jobs** are those that arise from economic activity in an area, but which are not directly related to the renewable energy industry. For example, renewable energy technicians may spend part of their wages on buying property, thus inducing jobs in the real estate sector; Similarly, if workers were injured during the construction of a renewable energy project, then the medical staff providing patient care services would be considered as induced jobs.

The model also allows assessment of job impacts arising from differing levels of local content and provides outputs for different parts of the value chain. Currently, the technologies covered in the I-JEDI model for South Africa are solar PV (utility and distributed power), onshore wind, biopower, coal, and natural gas. Figure 4-1 shows a sample output from the I-JEDI model.

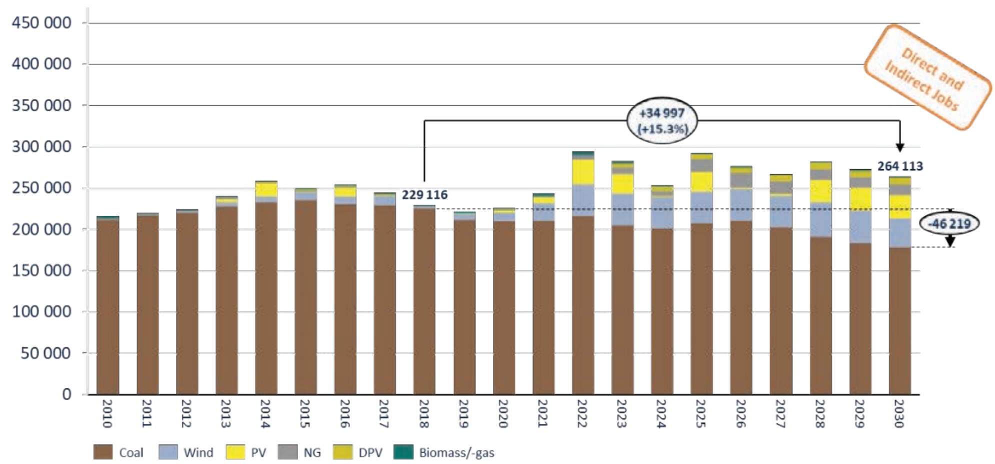

Figure 4-1: Predicted annual employment opportunities (IRP2019 scenario, 2019)

The technologies covered in the I-JEDI modelling under this assessment include:

- Coal
- Wind
- Solar PV and distributed solar PV
- Biopower (used for biomass)

The assumptions required for the modelling are (detailed numbers are provided in Section 3):

- Capacity (MW)
- Local content
- Exchange rate
- Rate of construction (per technology)

To model potential job losses and creation, the decommissioning capacity per scenario per year was required, as well as the capacity per annum for each technology. Further, the employment numbers relating to the power stations were tested with Eskom to ensure alignment of the results. For mining-related employment, the calculations were discussed with a former mining industry expert and compared to data from the I-JEDI model.

4.5 Analysis and quantification of value creation

To quantify the output value gains offered by deployment of the renewable energy technologies covered, the I-JEDI model employed the same assumptions as the employment analysis. The model provides a measure of gross output from each scenario modelled. Keyser et al. (2016, p. 13) define gross output as: "a measure of total economic activity. It includes payments that industries and businesses make to one another for inputs used in production. Such inputs could include raw materials, services, or anything a business purchases to produce its products or services. Gross output also includes value added".

Table 4-19: Sectors covered under I-JEDI

Industry	SIC equivalent
Agriculture	SIC 1 – Agriculture, forestry, and fishing
Mining and extraction	SIC 2 – Mining and quarrying
Utilities	SIC 4 – Electricity, gas, and water
Construction	SIC 5 – Construction
Manufacturing	SIC 3 – Manufacturing
Sales	SIC 6 – Wholesale and retail trade, catering, and accommodation
Transportation and warehousing	SIC 7 – Transport, storage, and communication
Information	SIC 7 – Transport, storage, and communication
Finance, professional, and business services	SIC 8 – Finance, insurance, real estate, and business services
Education and health care	SIC 92 – Community, social, and personal services
Other	

The energy transition in Mpumalanga is also a chance to employ more women, who are currently underrepresented in the power sector. © Shutterstock/AS photostudio

5. Input data and assumptions on local content

5.1 Local content assumptions for wind energy

Table 5-1 depicts the moderate local content assumptions over the study period, guided by inputs from SAWEA and the study authors' own calculations. The moderate local content level reflects current national-level forecasts.

Part of value chain	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Turbine (generator, gearbox, nacelle)	30%	30%	30%	30%	33%	42%	55%	60%	60%	65%	65%	65%
Blades	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Tower	60%	60%	60%	60%	66%	66%	70%	80%	80%	80%	80%	80%
Logistics	50%	50%	50%	50%	50%	60%	60%	60%	60%	60%	60%	60%
Construction												
Electrical balance of plant	85%	85%	85%	85%	85%	90%	92%	93%	93%	93%	93%	93%
Construction (excluding site improvements)	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Other												
Engineering and other professional services	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Site improvement (e.g., road construction)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Operations												
Plant operations (staff, equipment such as trucks)	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Spares	20%	20%	20%	20%	20%	20%	20%	20%	35%	35%	35%	35%
Civil works (access road maintenance, etc.)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%

Table 5-1: Wind moderate local content assumptions (source: SAWEA 2021; own calculations)

Table 5-2 depicts the high local content assumptions, guided by inputs from SAWEA. To obtain the higher local content, the rate of change per annum was increased by 5% as compared to moderate LC.

Part of value chain	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Turbine (generator, gearbox, nacelle)	30%	30%	30%	30%	33%	45%	58%	72%	76%	76%	76%	76%
Blades	0%	0%	0%	0%	0%	0%	5%	5%	5%	5%	5%	5%
Tower	60%	60%	60%	60%	66%	70%	75%	85%	86%	86%	86%	86%
Logistics	50%	50%	50%	50%	50%	60%	60%	60%	60%	65%	65%	65%
Construction												
Electrical balance of plant	85%	85%	85%	85%	85%	94%	98%	98%	98%	98%	98%	98%
Construction (excluding site improvements)	80%	80%	80%	80%	80%	90%	90%	90%	90%	90%	90%	90%
Other												
Engineering and other professional services	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Site improvement (e.g., road construction)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Operations												
Plant operations (staff, equipment such as trucks)	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%	75%
Spares	20%	20%	20%	20%	20%	20%	20%	20%	35%	35%	35%	35%
Civil works (access road maintenance, etc.)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%

Table 5-2: Wind high local content assumptions (source: SAWEA 2021; own calculations)

5.2 Local content assumptions for Solar PV

Table 5-3 shows the moderate (national) local content level for solar PV. The requirements for dtic are used, as well as I-JEDI assumptions.

Part of value chain	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Equipment												
Module	24%	24%	24%	24%	28%	28%	28%	28%	38%	38%	38%	38%
Inverter	40%	40%	40%	40%	58%	58%	58%	58%	77%	77%	77%	77%
Installation												
Construction and installation costs	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Other												
Design and civil engineering	75%	75%	75%	75%	85%	85%	85%	85%	90%	90%	90%	90%
Other (public relations, legal, environmental studies)	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Infrastructure: electricity and other	90%	90%	90%	90%	95%	95%	95%	95%	95%	95%	95%	95%
Logistics	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Operations												
O&M services	70%	70%	70%	70%	90%	90%	90%	90%	90%	90%	90%	90%
Spares	15%	15%	15%	15%	30%	30%	30%	30%	40%	40%	40%	40%

Table 5-3: Solar PV moderate local content assumptions (source: dtic, 2021; I-JEDI & own calculations, 2021)

Table 5-4 depicts the high local content assumptions, guided by inputs from dtic. To obtain the higher local content level, the rate of change per annum was increased by 5% as compared to moderate LC.

Part of value chain	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Equipment												
Module	24%	25%	25%	25%	31%	31%	31%	31%	43%	43%	43%	43%
Inverter	40%	42%	42%	42%	63%	63%	63%	63%	87%	87%	87%	87%
Installation												
Construction and installation costs	90%	95%	95%	95%	99%	99%	99%	99%	100%	100%	100%	100%
Other												
Design and civil engineering	75%	79%	79%	79%	93%	93%	93%	93%	100%	100%	100%	100%
Other (public relations, legal, environmental studies)	80%	84%	84%	84%	88%	88%	88%	88%	93%	93%	93%	93%
Infrastructure: electricity and other	90%	95%	95%	95%	100%	100%	100%	100%	100%	100%	100%	100%
Logistics	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Operations												
Maintenance and repair services	70%	74%	74%	74%	98%	98%	98%	98%	100%	100%	100%	100%
Spares	15%	16%	16%	16%	32%	32%	32%	32%	45%	45%	45%	45%

Table 5-4: Solar PV high local content assumptions (source: dtic, 2021; I-JEDI & own calculations, 2021)

5.3 Local content assumptions for Solar DPV (distributed solar PV)

Table 5-5 shows the moderate (national) local content level for solar DPV. The requirements for dtic are used, as well as I-JEDI assumptions.

Table 5-5: Solar DPV moderate local content assumptions (source: dtic, 2021; I-JEDI & own calculations, 2021)

Part of value chain	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Equipment												
Module	24%	24%	24%	24%	28%	28%	28%	28%	38%	38%	38%	38%
Inverter	80%	80%	80%	80%	85%	85%	85%	85%	85%	85%	85%	85%
Installation												
Construction and installation costs	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Other												
Design and civil engineering	75%	75%	75%	75%	85%	85%	85%	85%	90%	90%	90%	90%
Other (public relations, legal, environmental studies)	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Infrastructure: electricity and other	90%	90%	90%	90%	95%	95%	95%	95%	95%	95%	95%	95%
Logistics	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Operations												
Maintenance and repair services	70%	70%	70%	70%	90%	90%	90%	90%	90%	90%	90%	90%
Spares	15%	15%	15%	15%	30%	30%	30%	30%	40%	40%	40%	40%

Table 5-6 depicts the high local content assumptions, guided by inputs from dtic. To obtain the higher local content, the rate of change per annum was increased by 5% as compared to moderate LC.

Table 5-6: Solar DPV high local content assumptions (source: dtic, 2021; I-JEDI & own calculations, 2021)

Part of value chain	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Equipment												
Module	24%	24%	24%	24%	29%	29%	29%	29%	41%	41%	41%	41%
Inverter	80%	82%	82%	82%	89%	89%	89%	89%	91%	91%	91%	91%
Installation												
Construction and installation costs	90%	92%	92%	92%	95%	95%	95%	95%	100%	100%	100%	100%
Other												
Design and civil engineering	75%	77%	77%	77%	89%	89%	89%	89%	100%	100%	100%	100%
Other (public relations, legal, environmental studies)	80%	82%	82%	82%	84%	84%	84%	84%	86%	86%	86%	86%
Infrastructure: electricity and other	90%	92%	92%	92%	100%	100%	100%	100%	100%	100%	100%	100%
Logistics	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Operations												
O&M services	70%	72%	72%	72%	94%	94%	94%	94%	100%	100%	100%	100%
Spares	15%	15%	15%	15%	31%	31%	31%	31%	42%	42%	42%	42%

5.4 Local content assumptions for biopower

Table 5-7 shows the moderate (national) local content level for biopower (biomass/gas). I-JEDI assumptions are used.

Table 5-7: Biopower moderate local content assumptions (source: I-JEDI & own calculations, 2021)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Equipment												
Feedstock handling equipment	10%	10%	10%	10%	20%	20%	20%	20%	30%	30%	30%	30%
Turbines, boilers, and air quality control equipment	10%	10%	10%	10%	20%	20%	20%	20%	30%	30%	30%	30%
Other equipment	0%	0%	0%	0%	10%	10%	10%	10%	20%	20%	20%	20%
General construction												
Construction	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Contractors and balance of plant												
Balance of plant	20%	20%	20%	20%	30%	30%	30%	30%	40%	40%	40%	40%
Professional services (legal, engineering, development, public relations etc.)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Operations												
Feedstock												
Annual feedstock transportation cost	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Operations												
Plant operators, including maintenance	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Materials												
Chemicals (including ammonia)	50%	50%	50%	50%	60%	60%	60%	60%	70%	70%	70%	70%
Water	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Solids/ash disposal	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 5-8 depicts the high local content assumptions for biopower. To obtain the higher local content, the rate of change per annum was increased by 5% as compared to moderate LC.

Table 5-8: Biopower high local content assumptions (source: I-JEDI & own calculations, 2021)

	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Equipment												
Feedstock handling equipment	10%	10%	10%	10%	25%	25%	25%	25%	40%	40%	40%	40%
Turbines, boilers, and air quality control equipment	10%	10%	10%	10%	25%	25%	25%	25%	40%	40%	40%	40%
Other equipment	0%	0%	0%	0%	15%	15%	15%	15%	30%	30%	30%	30%
General construction												
Construction	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Contractors and balance of plant												
Balance of plant	20%	20%	20%	20%	35%	35%	35%	35%	50%	50%	50%	50%
Professional services (legal, engineering, development, public relations etc.)	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Operations and maintenance (O&M)												
Feedstock												
Annual feedstock transportation cost	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Operations												
Plant operators, including maintenance	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Materials												
Chemicals (including ammonia)	50%	50%	50%	50%	65%	65%	65%	65%	80%	80%	80%	80%
Water	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Solids/ash disposal	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

6. Clean energy potential in Mpumalanga and South Africa

6.1 Wind and solar PV potential

Strategic environmental assessment (SEA)

The Strategic Environmental Assessment (SEA) for Wind and Solar PV in South Africa, conducted by CSIR on behalf of the Department of Environment Forestry and Fisheries, indicates that there is promising resource potential for both solar and wind in Mpumalanga province, but with some environmental constraints. Following phase two of the assessment it was decided that one of the Renewable Energy Development Zones (REDZ) would be developed in Emalahleni, with a focus on developing solar PV. Although wind was not selected to be explored, the SEA does show that there is good resource potential in some parts of the province. Figure 6-1 shows the results of Phase 2 of that assessment.

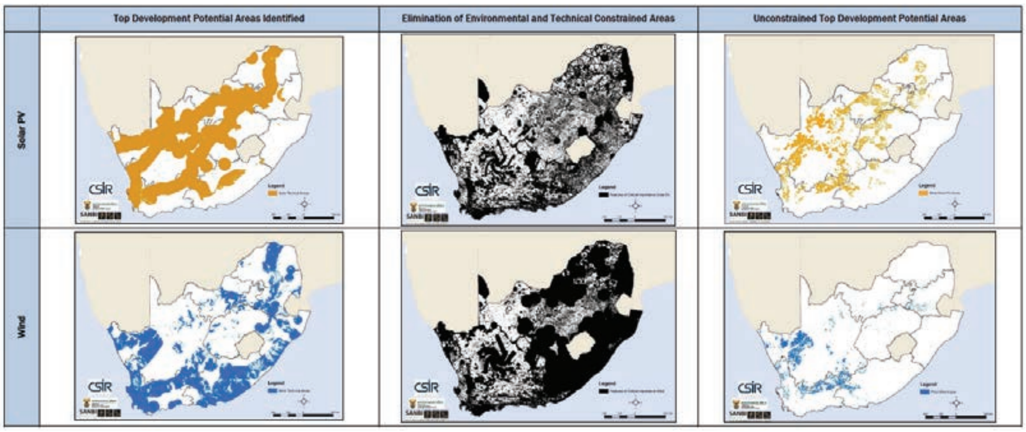

Figure 6-1: Strategic environmental assessment for wind and solar PV Phase 2 (source: DEFF, 2019)

Renewable Energy Development Zone (DEFF, 2019)

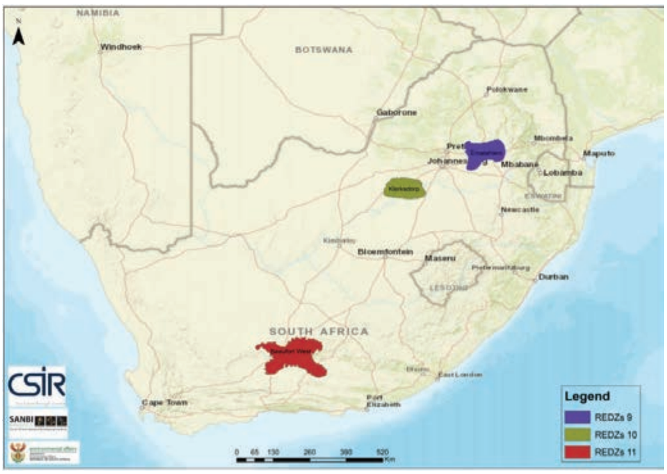

Figure 6-2: Additional Renewable Energy Development Zones (REDZs)

NREL & CSIR wind and solar PV assessment (NREL/CSIR, 2017)

In addition, a short study conducted by CSIR and NREL on solar PV and wind resources in South Africa showed that some areas of the province have good resources. The study also estimated the costs associated with different levels of resource potential, and although Mpumalanga will require a premium over other parts of the country that have more resources, its transmission capacity availability and its role as the centre of the Just Transition could justify the payment of the premium to ensure that the impact of the decline in the coal economy is lessened.

Furthermore, the latest Transmission Development Plan from Eskom indicates that the wind profile for the Mpumalanga region is counter to the demand profile of the country i.e., the higher wind capacity factors are experienced during off-peak demand. This may be deemed negative; however, if the supply to the region shifts mostly to industrial processes that will require power throughout the day and night, the deviated load profile can complement and balance other capacity factors.

South Africa Wind and Solar Energy Potential: Geospatial analysis using NREL's Renewable Energy Potential (reV) model. Figure 6-3 shows the wind resource potential identified in the study.

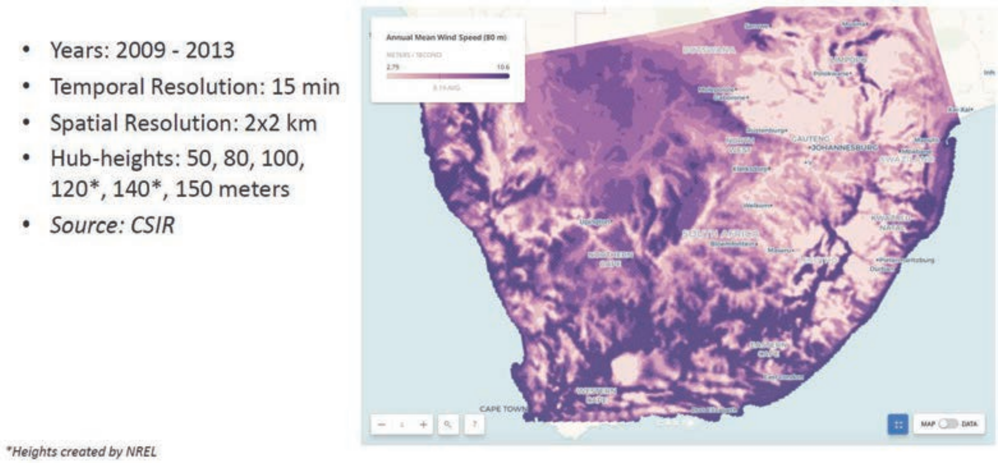

Figure 6-3: Wind resource potential (source: NREL/CSIR, 2017)

Figure 6-4 depicts the optimal turbine class, with the most promising wind class (class 1) shown in purple.

Figure 6-4: Optimal turbine class (NREL/CSIR, 2017)

Figure 6-5 depicts the resulting turbine multi-year mean capacity factor and the related levelised cost of energy (LCOE). As can be seen, the lower classes with better wind resource have lower LCOEs, and vice versa.

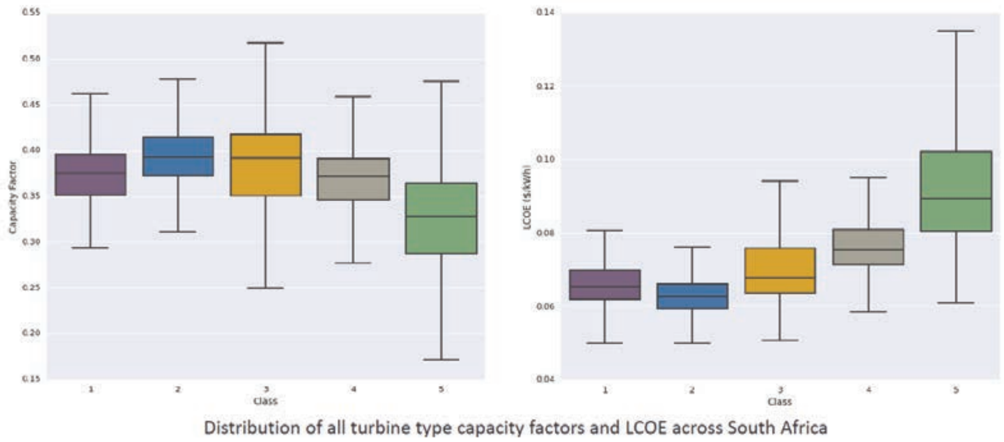

Figure 6-5: Turbine multi-year mean capacity factor and LCOE (NREL/CSIR, 2017)

6.2 Potential for distributed generation

To assess the potential for distributed solar PV (DPV) power generation, a high-level assessment was conducted. Mpumalanga has 48% urban households, which represents 5% of total urban households in South Africa (Quantec, 2021). In addition, as the commercial and industrial markets account for approximately 70% (GreenCape, 2021) of the total distributed generation market, an assessment was conducted of the gross value added (GVA) by Mpumalanga sectors, wherein the overall weighted average for GVA for Mpumalanga was 11% of the SA total, with the share of mining GVA from Mpumalanga province being 22% of the SA total.

Based on this, the share of new capacity for distributed generation in Mpumalanga is estimated at 15% for this analysis. In Scenario 1, IRP 2019 has provided for 500 MW p.a. to DG[17], cogeneration, biomass, and landfill technologies from 2023. In the meantime, capacity that has been allotted is needed to fill the supply gap; this information was extracted from the work by Meridian and CSIR (Wright & Calitz, 2020).

6.3 Potential for biomass

Mpumalanga has a high level of biomass availability, and biomass is part of the industrialisation strategy for the province. The Mpumalanga Industrialisation Development Plan 2015 (Mpumalanga DEDT, 2015) includes a Biomass Energy Conversion Project that incorporates power generation from biomass sources. Furthermore, the province's participation in the REIPPPP was primarily in biomass. Sappi was awarded a 25 MW project, and according to the Mpumalanga provincial government other interested parties are looking to establish biomass generation facilities. According to their Green Economy Roundtable, the province can develop approximately 100 MW of wood/co-gen power plants from sawn timber. However, the province's biomass potential has not been fully quantified (Mpumalanga DEDT, 2015).

As seen in Figure 6-6, the most promising biomass resources are concentrated in four provinces – namely Kwa-Zulu Natal, Mpumalanga, Eastern Cape, and Free State. Mpumalanga has large amounts of sugarcane

[17] Following finalisation of the study, Schedule 2 under the Electricity Regulation Act (of 2006) was amended in August 2021 such that projects up to 100MW were exempt from licensing (but have to register instead). This effectively opens up the market to private projects in addition to this provision.

bagasse and sawmill waste. It is also hoped that the development of biomass technologies will create jobs and provide opportunities for small businesses, especially modern uses such as converting modern fuels and biogas, which could link to the green hydrogen economy (Mpumalanga DEDT, 2015).

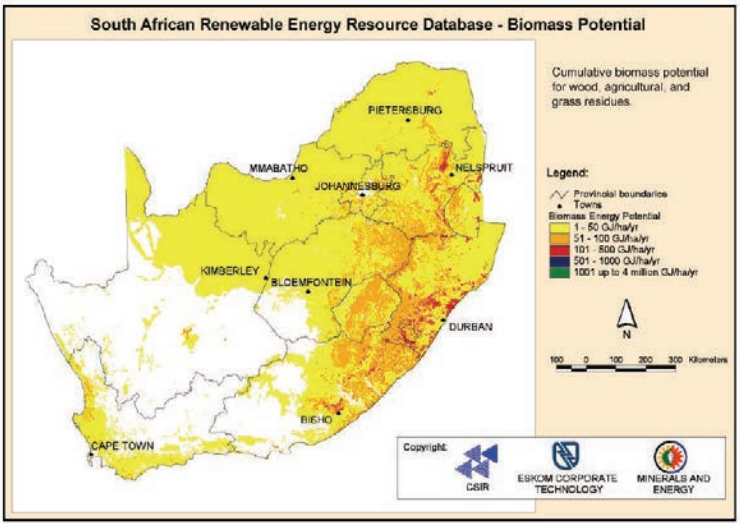

Figure 6-6: South African biomass potential (Mpumalanga DEDT, 2015)

6.4 Potential for battery storage

Battery storage technology provides another employment opportunity for Mpumalanga. The continued development of vanadium redox flow battery (VFRB) technology means that the province can take advantage of vanadium deposits in the Emalahleni district municipality, which is set to be the most impacted by the decline of the coal economy. Figure 6-7 is a map of Bushveld Minerals' high-grade vanadium resources in South Africa.

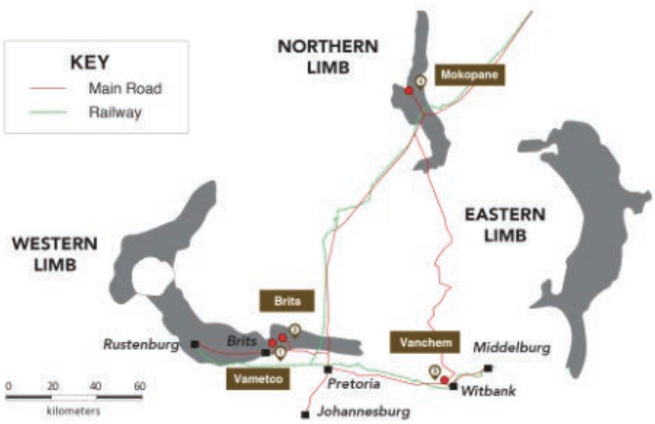

Figure 6-7: Map of Bushveld Minerals' vanadium resources (source: Bushveld Minerals)[18]

[18] https://www.bushveldminerals.com/bushveld-vanadium-2/

A utility-scale combination of lithium-ion and VRFB (vanadium redox flow battery) is considered for battery storage to support fast-reaction grid stability services. A study by the International Development Corporation (IDC) and the United States Trade & Development Agency (Parsons, 2019) identified these two technologies as having the most significant and long-term growth potential for utility-scale storage in South Africa, compared with other types. Lithium-ion is an established battery technology that is already used in many applications, whereas *VRFBs are an emerging technology that is well-suited to long-duration storage applications such as bulk grid renewable integration relative to Li-ion batteries. Furthermore, VRFBs have a lower variable cost and longer economic life; however, they have slower response time and comparatively high capital cost/lower efficiency* (Parsons, 2019). VRFBs are a stable technology that can consistently deliver value, as the battery cells can operate for decades with zero degradation, and employ safe, fault-tolerant technology with minimal fire risk. Table 6-1 shows the results of a study by Parsons et al. on the potential of different storage technologies in South Africa.

Eskom is also piloting a battery storage programme, and *in October 2018 committed to distributed energy storage, with a battery storage development programme for up to 360 MW/1440 MWh of solar-plus-storage and energy storage projects starting in mid-2019* (Parsons, 2019). *If the technologies and projects prove successful, there is potential to scale up the capacity of similar energy storage technologies to facilitate future wind and solar integration in South Africa* (Parsons, 2019). Eskom has included battery storage as part of its plans for a just energy transition, proposing 61 MW/244 MWh of battery storage for Komati. Furthermore, the World Bank, through the International Finance Corporation (IFC) and Clean Technology Funds (CTF), has committed USD 30 million to a Renewable Energy Grid Integration Program that seeks to kick-start and finance energy storage and renewable energy in South Africa (World Bank, 2021a). The programme will complement the existing World Bank and AfDB-funded distributed battery storage (BSP) programme for Eskom, which uses approximately USD 250 million of CTF funding. The BSP seeks to install batteries at some existing Eskom substations close to locations where wind and solar PV feed into the Eskom grid (World Bank 2021a). Considering all the activity in developing battery storage capacity for South Africa, it was identified as a key component in enabling the just energy transition in Mpumalanga, and a potential source of employment.

Technology	Maturity	Risks/Barriers	Disadvantages	Advantages	Best Applications **	Future potential for SA utility-scale energy storage
Lead-Acid Battery	mature	environmental consideration	• low cycle life and DoD • Deteriorates with microcycles • limited lifetime	• Very mature technology • Low capital cost	**CEMS**	none
Advanced Lead Acid Battery	mature	environmental consideration	Low cycle life and limited DoD	• Better performance than lead-acid • Capital cost relatively low	**AS, GIS, CEMS**	Moderate-, near-, to mid-term
Nickel-Cadmium Battery	mature	environmental - toxic cadmium	• Low cycle life • Exhibits memory effect • low energy-to-weight • Relatively expensive	• Few maintenance requirements • Can operate in low temperatures	CEMS	none
Lithium Ion Battery (chemistry dependent)	commercial	• Safety - thermal runaway • More expensive than Lead-Acid	• limited but improving cycle life • Deep discharge cycles lower lifetime • Requires monitoring / BMS	• high round trip efficiency • high energy-to-weight ratio • continuing performance improvements • continuing manufacturing cost reductions	**BES, AS,** GIS, **CEMS**	Significant near- to long-term
Sodium Sulfur Battery	mature	• Safety - containment issues • Competition from other technologies	• limited cycle life • requires external heat system • high temperature system • large daily self-discharge	• high power and energy density • Longer discharge times than Li-ion	**BES, AS, GIS**, CEMS	Moderate near-term
Sodium Nickel Chloride	commercial	Competition from other technologies	Large daily self-discharge	Able to operate in relatively harsh climates	CEMS	limited
Vanadium Redox Flow	demo	• Not proven at utility scale • Rx stack membrane degradation	• lower round trip efficiency • low energy density • requires mechanical systems • high cost of Vanadium	• Power and energy scale independently • Mature for a flow technology • Vanadium is a SA resource • high cycle life, full DoD	**BES, AS, GIS, CEMS**	Significant now & long term
Iron-Chromium Flow	demo	• Not proven at utility scale • Toxicity of Chromium • Less mature than other flow batteries	• lower round trip efficiency • low energy density • requires mechanical systems	• Power and energy scale independently • small daily self-discharge • high cycle life, full DoD	**BES, AS, GIS, CEMS**	Moderate mid- to possibly long-term

Table 6-1: Battery storage technology and potential for SA market (Source: Parsons, 2019)

6.5 Potential for hydrogen

Global production of hydrogen is currently between 50 and 70 MTPA per annum, of which about half is used for ammonia production. Green hydrogen can be used to decarbonise several applications, e.g., in refining processes; steel production; and powerfuels, methanol, and ammonia production. Currently, South Africa consumes 2+ MtPA of mainly coal-sourced 'grey' hydrogen for synthetic fuels (synfuels), steel production, and oil/petrochemical refining (IHS Markit, 2021). Figure 6-8 illustrates the various types of hydrogen and their applications, which shows just how important hydrogen can be to decarbonising several sectors. South Africa can take advantage of the hydrogen economy due to its technical capabilities around Fischer–Tropsch technologies, abundant platinum reserves (80% of global resources), and abundant solar, wind, and biomass resources.

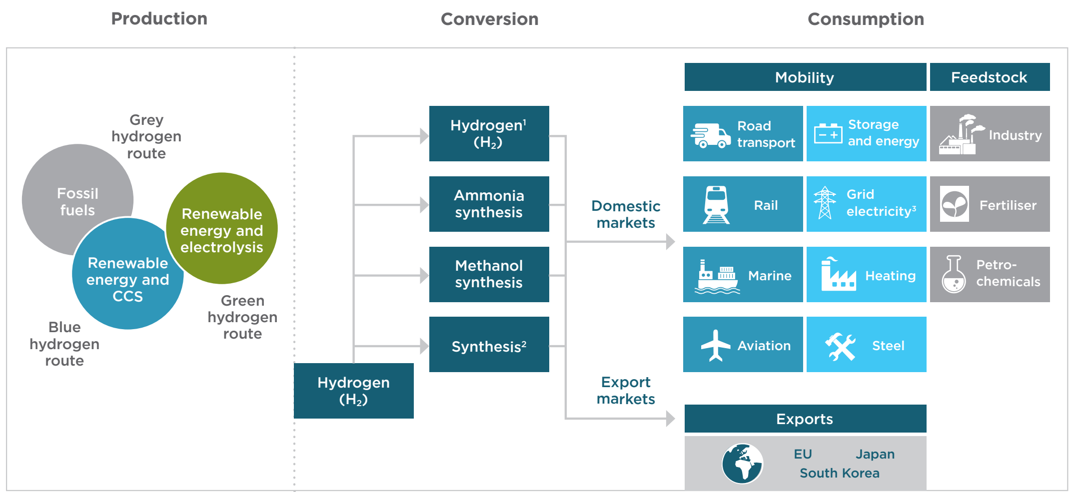

Figure 6-8: Hydrogen pathways and applications (source: Sasol; McKinsey Energy Insights, 2021)

In June 2021, IHS Markit published the Super H2gh Road Scenario for green hydrogen production in South Africa, which includes ambitious targets for decarbonisation (see Figure 6-9).

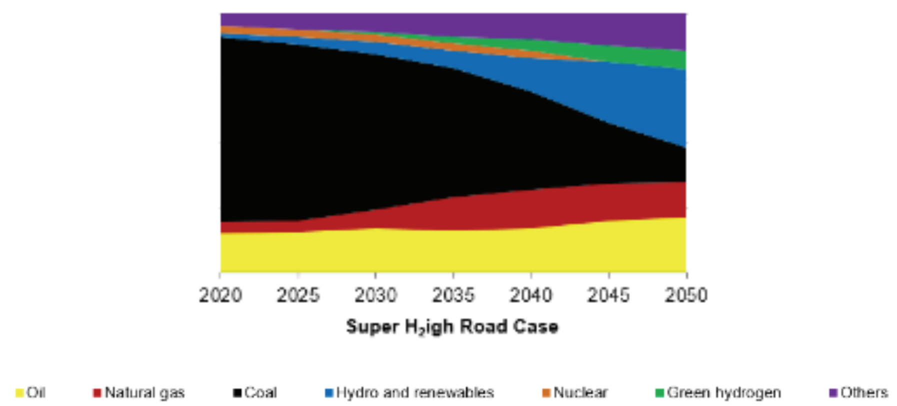

Figure 6-9: Primary energy consumption mix in the Super H2igh Road Scenario (source: IHS Markit,

Under the Super H₂gh Road Scenario proposed by IHS Markit, green hydrogen-related projects would require an additional 6 GW of solar and wind capacity to be added to the grid; see Figure 6-10.

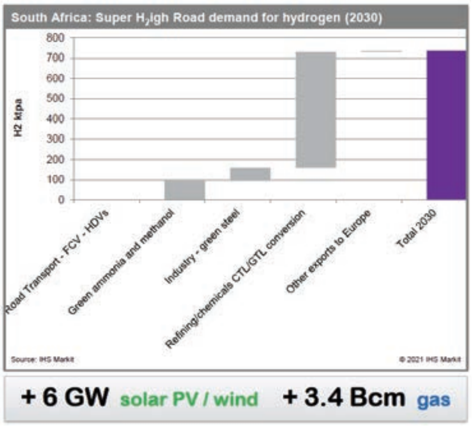

Figure 6-10: Super H_2igh Road Scenario demand for green hydrogen in South AfricaRoad Scenario (IHS Markit, 2021)

The IHS Markit study highlights the types of projects that could be pursued in the hydrogen economy, including an analysis of proposals to convert Saldanha Steel's dormant DRI (direct reduction of iron) plant to use green hydrogen produced from electrolysis using renewable energy sources, and a renewably-powered electric arc furnace. The economic case for the retrofit is illustrated in Figure 6-11 (IHS Markit, 2021). This case is particularly interesting for Mpumalanga, given that—with adequate investment—the dormant Highveld Steel plant could potentially be restarted if reconfigured to use green hydrogen similarly to the Saldanha Steel DRI plant. The motivation for restarting the plant would be to manufacture steel for components used in the renewable energy value chain and to establish another use for hydrogen in Mpumalanga.

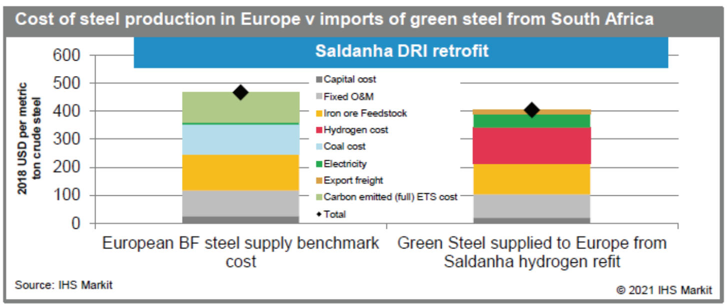

Figure 6-11: Cost of steel production in Europe vs. imports of green steel from South Africa (IHS Markit, 2021)

6.6 Mpumalanga value proposition for establishing renewable energy value chains

Proximity to load centres

Due to the development of the minerals complex in and around Mpumalanga, which resulted in the establishment of Eskom's coal-fired power stations, the province has access to the main load centres in South Africa, and this is set to continue. Eskom's latest TDP indicates that over the next 10 years load will be concentrated in Mpumalanga, primarily in Gauteng, and shows how this will grow over the period under review.

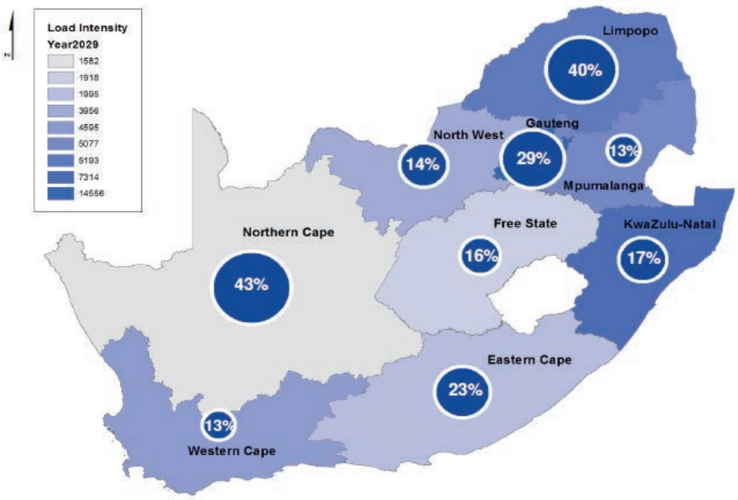

Figure 6-12: Key growth areas for TDP period (2020–2029) (source: Eskom, 2020)

Transmission network availability

Currently in South Africa the REIPPPP is undergoing its 5th round; historically, developers looked to develop projects in the most attractive regions for solar PV (primarily Northern Cape) and wind (primarily Eastern and Western Cape). However, the transmission transfer capacity in these areas is constrained, exacerbated by delays in new projects that were meant to extend and strengthen the transmission network in and to these areas where projects were being constructed. A recent assessment of interest for project development connection versus substation capacity showed that Mpumalanga had the highest available transmission capacity but attracted the least interest from developers (see Figure 6-13). Either significant additional investment will be necessary to increase transmission capacity in areas with a deficit, or else developers could just construct projects where capacity is already available. This makes a compelling case for the development of renewable energy in the Mpumalanga region.

Consequently, careful consideration should be given to less attractive parts of the country that may have less rich solar PV resources (such as Mpumalanga), since their greater available transmission capacity may justify the cost of extending the transmission network to support investment in renewable energy assets in these regions. In the case of Mpumalanga, the planned decommissioning of coal-fired stations will release additional transmission capacity on the regional grid, thereby favouring such proposals.

Generation Connection Capacity

Assessment 2023, Phase 2 (Supporting data for Chapter 2.2 of Executive Report)

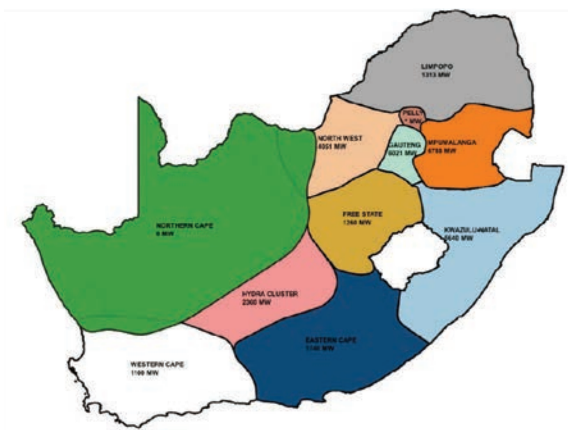

Figure 6-13: Spatial considerations for renewable capacity rollout (source: Satimburwa et al., 2021)

7. Quantification of employment effects in Mpumalanga

7.1 Battery storage: employment calculation

Battery storage: assumptions for job calculations

Mpumalanga capacity	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Scenario 1	0	33	61	202	0	0	0	0	0	0	239	0	535
Scenario 2	0	33	61	350	0	0	189	0	0	0	14	144	791
Scenario 3	0	33	61	125	32	0	0	0	0	119	119	163	652
Scenario 4	0	33	61	117	117	117	63	63	63	119	119	144	1015

Table 7-1: Battery storage capacity in Mpumalanga, (Source: own calculation, based on Wright & Calitz, 2020

2016	2021	2025
403.1	50.9	32.5

Table 7-2: Rate of decline in jobs/MW over 10 years for battery storage in the US (Source: Navigant Research (Parsons 2019)

Rate of change (2016–2021)	Rate of change (2021–2025)
-87%	-36%
-34%	-11%

Table 7-3: Rate of change in decline based on jobs/MW (Source: own calculations, based on Navigant Research (see Parsons, 2019))

2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
200	132.2	87.4	57.8	38.2	25.3	22.6	20.2	18.0	16.1	14.4

Table 7-4: Calculation of jobs per MW per annum based on rate of change

Mpumalanga	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Scenario 1		6 630	8 072	17 634	-	-	-	-	-	-	3 842	-	36 178
Scenario 2		6 630	8 072	30 565	-	-	4 766	-	-	-	233	2 066	52 332
Scenario 3		6 630	8 072	10 948	1 839	-	-	-	-	2 149	1 921	2 341	33 899
Scenario 4		6 630	8 072	10 187	6 735	4 452	1 591	1 422	1 271	2 149	1 921	2 066	46 495

Table 7-5: Results based on using annual rate of decline

Mpumalanga	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Scenario 1	-	6 696	12 332	40 754	-	-	-	-	-	-	48 177	-	-
Scenario 2	-	6 696	12 332	70 638	-	-	38 125	-	-	-	2 917	28 990	-
Scenario 3	-	6 696	12 332	25 301	6 428	-	-	-	-	24 089	24 089	32 852	-
Scenario 4	-	6 696	12 332	23 543	23 543	23 543	12 726	12 726	12 726	24 089	24 089	28 990	-

Table 7-6: Jobs per MW for US (Source: Parsons, 2019)

Jobs/MW = 202

Mpumalanga	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
Scenario 1	-	332	611	2 018	-	-	-	-	-	-	2 385	-	-
Scenario 2	-	332	611	3 497	-	-	1 887	-	-	-	144	1 435	-
Scenario 3	-	332	611	1 253	318	-	-	-	-	1 193	1 193	1 626	-
Scenario 4	-	332	611	1 166	1 166	1 166	630	630	630	1 193	1 193	1 435	-

Table 7-7:
Jobs per MW for US (
Source: based on research by California Energy Storage Alliance)

Jobs/MW = 10

The CESA estimates were not incorporated in the present study, as they were beyond the ranges presented in the other studies.

Net employment quantification of jobs per annum

The CESA estimates were not incorporated in the present study, as they were beyond the ranges presented in the other studies.

Moderate LC

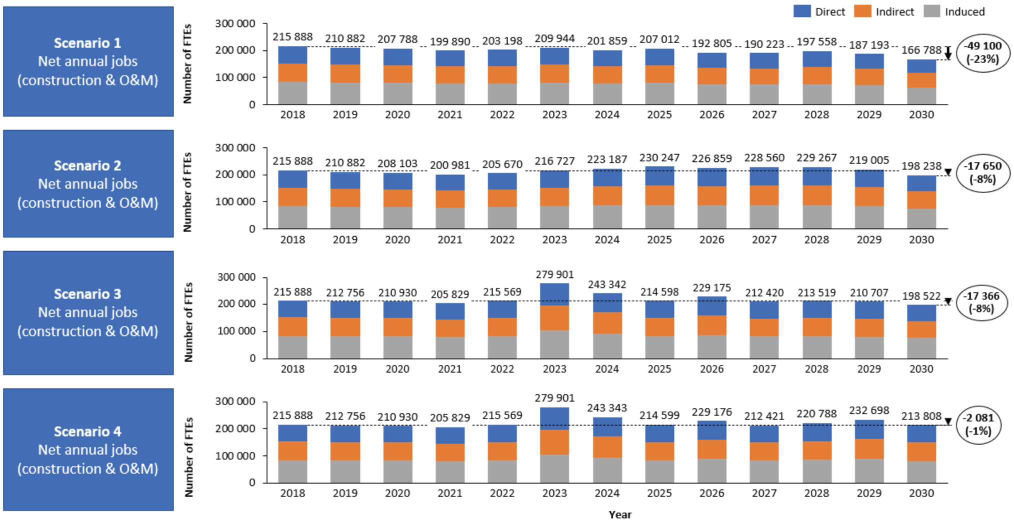

Figure 7-1: Net jobs for Mpumalanga for moderate LC (source: own calculations based on I-JEDI)

High LC

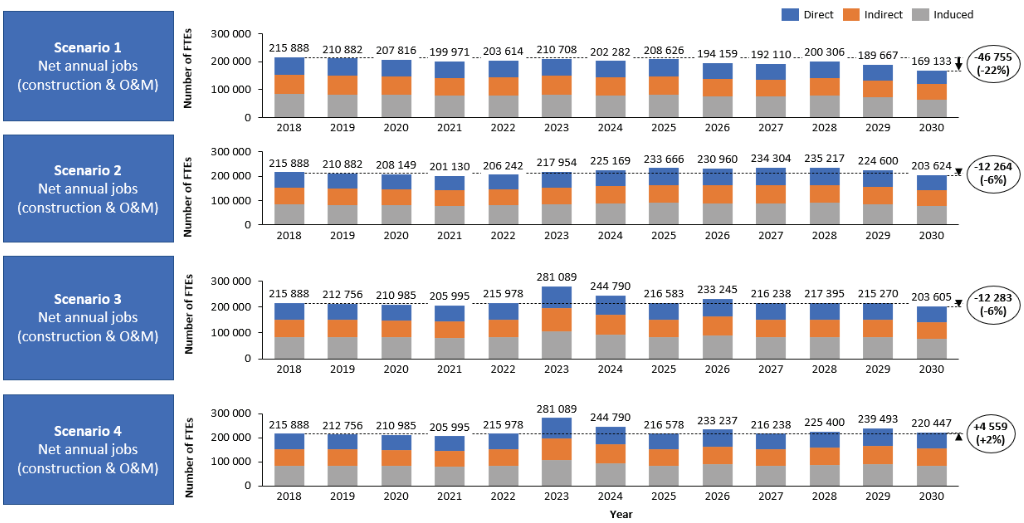

Figure 7-2: Net jobs for Mpumalanga for high LC (source: own calculations based on I-JEDI)

8. Quantification of localisation and value creation in Mpumalanga

This section describes the value chains involved in both renewable and coal-based power generation. This assessment reveals similarities in the value chain, wherein existing players in the coal value chain can transfer or amend some of their services to clean technology value chains.

8.1 Coal-to-electricity value chains in Mpumalanga

The coal value chain includes exploration, beneficiation, and transportation to the coal power plant for electricity generation purposes. Table 8-1 summarises these various stages of the value chain together with potential services and products as well as current suppliers.

Table 8-1: Coal-to-electricity value chain (different sources)

	Mining/coal extraction	Beneficiation	Manufacturing	Transportation	Construction and installation
Description	This involves the mining of coal. The extraction process may take place on the surface or underground.	The beneficiation process involves cleaning and processing extracted coal to remove rocks, dirt, ash, and other undesirable materials.	This stage of the value chain involves producing equipment used in the construction and installation phase.	This stage involves the transportation of coal from the mining unit to the beneficiation unit and power plant.	This stage involves the burning of coal to produce electricity.
Services/products	• Underground loaders • Shovels • Hydraulic machines • Roof bolters • Tunnel-boring machines • Rotary blast-hole drill rigs • Bucket-wheel excavators • Bulldozers • Underground coal-haulers • Draglines (crawler and walking types) • Trucks • Rear-dump trucks	• Crushers • Conveyer belts • Hammer samplers • Sizing screens • Over-belt magnets (to remove tramp metal) • Dense-media separators (DMS) or Dense-media cyclone, floats drain-or-rinse screen (dewatering) • Centrifuges (used to separate solids /liquids) • Desliming screening (removes any ultra-fine coal particles) • Pumps • Classification cyclones (hydro- and flotation types)	• Steam turbines • Boilers • Burners and generators	• Trains • Trucks • Conveyor belts and barges • Slurry transportation and ships (boats)	• Steam turbines • Boilers • Burners and generators • Electric Balance of Plant (BoP); Mechanical BoP; Engineering, construction, & procurement (EPC)

	Mining/coal extraction	Beneficiation	Manufacturing	Transportation	Construction and installation
Suppliers in Mpumalanga (not exhaustive)	FLSmidth	• Weir Minerals Africa • Mpumamanzi Group • Public Bonds and Projects • Rowani Trading and Projects • Vusev • Balleo Engineering • Micron Laboratory Services		• African Commodity Handling Projects	• Elephantus Trading Enterprise • Bearings International

8.2 Clean technology value chains in South Africa

Like the coal value chain, clean technology value chains have several stages which involve the extraction of raw materials, manufacturing, and processing of the raw materials into components, plus transportation and construction operations. The stages of the value chains, including services and products as well as current suppliers, are summarised in Table 8-2 to Table 8-6.

Table 8-2: Solar PV value chain

	Extraction of raw materials	Beneficiation	Manufacturing	Transportation	Construction and installation (solar PV plants)
Description	This stage involves the raw materials associated with the manufacture of equipment required for solar panels. This also involves several suppliers to both the solar PV industry and other sectors.	This stage involves the transformation of metal/mineral products into higher-value products that can be consumed locally or exported. In addition, the raw materials are processed to improve their physical or chemical properties.	This stage involves the manufacturing of silicon wafers and PV cells, which are subsequently assembled into a complete solar panel.	Raw materials and manufactured products are typically transported between sites along the value chain (e.g., finished products are moved from a manufacturing facility to a solar PV power plant.	The construction and installation of solar PV power plants. Upon the completion of the plant, it is connected to the grid.
Services/Products	• Crystalline silicon • Steel • Copper • Aluminium • Cement & concrete	• Crushers (jaw and cone types) • Grinding systems • Wet or dry classifiers • Dense-media separation (DMS) • Hydro-cyclones • Floatation • Blending systems • Cooling systems • Sintering systems • Magnetic separators • Melting systems • Refining systems	• Wafer manufacturing • Cell manufacturing • Solar module assembly • Solar panel assembly • Inverters	• Vehicles • Trucks • Cranes	• Modules • Inverters • Electrical balance of system (BoS) • Mechanical BoS • Installations
Suppliers in SA	• ArcelorMittal • Allied Steelrode • PPC • Columbus Stainless Steel (PTY), Ltd.	• Micron Laboratory Services • FLSmidth • VUSEV • HATCH • Tugela Mining and Minerals (Pty,) Ltd. • Multotec Group	• ART Solar • Siemens Gamesa Renewable Energy (Pty), Ltd. • Ellies Electronics (Pty), Ltd.		

Table 8-3:
Wind power value chain

	Extraction of raw materials	Beneficiation	Manufacturing	Transportation	Construction and installation (wind power plants)
Description	Gathering raw materials (inputs) to be used in manufacturing and assembling equipment needed to erect wind turbines.	This stage involves the transformation of metal/mineral products into higher-value products that can be consumed locally or exported. In addition, the raw materials are processed to improve their physical or chemical properties.	Manufacturing of wind turbines, towers, blades, and the processes of assembling these components.	The equipment and its components are transported to the site of the wind power plant.	The construction of the wind power plant takes place, in which the equipment and its components, as well as the associated infrastructure, are installed on-site.
Services / Products	• Steel/concrete for towers • Reinforcement steel • Fibreglass or carbon fibre • Copper and aluminium • Epoxy resin	• Crushers • Grinding systems • Wet or dry classifiers • Dense-media separators • Hydro-cyclones • Floatation • Blending systems • Cooling systems • Sintering systems • Magnetic separators • Melting systems • Refining systems • Roiling and coiling systems • Annealing and pickling • Briquetting press	• Wind turbine systems • Rotors • Blades • Power converters • Hydraulic and pneumatic systems • Electronics • Wind sensors • Brake system • Screws • Heat exchanger cables • Switch yards	• Vehicles • Trucks • Cranes	• Wind turbines, towers, blades, and installation • Balance of plant or system (BoP/BoS)
Suppliers in SA or MP	• Columbus Stainless Steel (PTY), Ltd. (MPU)	• Micron Laboratory Services • FLSmidth • VUSEV • HATCH • Tugela Mining and Minerals (Pty), Ltd. • Multotec Group	• BFG Africa (GP) • General Electric South Africa (PTY), Ltd. (GP) • Goldwind Africa (PTY), Ltd. (GP)		• BTE Renewables

Table 8-4:
Biomass value chain

	Extraction of raw materials	Beneficiation	Manufacturing	Transportation	Bio-power plant
Description	This stage involves sourcing biomass feedstock. Usually from several industries, including: agricultural (plant and livestock), sugar, forest, food, pulp and paper, wood mills, and furniture industries; And, by extension, from municipal treatment plants.	This stage involves the transformation of biomass feedstocks into higher-value products that can be consumed locally or exported. In addition, the raw materials are processed to improve their physical or chemical properties.	The biomass feedstock is processed and transformed into biofuels (secondary energy), including liquid, solid, and gaseous fuels	Biomass and biofuels are transported to their respective units, such as manufacturing or processing units, and power plants.	The generation of electricity involves two methods, direct or indirect: Direct combustion of biomass feedstock, in which heat is released during the reaction process. In indirect methods, biofuels instead of biomass are combusted to generate electricity.

	Extraction of raw materials	Beneficiation	Manufacturing	Transportation	Bio-power plant
Services/Products	Feedstock (raw inputs): • Wood waste (chippings) • Forestry residues • Food waste • Municipal solid waste • Sugar and starch crops, sawdust, algae • Animal waste (e.g., animal dung, etc.)	• Crushers • Shredders and chippers • Hammer mills for wood & feed pellet processing • Conveyor belts • Screw-feeders • Magnetic separators • Silo and sieve systems • Distributive feed screws • Cooling systems • Conveyors (flat and slant types) • Torrefaction reactors • Briquette machines	• Digesters, • Boilers, flares, and valves • Char and ash disposal systems • Temperature sensors • Balers and woodchippers • Biomass pellet compressors • Wood-cutting machines • Mechanical harvesters • Moulding machines • Conveyor belts • Thrashers, trimmers, and sickles • Feed preparation, grinding, and drying (pre-treatment) • Pyrolysis reactors • Cyclonic char • Collector and condenser • Bio-fuel storage.	• Heavy trailers • Trucks • Haulage wagons	• Combustion engines • Steam turbines • Gas turbines • Steam valves • Steam condensers • Bubbling and circulating fluidised bed combustion boilers (stoker grate boilers) Electrical BoP • Transformers • Switchgear • Circuit breakers • Surge arresters • Electrical busbars Mechanical BoP • Cooling water systems (Cooling tower) • Compressed air systems
Suppliers in SA or MP	• Sappi Southern Africa • Africa Biomass Company	• Weir Minerals Africa • Mpumamanzi Group • Public Bonds and Projects • Rowani Trading and Projects	• VUSEV (supplier)	• African commodity handling projects	• Bearings International • Elephantus Trading Enterprise

Table 8-5: Battery energy storage value chain

	Extraction of raw materials	Beneficiation	Manufacturing	Transportation	Battery energy storage plant
Description	A wide array of minerals is used in the production of lithium-ion batteries (LIB). These include mixed oxides, and phosphates (used to produce cathodes), graphite- a form of carbon-coated copper foil (produces anode) and aluminium foil which is used as the current collector for the cathode electrode across each of the LIB chemistry applications.	This stage involves the transformation of metal/mineral products into higher-value products that can be consumed locally or exported. In addition, the raw materials are processed to improve their physical or chemical properties.	This involves the manufacturing of battery cells. Modules, containing multiple assembled battery cells, are connected to management systems monitoring and controlling temperature to form battery packs. LIB cells consist largely of four components: A cathode (positive electrode) that determines the capacity and average voltage of a battery; an anode (negative electrode); an electrolyte solution; and a separator, which ensures the safety of a battery and prevents it short-circuiting and overheating.	Depending on the size of battery product, several modes of transportation are used to deliver the products to the place of operation. These include trucks and other vehicles.	This stage of the value chain involves assembled battery packs ready for utilisation. LIBs are assembled in battery packs to be used in electric vehicles and stationary energy storage.

	Extraction of raw materials	**Beneficiation**	**Manufacturing**	**Transportation**	**Battery energy storage plant**
Services/Products	Raw materials (inputs): • Lithium • Cobalt • Manganese • Nickel • Graphite (carbon) • Bauxite • Silicon • Copper • Iron • Aluminium • Phosphate rock • Titanium	• Crushers • Vibrating screens • Scrubbers (attrition & drum types) and log washers • Dense-media separation (DMS) • Spiral classifiers • Heavy-media separation & Jig • Teeter bed separators (e.g., Flotex density separator, Allflux separator, etc.) • Centrifugal concentrators • Magnetic separation (LIMS, MIMS, WHIMS, HGMS & VPHGMS) • Floatation (conventional & column) and selective flocculation • Pelletising and roasting	• Battery cells • Battery modules • Battery packs	Trucks and other vehicles	• Battery packs • Charge controllers • Inverters • Safety disconnect equipment • Grounding equipment • Design and installation • Engineering and procurement • Balance of system (electrical and mechanical)
Suppliers in SA & Manufacturers	• African Rainbow Minerals, • Anglo Platinum, Ltd. • Impala Platinum Holdings • Xstrata (Pty), Ltd. • Norilsk Nickel • Afrimat Demaneng (Pty), Ltd. • Afro Mineral Trading AG • Assmang Chrome - Machadodorp (Mine) • Manganese Metal Co. (Pty), Ltd. • Emalahleni Smelters • Blue Ridge Platinum • Booysendal	• Weir Minerals Africa • Mpumamanzi Group • Public Bonds and Projects • Rowani Trading and Projects	• Lithium Batteries SA • Just Batteries/Potensa • Eternity Technologies South Africa • Sinetech • REVOV Batteries (Pty), Ltd.		

Table 8-6: Green hydrogen value chain

	Extraction of raw inputs	Beneficiation	Manufacturing	Transportation	Hydrogen plant
Description	Green hydrogen is used as a decarbonisation vector for "hard to abate" sectors such as transport, aviation, steelmaking etc. At a lower price point, green hydrogen (or ammonia) could be used as a proxy for fossil natural gas to produce energy	Beneficiation involves the transformation of metal/mineral products and biomass feedstocks into higher-value products that can be consumed locally or exported. In addition, the raw materials are processed to improve their physical or chemical properties.	'Green' hydrogen is produced via the electrolysis of ultra-pure water, using renewable energy:	Hydrogen is transported from the point of production to the point of use via different modes of transportation. These modes involve the use of pipelines to deliver hydrogen in regions where demand is high, whereas liquid tanker trucks and tube trailers are considered when the demand is at small scale.	A fuel cell device converts the chemical energy of a feedstock (e.g., H_2) into electrical energy. In a hydrogen fuel cell, a catalyst at the anode separates hydrogen molecules into protons and electrons, which take different paths to the cathode. The electrons pass through an external circuit, creating a flow of electricity. Source: U.S. Office of Energy Efficiency & Renewable Energy (Fuel Cell Basics): https://www.energy.gov/eere/fuelcells/fuel-cell-basics
Services/Products	Inputs: ● Fossil fuels ● Biomass ● Water ● Electricity	● Crushers ● Shredders and chippers ● Hammer mills for wood & feed-pellet processing ● Conveyor belts ● Screw feeders ● Magnetic separators ● Silo and sieve systems ● Feed distribution screws ● Cooling systems ● Conveyors (flat and slant types) ● Torrefaction reactors ● Briquette machine ● Over-belt magnets (to remove any tramp metal) ● Dense-media separators (DMS) or dense-medium cyclones; floats drain or rinse screen (dewatering) ● Centrifuges (used to separate solids/liquids) ● Desliming screening (removes any ultra- fine coal particles) ● Pumps ● Classification cyclones (hydro or flotation types)	● Electrolyser stacks ● Hydrogen compressors ● Hydrogen storage tanks ● Combustible-gas detectors ● Demisters ● Pumps ● Heat exchangers Transformers ● Rectifiers ● Controllable valves ● Dryers ● Back-pressure regulators ● Oxygen/water separators ● Water/hydrogen separators	● Pipelines ● Cryogenic liquid tanker trucks or ● Gaseous tube trailers	● Fuel cell stacks ● Fuel processors ● Power conditioners ● Air compressors ● Humidifiers

	Extraction of raw inputs	Beneficiation	Manufacturing	Transportation	Hydrogen plant
Suppliers in SA or Mpumalanga	• Sappi Southern Africa Biomass Company	• Weir Minerals Africa • Mpumamanzi Group • Public Bonds and Projects • Rowani Trading and Projects	• Hydrox Holdings • Air Liquide • Afrox gases	• XONELOG IX	• Air Products South Africa • HySA

8.3 Value creation per local content

To illustrate the potential value that can be gained from investing in renewable energy deployment, the I-JEDI model outputs included estimates of gross output value. This was modelled for all technologies at the moderate and high local content levels.

Annual gross output value per scenario – moderate local content

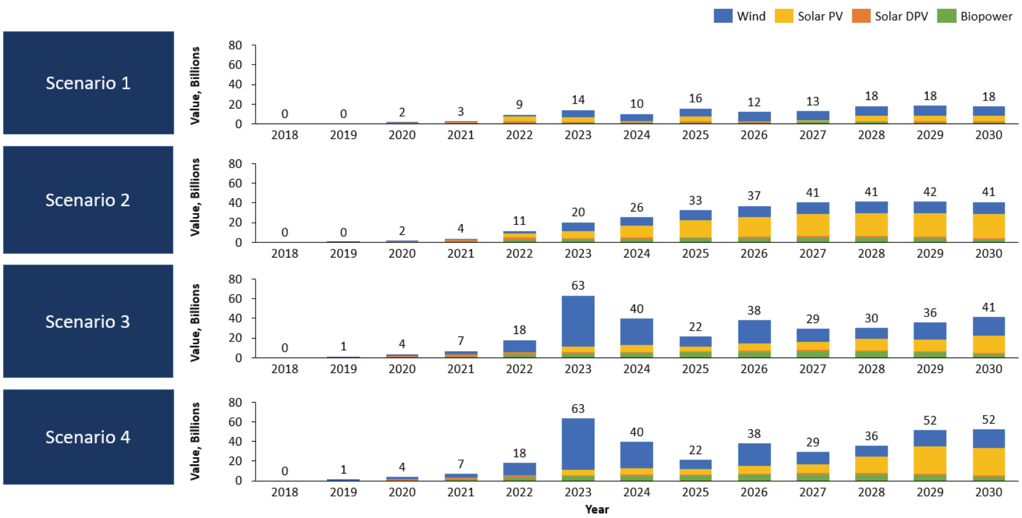

Figure 8-1: Construction and O&M annual gross output value, moderate local content (billion ZAR, I-JEDI)

Annual gross output value per scenario – high local content

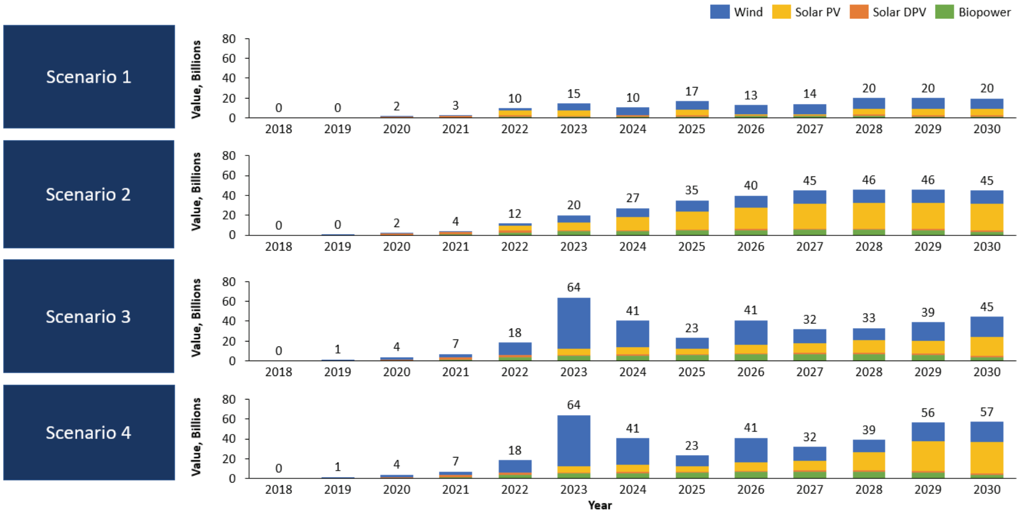

Figure 8-2: Construction and O&M annual gross output value, high local content (billion ZAR, I-JEDI)

Sectoral gross output value

Moderate local content

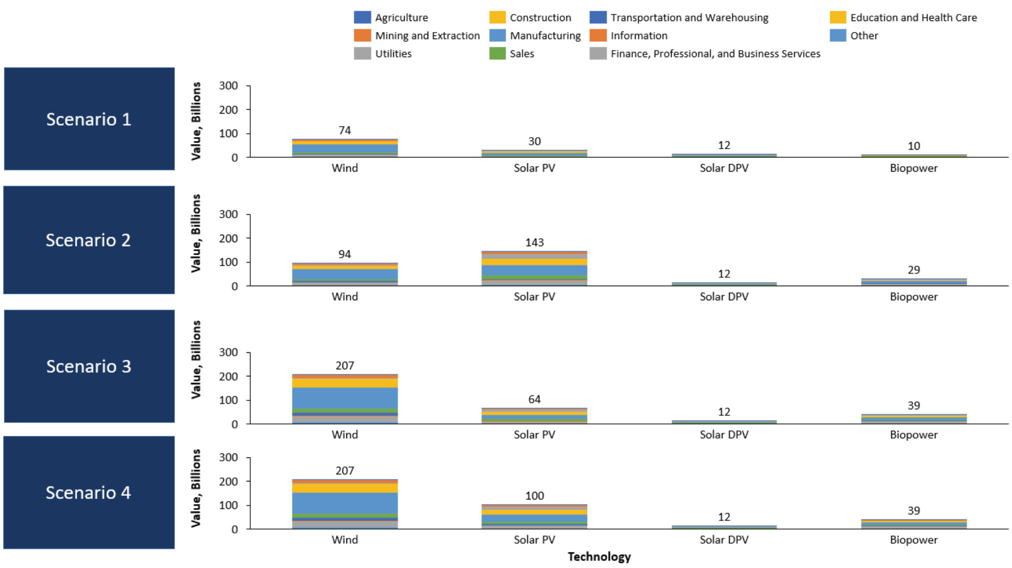

Figure 8-3: Gross output value per sector by technology, moderate local content (billion ZAR, I-JEDI)

High local content

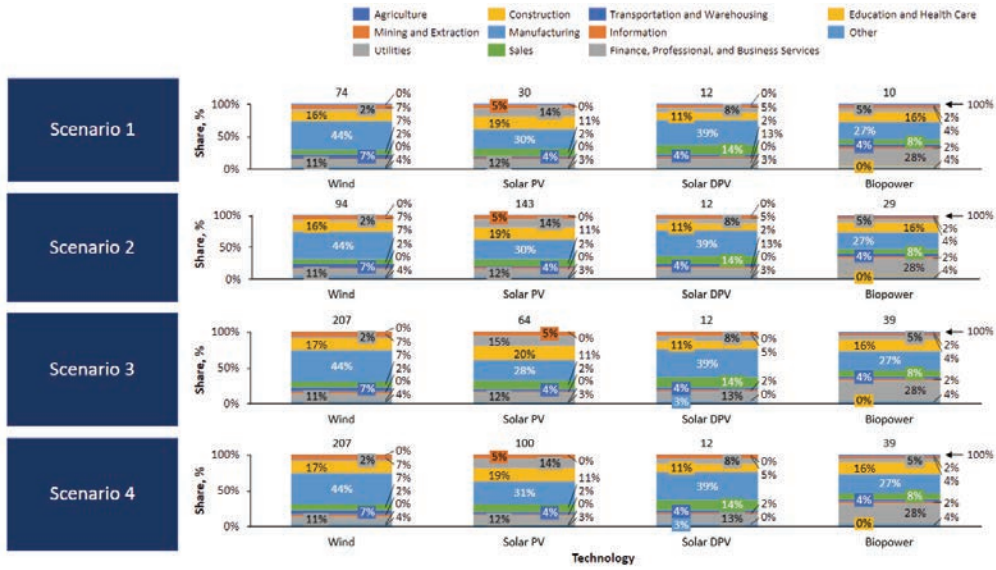

Figure 8-4: Share of gross output value, moderate local content, 2030 (percentage)

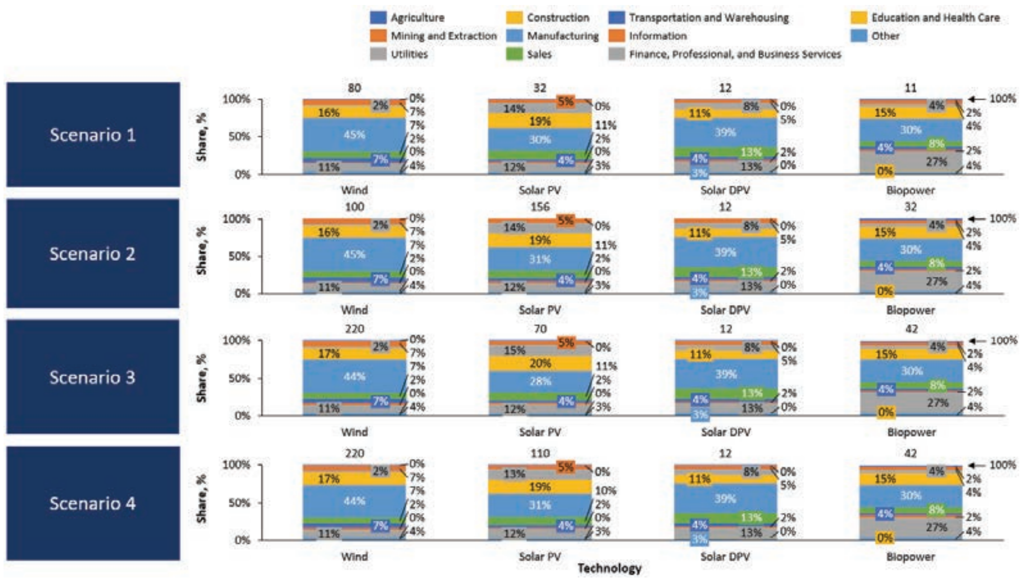

Figure 8-5: Share of gross output value, high local content, 2030 (percentage)

9. Quantification of skills requirements and gender-inclusiveness

9.1 Baseline assessment: skills and gender balance in the renewable sector

Eskom

Table 9-1 shows the education level of employees working at Eskom power plants. The data show that only 55% of employees have a post-matric qualification, and 5% lack any form of educational qualification. Most employees without qualifications work in bulk material services, i.e., the coal-handling section of the power plant, in roles such as general workers and vehicle drivers. Table 9-1 also shows that 33% of Eskom employees have a matric as their highest qualification. In terms of gender balance, Table 9-1 shows that 67% of female employees have a post-matric qualification compared to 49% of male employees. Furthermore, only 2% of female employees have no educational qualification, compared to 7% among male employees. Overall, 31% of Eskom employees are female.

Table 9-2 shows that only 2% of Eskom employees are involved in elementary occupations, whereas 58% are in skilled to highly skilled roles (i.e., artisans, lab technicians, electrical engineers, or managers).

Table 9-2 also shows that 28% of Eskom employees work as plant operators or in related roles. The data suggest that, although only 55% of employees have a formal post-matric qualification, they obtain further professional skills on the job.

Highest qualification	Female		Male		Total	
	Number of employees	Percentage	Number of employees	Percentage	Total number of employees	Total percentage
No formal school qualification	42	2%	301	7%	343	5%
Primary	3	0%	93	2%	96	1%
Secondary	26	1%	368	8%	394	6%
Matric	621	30%	1528	34%	2149	33%
Certification	484	24%	961	21%	1444	22%
Degree or diploma	874	43%	1236	28%	2111	32%
Total	**2050**		**4487**		**6537**	

Table 9-1: Eskom employee education level, by gender (Eskom, 2021)

Employment sector	Female		Male		Total	
	Number of employees	Percentage	Number of employees	Percentag e	Total number of employees	Total percentage
Learner (unskilled)	35	2%	29	1%	64	1%
Elementary occupations (low-skilled)	19	1%	119	3%	138	2%
Plant and machine operators and assemblers (semi-skilled to skilled)	356	17%	1473	33%	1829	28%
Clerical support workers (skilled)	359	18%	215	5%	573	9%
Artisan (skilled to high-skilled)	125	6%	506	11%	631	10%
Finance (skilled to high-skilled)	106	5%	42	1%	147	2%
Technicians and associated professionals (skilled to high-skilled)	769	38%	1595	36%	2364	36%
Managers (high-skilled)	157	8%	250	6%	407	6%
Professionals (high-skilled)	115	6%	263	6%	378	6%
Total	**2050**		**4487**		**6537**	

Table 9-2: Eskom employees per occupation, by gender (Eskom, 2021)

Coal Mining

The data in Table 9-3 show educational levels amongst employees working in coal mining: 35% of employees do not have a matric-level qualification, 34% have a matric as their highest qualification, and only 19% have a post-matric qualification.

In terms of gender balance, Table 9-3 shows that 24% of female employees have a post-matric qualification compared to 18% of males, and 26% of female employees have no matric qualification compared to 37% of males. Overall, 21% of employees are female.

Table 9-4 show that only 14% of employees in coal mining work in elementary occupations and 15% are artisans.

Table 9-4 also shows that 43% of all employees are plant and machine operators, falling to 34% among female employees. Although only 19% of employees have a formal post-matric educational qualification, employees in the sector do gain technical skills in their jobs.

Table 9-3: Education level by age and gender in coal mining (Source: MQA, 2021)

Highest qualification	Female		Male		Total	
	Number of employees	Percentage	Number of employees	Percentage	Total number of employees	Total percentage
No schooling	2	0.2%	10	0.3%	12	0.3%
Primary	8	1%	241	7%	249	6%
Secondary (no matric)	228	25%	1032	30%	1260	29%
Matric	377	42%	1087	32%	1464	34%
Certificate (N3–6)	83	9%	413	12%	495	11%
Degree or diploma	135	15%	224	6%	358	8%
Do not know	55	6%	399	12%	454	10%
Other	11	1%	34	1%	45	1%
	898		**3440**		**4337**	

Table 9-4: Coal mining employees per occupation (Source: MQA, 2021)

Employment sector	**Female**		**Male**		**Total**	
	Number of employees	**Percentage**	**Number of employees**	**Percentage**	**Total number of employees**	**Total percentage**
Learner (unskilled)	59	7%	65	2%	125	3%
Elementary occupations (low-skilled)	126	14%	482	14%	607	14%
Miners (low-skilled)	4	0.4%	13	0.39%	17	0.4%
Plant and machine operators and assemblers (semi-skilled to skilled)	302	34%	1579	46%	1881	43%
Service and sales workers (skilled)	4	0.5%	9	0.27%	13	0%
Clerical support workers (skilled)	88	10%	65	2%	153	4%
Technicians and associated professionals (skilled to high-skilled)	133	15%	447	13%	580	13%
Managers (high-skilled)	18	2%	79	2%	97	2%
Professionals (high-skilled)	79	9%	131	4%	210	5%
Artisans (high-skilled)	81	9%	550	16%	631	15%
Miner overseers (high-skilled)	3	0.4%	19	0.56%	23	1%
Grand total	**897**		**3440**		**4337**	

Mpumalanga

Table 9-5 shows educational levels in Mpumalanga province and its three district municipalities. The data show that 58% of the population do not have a matric-level qualification, 30% have a matric as their highest qualification, and only 12% hold a post-matric qualification.

Highest qualification	Nkangala DM	Ehlanzeni DM	Gert Sibande DM	Mpumalanga	Total percentage
No qualification (up to school Grade 6)	160500	227900	133800	522200	19%
Secondary (no matric)	390000	395000	268000	1053000	39%
Matric	299000	325000	192000	816000	30%
Certificate (N3-N6)	5960	5440	3600	15000	1%
Degree or Diploma	107750	116500	65350	289600	11%

Table 9-5
Education level in Mpumalanga (Source: Mpumalanga COGTA, 2018)

Highest qualification	Female		Male		Total	
	Number of employees	Percentage	Number of employees	Percentage	Total number of employees	Total percentage
No formal school qualification	42	2%	301	7%	343	5%
Primary	3	0%	93	2%	96	1%
Secondary	26	1%	368	8%	394	6%
Matric	621	30%	1528	34%	2149	33%
Certification	484	24%	961	21%	1444	22%
Degree or diploma	874	43%	1236	28%	2111	32%
Total	**2050**		**4487**		**6537**	

Table 9-6:
Employment types and skill levels among employees in Mpumalanga, 2016

9.2 Skill-level requirements in the renewable energy sector

Jobs in wind, solar PV, and biomass technologies require different skill levels, as shown in Table 9-7. The skills requirements are divided into four major sub-sectors:

- Manufacturing;
- Project development;
- Construction and installation; and
- Operation and maintenance (O&M).

Skills required for wind energy

Different occupations and skill levels are needed at each step of the value chain. For example, employees involved in manufacturing wind turbine towers will require experience with steel, whereas turbine manufacturing involves different roles, including computer-controlled machine tool operators, assemblers, welders, quality-control inspectors, and industrial production managers. The project design phase will demand experts in resource assessment, engineers, and experts in finance. The construction of wind farms is then carried out by employees that have the capacity to lay foundations or erect turbine towers, and crane operators are needed to attach the blades to the turbine. Operations and maintenance tasks include calibrating electronic sensors, monitoring the operation of turbines, and cleaning blades.

- **Skills required in manufacturing:** The challenges involved in manufacturing wind farm components are similar to those for any heavy mechanical and electromechanical product. The roles include manufacturing engineers, manufacturing technicians, manufacturing operators, and quality assurance specialists.

- **Skills required in project development:** This phase includes acquiring land and environmental permissions (either EIA or an SEA within a REDZ) by submitting applications to DMRE and DFFE respectively. The roles include design engineers, environmental scientists, town planners and lawyers.

- **Skills required in construction and installation:** The main occupational categories in the construction phase include civil and electrical engineers. Various categories of technicians, electricians, and construction workers are also required.

- **Skills required in operation and maintenance:** On a daily basis, the main roles are undertaken by technicians responsible for operating and maintaining the turbines, and their connection to the grid. Managerial and financial skills are also required.

Skills required for solar PV

The skills required for the solar PV value chain are mainly engineers and technicians to process raw materials such as silicon or other semiconductor materials. Engineers and technical workers are also required to assemble the system components at the manufacturing stage. The project development stage needs qualified personnel to conduct solar resource assessments, plus solar PV system designers, energy experts, business managers, and financial analysts. Construction workers include technical personnel and electricians, who are required for installation purposes. Maintenance of the plants also requires technical staff.

- **Skills required in manufacturing:** The skills required in developing and manufacturing electronic components includes researchers in chemistry, physics, materials science, systems design, and process engineering among others, and a range of manufacturing skills related to diffusing and processing silicon. The components are mounted into panels, which is more labour intensive, and this requires a range of skills in fabricating, assembling, and testing products, at levels including professional engineer, technician, and manufacturing operator (Study.com, 2019).

- **Skills required in project development:** Occupations in this phase include engineers of various disciplines, and site-related professions such as land use negotiators. Financial occupations and environmental assessment skills are also required.

- **Skills required in construction and installation:** During the construction phase, activities are undertaken by EPC contractors that require electrical grid operators for installing power lines to connect the solar farm to the grid. Construction work also includes employees in civil, mechanical, and electrical engineering. Various technicians, electricians, and construction workers are also required.

- **Skills required in operation and maintenance:** The skills required at this stage are dominated by the technicians and electricians that monitor the system (which may be conducted remotely and relatively infrequently), plus the provision of maintenance services.

Skills required for biomass

Managers, professionals, and technicians form the majority of the workforce, and low- to medium-level qualifications are required for office management, assembling and testing, field installation, services, and biomass production.

- **Skills required in manufacturing:** The occupations relating to manufacturing include manufacturing engineers and technicians, as well as supporting roles such as quality assurance, procurement and logistics, and marketing and sales staff.

- **Skills required in project development:** This stage of the value chain requires a wide range of skills, with most roles being highly skilled, plus some medium-skilled support staff. Skills in resource assessment are essential, to ensure access to an adequate supply of suitable biomass. Scientific and engineering skills are also required to match the technology to the supply of biomass, and to develop a suitable plant design. In addition to the electrical and mechanical engineering skills required in other renewables subsectors, biomass requires skills in chemical engineering for processes such as gasification and anaerobic digestion.

- **Skills required in construction and installation:** Construction skills are required for physical installation. Skills specific to the technology are required for commissioning, which may include biosciences, laboratory technicians, electrical or mechanical engineers, or information technology and software engineers (including process automation) among others. Business developers and biomass procurement specialists have important roles in establishing the supply of biomass and end-markets for heat and biofuel products.

- **Skills required in operation and maintenance:** The main skills required are technicians for operating and maintaining the equipment, electricity generation, fuel production, and heat production. Scientific and laboratory skills are required to test biomass, to manage processes such as gasification or anaerobic digestion, and to ensure that any biofuels produced comply with specifications.

- **Skills required in biomass production:** Biomass production requires substantial numbers of agricultural or forestry workers to plant, manage, and harvest biomass crops. Other roles include biomass production managers and plant breeders and foresters. Significant numbers of transportation workers are required, as the biomass must typically be transported and processed.

Wind and solar will make the largest contributions to job creation in Mpumalanga. © Dennis Schroeder/NREL

Type of technology	Project phase	Project activity	Occupation/role
Solar PV (200 MW)	Manufacturing	Module assembly	Panel assemblers (electrical and mechanical)
	Development	Site assessment	Solar site assessors
		Permitting	Legal practitioners
		EIA process	Environmental scientists
		Banking	Finance
	Construction and installation	Civils (site clearing, foundation, basic construction, etc.)	Construction workers, heavy vehicle operators
		Structure erection, and grid work	Electrical technicians
		Transportation of equipment	Transport workers
		Solar panel installation	Welders; roofers; electricians; pipe fitters and general workers
	Operation and maintenance	Operation and maintenance services	General workers for cleaning solar panels and cutting grass; plumbers specialising in solar; electricians; security guards
Wind (240 MW)	Manufacturing	Component manufacturing of towers and blades	Manufacturing engineers, technicians, and operators; Industrial mechanics
	Development	EIA process and permitting	Environmental scientists and meteorological technician
		Resource assessment	Resource scientists; design engineers
	Construction and installation	Civil works, electrical, transportation, EPCs	Electrical and mechanical engineers; construction technicians; construction workers; managers
		Transportation of equipment	Transportation workers
	Operation and maintenance	Operation and maintenance	Wind turbine technicians
			Field electricians
			Power line technicians
			Brid carcass monitoring and security guards
Biomass (25 MW)	Manufacturing	Plant design (digestors, refineries, components, etc)	Agricultural, biological, chemical, and physical scientists; mechanical and electrical engineers
	Development	EIA process and permitting	Environmental scientists; project designers
		Resource assessment	Resource assessment specialists
	Construction and installation	Plant construction	General and professional construction workers; biochemists; and microbiologists
		Conversion (heat, power, or fuel)	plumbers; electricians
		Transportation of equipment	Transport workers
	Operation and maintenance	Operation and maintenance	Laboratory technicians and assistants; operations and maintenance specialists; biochemists and microbiologists
	Biomass production	Cultivation	Agricultural scientists; plant breeders and foresters
		Harvesting	Agricultural/forestry workers
		Transport	Transport workers

Table 9-7: Job categories and skill requirements in solar PV, wind, and biomass technologies across the value chain (RES4Africa foundation, 2020; ILO; 2011)

Skill level requirement	Numbers employed	Period (years)	Job years	Job percentage
Skilled	1737	1	1737	10% skilled
High-skilled	1764	1.5–2	3528	20% high-skilled
High-skilled				
High-skilled				
High-skilled				
Skilled	866	1.5–3	2598	15% skilled
Skilled	1039	15–3	3117	18% skilled
Low-skilled	272	1..5–3	816	4.7% low-skilled
Skilled and low-skilled	298	1.5–3	894	2.5% skilled 2.5% low-skilled
High-skilled, skilled; low-skilled	187	25	4675	9% high-skilled 13% skilled 5% low-skilled
High-skilled	4277	1	4277	28% high-skilled
High-skilled	102	1.5–2	204	14% high-skilled
High-skilled				
High-skilled; low-skilled	1056	1.5–2	2112	7% low-skilled 7% high-skilled
Low-skilled	157	1.5–2	314	2.1% low-skilled
High-skilled	324	25	8100	18% high-skilled 10% low-skilled 26% skilled
Skilled				
Skilled				
Low-skilled				
High-skilled	372	1	372	9% high-skilled
High-skilled	675	1.5–2	1350	32% high-skilled
High-skilled				
High-skilled; low skilled	186	1.5–2	372	9% high- and low-skilled
Skilled				
Low-skilled	65	2	130	3% low-skilled
High-skilled; skilled	83	20	1660	39% high-skilled and skilled
High-skilled	1			
Low-skilled	12	20	240	6% low-skilled
Low-skilled	4	20	80	2% low-skilled

10. Maps of coal power plants and mining sites

10.1 Map of Eskom power stations

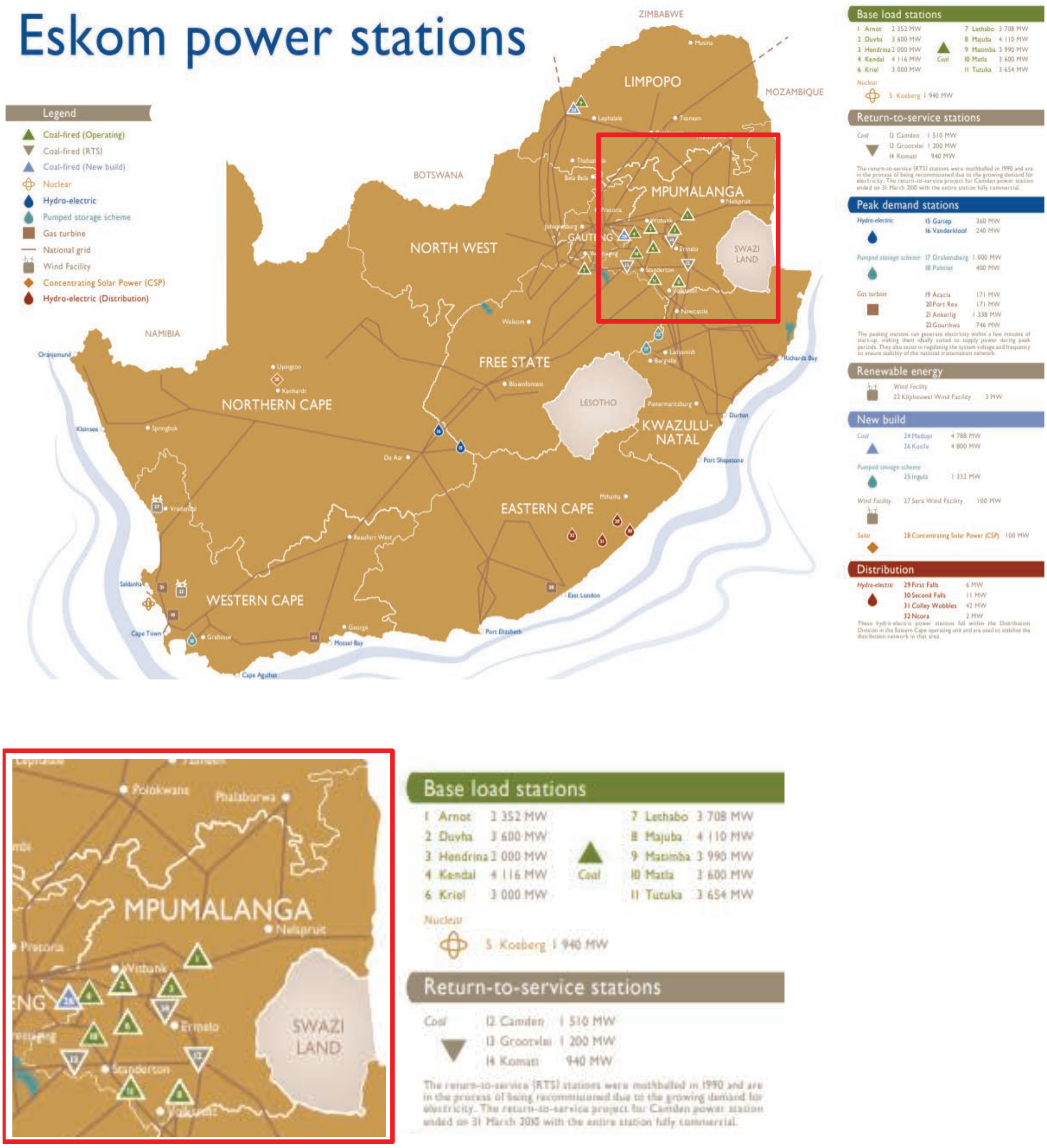

Figure 10-1: Map of Eskom power stations and major transmission lines[16] (Eskom[17])

[16] Some maps in this report that were taken from third parties show Eswatini by its former English name Swaziland.

[17] https://www.eskom.co.za/wp-content/uploads/2021/04/EskomGenerationDivMapREV81.pdf

10.2 Maps of mining sites in Mpumalanga

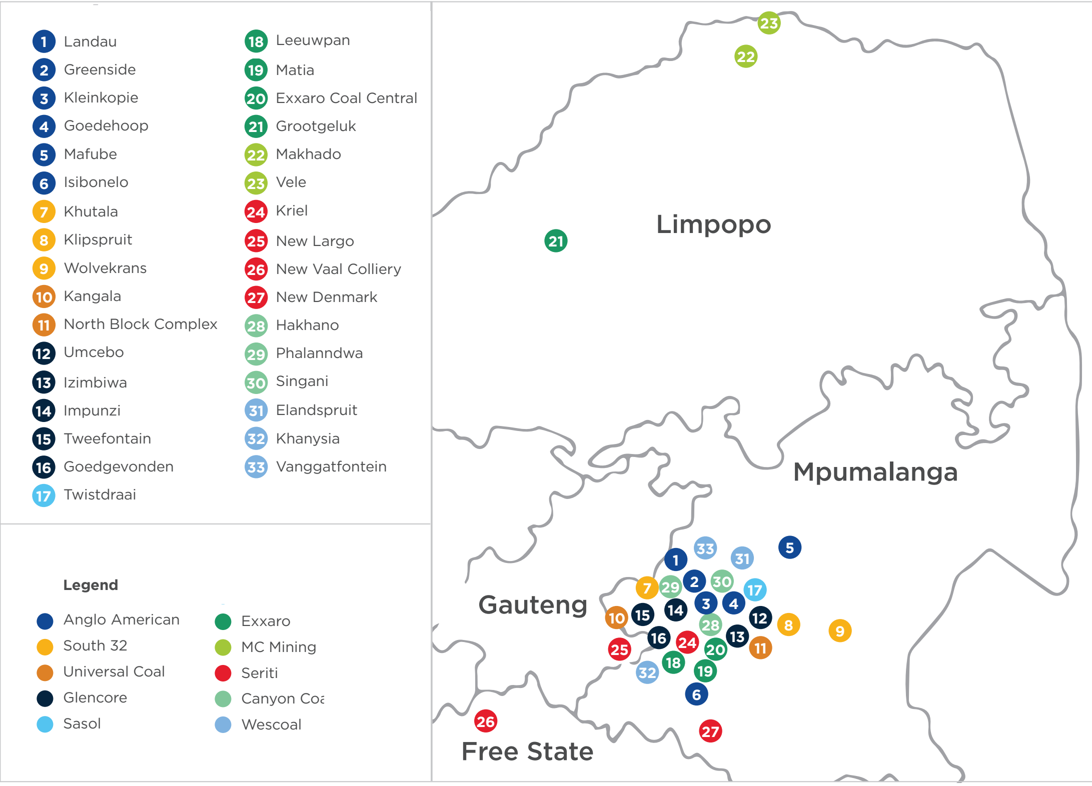

Figure 10-2: Coal mining areas in South Africa (Minerals Council of SA, 2021)

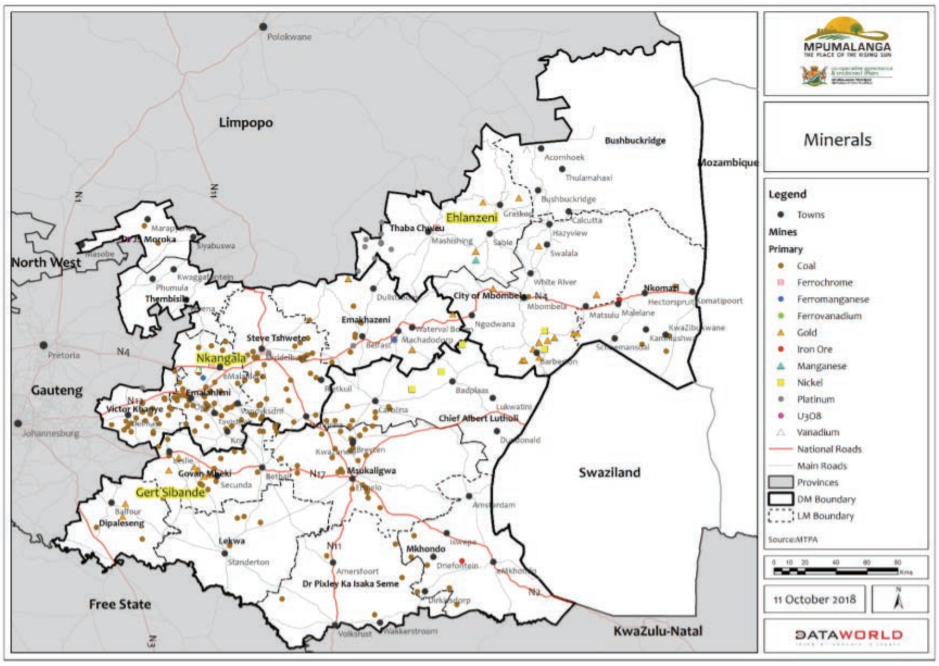

Figure 10-3: Mining areas in Mpumalanga by district
(Mpumalanga Department of Cooperative Governance and Traditional Affairs, 2018)

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Abbreviations

BBBEE	Broad-Based Black Economic Empowerment
BMU	German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety
CSIR	Council for Scientific and Industrial Research
CSP	Concentrated Solar Power
DFFE	Department of Forestry, Fisheries, and Environment
DHET	Department of Higher Education and Training
DMRE	Department of Mineral Resources and Energy
ED	Enterprise development
EoI	Expression of interest
EWSETA	Energy and Water Sector Education Training Authority
GHG	Greenhouse gas
GW	Gigawatt
IASS	Institute for Advanced Sustainability Studies

IDC	International Development Corporation
IEP	Integrated Energy Plan
IET	International Energy Transition
I-JEDI	International Jobs and Economic Development Impacts
IKI	International Climate Initiative
I-O	Input-Output
IPP Offices	Independent Power Producer Procurement Programme Offices
IRP	Integrated Resource Plan
Mpumalanga DEDT	Mpumalanga Department of Economic Development and Tourism
MQA	Mining Qualification Authority
MTPA	Million metric tonnes per annum
NDC	Nationally Determined Contribution
NDP	National Development Plan
NREL	National Renewable Energy Laboratory
PFMA	Public Management Finance Act
PV	Photovoltaic
R&D	Research and development
REI4P	Renewable Energy Independent Power Producers Procurement Programme
RENAC	Renewables Academy
RFP	Request for proposal
SALGA	South African Local Government Association
SED	Socio-economic development
SAPVIA	South African Photovoltaic Industry Association
SAREM	South African Renewable Energy Masterplan
SARETEC	South African Renewable Energy Technology Centre
SAWEA	South African Wind Energy Association
SDG	Sustainable Development Goals
TVET	Technical vocational education and training

COBENEFITS assessments in South Africa

This COBENEFITS study has been realised in the context of the project "Mobilising the Co-Benefits of Climate Change Mitigation through Capacity Building among Public Policy Institutions" (COBENEFITS).

In South Africa, the project is guided by the Council for Scientific and Industrial Research (CSIR) and a council consisting of representatives of the Department of Forestry, Fisheries, and the Environment (DFFE), Department of Mineral Resources and Energy (DMRE), Department of Trade and Industry (DTI), Department of Science and Technologies (DST), and the IPP Office.

COBENEFITS has assessed important social and economic co-benefits of increasing the shares of carbon-neutral renewable energy in South Africa's power systems. Building on these assessment results, the project consortium has worked with the government of South Africa to develop policy options to unlock these co-benefits for the country's citizens and businesses. The results of the co-benefits assessments have been published in the COBENEFITS South Africa Study series, which can be downloaded from

www.cobenefits.info

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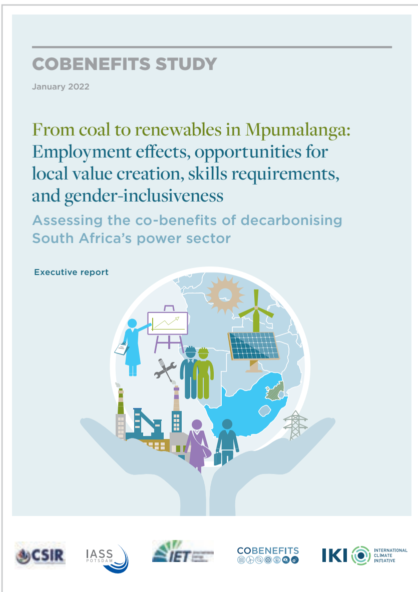

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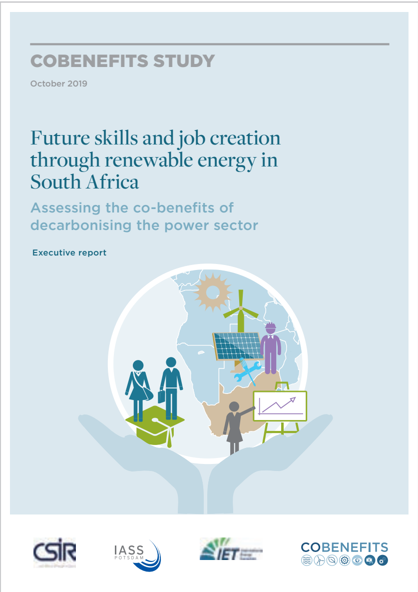

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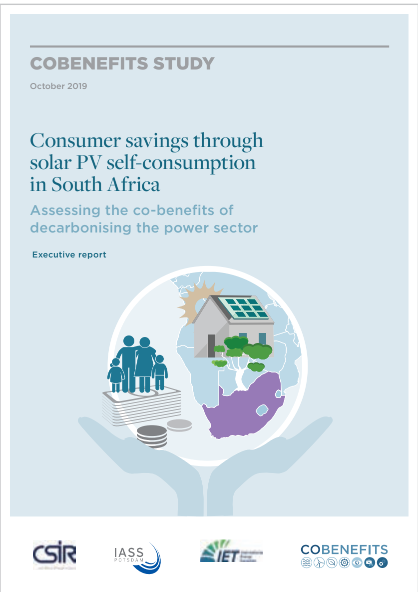

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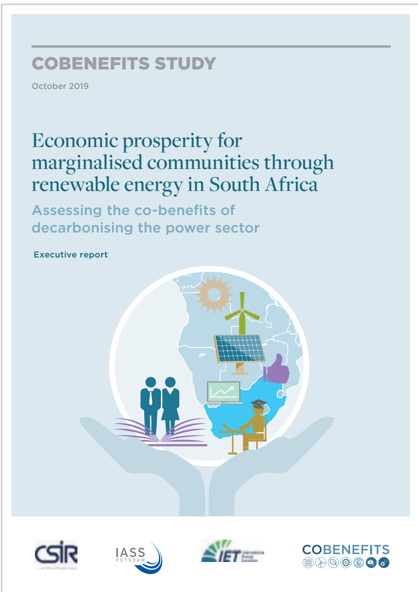

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COBENEFITS
Unlocking social and economic co-benefits for a just and sustainable energy future

The COBENEFITS project supports national authorities and knowledge partners in countries worldwide to connect the social and economic co-benefits of decarbonising the power sector to national development priorities and to mobilise these co-benefits for early and ambitious climate action. The project supports efforts to develop enhanced NDCs with the ambition to deliver on the Paris Agreement and the 2030 Agenda on Sustainable Development (SDGs) and to enable a Just Transition.

COBENEFITS facilitates international mutual learning and capacity building among policymakers, knowledge partners, and multipliers through a range of connected measures: country-specific co-benefits assessments, online and face-to-face training, and policy dialogue sessions on enabling policy options and overcoming barriers to unlock the identified co-benefits in the target countries.

COBENEFITS Technical Annex
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