COBENEFITS STUDY

January 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

Executive report

Imprint

This COBENEFITS Report 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).

This project is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV) supports this initiative on the basis of a decision adopted by the German Bundestag. The COBENEFITS project is coordinated by the Institute for Advanced Sustainability Studies (IASS, lead) in partnership with the Renewables Academy (RENAC), the Independent Institute for Environmental Issues (UfU), International Energy Transition GmbH (IET), and in South Africa the Council for Scientific and Industrial Research (CSIR).

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This Executive Report is accompanied by a Technical Report with more background information, modelling assumptions, and other data – available at www.cobenefits.info

This report is dedicated to our colleague and friend, **Ntombifuthi Princess Ntuli**, who left us far too early. She was an anchor for the COBENEFITS project in South Africa. Her dedication and amazing sense of humour remain an inspiration for all of us who are trying to move the South African energy transition forward.

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Executive Summary

COBENEFITS

South Africa's NDC ambition to deliver social and economic co-benefits: Building the database

In October 2021, South Africa registered its new Nationally Determined Contributions (NDCs) at the UNFCCC as its contribution to the global action on climate change. After initially announcing plans to limit greenhouse gas (GHG) emissions to 398–440 $MtCO_2e$ in March 2021, there was a consensus by business and civil society stakeholders that the Department of Forestry, Fisheries & the Environment (DFFE) had not been sufficiently ambitious, which in September 2021 led to a revised limit of 350–420 $MtCO_2e$ by 2030. Whilst these new targets were welcomed, their attainment will be conditional on South Africa receiving appropriate financial support from developed nations and—even more importantly—on the ability of the South African political economy to address both existing vested interests in fossil fuels and the requirements for a Just Transition.

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, to establish a partnership to support decarbonisation of the South African economy and a Just Transition. 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 support the closure of Eskom coal plants, just energy transition initiatives, and South Africa's transition to the green hydrogen and electric vehicle sectors.

Coal has contributed to the South African economy for more than a century and remains a dominant part of the energy mix. Mpumalanga is the centre of the South African coal industry, accounting for approximately 80% of total coal production. Most of Eskom's coal-fired plants are also located in the province. Consequently, Mpumalanga's regional economy is highly dependent on the exploitation of coal.

However, the transformation of the South African energy system is gathering momentum. The Integrated Resource Plan (IRP) 2019 anticipates that 10.7 GW of existing coal-fired power stations will be decommissioned by 2030, with only Medupi and Kusile expected to remain operational by 2040. According to the DFFE, about 80–90% of greenhouse gas emission reductions in South Africa should come from the power sector, as it is both the largest emitter and the cheapest sector to mitigate in due to declining renewable energy prices.

Without deliberate and appropriate planning, the gradual phase-out of coal would be expected to lead to substantial economic and socio-economic losses. A regional and national plan is therefore needed to ensure that this process meets the principles of a Just Transition, which include social inclusion, decent work for all, and poverty reduction. As part of Eskom's Social Plan, the utility is considering options for repurposing the sites of coal-fired power plants that are scheduled for decommissioning, namely Camden, Grootvlei, Komati, and Hendrina, and also (potentially) a single unit at Arnot (Eskom Holdings SOC Ltd, n.d.) (Fabricius et al. 2020).

This study builds on a unique and hitherto confidential, unpublished set of employee data for Eskom and coal mines, provided by Eskom (under a non-disclosure agreement) and the Mining Quality Authority (MQA).

The sourced data sets connect gender, qualification levels, and years of service, thereby enabling analysis of the skills and gender balance in the coal industry, and assessment of the potential for transferring expertise to the renewable energy sector.

In addition, interviews were conducted with enterprise development (ED) managers to understand barriers and opportunities for women in the renewables sector. Based on these valuable data sets and economic modelling, the study analyses and quantifies the socio-economic implications of repurposing coal-fired 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 findings also highlight important framework conditions necessary for fully harnessing these benefits.

The COBENEFITS project in South Africa has previously commissioned and published a series of studies quantifying the country-wide socio-economic benefits related to renewable energy deployment in the electricity sector with an outlook to 2050. The key findings from the COBENEFITS South Africa Assessment series were compiled in a COBEFITS Policy Report for South Africa (IASS/UfU/IET/CSIR, 2020). In a continuation of the COBENEFITS series of studies on South Africa, this report presents a regional focus on Mpumalanga province, analysing planned real-world projects, and focuses on short-term effects until 2030.

This Executive Report is accompanied by a Technical Report providing detailed modelling inputs/outputs, data sets, and analyses.

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.

Key policy opportunities:

- **Policy opportunity 1: Mpumalanga can compensate a large share of jobs[1] 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[2] 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[3] 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.

[1] 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.

[2] 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).

[3] 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[4].** 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.

[4] 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:

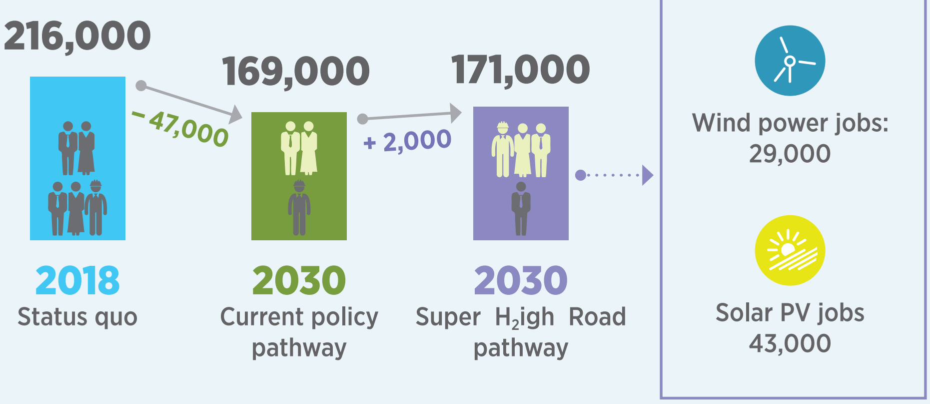
- **Upskilling and higher education are pre-requisites for a successful energy transition in Mpumalanga.** The bulk of job creation in renewable energy is within the high-skilled labour group (estimated as 68 – 80 %), although employment is also created in low-skilled roles—especially during project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

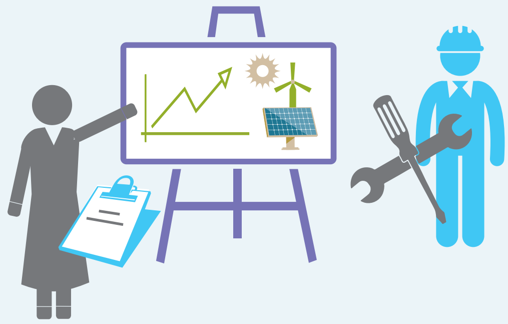
- **The current educational level among coal workers is much higher than the provincial average: 22 % of coal-mining employees and 55 % of Eskom employees have post-matric qualifications, compared with only 11 % among Mpumalanga's working-age population.** Eskom employees often acquire technical skills 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.

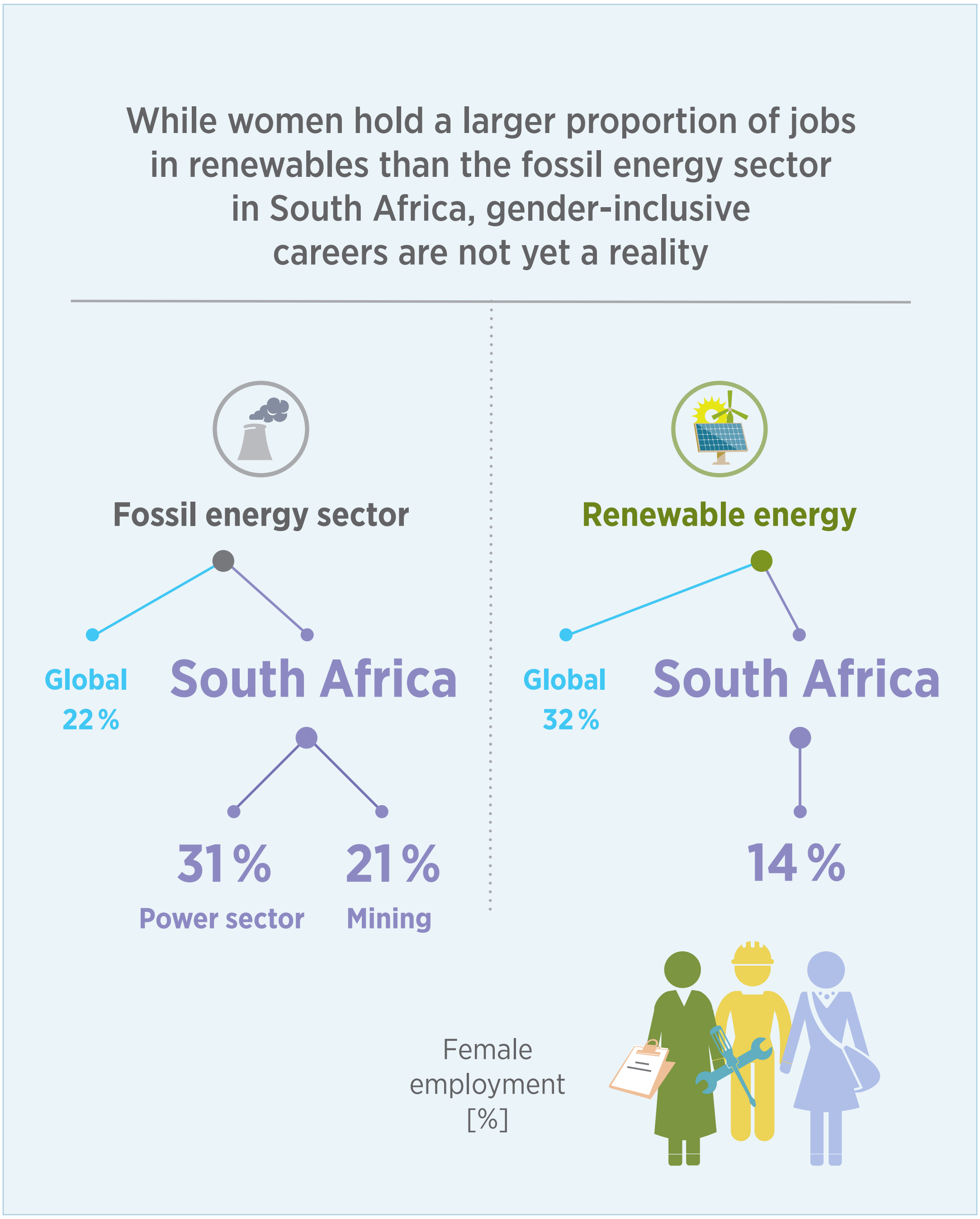
- **Women are presently underrepresented in the energy sector. According to Eskom and MQA data sets, Eskom employs 31 % females and coal mines employ 21 % females in Mpumalanga.** However, those female employees are usually better educated than their male colleagues (e.g., 67 % of females compared to 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:

Expected job losses in Mpumalanga’s energy sector under the current policy can be reduced through an ambitious decarbonisation pathway

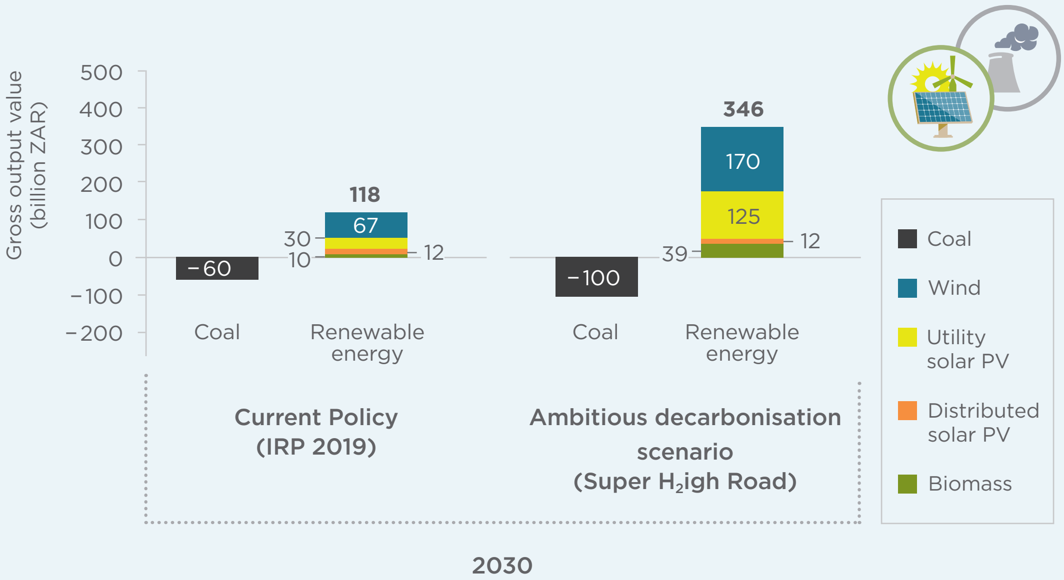






Data sources: IRENA 2019, IASS 2021c, ESKOM 2021, MQA 2021

Value creation with renewable energy in Mpumalanga can increase from R118 bn to R346 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.

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.

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)[5] .

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.

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).[6]

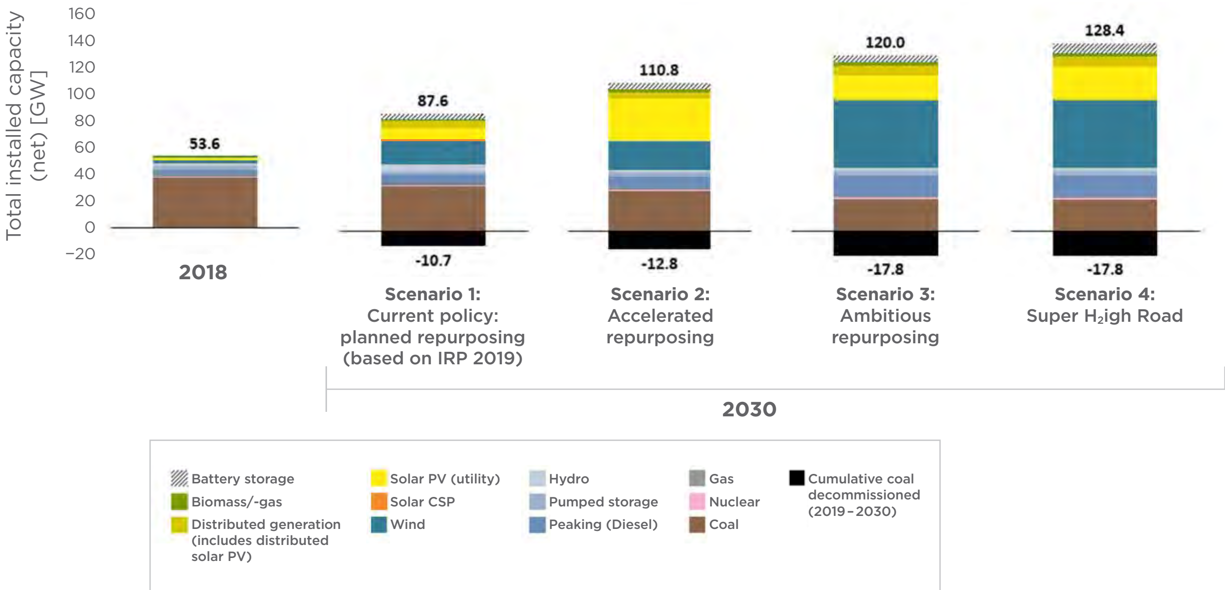


Figure 0-1: COBENEFITS South Africa: Power system reference scenarios Installed capacity (GW) (source: IRP 2019, CSIR Energy Centre analysis)

[5] 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.

[6] 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 high level.

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

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 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 (under a non-disclosure agreement) 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.

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1. The transition from coal to renewables in Mpumalanga

- Coal has contributed to the South African economy for more than a century as a dominant part of the energy mix. About 80% of total coal production in RSA is undertaken in the Mpumalanga province and, consequently, most of Eskom's coal-fired plants are also located there.
- There is broad consensus from all social partners on the need for an urgent transition away from fossil-fuel dependency, which will require all stakeholders to recognise the need to shift from their traditional roles in the South African economic and political landscape.
- This energy transition needs to be implemented with the development of a co-created Just Transition plan that will ensure that all stakeholders and communities affected by the move away from fossil-fuel extraction and exploitation will be protected from loss of livelihood, and provided opportunities in new and more sustainable economic sectors.
- South Africa will need large amounts of green finance to support not only the techno-economic needs of the energy transition but also to address the deep-rooted structural and socio-economic implications to realise a Just Transition in tradition regional mining economies. If approached strategically by Mpumalanga stakeholders, this can represent an opportunity to be grasped rather than a risk to be mitigated.

1.1 Coal dependency in Mpumalanga and South Africa

As a country blessed with large reserves of gold, platinum, iron ore, and manganese, the availability of cheap electricity was a key enabler for a substantial mining sector in South Africa. In addition, whilst protectionism between the political economy and business sector is a common theme of the minerals/energy industrial complex model found across the world, in South Africa it was further exacerbated by the apartheid regime in that the model was defined along racial as well as class lines.

After 1994, and the introduction of economic policies to remove previous levels of state support and increase access to the free market, many state-owned enterprises (including Eskom) have still not transitioned from their vertically integrated monopoly model; This contrasts with a seismic shift in global electricity market structures. Through various degrees of deregulation, a set of electricity market models have been created, ranging from a hybrid of independent power producers (IPPs) and state-owned utilities to fully liberalised markets where generation is privately owned.

Coal has contributed to the South African economy for more than a century and remains a dominant part of the energy mix. About 80% of the total production of coal in RSA is undertaken in the Mpumalanga province and, consequently, most of Eskom's coal-fired plants are also located there. This has resulted in huge dependency on the exploitation of coal in the Mpumalanga regional economy and the municipalities of eMalahleni (Witbank), Steve Tshwete (Middelburg), Govan Mbeki (Secunda), and Msukaligwa (Ermelo) (TIPS 2021).

Figure 1-1: Map Eskom power stations and major transmission lines (source: Eskom, 2022)

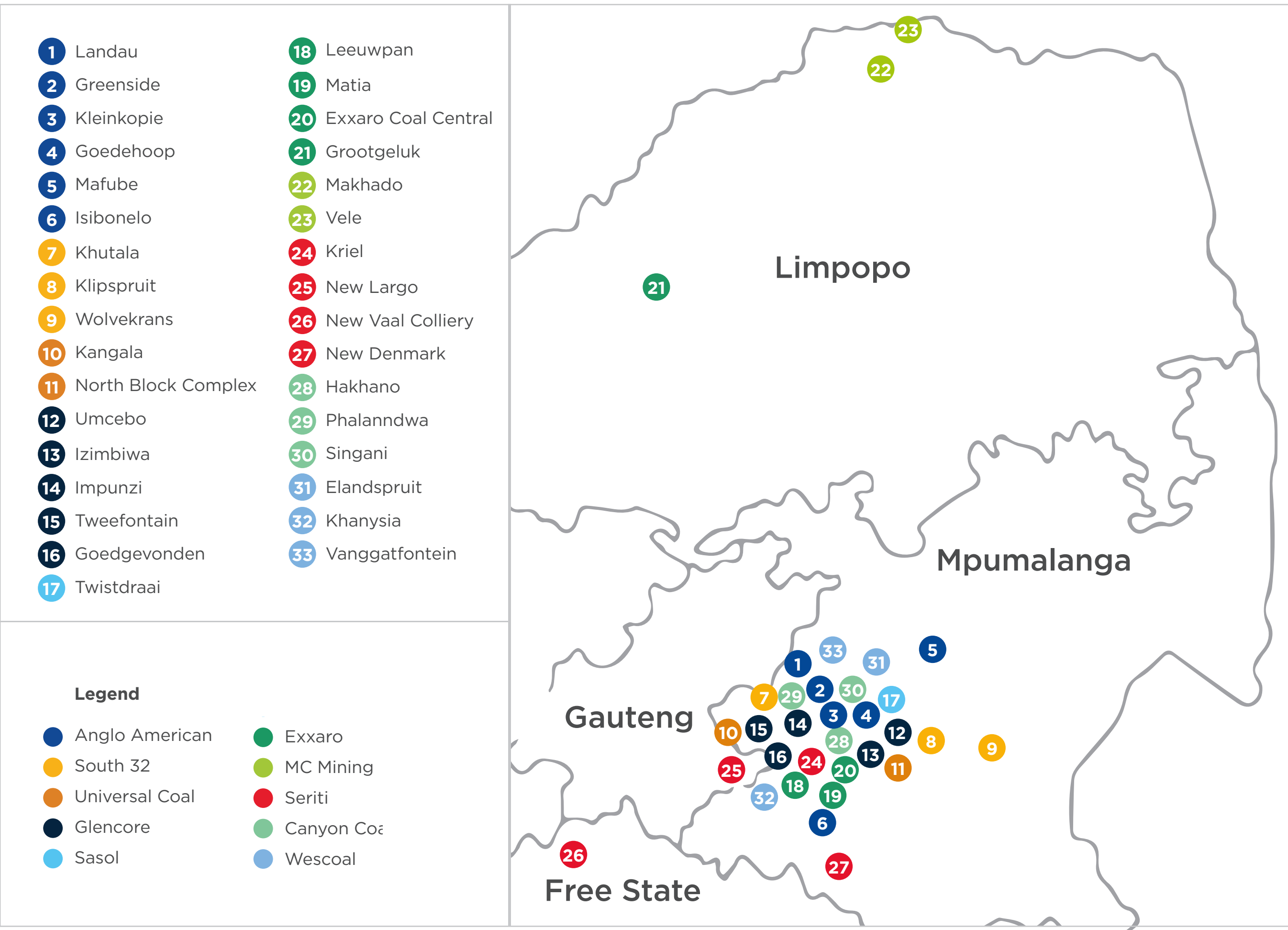


Figure 1-2: Coal mining areas in South Africa (source: Minerals Council South Africa, 2021)

South African stakeholders have accepted the inevitability that the country's energy economy must transition rapidly to a less carbon-intensive mix of generation technologies in the near future (NPC 2012, DMRE, 2019, COSATU, 2021, Planting, 2021). Now, decision makers need to communicate the related opportunities in a way that speaks to and galvanises people (IASS, 2021a). Whilst the setting out of the technoeconomic and socioeconomic pathways for South Africa's Just Transition is clear, the reality is somewhat more complicated.

- Whilst Just Transitions in other parts of the world have been primarily driven by civil society and organised labour, in South Africa the political economy has often meant that these groups are more fractured where leadership of these stakeholders has split allegiances and, in many cases, has been co-opted by business and/or government.
- Whilst governmental and labour positions have consistently promoted the idea of public ownership of renewable energy via Eskom and municipalities, fiscal constraints at a national level and dysfunctional municipal management throughout local government presently make such a model unfeasible.
- Access to green funding is one of the options for refinancing both part of Eskom's debt mountain as well as the Just Transition. However, the availability of concessionary or grant funding are increasingly conditional on companies such as Eskom and Sasol committing to a trajectory of net zero emissions by 2050.

1.2 Decommissioning and repurposing of coal-fired power plants in Mpumalanga

The transformation of the South African energy system is gathering momentum. IRP 2019 (DMRE, 2019) anticipates that some 11 GW of existing coal power stations will be taken out of service by 2030, and only Medupi and Kusile, and the additional 1.5 GW planned for in the IRP, are expected to remain operational by 2040. The IRP also formalises South Africa's energy transition, as it is expected that up to 2030 the bulk of replacement generation will be supplied by wind and solar PV, supported by natural gas-fired power generation and battery storage.

Without deliberate and detailed planning, the gradual phase-out of coal is expected to lead to substantial economic and socio-economic losses in the South African economy—and especially society—on a regional level. Both regional- and national-level plans are therefore needed to ensure that this undertaking is associated with the principles of a Just Transition, which include social inclusion, decent work for all, and the reduction of poverty.

As part of Eskom's Social Plan, the utility is considering options for repowering and/or repurposing the sites of coal-fired power plants that are planned to be decommissioned. Eskom is currently considering decommissioning four power plants, namely Camden, Grootvlei, Komati, and Hendrina, and also potentially a single unit at Arnot (Eskom Holdings SOC Ltd, n.d.; Fabricius et al. 2020).

Eskom has established a Just Energy Transition unit that is responsible for establishing a Social Plan to ensure an End-of-Life Management Strategy that acknowledges the need for a plan that properly addresses the environmental and socioeconomic legacies of fossil fuel exploitation. In March 2020, Eskom issued an Expression of Interest (EoI)[9] requesting interested parties to submit proposals for repurposing the power plants with cleaner technology based on four principles (World Bank 2020):

i. Re-use of the existing power transmission infrastructure,

ii. Development of new generation capacity needed in upcoming years,

iii. Providing relevant ancillary services to the system, and

iv. Mitigating the socio-economic impacts of the proposed site and operating asset changes.

In July 2021, Eskom published its planned projects for the just energy transition, recognising the major roles of renewable energy, battery storage, and natural gas in South Africa's energy transition.

Whilst consideration has been given to extending the life of several of Eskom's power stations due for decommissioning, most of the fleet has substantially exceeded minimum emissions standards (MES) as required under the Air Quality Act (AQA) since 2010.

[7] Eskom Expression of Interest "Decommissioned power station repurposing – Opportunities for innovative technology solutions to support a low carbon growth, enterprise development and sustainable jobs"

Whilst Eskom was granted postponement of compliance with MES for most of their plants in 2015 (for a 5-year period), revisions[8] to the AQA regulations in 2018 required Eskom to comply with the following:

1. Any power station that is to be decommissioned before 2030 can apply for a one-off suspension from new plant standards, conditional on there being a detailed decommissioning schedule.

2. Any power station that will be decommissioned post-2030 will need to comply with new plant standards by 2025 or else shut down.

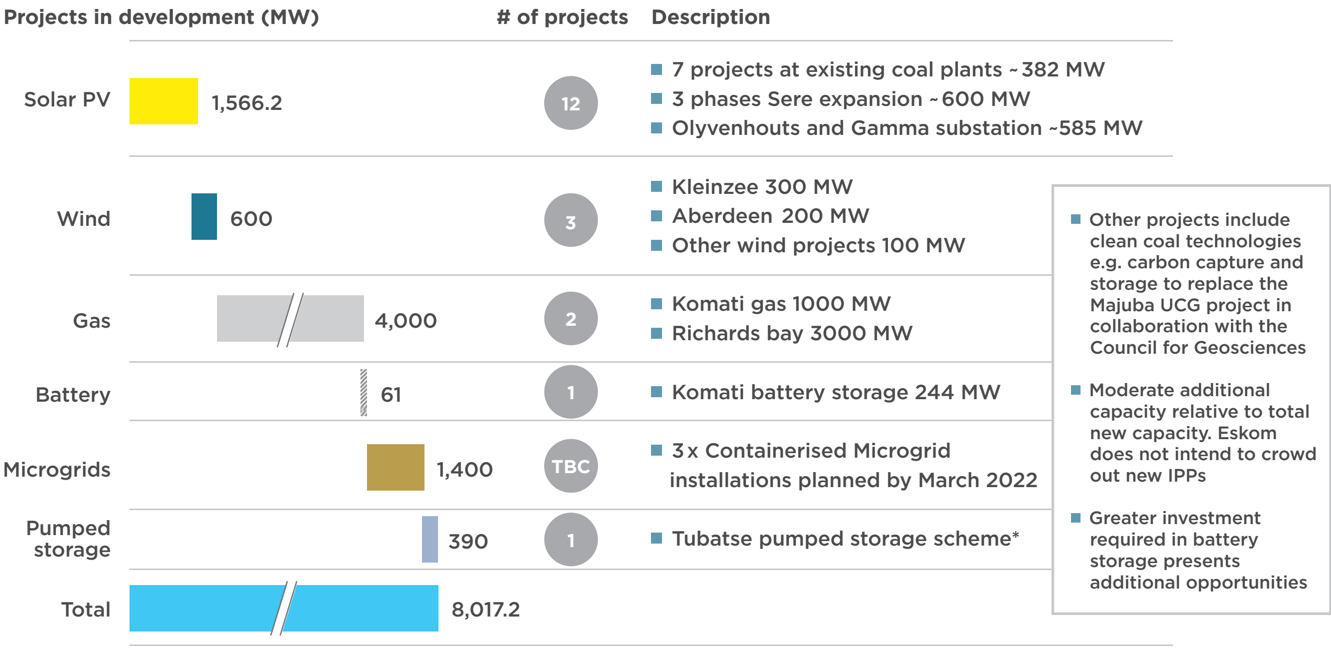


Figure 1-3: Eskom planned projects under JET programme (source: Eskom, 2021)

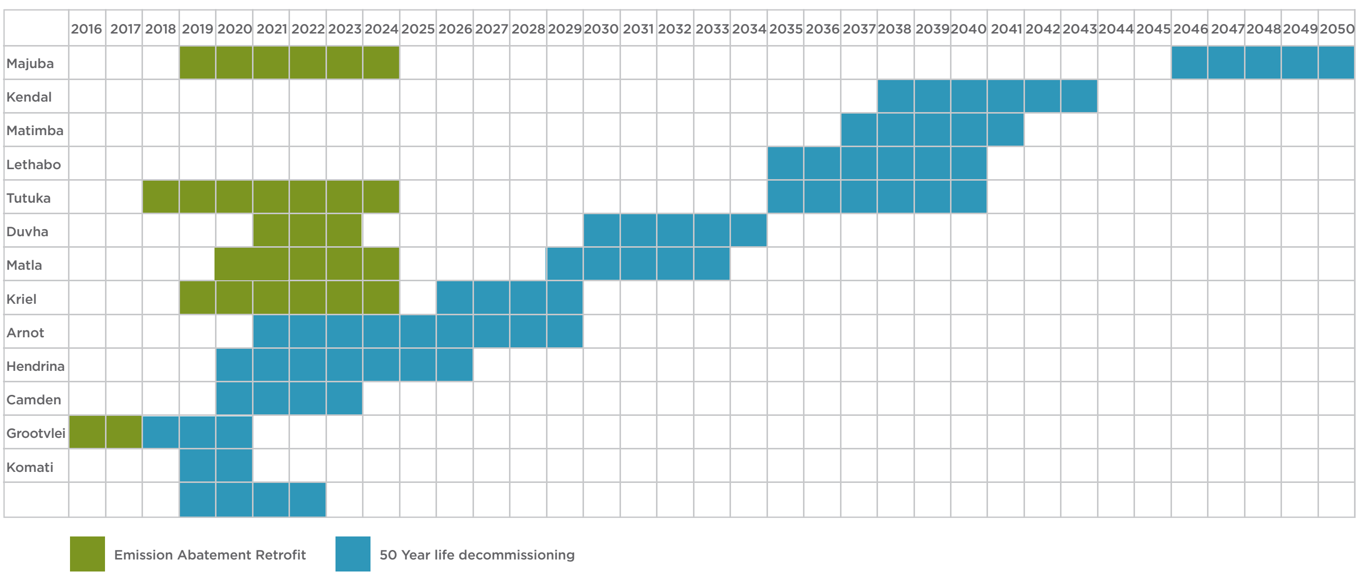


Figure 1-4: Emission Abatement Retrofit Programme and 50-year Life Decommissioning (source: DMRE, 2019)

[8] https://cer.org.za/wp-content/uploads/2018/10/National-Environmental-Managerment-Air-Quality-Act-39-2004-the-2017-National-20181026-GGN-41996-01144.pdf

1.3 Implications and opportunities of making Mpumalanga a hub for clean energy technologies

There are many implications and opportunities related to Eskom's decommissioning plan and the transition from coal to renewables in Mpumalanga.

- A successful post-decommissioning plan that demonstrates Just Transition dividends can allow South Africa to commit to more ambitious NDCs with the support of social partners.

- The repurposing of power stations by means of clean generation technologies is an effective way of ensuring that the region remains economically active and meets socio-economic objectives in a cost-effective manner.

- Increased wind and solar deployment (for both energy security and green hydrogen production) will support industrialisation of the renewable energy value chain as anticipated in the South African Renewable Energy Masterplan (SAREM).

- The creation of new investment and employment opportunities in Mpumalanga, resulting from the transition to a green economy, must also consider the need to reskill coal sector workers.

- The available grid infrastructure in Mpumalanga is a crucial asset for developing renewable energy within the province.

- The rehabilitation of contaminated land for clean energy technologies is a crucial element that needs to be considered.

- Accelerated coal closure will allow Eskom greater access to green concessionary finance.

- Increased renewable energy deployment will align South Africa's power development more closely with least-cost planning.

- Alignment with the National Development Plan (NDP) recommendation to declare Mpumalanga a Just Transition "hot spot" to implement Just Transition projects, the Sustainable Development Goals (SDGs), and regional development strategies (e.g., the Mpumalanga Green Economy Cluster).

1.4 Policies for the transition driven by the Mpumalanga provincial government

Next to the decommissioning plans from national level, the provincial government is also actively pushing for green prosperity opportunities in Mpumalanga. This includes: (1) the Mpumalanga Green Growth Strategy; (2) The Mpumalanga Green Economic Cluster; and (3) the development of trade and industrial policy strategies.

Policy 1: Green growth strategy

In 2016 the Mpumalanga Provincial Government published a Mpumalanga Green Economy Development Plan setting out its ambitions for the green economy. The plan, under the leadership of the Mpumalanga Department of Economic Development & Tourism (DEDT), looked to build on a number of provincial policies developed since 2013 and in recognition of the need to diversify the Mpumalanga economy away from its dependence on fossil fuel and extractive industries. In particular, this looked to build on previous positions articulated in:

- The 2011 Mpumalanga Economic Growth and Development Path

- The 2013 Vision 2030 for the Mpumalanga Province

The plan took lessons from similar green economy plans developed by other provinces since 2010, and aims to shift Mpumalanga's reliance on coal-based energy toward developing green and biomass-based energy, sustainable agriculture, tourism, and "eco-conscious towns" by 2030, and focused on the following specific objectives:

1. Developing a sector plan based on the province's strengths in natural resource endowments

2. Expanding on the economic, green, and environmental initiatives that were already underway in the province to facilitate quick wins

3. Supporting the DEDT's drive on sustainable economic development

4. Developing an action for implementation

Policy 2: Mpumalanga green economy cluster

To develop the recommendations in the Green Economy Development Plan and the National Planning Commission's (NPC) Pathways to a Just Transition process in 2019 of creating a "hot spot" in Mpumalanga to establish Just Transition projects, DEDT entered into a formal Memorandum of Understanding (MOU) with the Green Cape Sector Development Agency[9] (GreenCape) in 2020 to develop a set of interventions that would assist the province in establishing a green economy.

The results of this collaboration have seen the establishment of briefing reports related to green economy opportunities in the water, energy, and agriculture sectors in the province.

Policy 3: Trade & Industrial Policy Strategies (TIPS)

Much of TIPS' work in Mpumalanga on industrial policy has been viewed through the lens of the Just Transition, with green economy or sustainability solutions explored as potential diversification options to draw in workers from impacted value chains. In addition, it includes a focus on climate-compatible industrial development.

1.5 The gender imbalance in the current electricity sector

The coal and electricity sectors in South Africa are heavily male-dominated. According to Eskom (2021) and MQA (2021), female employment is 31% within Eskom and 21% in coal mining. However, overall, women working in the South African electricity sector today are more highly skilled: 67% of female employees have a post-matric qualification compared to 49% of their male counter-parts (see tables 1-1 and 1-2). Nevertheless, in the coal power sector (Eskom) female employment is consistently around 30% for all occupational skill levels (see Table 1-3). Women only occupy the majority of jobs within Eskom's finance sector and as clerical support staff, at 72% and 63% respectively.

The low representation of females in the coal sector is driven by the traditional image of the mining sector, underpinned not only by strong and persistent perceptions but also real experiences, as one of those sectors considered unsuitable for women. Only a few 'light' or 'physically less demanding' areas of work, such as catering/cooking, cleaning, caregiving, and other similar activities are considered suitable for women (Mangaroo-Pillay & Botha, 2020). However, addressing female participation in the labour market is not only crucial to promoting gender justice, equity, and inclusiveness: Ignoring gender imbalances also fails to tap economic opportunities for the region, communities, and households (IASS, 2021b).

As an emerging sector, renewable energy provides an opportunity for women to participate, as it lacks the established "male industry" perceptions of the old energy industry (IASS, 2021b). However, females are still underrepresented, accounting for only 14% of employees within the sector (IPP Office, 2020). The IPP Office also reported that construction procurement from women-owned vendors represented 5% of total procurement, compared with 4% commitment and 5% target. Operational procurement of 6% has been achieved, exceeding the 5% target. The SED[10] spending on education has shown that women and girls have received 60% of total bursaries. Although the renewable energy sector is currently also male dominated, leading organisations in the sector are providing mentorship and coaching opportunities for women to take on leadership roles (see also chapter 5).

[9] GreenCape is a non-profit organisation established in 2010 to drive the widespread adoption of viable green economy solutions in the Western Cape Province.

[10] Socioeconomic development scheme.

Highest qualification	Female		Male	
	Number of employees	Percentage	Number of employees	Percentage
No formal school qualification	42	2%	301	7%
Primary	3	0%	93	2%
Secondary	26	1%	368	8%
Matric	621	30%	1528	34%
Certification	484	24%	961	21%
Degree or Diploma	874	43%	1236	28%
Total	**2050**		**4487**	

Table 1-1: Eskom employee education level, by gender

Source: Eskom, 2021

Employment sector	Female		Male	
	Number of employees	Total share	Number of employees	Total share
Artisan (skilled to high-skilled)	125	6%	506	11%
Clerical support workers (skilled)	359	18%	215	5%
Elementary occupations (low-skilled)	19	1%	119	3%
Finance (skilled to high-skilled)	106	5%	42	1%
Learner (unskilled)	35	2%	29	1%
Managers (high-skilled)	157	8%	250	6%
Plant/machine operators and assemblers (semi-skilled to skilled)	356	17%	1473	33%
Professionals (high-skilled)	115	6%	263	6%
Technicians and associate professionals (skilled to high-skilled)	769	38%	1595	36%
Total	**2050**		4487	

Table 1-2: Eskom employees per occupation group, by gender

Source: Eskom, 2021

Occupation skill-level	Female		Male	
	Number of employees	Gender share	Number of employees	Gender share
Total	**2050**	**31%**	**4487**	**69%**
Skilled to high-skilled	**1272**	**32%**	**2656**	**68%**
Artisan	125	20%	506	80%
Finance	106	72%	42	28%
Managers	157	39%	250	61%
Professionals	115	30%	263	70%
Technicians and associate professionals	769	33%	1595	67%
Semi-skilled to skilled	**715**	**30%**	**1688**	**70%**
Clerical support workers	359	63%	215	37%
Plant/machine operators and assemblers	356	19%	1473	81%
Unskilled to low-skilled	**54**	**27%**	**148**	**73%**
Elementary occupations	19	14%	119	86%
Learner	35	55%	29	45%

Table 1-3: Eskom employees per occupation skill-level and gender

Source: Eskom, 2021

2. Methodology and approach for quantifying the impacts of the Mpumalanga transition

The objective of this study is to calculate and quantify the socio-economic benefits of repurposing coal power plants and deploying renewable and other clean energy technologies in Mpumalanga. The impacts are quantified in terms of employment effects, skill development needs, and industrial opportunities.

The socio-economic effects of the energy transition have been assessed for many regions and countries around the world.[11] Whereas climate negotiations were previously dominated by the notion of "burden sharing", socio-economic opportunities and "oppor-tunity sharing" have now moved to the centre of the debate (IASS, 2017).

2.1 Four regional power generation scenarios

The scenarios explored in this assessment for Mpumalanga aim to depict a spectrum of increasingly ambitious and rapid energy transition.

Scenario 1 is considered as the base case and is founded on IRP 2019. Scenarios 2 to 4 are based on options that were applied in previous reports and discussed with key stakeholders in South Africa (e.g., Eskom, DMRE, etc).[12]

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).

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 also 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.

[11] For all analysis carried out under the framework of the COBENEFITS project, see https://www.cobenefits.info/

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

[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.

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).

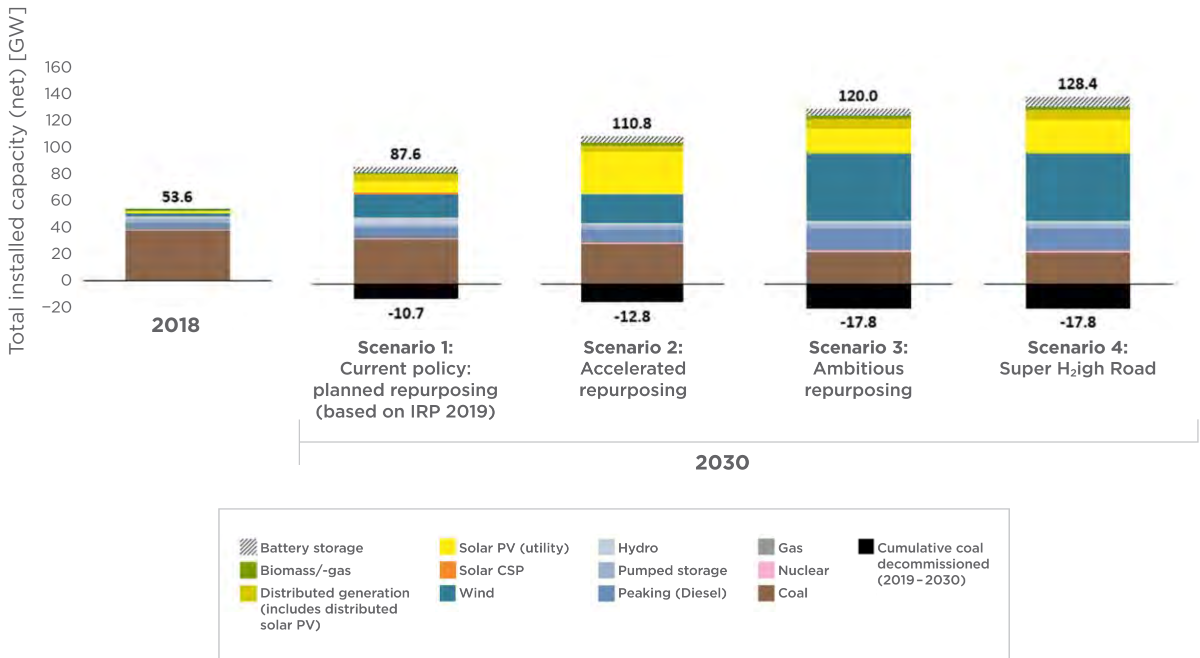


Figure 2-1: COBENEFITS South Africa: Power system reference scenarios Installed capacity (GW) (source: IRP 2019, CSIR Energy Centre analysis)

2.2 Assumptions regarding installed capacity in Mpumalanga in relation to national deployment

Most scenarios for the development of the electricity sector in South Africa have a national focus. For the purposes of this study, assumptions needed to be made about how much of the national deployment of renewables can be realised in Mpumalanga (see Table 2-1). The wind and solar PV assumptions were based on discussions with industry experts, who provided an indication of what they thought may be feasible. For distributed solar (DPV), an assessment of the number of households and Mpumalanga gross value added (GVA) by sector was used to provide a view on this potential. Battery storage followed the lower bound of solar PV and wind. Biomass assumed absolute numbers, with an incrementally higher amount for Mpumalanga as one of the regions with high biomass and government interest in sector development. The assumptions were used to aid initial estimates of the impact of increased shares of renewable energy in Mpumalanga.

Table 2-1: Mpumalanga share of national capacity

Source: assumptions based on discussions with industry insights

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

Historically, investors have not focused on Mpumalanga as a location for renewable energy installations, because its solar and wind resources were seen as less attractive than those of other provinces (as measured by REIPPPP). However, constraints on grid transmission capacity presently put Mpumalanga at an unexpected advantage. Eskom's Generation Connection Capacity Assessment (GCCA) 2023 Phase 2, which was released in October 2021, shows that Mpumalanga has the highest potential connection capacity in the country (see also IASS, 2021c).

2.3 Qualitative and quantitative assessment methodologies

Combined with the above qualitative methods, quantitative analysis is used to estimate the gross impacts of increased renewable energy deployment arising from each scenario. This employed a combination of modelling from the International Jobs and Economic Development Impacts (I-JEDI) model and desktop literature to estimate the additional jobs/MW for distributed solar PV and battery storage. Two levels of local content are explored. A qualitative analysis included a review of the existing literature and inputs from industry experts to obtain a view on resource potential, transmission considerations, land considerations, and mining employment considerations. Figure 21 provides a brief overview of the research methodology; A more detailed description is included in IASS, 2021c.

Employment effects	Value creation & localisation	Skill requirement
▪ Quantify impact on coal-related employment using I-JEDI model ▪ Quantify potential employment from RE deployment using I-JEDI model ▪ Identify Jobs/MW estimate for battery storage in literature ▪ Quantify net employment effects	▪ Conduct literature review of current Mpumalanga initiatives ▪ Produce value chains for coal and RE using a literature review to identify supply chain needs ▪ Quantify value creation from RE value chains using I-JEDI model	▪ Collect skills data from relevant parties (e.g., Eskom, Minerals Council, MQA) ▪ Conduct interviews with experts to assess RE skill requirements ▪ Analyse potential skills that can be transferred

Figure 2-2: Summary of research methodology (source: own)

Quantification of employment impacts and value creation potential

The I-JEDI input–output model was used to quantify the gross employment effects (job losses in the coal sector and job creation in renewables) and impacts on local value creation.[15] The model is capable of quantifying positive and negative impacts associated with the deployment and decommissioning of different power generation technologies. I-JEDI estimates job numbers in terms of direct, indirect, and induced categories as defined below; examples are provided in Figure 23:

- **Direct jobs** are those directly related to the power plant.
- **Indirect jobs** are associated with activities related to the power plant.
- **Induced jobs** are those that arise from economic activity in the area, but which are not directly related to the power plant.

Figure 2.3: Direct, indirect, and induced jobs (source: Adapted from NREL by SAPVIA; CSIR, 2021)

The model allows for the assessment of job impacts arising from differing levels of local content, and provides outputs in terms of different parts of the value chain and associated industries.

Data to quantify coal mining impacts

To quantify the employment impact of the mining sector in relation to power generation, baseline data were obtained from the MQA (2021), which provided total employment by mine for companies that submitted their information. The mines that supplied information on specific power plants were then identified, and a jobs/MW number was then calculated.

Literature review to estimate the impact of battery storage and hydrogen deployment

A literature review was conducted to quantify the number of jobs resulting from an increase in battery storage. Due to variations in numbers, and because South Africa is still a growing market for battery storage, a range approach was employed.

For the hydrogen analysis, a literature review was conducted to assess how much renewable energy was required for the take-off of the green hydrogen economy. Estimates were based on expert insights, and also leveraged from the work conducted by IHS Markit in April 2021 on the Super H2gh Road scenario.

Data to assess skill levels, skill gaps, and gender-inclusivity

To analyse the skills and gender balance in the coal industry, and to assess the potential for transferring expertise to the renewable energy sector, employee data were sourced from Eskom (2021) and MQA (2021) respectively; employee data included: age, gender, highest qualification, job description, and years of service.

[15] The model was developed by the National Renewable Energy Laboratory (NREL) and adapted by CSIR for South Africa.

The skills required for renewable energy technologies in South Africa were sourced from a literature review and interviews with EPC contractors and SARETEC. Data on gender considerations were collected through a literature review, together with expert interviews with the South African Local Government Association (SALGA) and four Enterprise Development (ED) managers involved in wind and solar plants.

Skills can be measured based on qualifications and/or occupations. In this report, both educational qualifications and occupations are used to evaluate the skill levels of workers in the old energy sector. The analysis aims to determine whether skills presently found within the old energy sector could be utilised in renewables or other sectors within the province.

Skills Development

- What are education and skill levels in old energy sector?
- What are skill attainment levels of RE sector?
- Can the needed skillset be sourced from old energy sector?
- Training facilities that currently exist to re-skill/ up-skill workers

Gender Consideration

- Gender balances in the old energy sector
- Current female participation in workforce
- Societal challenges facing women that could hinder balanced participation in RE sector
- Barriers for women in RE sector
- Programmes to mitigate barriers in RE sector

Figure 2-4: Methodology to assess skills and gender inclusivity in the electricity sector

2.4 Scope of the study

This assessment focused on the Mpumalanga province of South Africa as the main area that is to be affected by the transition away from coal. Since most previous studies have focused on the national level, this regional analysis can provide new insights for steering the energy transition politically. This focus on Mpumalanga requires making various assumptions and approximations, which will need to be tested and quantified in future research.

The local content assumptions were informed by I-JEDI modelling (described previously) as well as data from the Department of Trade, Industry, and Competition (dtic) and inputs from industry. Local content assumptions are a key component of the modelling, as they inform what value and how many jobs are created. An attempt was made to ascertain local content potential for Mpumalanga; however, this was unsuccessful as developers view information on localisation as their competitive advantage; furthermore, the RE market in Mpumalanga is under-developed. Therefore, for the purpose of the modelling exercises, the national-level assumptions were assumed to apply to Mpumalanga.

Ascertaining local content is challenging because the potential for local content differs vastly according to how the market develops—which is currently occurring very rapidly. The assumption made is that there will be a steady demand for alternative energy, that will allow for the development of a private market in addition to continuation of the REIPPPP. Based on discussions with industry experts, developers could decide, in addition to the initial local content opportunities, to also focus on other parts of the value chain that may not yet be developed, e.g., manufacturing blades for wind turbines. Consequently, further work is required to understand what local content levels might be achievable under varying national and local roll-outs of new renewable energy capacity—especially for Mpumalanga, if enticing policy interventions and resultant investments could be realised.

Employment related to battery storage is not covered by the I-JEDI model, thus the literature review provided insight into the employment potential of this sector. The shortcomings of the numerical data obtained from the literature review, which was sourced from international markets, are that South Africa does not have detailed reporting on jobs numbers from the battery storage market.

Similarly for hydrogen, the numbers of jobs directly related to hydrogen production are not well established internationally, and so the available literature provided limited insight into these job intensities. However, it was possible to model renewable energy deployment numbers for this scenario, whereas a more detailed investigation of the jobs required in the production and use of green hydrogen is required in order to quantify the full impact of the hydrogen economy.

The role of gas in Mpumalanga was beyond the scope of this study, so was not explored. However, it should be noted that there is a potential role for gas in repowering some of the current coal-fired power stations.[16] However, the use of gas would perpetuate greenhouse gas emissions, and therefore any investment in gas would need to consider deep decarbonisation requirements in line with the Paris Agreement. Given the multi-fold global warming potential of gas (methane)—and the related risks of fugitive emissions from gas exploration, transport, and use: fossil gas "cannot be recommended as feedstock of sustainable energy systems nor as a bridging fuel for the transition towards a renewables-based energy system" (IASS, 2016). In addition, reliance on gas involves a very high risk of stranded assets, since the electricity sector needs to be fully decarbonised by 2050 (IEA, 2021).[17] Future research should assess whether or not, in practice, there would be any requirement at all for gas capacity as a balance for renewable energy generation, particularly in light of persistently declining costs of battery storage.

There is currently limited data on the land impacted by (coal) mining. For future research, it is essential to obtain data on how much land is impacted and needs rehabilitating, in order to assess how much of that land can be used for renewable energy deployment versus other productive uses.

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

[16] Natural gas has comparatively low investment costs (especially for open cycle gas turbines), as the existing power station infrastructure can be converted (Gerbelová, Spisto, and Giaccaria 2021, 110). Mpumalanga is close to Mozambique, which has abundant gas reserves, and the existing 865-km ROMPCO gas pipeline could be available for additional imports. Additional costs will be incurred to connect to the gas pipeline (ibd.).

[17] In addition, this would involve increasing South Africa's dependency on natural gas imports, which would present similar problems to the current dependence on oil and gas imports to meet fuel needs.

3. Methodology and approach for quantifying the impacts of the Mpumalanga transition

Employment:

- **When analysing South Africa as a whole, the transition away from coal towards renewables will result in net job gains until 2050.** By this horizon, more than 150,000 jobs will have been created in the power sector (IASS/CSIR, 2019). However, this is not necessarily the case for Mpumalanga province specifically: Most coal-fired power plants are based in Mpumalanga; however, not all renewable energy deployment with take place in the province, and hence the energy transition as it is currently planned will result in net job losses in the province's electricity sector by 2030 (see Figure 321). 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.
- **However, Mpumalanga can compensate all job losses in the declining coal sector by investing heavily in renewable energies in combination with creating a regional manufacturing hub for the clean energy sector.** 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 than under the current IRP 2019 Scenario (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).
- **The two most important technologies for the energy transition in South Africa and Mpumalanga will be wind energy and solar PV.** 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 on a per-MW basis. However, the restricted potential for sustainably produced biomass and the competition for biomass use from other sectors constrain scalability.** In total, 4,600 (1,400 direct, 1,400 indirect, and 1,800 induced) jobs 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.
- **Battery storage can create 36,000 additional jobs under the IRP 2019 scenario and 46,000 jobs under the Super H_2igh Road Scenario,** based on employment factor estimates from the US.
- **The number of jobs lost in the coal sector (operation and maintenance jobs) will depend on the number of power plants decommissioned.** Therefore, any schedule for accelerated decommissioning of coal needs to be accompanied by faster upscaling of renewable and clean technologies. In the IRP 2019 scenario (10.7 GW decommissioned), 74,000 FTE O&M jobs (22,000 direct, 23,000 indirect, and 29,000 induced) would be lost at coal-fired power stations, compared with the loss of 124,000 FTE O&M jobs (36,000 direct, 39,000 indirect, and 49,000 induced) in Scenarios 3 and 4 (17.8 GW decommissioned). The estimated reductions in O&M jobs are cumulative for the period 2019 to 2030. However, not all job losses in Mpumalanga's fossil fuel sector can be compensated by clean energy jobs. Hence, coal decommissioning would result in net job losses in the province by 2030.
- **Direct job losses in the Mpumalanga coal sector are lower than total job losses (direct, indirect, and induced).** 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.

This section assesses the regional employment effects associated with the energy transition in Mpumalanga. The first part of the assessment involved looking at the negative impact on jobs in the coal sector, focussing on coal power plants and the related coal mines. The second part of the assessment considered potential job creation arising from the expansion of clean technology solutions in the region. To analyse the impact of localisation on value creation, the jobs in each scenario were modelled at a moderate level (assuming national levels for local content and growth) and a more ambitious local content level for each scenario (details on each, and modelling assumptions, are provided in IASS (2021c). The last part of this assessment illustrates the resulting jobs differential for each scenario.

3.1 Employment impact on the coal sector in Mpumalanga

The closure of coal power stations and mines in Mpumalanga will result in job losses, including direct as well as indirect and induced jobs in the extended network of suppliers and merchants relying on the economic activity of power plants as anchors of employment. However, these job losses will occur gradually, and policymakers have the chance to anticipate this process and prepare the transition of workers.

In this study, four different scenarios were assessed, involving varying extents of coal decommissioning between 2020 and 2030 (see Section 2.1).

The modelling forecasts depict job losses in the Mpumalanga region for coal power stations and related employment, as well as the coal mining industry in Mpumalanga (see Table 3-1). The potential for transferring coal workers to the clean energy sector or to other industries in Mpumalanga is not depicted in this analysis. However, net effects will be presented in Section 3.1.3.

It should be noted that the I-JEDI forecasts speak not only to jobs at the power stations, but all related employment, including indirect and induced jobs. Coal mining-related employment is considered under indirect employment. Although the model provides outputs for both construction and O&M jobs, only operational jobs were considered when assessing job losses, since those are assumed to still exist and would be impacted by decommissioning.

Employment impact related to decommissioning coal power stations

The total number of full-time equivalent (FTE) employment losses under Current policy: planned repurposing (IRP 2019) scenario (1) for 2019–2030 is expected to amount to 74,000 FTE job losses (22,000 direct, 23,000 indirect, and 29,000 induced) (see Figure 3-1).

Accelerated repurposing scenario (2) represents an accelerated decommissioning of additional coal-fired power plants, and results in an additional 33% loss in FTE employment for the same period, amounting to 88,500 FTE job losses (26,000 direct, 28,000 indirect, and 35,500 induced) (see Figure 3-2).

The most ambitious decommissioning schedules, in the Ambitious repurposing scenario (3) and the Super H_2igh Road scenario (4), assume the same level of decommissioning. The total number of FTE employment losses almost doubles compared to the Current policy: planned repurposing (IRP 2019) scenario (1), amounting 124,000 FTE job losses (36,000 direct, 39,000 indirect, and 49,000 induced), an increase of 50,000 FTE job losses (see Figure 3-3).[18]

Scenario	Decommissioned Capacity (MW)
Current policy: planned repurposing (IRP2019) (1)	10,682
Accelerated repurposing (2)	12,756
Ambitious repurposing scenario (3)	17,815
Super H_2igh Road Scenario (4)	17,815

Table 3-1: Decommissioned capacity in Mpumalanga per scenario

Source: CSIR Energy Centre Analysis

[18] This reduction in employment without contingency planning will exacerbate the region's already high unemployment levels. South Africa's prevailing unemployment rate of 34.4% greatly exceeds the global unemployment rate of 6.47% (World Bank 2021b).

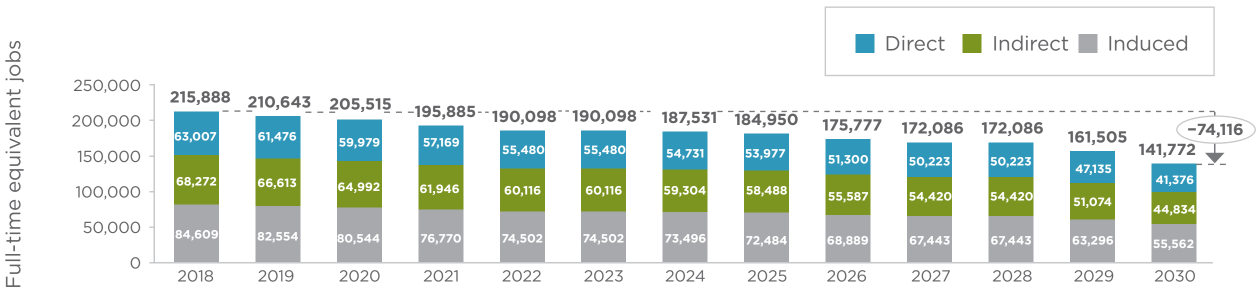


Figure 3-1: Current policy: planned repurposing scenario (IRP 2019) scenario (1) cumulative annual job losses (source: I-JEDI)

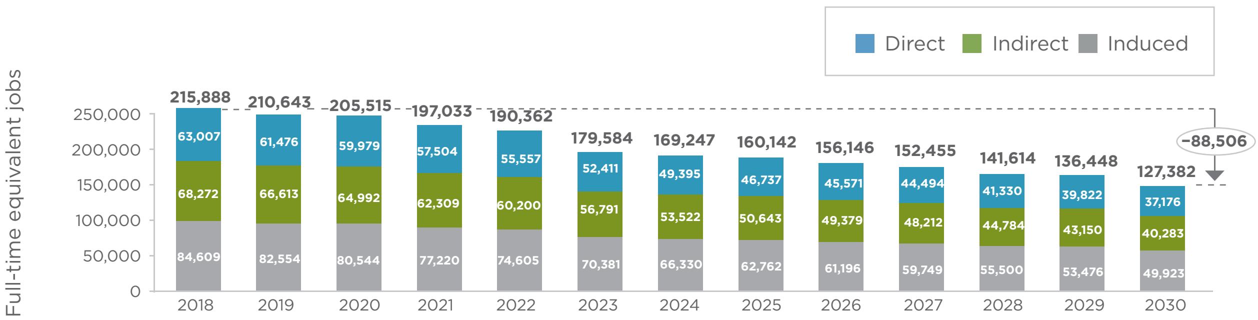


Figure 3-2: Accelerated repurposing scenario (2) cumulative annual job losses (source: I-JEDI)

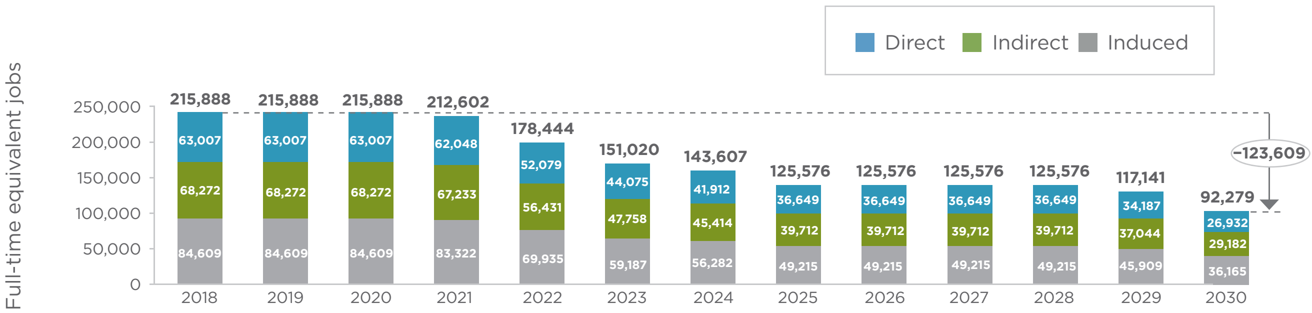


Figure 3-3: Ambitious repurposing scenario (3) & Super H₂igh Road Scenario (4) cumulative annual job losses (source: I-JEDI)

Impact on direct employment at Eskom power stations

The I-JEDI model provides results for utility FTE losses, which would theoretically represent Eskom's direct employment losses. In the Current policy: planned repurposing (IRP 2019) scenario (1), utility FTE losses are expected to be 6,500 over the period 2019–2030 (see Figure 3-4), versus total direct job losses of 21,600. The remaining losses are attributed to other sectors of the economy. Under the Accelerated repurposing scenario (2), the expected FTE employment losses amount to 7,800, representing an ~20% increase, versus total direct job losses of 25,800 (see Figure 3-5). Potential utility FTE losses for the Ambitious repurposing scenario (3) and the Super H₂igh Road Scenario (4) were 11,000, versus total direct job losses of 36,000, representing an increase of ~65% compared with Current policy: planned repurposing (IRP 2019) scenario (1) (see Figure 3-6).

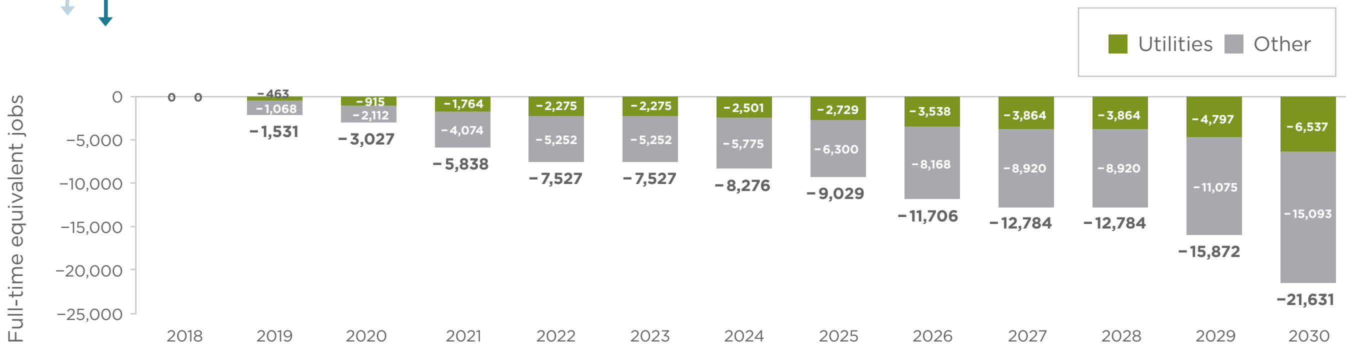


Figure 3-4: Current policy: planned repurposing scenario (IRP 2019) (1) direct utilities job losses (source: I-JEDI)

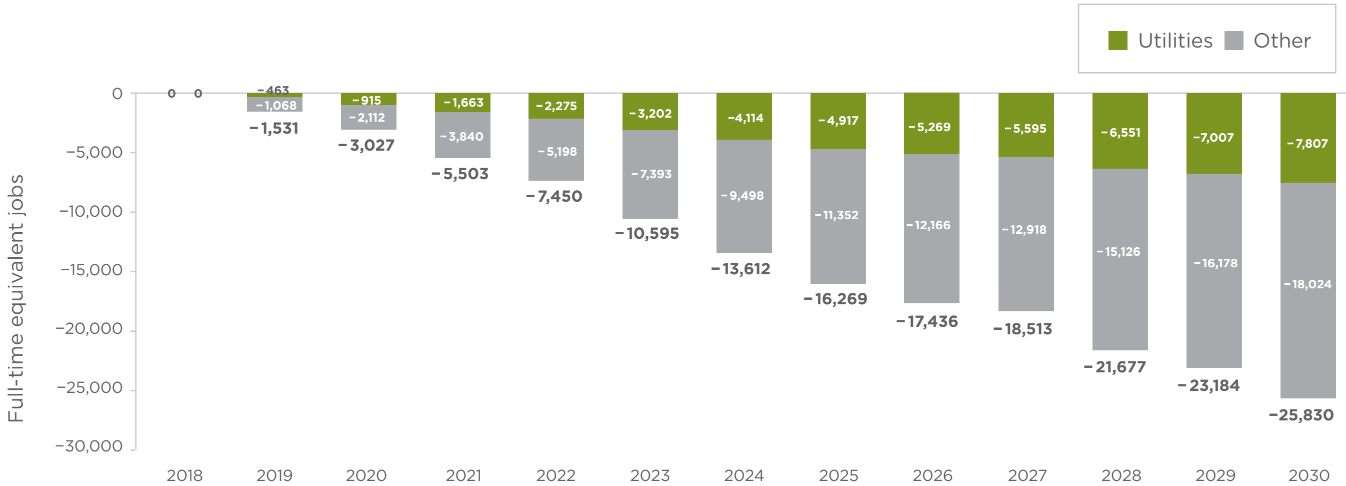


Figure 3-5: Accelerated repurposing scenario (2) direct utilities job losses (source: I-JEDI)

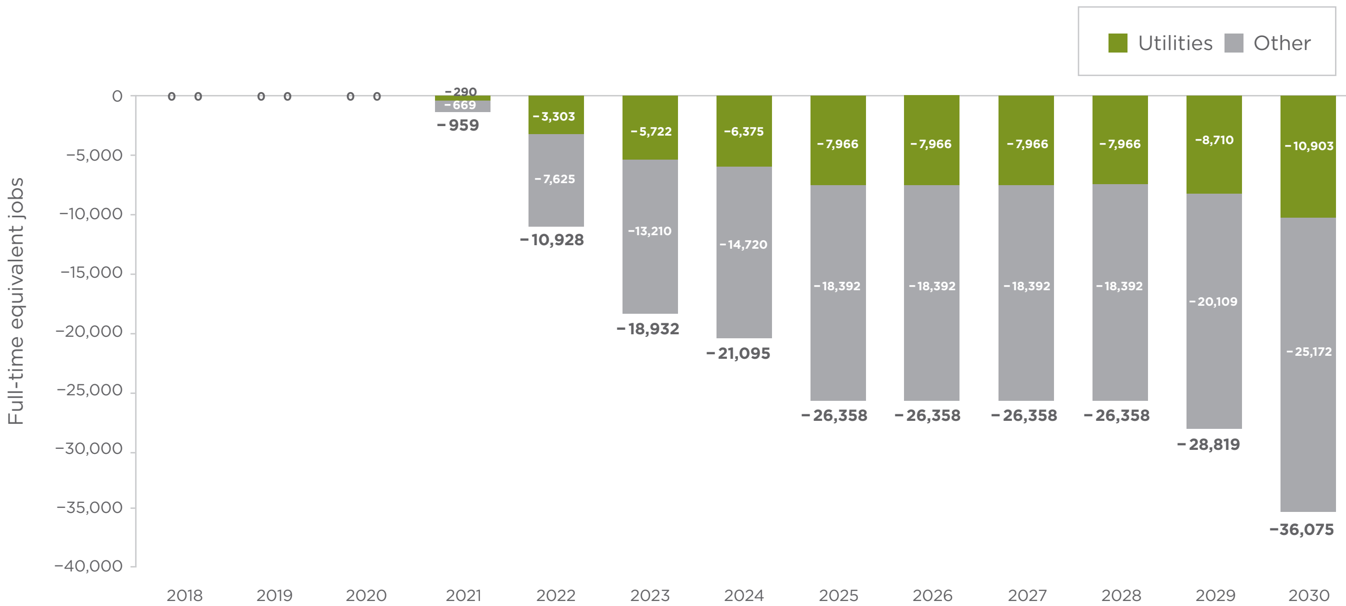


Figure 3-6: Ambitious repurposing scenario (3) and Super H_2igh Road Scenario (4) cumulative annual job losses (source: I-JEDI)

In sum, compared with real-world 2018 job levels in the coal sector in Mpumalanga, even the currently planned decommissioning of coal-fired power plants under the IRP 2019 will lead to a drastic decline in employment. Most job losses will not occur directly within the Eskom power stations but as indirect or induced job losses (see Figure 3-7). Therefore, dedicated policy measures are needed to support employees in the transition to new sectors (see also chapter 5 on skills), irrespective of the speed of coal decommissioning in Mpumalanga.

Employment losses for the ambitious decommissioning will result in ~85% more job losses compared to the IRP scenario; similarly, direct utility job losses will increase by ~65%.

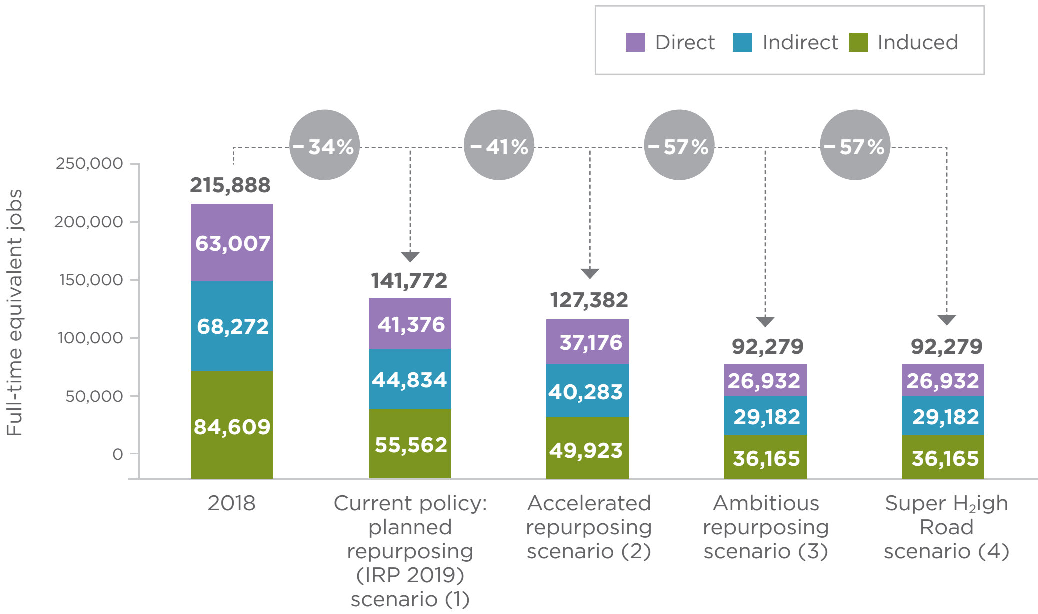


Figure 3-7: Job losses per scenario (source: I-JEDI)

Impact on the coal mining sector in Mpumalanga

Coal is the second-largest employer in South Africa's mining sector, with approximately 91,459[21] employees in 2020, accounting for approximately 20% of total mining employment. This study assesses potential job losses in coal mining, resulting from the ripple effect of closing Mpumalanga's coal-fired power stations.

Coal sales are split between local consumption and exports. Eskom's coal-fired power plants account for the largest share of local consumption, representing approximately 47% of total consumption. The majority of the 33 operational coal mines (see IASS (2021c) for detailed map) that are registered members of the Minerals Council South Africa (MINCOSA) are located in Mpumalanga. There are many smaller coal mines scattered across the province, which are not members of MINCOSA and therefore not included in this study.

Direct employment losses until 2030 amount to 4,800 in Current policy: planned repurposing (IRP 2019) scenario (1), increasing by 19% to 5,764 in Accelerated repurposing scenario (2). In Scenarios 3 and 4, job losses are 67% higher than under Scenario (1), with an estimated 8,000 FTE losses by 2030 (see Figure 3-9). To calculate these numbers, employment data were sourced from the MQA (2021) and from research conducted on which mines may supply specific power plants (see IASS (2021c) for details).

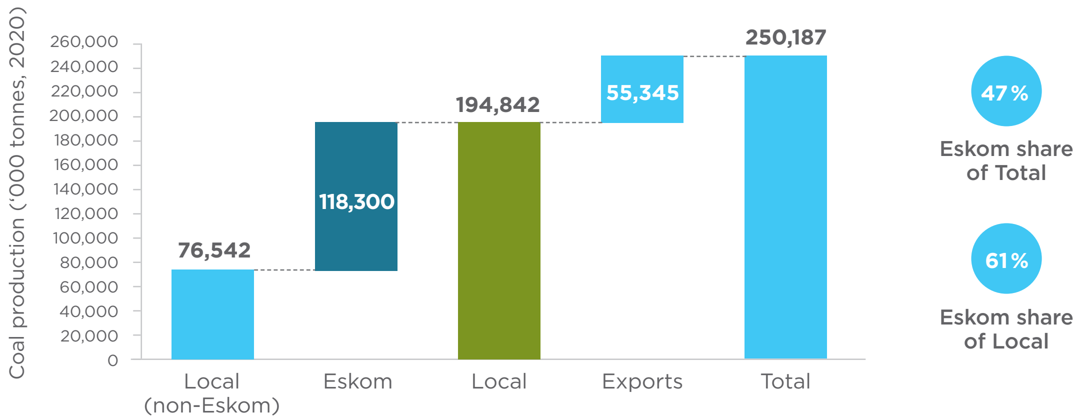


Figure 3-8: Coal production and consumption (source: MCSA, 2020)

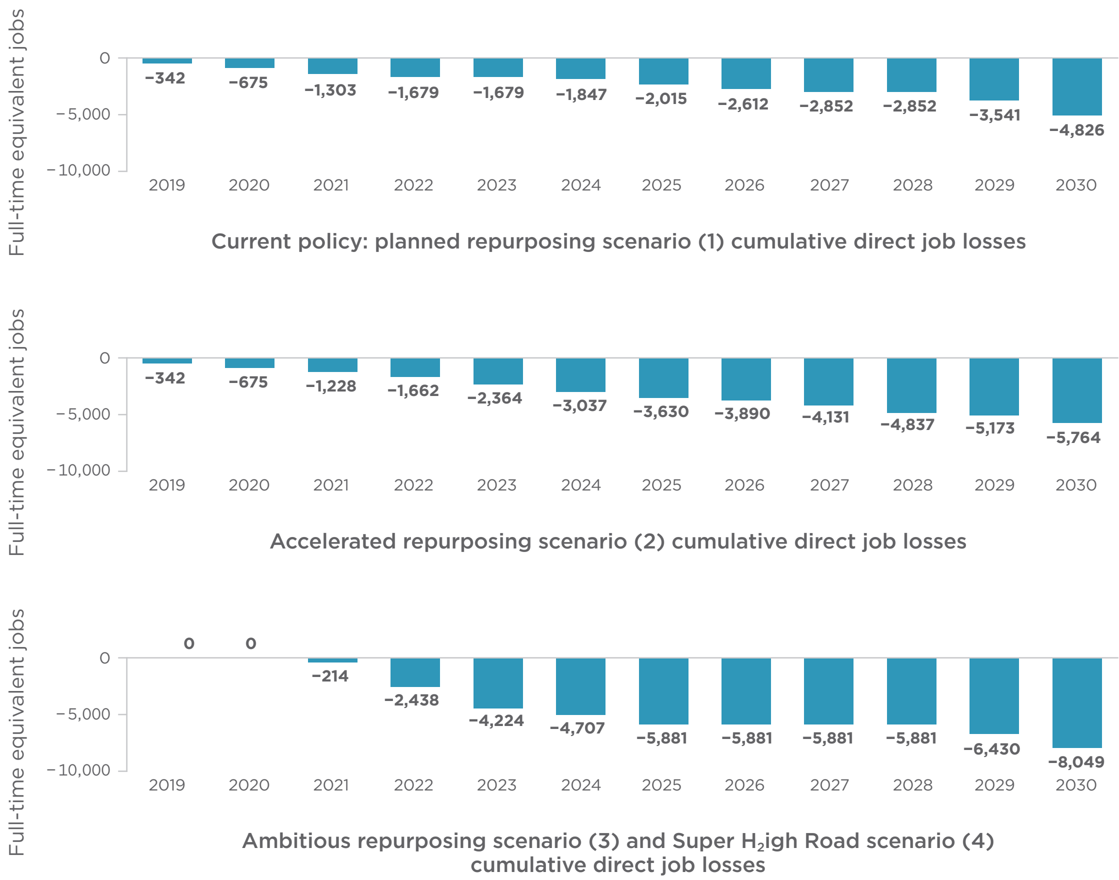


Figure 3-9: Cumulative annual mining job losses (source: own calculation)

3.2 Renewable energy, battery, and hydrogen potential in Mpumalanga

The IRP is South Africa's cardinal electricity planning policy instrument and determines the allocation of generation technologies to ensure energy security. Following successful procurement of renewables in the first four auction rounds of the REIPPPP programme between 2011 to 2015, no new procurement rounds were launched between 2015 and 2020.[19] This has negatively impacted the development of renewable energy value chains and employment, with multiple manufacturing facilities having closed in the intervening period.

Renewable energy deployment in the REIPPPP was highly skewed towards Northern, Eastern and Western Cape due to attractive renewable energy resources. Although Mpumalanga has previously not been the preferred region for renewable energy deployment, this could change as it is closer to the primary load centre in Gauteng and has existing transmission grid infrastructure—with additional capacity to become available after coal-powered stations are decommissioned. Furthermore, GCCA 2023 Phase 1, released in July 2021 by Eskom Transmission, shows that there will be zero MW of available capacity to connect in the Northern Cape Supply Area (Satimburwa et al. 2021) until evacuation capacity is built, which is only likely to happen after 2027.

Wind and solar PV potential in Mpumalanga

The Strategic Environmental Assessment (SEA) for Wind and Solar PV in South Africa, conducted by CSIR on behalf of the Department of Forestry, Fisheries, and Environment (DFFE), indicates that there is promising resource potential for both solar and wind in Mpumalanga (DFFE, 2019), with significant land available even when restricted by environmental considerations. Results from SEA Phase 2 allowed for solar PV-focused Renewable Energy Development Zones (REDZ) to be developed in Emalahleni in Mpumalanga and Klerksdorp in the NW Province, as each area will be further impacted by coal- and gold-mining closures. Although wind was not selected for development, the SEA does show that there is good resource potential in some parts of the province (see IASS (2021c). A short study conducted by CSIR and NREL on solar PV and wind resources in South Africa shows that Mpumalanga has some areas with good resources (see IASS, 2021c, and NREL/CSIR, 2017). The study also showed the tariff premium that may be associated with different levels of resource potential. Although Mpumalanga will require a premium over provinces with more attractive resources, its proximity to the Gauteng and KwaZulu Natal load centres and its role as the centre of the Just Energy Transition may justify the payment of the tariff premium.

Biomass potential in Mpumalanga

Biomass is part of the industrialisation strategy for Mpumalanga due to comparatively high levels of biomass availability. The most promising biomass resources in South Africa are concentrated in Kwa-Zulu Natal, Mpumalanga, Eastern Cape, and Free State (see IASS, 2021c, for resource map). The Mpumalanga Industrialisation Development Plan 2015 includes a planned *Biomass Energy Conversion Project*, which includes power generation (Mpumalanga DEDT, 2015). According to the provincial government, several parties are looking to establish biomass power generation facilities there. However, full quantification of biomass electricity potential has not been conducted (Mpumalanga DEDT, 2015). 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 fuels and biogas, which could link to the green hydrogen economy (Mpumalanga DEDT, 2015).

Opportunities for battery storage in Mpumalanga

Battery storage is on the verge of becoming commercially viable at grid scale. A study by Parsons identified lithium-ion and vanadium flow reflux battery (VFRB) technologies as having the most significant and long-term growth potential for utility-scale storage in South Africa (Parsons, 2019) (see IASS, 2021c).

The continued development of VFRB technology means that Mpumalanga can take advantage of the vanadium deposits in the eMalahleni district municipality, which is set to be the most impacted by the decline in the coal economy. This creates an opportunity for employment from battery storage production.

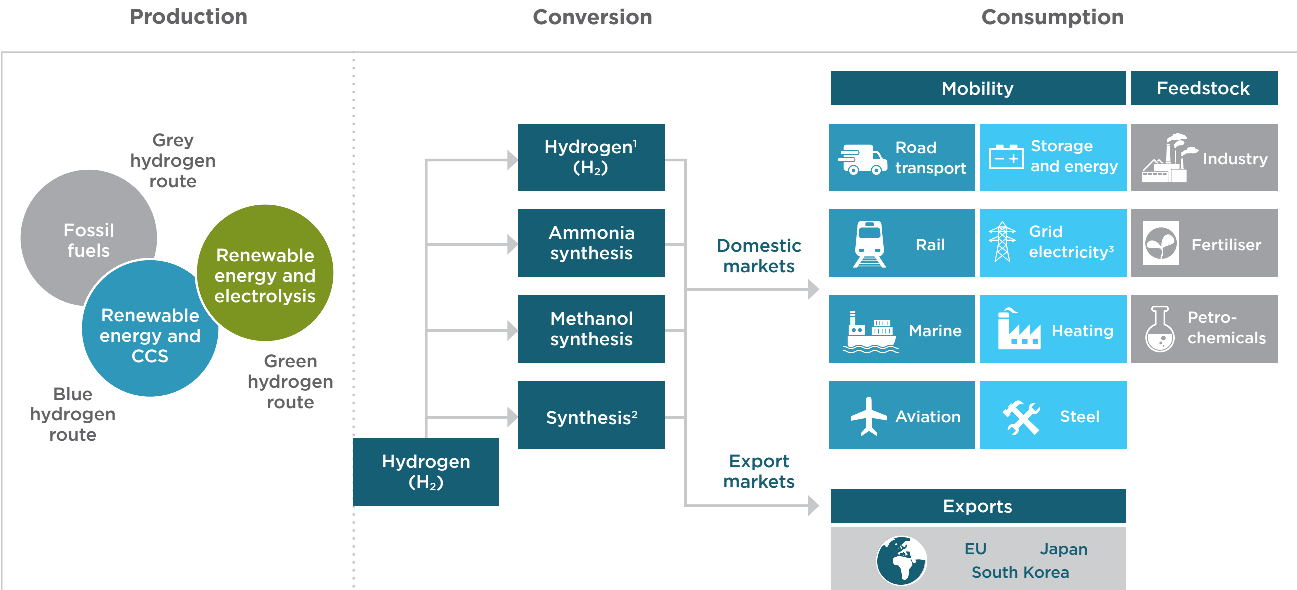
[19] Preferred bidders for Round 5 were announced in 2021.

Eskom is piloting a battery storage programme (Parsons, 2019) and has included battery storage as part of its plans for a just energy transition, proposing 61 MW/244 MWh of battery storage for Komati Power Station. Furthermore, the World Bank, through the International Finance Corporation (IFC) Clean Technology Fund (CTF), has committed USD 30 million to the Renewable Energy Grid Integration Program, which seeks to kick-start and finance energy storage and renewable energy in South Africa (World Bank, 2021a).

The potential for hydrogen in Mpumalanga

The global production of hydrogen is currently between 50 and 70 MT per annum, approximately half of which is used for ammonia production. Green hydrogen can be used to decarbonise several applications where the current source is fossil fuel-based. Hydrogen is recognised as a key contributor to decarbonisation programmes in developed countries (IHS Markit, 2021).

Currently, South Africa consumes 2+ MTPA of mainly coal-sourced 'grey' hydrogen—for synthetic fuels (synfuels), steel production, and petrochemicals/oil refining (IHS Markit, 2021). A shift to hydrogen would therefore provide South Africa with opportunities for decarbonising industrial processes, the integration of fuel-cell technologies for long-haul transportation, and backup power (IHS Markit, 2021). In addition, there are opportunities for hydrogen exports to markets such as the European Union, Japan, and South Korea. Figure 3-10 illustrates the various types of hydrogen and their potential applications. South Africa could take advantage of the hydrogen economy due to its technical capabilities around Fischer-Tropsch technologies, abundant platinum resources (80% of global resources), and its abundant solar, wind, and biomass resources as primary feedstock.



- Grey H_2: process: steam methane reforming (SMR); source: gas
- Blue H_2: process: SMR; source: gas; **plus** CCS
- Green H_2: process: electrolysis; source: renewable

1. H_2 is difficult and costly to transport. Methods include: Compressed H_2 | Liquid H_2 | Liquid organic hydrogen carrier (LOHC) | Ammonia with reconversion to H_2
2. Synfuels using CO_2 from an industrial source (e.g. cement plant) or direct air capture (DAC) and in future FT produced CO_2 and biomass
3. H_2 for electricity has a low efficiency. It will only used in cases with high cost alternatives

Figure 3-10: Hydrogen pathways and applications (source: McKinsey insights)

In June 2021, IHS Markit published the Super H_2igh Road scenario for green hydrogen ramp-up in South Africa, which contains ambitious targets for decarbonisation. Under the Super H_2igh Road Scenario, green-hydrogen-related projects would require an additional 6 GW of solar and wind capacity by 2030 (see also IASS, 2021c).

Current planned green hydrogen projects in the Mpumalanga region include:

- Sasol refining/chemicals at their Secunda Coal-to-Liquids (CTL) plant; conversion to use green hydrogen (pilot to use 15 % biomass)
- Production of sustainable aviation fuel (SAF) e.g., the project being developed by Enertrag, Navitas Energy, Linde, and Sasol in Mpumalanga

Other potential applications and projects include:

- The production of chemicals such as green ammonia and methanol
- The conversion of long-haul trucks and buses to hydrogen fuel cell technology
- The revival of the dormant

Highveld steel production, which could be converted to hydrogen-based direct reduced iron (DRI) for green steel production, which could be used in the production and export of renewable energy components.

3.3 Employment opportunities related to clean energy deployment in Mpumalanga

Gross employment opportunities in Mpumalanga were modelled based on the potential for clean energy technologies and the assumed capacity additions in line with the four scenarios. For each scenario, two levels of local content were assumed, mirroring moderate or high levels of local manufacturing in the province (see Table 3-2 and IASS, 2021c). Unless otherwise indicated, the figures shown in the report refer to the moderate level.

Level	Explanation
Moderate	Local content mirrors national levels, based on data from dtic, industry associations, and general online searches.
High	This is an ambitious level of local content, which increases the moderate level at a rate of 5 % per annum.

Table 3-2: Local content levels

Source: own

Employment opportunities related to renewable energies

Deploying renewable energy technologies in Mpumalanga can create many thousands of jobs, compensating for most or all the job losses that can be expected from the phase-out of coal-fired power stations (depending on the scale of renewable energy deployment). The following graphs show the direct, indirect, and induced FTE jobs created by 2030. For construction, the jobs created occur in a single year and cease once construction is completed. The O&M jobs, on the other hand, are permanent in nature and therefore accumulate over the period of assessment.

Assuming moderate levels of local content, total construction FTE jobs created in Mpumalanga in 2030 amounts to 20,000 FTEs for the Current policy: planned repurposing (IRP 2019) scenario (1), including 5,000 O&M jobs. For the Accelerated repurposing scenario (2), the total number of jobs was estimated to be 45,000, which is more than double the Current policy: planned repurposing (IRP 2019) scenario (1); O&M jobs increased to 11,000. Similarly, the Ambitious repurposing scenario (3) leads to 43,000 jobs in 2030 (see Figure 3-11), with 12,000 cumulative O&M jobs. In the Super H_2igh Road scenario (4), 58,000 construction jobs are created in 2030 alone, and 14,000 O&M jobs cumulatively for the period 2020 to 2030. This represents an increase of over 180% compared with the Current policy: planned repurposing (IRP 2019) scenario (1).

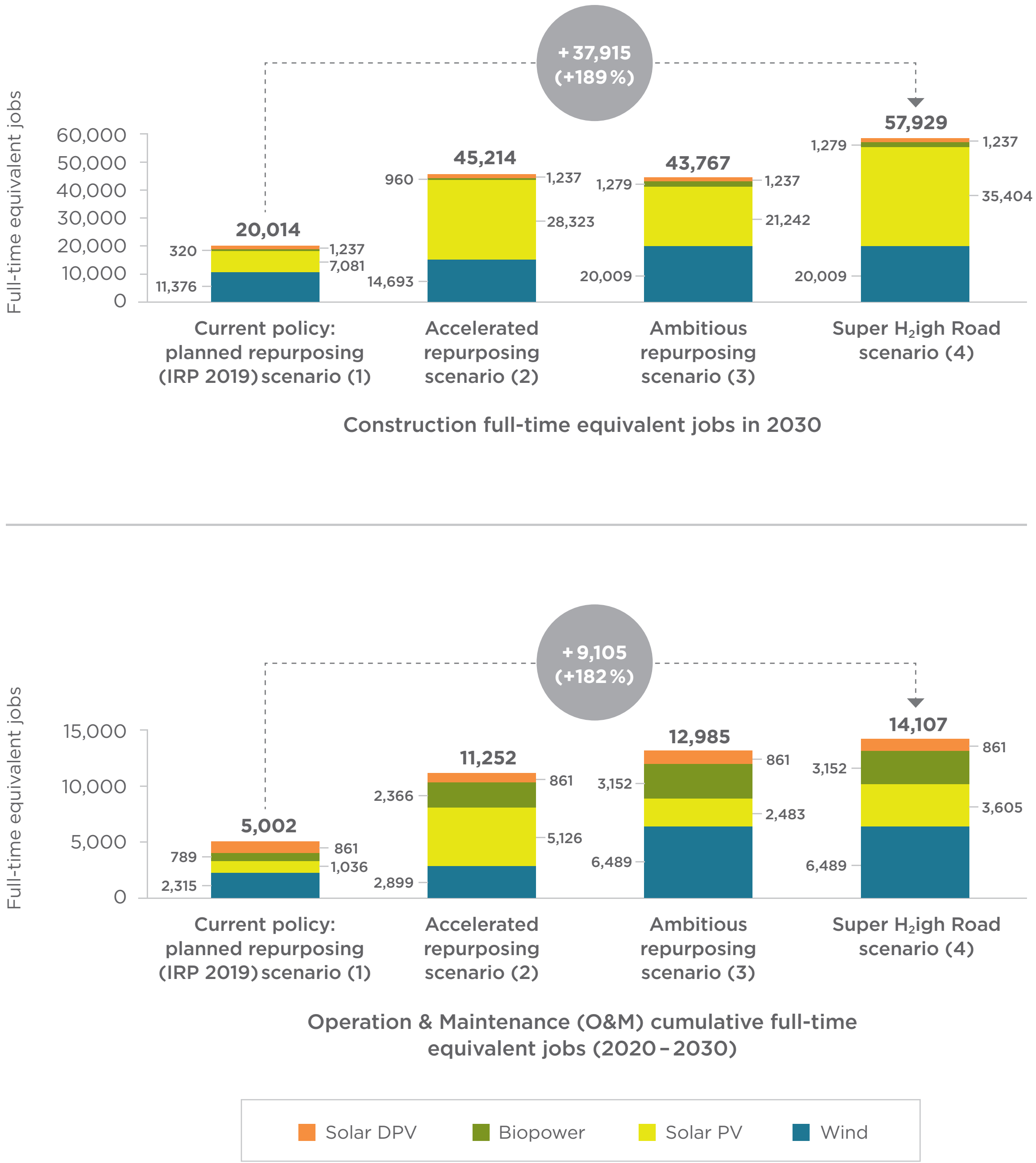


Figure 3-11: Construction and O&M renewable energy jobs (FTE) by 2030 in Mpumalanga (moderate local content) (source: I-JEDI)

Total construction and O&M jobs in Mpumalanga in 2030 range between 25,000 jobs (Current Policy: planned repurposing (IRP 2019) scenario (1)) and 72,000 jobs (Super H_2igh Road scenario (4)). The Advanced repurposing scenario (2) and Ambitious repurposing scenario (3) create 56,500 and 56,000 FTE jobs respectively over the same period (see Figure 3-12).

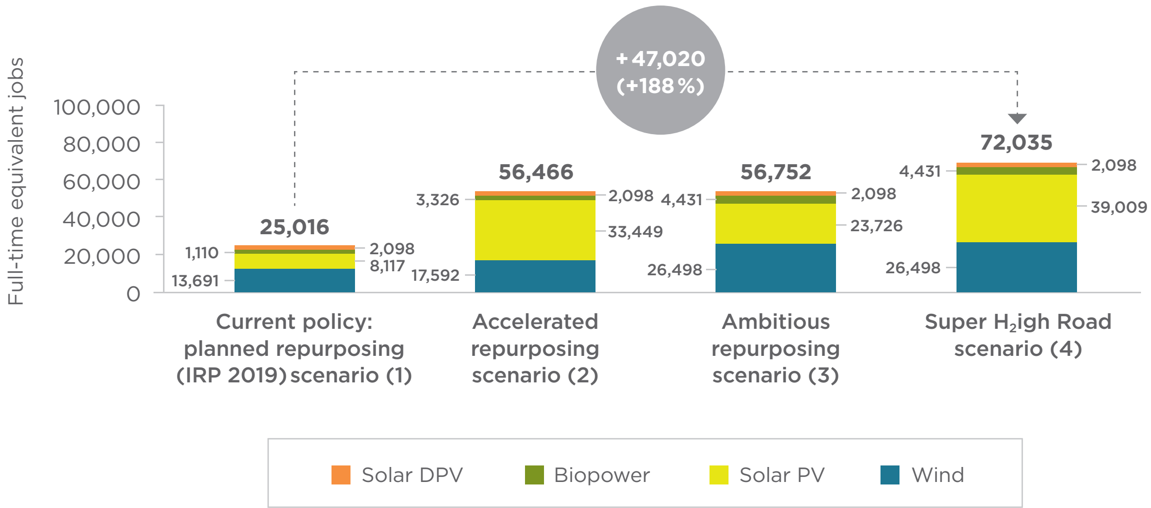


Figure 3-12: Total construction & O&M jobs (FTE) from renewable energy in Mpumalanga by 2030 (moderate local content) (source: I-JEDI)

By increasing the local content, total construction jobs in 2030 can be further increased to 22,000 FTE under the Current policy: planned repurposing (IRP 2019) scenario (1) and 64,000 under the Super H2igh Road scenario (4). O&M employment increases by 9,000 by shifting from the Current policy: planned repurposing (IR P2019) scenario (1) to the Super H_2igh Road Scenario (4). There are jobs linked to manufacturing in both construction and O&M segments. Overall, on average, the share of direct, indirect, and induced employment from manufacturing is approximately 30%, depending on the technology. In this assessment, manufacturing jobs in the wind sector accounted for the highest share, whereas biopower provided the lowest share of employment from manufacturing.

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

Figure 3-13: Construction and O&M renewable energy jobs (FTE) by 2030 in Mpumalanga (high local content) (source: I-JEDI)

Table 3-3: Construction and O&M renewable energy jobs in Mpumalanga by 2030 (high local content)

Source: I-JEDI

		Scenario 1	Scenario 2	Scenario 3	Scenario 4
Construction FTE jobs by 2030	Total	22,212	50,030	48,539	64,133
	Direct	7,120	16,184	15,635	20,723
	Indirect	7,284	16,163	15,785	20,750
	Induced	7,807	17,682	17,118	22,661
O&M FTE jobs by 2030	Total	5,149	11,822	13,294	14,542
	Direct	1,513	3,443	3,878	4,249
	Indirect	1,762	4,118	4,467	4,923
	Induced	1,874	4,261	4,949	5,370
Total FTE jobs by 2030	Total	27,361	61,852	61,833	78,675
	Direct	8,634	19,627	19,513	24,971
	Indirect	9,046	20,281	20,252	25,673
	Induced	9,681	21,943	22,068	28,031

Total FTE jobs created over the assessment period can be increased by over 180%, from 27,000 in Current policy: planned repurposing (IRP 2019) scenario to 79,000 in Super H_2igh Road Scenario (4) (with 62,000 in the Accelerated and Ambitious repurposing scenarios, respectively). On average, the inclusion of higher local content results in 2,000 to 6,000 more jobs than the moderate local content scenario.

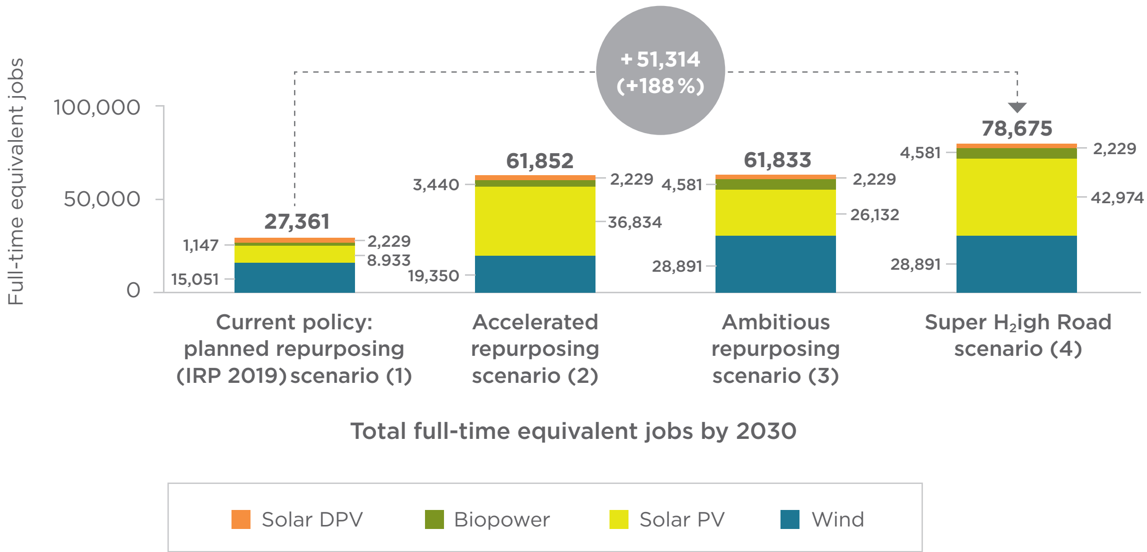


Figure 3-14: Total construction and O&M jobs (FTE) from renewable energy in Mpumalanga (high local content) (source: I-JEDI)

More jobs are created over time by wind and solar PV. This can be attributed to larger shares of wind and solar PV additions in all the scenarios over the assessment period, compared to other technologies. Figure 3-18 and Figure 3-19 present the annual results for all four scenarios for the two levels of local content.

At a jobs-per-MW level, by 2030 the most jobs can be created from construction of biopower plants, at 64 FTEs/MW (38% being construction jobs), followed by wind at 53 FTEs/MW (31% in construction) in 2030 (Figure 3-15 and Figure 3-16). Similarly, biopower has the highest potential for employment in O&M roles. The figures also show that as local content is increased, FTE employment per MW also increases. Despite the promising potential for increasing employment, such benefits must be balanced against issues such as threats to biodiversity, alternative uses of biomass, and other productive uses (e.g., agriculture and tourism).

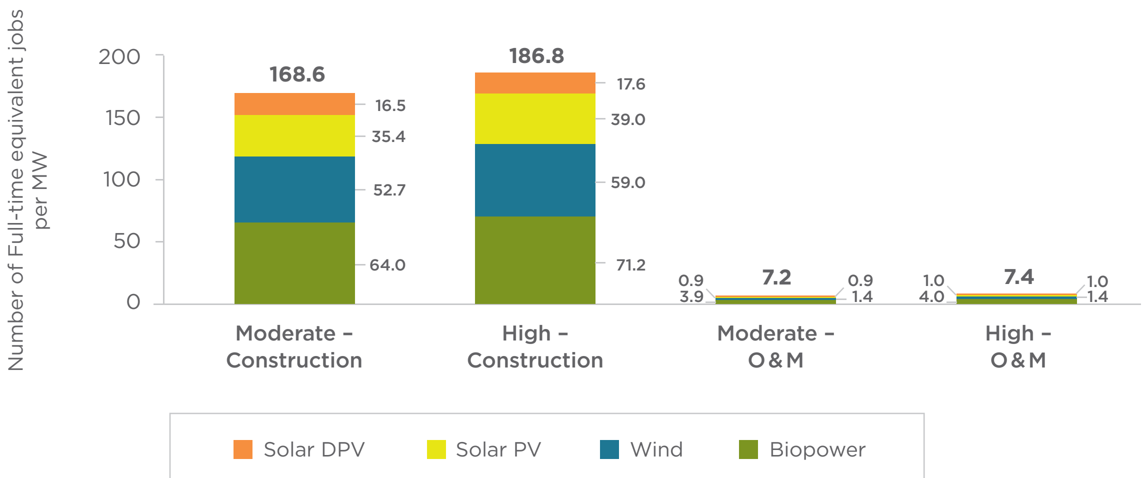


Figure 3-15: FTE per MW (source: I-JEDI)

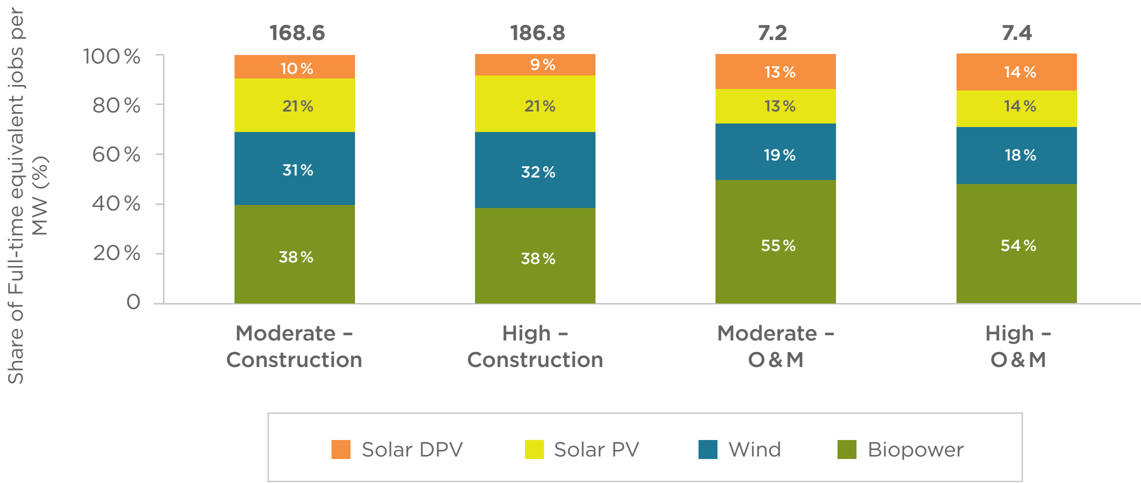


Figure 3-16: Share of Employment factors (FTE per MW) by technology (source: I-JEDI)

It should be noted that, despite the low predicted FTE per MW for distributed solar PV, the 2021 "Solar PV Industry Jobs Report" from SAPVIA and CSIR shows that surveyed companies in the value chain reported high employment numbers (see Figure 3-17). Therefore, the distributed (embedded) generation market provides a unique opportunity to boost employment.

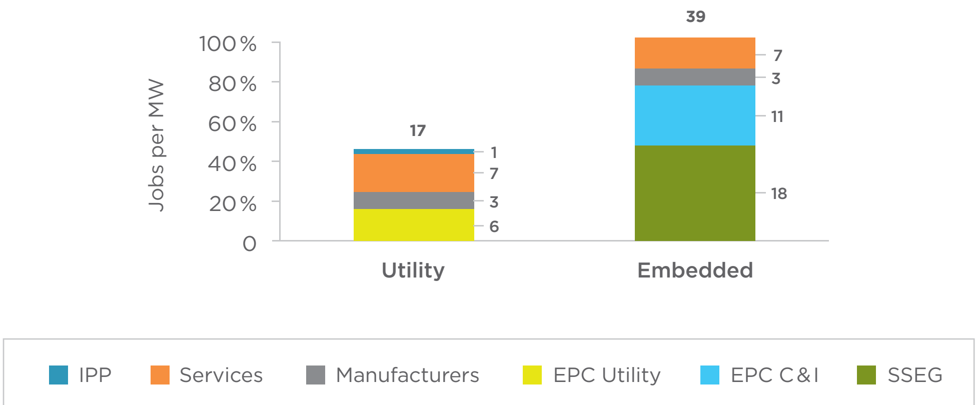


Figure 3-17: Comparison of of job factors for utility per MW for utility and embedded generation markets (source: CSIR & SAPVIA, 2021)

Figure 3-18: Job creation with renewables: projected annual job numbers (FTE) per renewable energy technology (direct, indirect, and induced jobs) for the current policy (IRP2019) and accelerated repurposing scenario for moderate and high local content levels (source: I-JEDI)

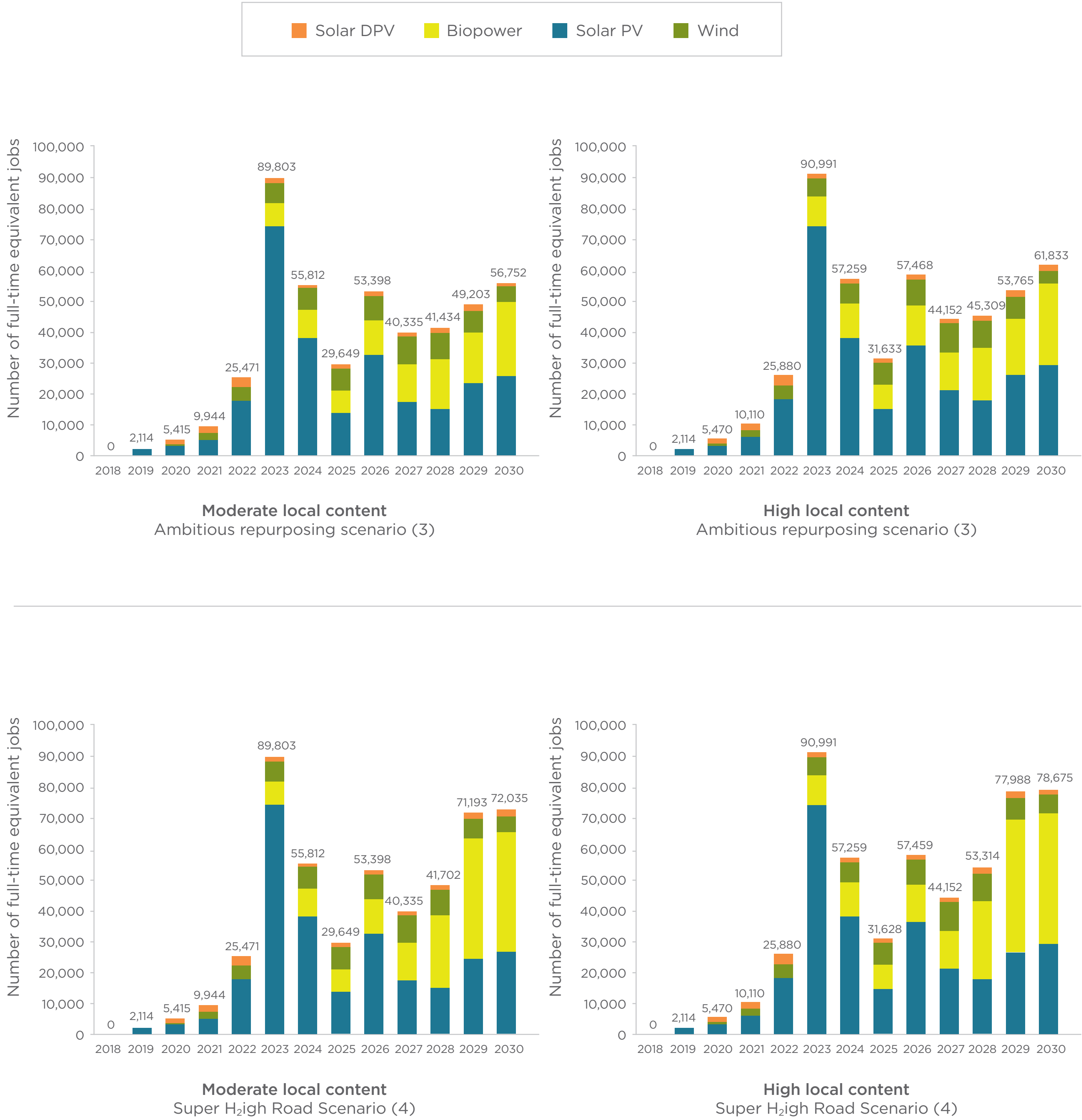


Figure 3-19: Job creation with renewables: projected annual job numbers (FTE) per renewable energy technology (direct, indirect, and induced jobs) for the assessed repurposing scenario and Super H₂igh Road scenario for moderate and high local content levels (source: I-JEDI)

Employment opportunities related to battery storage in Mpumalanga

A literature review was conducted to establish the potential for the four scenarios to create jobs associated with battery storage. Several studies showed varying estimates for potential job creation per unit of installed capacity (employment factors), as summarised below.

According to South Africa's Industrial Development Organisation (IDC), the Mpumalanga manganese beneficiation pilot facility, for example, could create 1,600 jobs if a full-scale commercial plant were to be established and production were to reach 10,000 tonnes per year (Parsons,2019). Furthermore, if South Africa becomes a global electrolyte player and the technology grows as forecast, developing the capability to produce VRFB electrolyte can result in the employment of 1,200 FTEs by 2027 (Parsons, 2019).

The Parsons (2019) study noted that calculating potential employment numbers was a challenge at this early stage of the technology's implementation in South Africa. Parsons (2019) also cited a study by Navigant Research, which assumed declining employment per MW over time as the technology matures and manufacturing processes become more streamlined. The large variations in employment potential reported in the literature make it difficult to reliably ascertain the true potential.

For this study, 200 jobs per MW was assumed at the start of 2020. Then, based on the Navigant Research learning rates, this figure reduced over time to 14 jobs per MW by 2030. This is similar to the CESA estimate of 10 jobs per MW for the USA where the battery storage market is better established (see IASS, 2021c, for detailed calculations). Table 33 depicts the battery storage numbers upon which the calculations are based. In the scenarios investigated, battery storage for the first two scenarios is concentrated in the earlier years where jobs per MW is higher, hence the higher figures for both compared to scenarios 3 and 4 (see Figure 3-20).

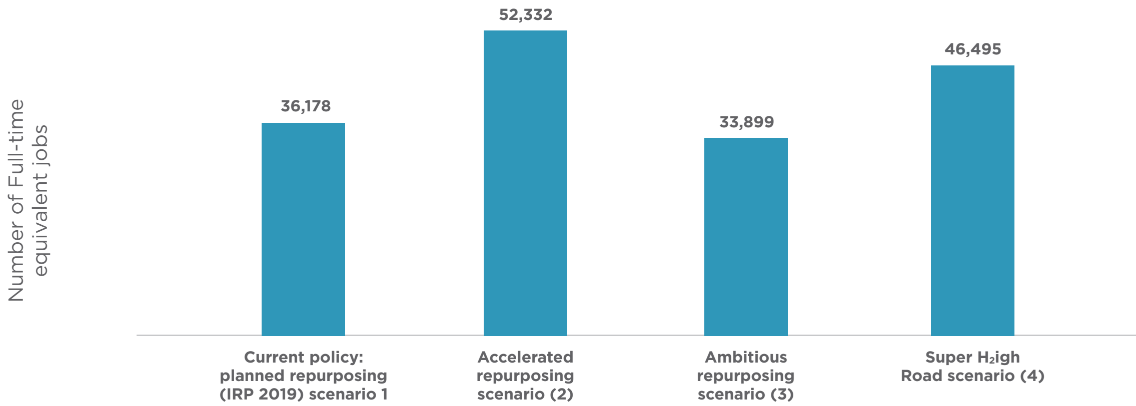
Table 3-4: Battery storage jobs literature review

Publication	Geography	Unit	Figure
Parsons, 2019 (USTDA/IDC)	USA	Jobs/MW	202 jobs (62,910 FTEs/311MW new installations; high number attributed to existing O&M jobs)
Navigant Research (IFC/Navigant, 2016)	USA	Jobs/MW	403 jobs/MW in 2016, 50.9 jobs/MW in 2021, 32.5 jobs/MW in 2025
CESA, 2020	USA	Jobs/MW	10 jobs/MW
Bushveld Energy	SA	Capex Job years/MW	110
Bushveld Energy	SA	Opex job years/TWh	50
Solar Foundation, 2016	USA	Jobs/MW	1.15 (Utility scale), 3.41 (Non-residential), 15.91 (Residential)

Table 3-5: Battery storage capacity in Mpumalanga (MW)

Source: own calculations using IRP 2019 and Wright & Calitz (2020)

Mpumalanga	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	Total by 2030
Current policy: planned repurposing (IRP2019) scenario (1)	0	33	61	202	0	0	0	0	0	0	239	0	534.45
Accelerated repurposing scenario (2)	0	33	61	350	0	0	189	0	0	0	14	144	791
Ambitious repurposing scenario (3)	0	33	61	125	32	0	0	0	0	119	119	163	652
Super H_2igh Road Scenario (4)	0	33	61	117	117	117	63	63	63	119	119	144	1015



Notes: Estimates were calculated using the Navigant US Jobs/MW number which employed learning rates over time. In 2016 the number was 403FTE/MW, which is to reduce to 50.9 FTE/MW by 2021 and 32.5 FTE/MW by 2025.

Figure 3-20: Potential job creation estimates for battery storage, 2020 – 2030 (source: own calculations based on Navigant, 2016)

3.4 Net jobs in Mpumalanga: Creating jobs through massive investments in clean energy and local manufacturing

When analysing South Africa as a whole, the transition away from coal towards renewables will result in net job gains through to 2050. By this horizon, more than 150,000 jobs will have been created in the power sector (IASS/CSIR 2019).

However, this is not necessarily the case when zooming into Mpumalanga. Most coal-fired power plants are based in Mpumalanga, yet not all renewable energy deployment with take place in the province, and so the energy transition as it is currently planned will result in net job losses in the province's electricity sector by 2030 (see Figure 321). In all scenarios, job losses in the coal sector will exceed the job creation potential in the Mpumalanga renewable energy sector. Therefore, a wider strategy for economic prosperity is needed, including other sectors such as tourism and agriculture. Under the Current policy: planned repurposing (IRP 2019) scenario (1) scenario with moderate local content, net job losses will amount to 49,000 FTE posts by 2030, representing a loss of more than 20%. In the case of higher local content, i.e., more manufacturing within Mpumalanga, this number is reduced to 47,000 net job losses.

The Accelerated repurposing scenario (2) has a slightly more aggressive decommissioning schedule than the Current policy: planned repurposing (IRP 2019) scenario (1), but a more aggressive renewable energy capacity build-out rate. By combining a quicker decommissioning schedule for coal with significant increase in renewable energy deployment, the net job losses can be reduced sharply. In this scenario, with moderate local content, the net jobs losses will amount to 32,000 FTEs by 2030; With higher shares of local content, job losses can be further reduced to 27,000 FTEs.

The Ambitious repurposing scenario (3) and the Super H2igh Road scenario (4) have the most aggressive decommissioning schedule, with an even stronger renewable energy capacity build out to take advantage of former mining land and the green hydrogen economy. However, the impact of faster decommissioning is illustrated by the high job losses in the Ambitious repurposing scenario (3) despite the increased renewable energy deployment. The net jobs losses amount to 67,000 FTEs by 2030, assuming moderate levels of local content. The net job losses can be slightly reduced (to minus 62,000 net jobs) by requiring higher shares of local content. In other words, the level of renewable energy deployment assumed under the Ambitious Scenario is not able to compensate for the greater job losses resulting from more rapid decommissioning of the existing coal fleet.

Under the Super H2igh Road Scenario (4), which like the Ambitious repurposing scenario (3) has a rapid decommissioning rate, compensated by faster ramp up in renewable and clean energy deployment, there are net job losses, but less than in the Ambitious repurposing scenario (3) and excelling the current policy (IRP 2019) pathway when assuming high levels of local content. In the H_2igh Road Scenario 4, there will be net job losses by

2030 in the case of moderate local content level of minus 52,000 FTEs. When assuming high levels of local content, slightly more jobs can be created with clean energy technology than will be lost in the coal sector, thereby reducing net job losses (minus 45,000 FTEs).

Like in the Ambitious repurposing scenario (3), the ambitious renewable energy build out was offset by aggressive decommissioning, however the addition of renewable energy for the green hydrogen economy reduced the impact of these losses.

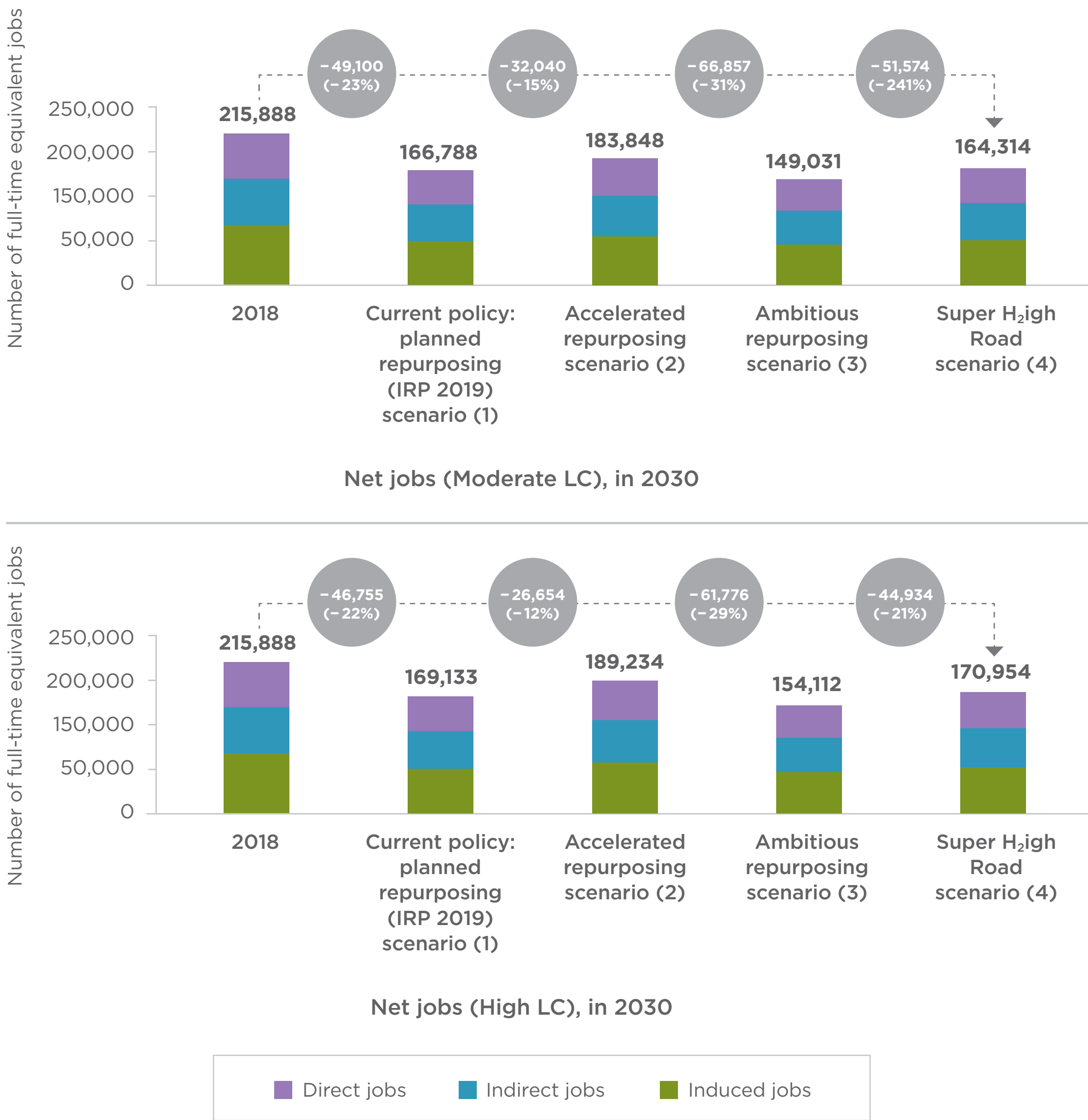


Figure 3-21: Net jobs in Mpumalanga by 2030 (source: I-JEDI)

Overall, the Accelerated repurposing scenario (2) has lowest impact in terms of net job losses in Mpumalanga. However, the trade-off is continued high levels of GHG emissions, which will not allow South Africa to meet its decarbonisation pathway and NDC targets in a timely manner.

In all the scenarios it can be seen that if Mpumalanga significantly increases the share of renewable energy and clean energy deployment and at the same time manages to create a strong regional industry with local manufacturing, more jobs can be created through clean energy sources to offset the job losses due to rapid decommissioning of coal units.

A higher share of renewables could compensate job losses in the coal sector.
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4. Local value creation and the green economy

Value creation with renewables:

- **By deploying renewables, Mpumalanga's gross output value can be increased substantially.** Between 2019 and 2030, renewable energy investment in Mpumalanga can reach R320 billion (USD 21 billion) in the Super H_2igh Road Scenario (4), a more than 170% increase over the R120 billion (USD 7.7 billion) in the Current policy: planned repurposing (IRP2019) scenario (1). By increasing local content from 30% today to 60–80%, local content within the province can be further uincreased 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 respectively.

This chapter explores the potential for value creation and industrial opportunities presented by the development of clean energy in Mpumalanga. As highlighted in Section 1.2, there are many programmes and initiatives to enable green prosperity in the province.

The renewable energy procurement program in South Africa (REIPPPP) has yielded notable benefits for the country. However, an increased focus on further value-chain localisation is necessary if South Africa wants to increase national and regional value creation. The most recent bid windows of the REIPPPP yielded local content for solar PV of approximately 62% and for wind of approximately 44% (Eberhard & Naude, 2017).

There is a distinct need to localise as much of the imported componentry of the renewable energy value chain as possible, to enable further employment creation. This localisation can be achieved in several ways, of which one is focused industrial policy. Explicit local content requirements within the REIPPPP, which increase over time as the renewable energy industry develops, will maximise the benefits of renewable energy deployment across the country. Aspirational renewable energy local content requirements should be moving towards approximately 65% or more for PV and wind, according to local content targets set by dtic for the REIPPPP (Eberhard & Naude, 2017).

4.1 Understanding opportunities along the coal and renewable energy value chains

Value creation can be generated along the various parts of the technological value chains. Therefore, an understanding of each part and its specific potential for value creation is a pre-requisite for policymakers seeking to establish stringent industrial policies.

The coal value chain and transfer of skills and technologies towards clean energy technologies

The coal value chain ranges from extraction of coal, beneficiation, and transportation to the coal power plant for electricity generation purposes (see Figure 4-1). A full list of the services and products related to each part of the value chain and a detailed breakdown are provided in IASS (2021c).

Extraction of Raw Materials	Beneficiation	Manufacturing	Transportation	Construction and installation
Examples: Underground loaders Shovels Hydraulic machines **Suppliers in MP:** Exxaro Thungela South32 FLSmidh Glencore Seriti	**Examples:** Crushers Conveyer belt Hammer sample **Suppliers in MP:** Weir Minerals Africa Mpumamanzi Group Public Bonds and Projects Rowani Trading and Projects	**Production of:** Steam turbines Boilers Burners and generators	**Examples:** Trains Trucks Conveyor belts and barges **Suppliers in MP:** African Commodity Handling Projects SG Coal Legend Logistics	**Examples:** Steam turbines Boilers Burners and generators Electric balance of plant (BoP) and mechanical BoP **Suppliers in MP:** Elephantus Trading Enterprise, and Bearings Inter-national

Figure 4-1: The coal-to-electricity value chain (services and products) (source: own)

The assessment of the coal value chain aims to provide insights into similarities in the clean energy value chains, to understand whether existing skills and services could be transferred. There are some complimentary aspects, e.g., raw materials mining; transportation of materials and manufactured parts; electrical balance of plant (small components); as well as components to connect facilities to the distribution and transmission grid.

There are some areas where services/products could be transferred. The main ones would potentially be in the extraction of raw materials—although processes will have to be tailored to the specific material being mined, and will require additional investment for conversion. The beneficiation part of the coal value chain is the least carbon-intensive and can continue to provide value through export markets while those still exist (Luo et al. 2017, 1855)—keeping in mind that, in the long-term, export market countries will reduce their own demand as they also work towards net zero.

The value chain of renewable energy technologies, and opportunities for Mpumalanga

Like the coal value chain, the clean technology value chains can be differentiated into extraction, beneficiation, manufacturing, transportation, and construction/installation (see Figure 4-2 to Figure 4-4).

Extraction of Raw Materials	Beneficiation	Manufacturing	Transportation	Construction and installation
■ **Examples:** ▪ Silicon crystalline ▪ Steel ▪ Copper ▪ Aluminium ▪ Cement and concrete ■ **Suppliers in MP:** ▪ ArcelorMittal ▪ Allied Steelrode ▪ PPC ▪ Columbus stainless steel (PTY) Ltd	■ **Examples:** ▪ Crushers (jaw and cone crushers) ▪ Grinding system ▪ Wet or dry classifier ▪ Dense medium separation (DMS) ■ **Suppliers in MP:** ▪ MICRON LABORATORY SERVICES ▪ FLSmidth ▪ VUSEV ▪ Hatch	■ **Production of:** ▪ Wafer ▪ Cell ▪ Solar mudule assembly ▪ Solar panel assembly ▪ Inverters	■ **Examples:** ▪ Vehicles ▪ Trucks ▪ Cranes ■ **Suppliers in MP:** ▪ Mpumalanga Crane Services ▪ Delmas Crane Hire	■ **Examples:** ▪ Module ▪ Inverters ▪ Electrical BOS ▪ Mechanical BOS, and installations

Figure 4-2: The solar PV value chain (services and products) (source: own)

Extraction of Raw Materials	Beneficiation	Manufacturing	Transportation	Construction and installation
■ **Examples:** ▪ Steel/concrete for towers ▪ Reinforcement steel ▪ Fibreglass or carbon fibre ▪ Copper and aluminium ■ **Suppliers in MP:** ▪ Columbus stainless (PTY) Ltd (MPU)	■ **Examples:** ▪ Crushers ▪ Grinding system ▪ Wet or dry classifier ▪ Dense medium separator ▪ Hydrocyclones ■ **Suppliers in MP:** ▪ FLSmidth ▪ VUSEV ▪ Hatch ▪ Tugela Mining and Minerals (Pty) Ltd ▪ Multotec group	■ **Production of:** ▪ Wind turbines ▪ Rotor ▪ Blades ▪ Power converters ▪ Hydraulic and pneumatic system ■ **Suppliers in MP:** ▪ BFG Africa (GP) ▪ General Electric South Africa (PTY) Ltd (GP) ▪ Goldwind Africa (PTY) Ltd (GP)	■ **Examples:** ▪ Vehicles ▪ Trucks ▪ Cranes ■ **Suppliers in MP:** ▪ Mpumalanga Crane Services ▪ Delmas Crane Hire	■ **Examples:** ▪ Wind turbine, tower, blade and installations ▪ Balance of plant or system ■ **Suppliers in MP:** ▪ BTE Renewables

Figure 4-3: The wind energy value chain (services and products) (source: own)

Steel production, which is an important component of the wind and solar PV value chain, is one opportunity for further value creation in Mpumalanga. The province has an important steel production capacity, with stainless steel being a multi-functional and adaptable metal (Global African Network 2020). Stainless steel production in the province is dominated by Columbus Stainless (Pty) Ltd. The company supplies the local and international markets, with 25% of the production supplied locally, which is likely to decline given the declining domestic demand (Global African Network 2020). The decline in demand for current products could be offset by increasing the localisation of solar PV and wind energy as the main users of steel products. Additionally, these renewable energy technologies present an opportunity for metals and machinery manufacturers with operations in Mpumalanga to expand their production capacity to produce renewable energy components.

Mpumalanga has a 2020–2025 strategic plan that supports the establishment of a Mining and Metal Industrial Centre of Competency, and an Iron and Steel Manufacturing Incubation Programme, with the former supporting the production of the chromite-based materials used in the production of stainless steel components (Mpumalanga DEDT 2020).

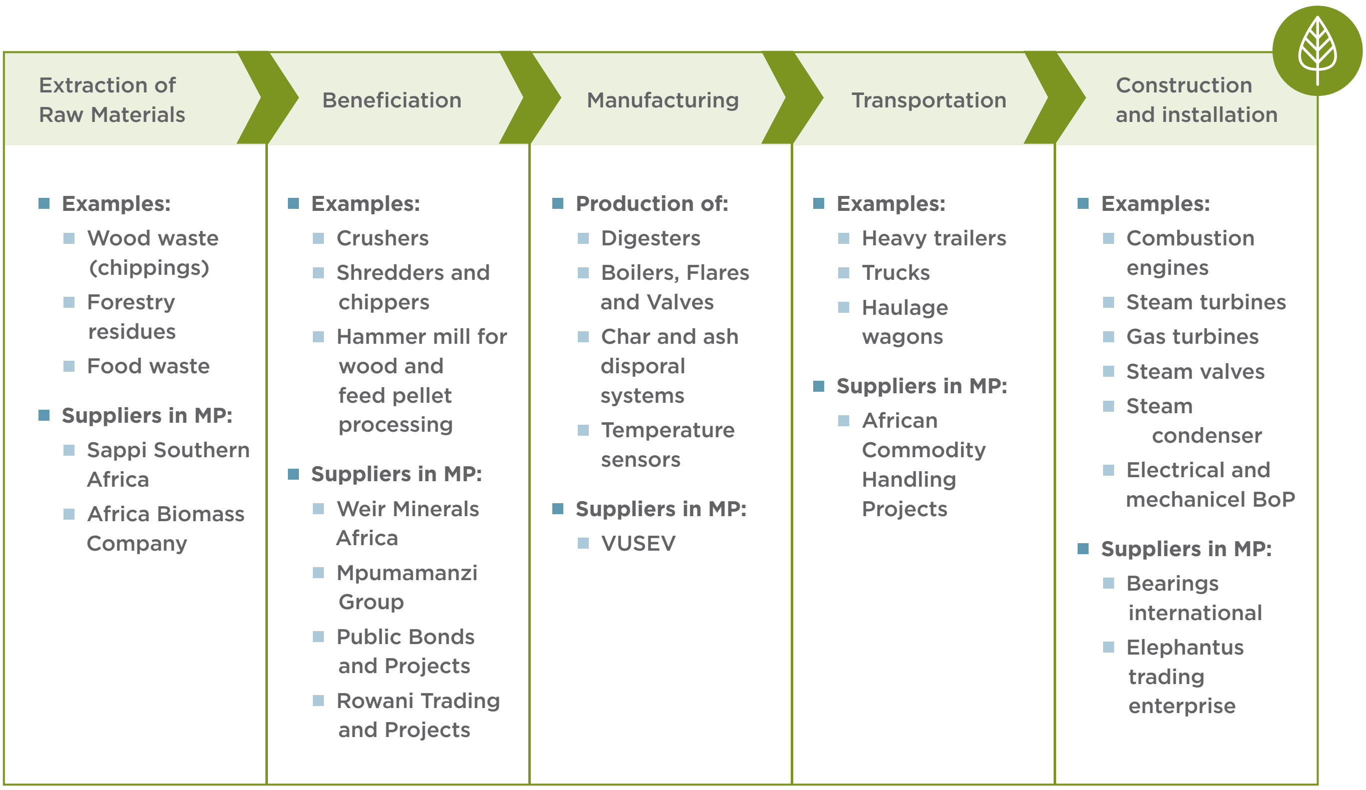

Figure 4-4: The biomass energy value chain (services and products) (source: own)

The abundance of supplies to agricultural activities such as cultivation of crops and livestock farming, and the fact that Mpumalanga has the second-largest sugar industry in South Africa (Global African Network 2018), are favourable for localisation of the biopower value chain. There is potential to convert some of the existing coal power generation capacity to biomass, however this may impose environmental strain by depleting biomass resources (Gerbelová, Spisto, and Giaccaria 2021, 110). The province plans to establish a forestry industrial park to take advantage of its rich supplies of forestry resources. The resulting forestry residues will add to the biopower energy value chain. To ensure a wider impact of biomass conversion opportunities, the *Biomass Energy Conversion Network* has been proposed (Mpumalanga DEDT 2020).

Extraction of Raw Materials	Beneficiation	Manufacturing	Transportation	Construction and installation
Examples: Raw materials (inputs): Lithium Cobalt Manganese Nickel Vanadium Silicon, copper, iron, aluminium **Suppliers in MP:** African Rainbow Minerals Anglo Platinium Ltd Impala Platinium Holdings Xstrata (Pty) Ltd Bushveld Minerals	**Examples:** Crushers Vibrating screen Scrubbers (attrition and drum) and log washers Dense medium separation (DMS) **Suppliers in MP:** Weir Minerals Africa Mpumamanzi Group Public Bonds and Projects Rowani Trading and Projects	**Production of:** Battery cells Battery modules Battery packs **Suppliers in MP:** Lithium Batteries SA Just Batteries/ Potensa Eternity Technologies South Africa Sinetech REVOV Batteries PTY Ltd. Bushveld Energy	**Examples:** Vehicles Trucks	**Examples:** Battery packs Charge controllers Inventers Safety disconnect equipment Grounding equipment Design and installation Electrical and mechanical BoP

Figure 4-5: The battery energy value chain (services and products) (source: own)

There is potential for localisation of the battery energy storage value chain in Mpumalanga, given that mining operations include nickel, platinum, chromite, vanadium, and magnetite (Mpumalanga DEDT, 2020). Also, the DMRE maintains a list and numbers of mining operations, which range from cobalt to manganese alloys, silicon alloys, copper, and nickel, all of which are used in manufacturing battery cells (DMRE, 2017).

Hydrogen production already takes place in Mpumalanga. However, the feedstock is mainly from fossil fuels, making the process highly carbon-intensive. Other feedstocks used in the production of hydrogen include biomass, water, and electricity. The production methods range from reformation to gasification and electrolysis. The latter has the potential to produce green hydrogen, provided that the electricity used is sourced from renewable energy technologies (Cropley and Norman 2008; Mayyas et al. 2019).

However, it will be challenging to establish greener processes, due to prevailing water shortages (Mpofu and Botha, 2021). Water supply from waste streams should therefore be considered. The existing production of hydrogen in Mpumalanga is dominated by Sasol and Afrox, among others (Patel, 2020). Sasol undertakes hydrogen production at its Secunda facilities for internal use and uptake by end users. Afrox uses its manufacturing plant in Pelindaba (Pretoria) for hydrogen production for sale in the domestic market. The expansion of hydrogen production capacity beyond these companies can help to support the localisation of the hydrogen value chain, as it can be supported by the availability of biomass in the region (Mpumalanga DEDT, 2020).

Extraction of Raw Materials	Beneficiation	Manufacturing	Transportation	Construction and installation
Examples: Fossil fuels Biomass Water Electricity **Suppliers in MP:** Sappi Southern Africa Africa Biomass Company	**Examples:** Crushers Shredders and chippers Hammer mill for wood and feed pellet processing Belt conveyor Screw feeder **Suppliers in MP:** Weir Minerals Africa Mpumamanzi Group Public Bonds and Projects Rowani Trading and Projects	**Production of:** Electrolyser stack Hydrogen compressor Hydrogen storage tank Combustible gas detector Demister Pump **Suppliers in MP:** Hydrox Holdings Air Liquide Afrox gases	**Examples:** Pipeline Cryogenic liquid tanker trucks or Gaseous tube trailers **Suppliers in MP:** XONELOGIX	**Examples:** Fuel cell stack Fuel proceccor Power conditioners Air compres-sors Humidifiers **Suppliers in MP:** Air Products South Africa HySA

Figure 4-6: The hydrogen energy value chain (services and products) (source: own)

4.2 Quantifying the value creation potential for Mpumalanga

Mpumalanga can significantly increase regional value creation by shifting towards clean energies.[20] Under Current policy: planned repurposing (IRP 2019) scenario (1), the potential loss of gross value from decommissioning coal-powered generation plants is R60 billion by 2030, which is offset by a gross added value of R118 billion (USD 7.6 billion) assuming moderate levels of local content, increasing to R128 billion (USD 8.3 billion) for a scenario with high levels of local content. These values increase by 172 % in the Super H_2igh Road Scenario (4) for moderate local content shares to R321 billion (USD 21 billion). With high levels of local content, value creation under the H_2igh Road Scenario amounts to R343 billion (USD 22 billion), a 190 % increase compared with the Current policy: planned repurposing (IRP2019) scenario (1) (see Figure 4-7).

Zooming in on the construction and O&M-related value creation by 2030, a similarly large increase can be observed between the Current Policy: planned repurposing (IRP 2019) scenario (1) and H_2igh Road scenario (4), with an ~170 % increase in gross output value of construction and ~185 % increase in O&M-related valued added (from R7.3 billion in Current Policy: planned repurposing (IRP 2019) scenario (1) to R196 billion in the H_2igh Road scenario (4); see Figure 4-8).

[20] To illustrate the value that can be gained from investing in RE deployment, the I-JEDI model outputs included the gross output value 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). This gross output value was modelled for all technologies at the moderate and high local content levels for the direct and indirect aspects.

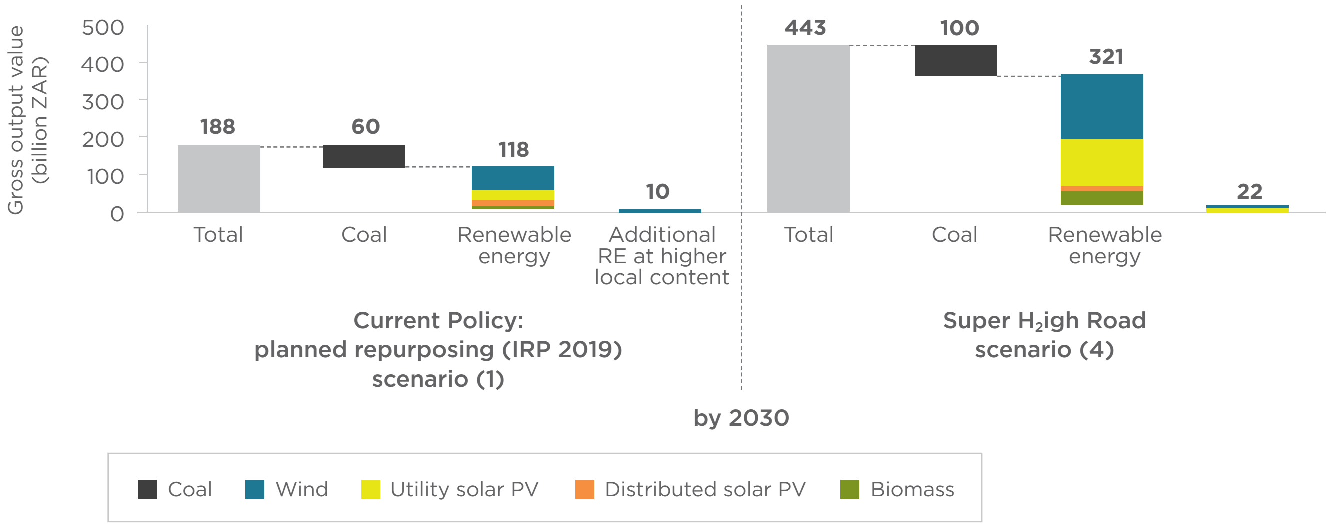

Figure 4-7: Overall impact of gross value added for Current Policy: planned repurposing (IRP 2019) scenario (1) and Super H_2igh Road Scenario (4) by 2030 (source: I-JEDI Modelling)

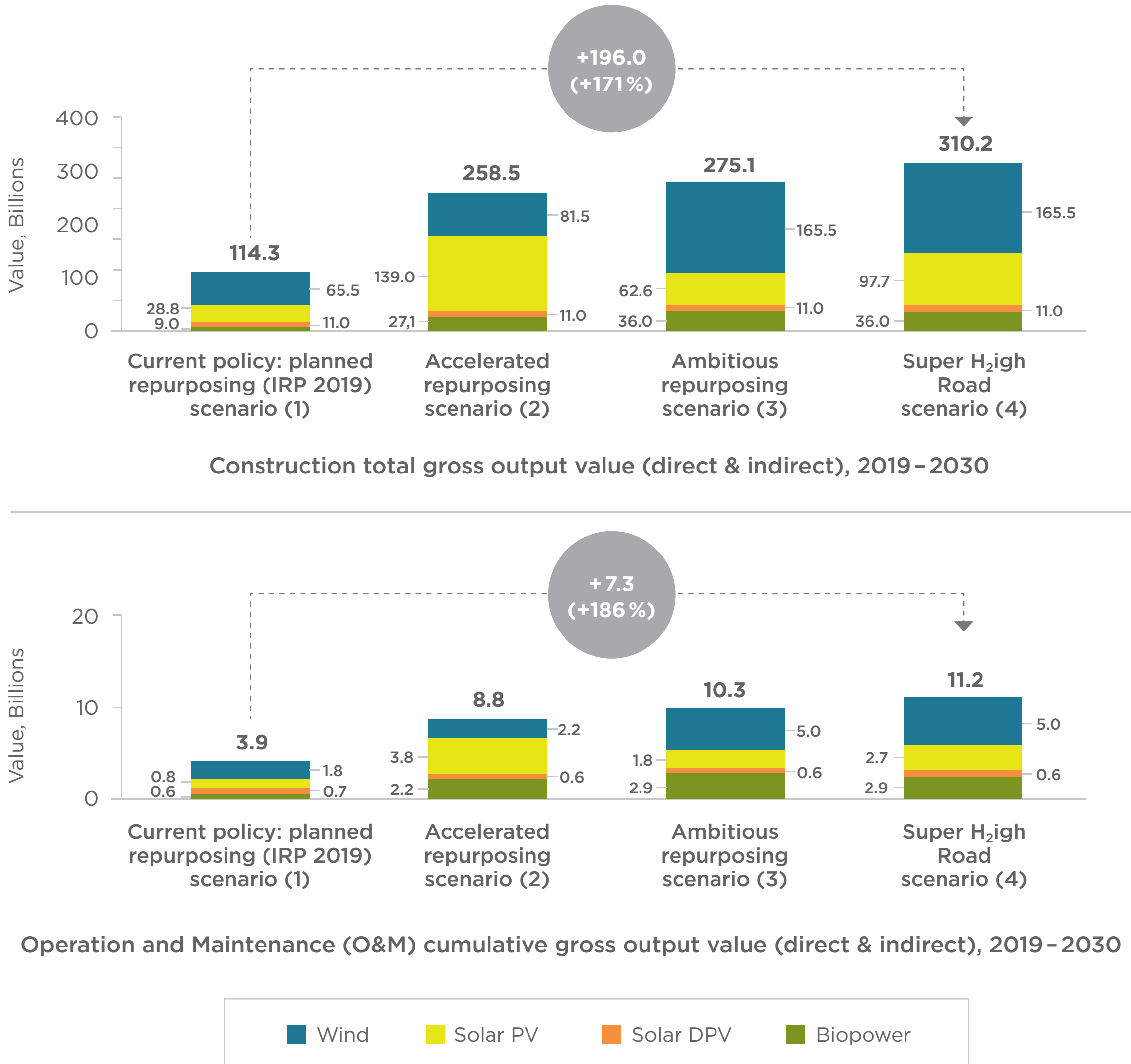

Figure 4-8: Gross output value at moderate local content (billion ZAR; I-JEDI)

Figure 4-9: Construction and Operation and Maintenance (O&M) annual gross output value (billion ZAR; I-JEDI)

Value creation via construction and O&M increases further when assuming higher levels of local content (see Figure 4-9.

Analysing the sectors where gross output value is primarily created, manufacturing accounts for the largest share, ranging between 27 % and 44 % depending on the technology. It contributes the most for wind power and distributed solar PV. Finance, professional, and business services is the second- largest sector, accounting for between 11% and 28% depending on the technology, while for biopower it is the largest share. The construction share ranges between 11% and 19%. The shares are similar in cases with high local content (see Figure 4-10 and IASS (2021c) for further information).

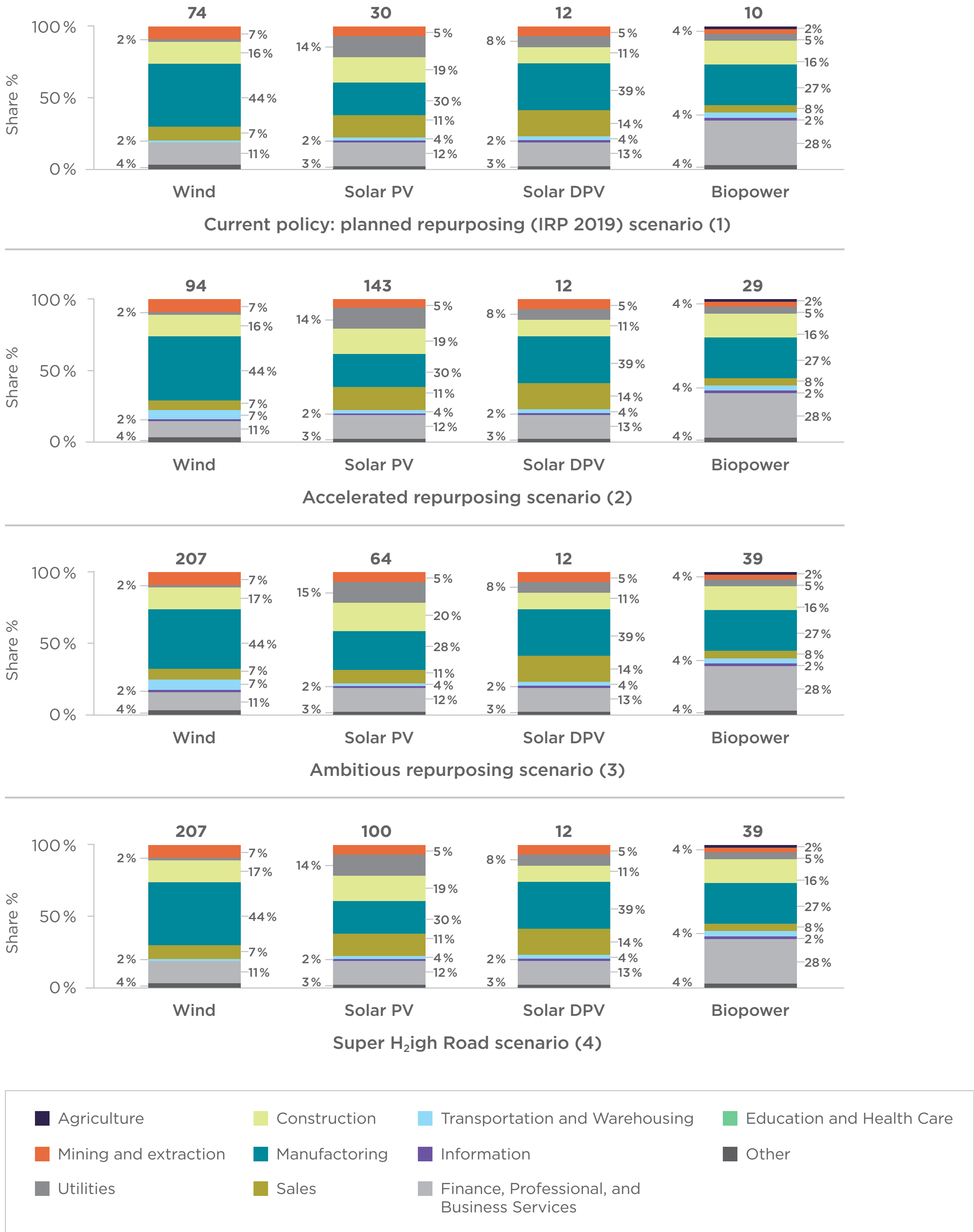

Figure 4-10: Share of gross output value, Moderate Local Content, 2030 (percentage) (source: I-JEDI)

5. Skills development and gender-inclusiveness for the clean energy sector

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 levels of education 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 underrepresented in absolute terms. Female underrepresentation is currently far worse in South Africa's renewable energy sector, where women account for only 10 % of employees.

This chapter aims to analyse the skill requirements of the clean energy sector and potential skill gaps. Consequently, a two-step approach is adopted. First, the skill requirements in the renewable energy sector are depicted. Second, the available skills in Mpumalanga in general and specifically within the coal sector, are highlighted.

5.1 Skill-level requirements in renewable energy

Type of occupations required

To understand skills requirements, occupations in the renewable energy sector (i.e., wind, solar PV, and biomass) first need to be identified. Occupations in the renewable energy sector are divided into five categories along the value chain:

- Manufacturing of renewable energy equipment
- Project development
- Construction and installation
- Employment in crop production (biomass only)
- Operation and maintenance (O&M)[21]

[21] There are also cross-cutting occupations contributing to more than one sub-sector, such as IT, accounting, marketing, human resource, sales, etc.

Occupations in manufacturing phase	Skills required in this phase are dependent on whether all the equipment and their components are manufactured locally. The skills vary according to various activities, including engineers (H), scientists (H), technicians/artisans (S), and logistic operators (L, M).
Occupations in project development phase	This phase requires a workforce with high levels of technical skills, such as engineers (H), scientists (H), lawyers (H), project designers (H). This is due to the nature of the phase, as it evaluates the technical, financial, and environmental viability of the project.
Occupations in construction phase	This phase requires a variety of skills such as engineers (H), technicians/artisans (S), logistic operators (L), and construction workers (L). This phase has potential to employ a significant number of people.
Occupations in crop production (biomass)	This requires crop breeders (H, S), scientists (H), harvesters (M,L) and transport workers (L).
Occupations in operation and maintenance phase	This phase requires a variety of skills such as engineers (H), scientists (H), technicians/artisans (S), inspectors (S), and plant operators (M).

The following coding is used to summarise the skill levels of occupations:

H =	High-skilled (professional/managerial)
S =	Skilled (technicians/artisans/supervisory)
M =	Medium/semi-skilled (machine operators)
L =	Low-skilled (general workers, transporters)

Wind energy Skill levels required for renewable energy sector are relatively high (see also CSIR/IASS, 2019).	**In the wind sector, 67 % of jobs are high-skilled, requiring a post-matric qualification. Most high-skilled jobs are in the manufacturing, development, and O&M phases.**
Solar PV	**In the solar sector, skilled workers account for more than 80 % of the total workforce, with unskilled workers accounting for only 12 %. The bulk of the high-skilled jobs are in the development phase.**
Biomass	**In the biomass sector, high-skilled jobs account for more than 60% of total workers, with low-skilled workers employed in biomass harvesting and the project construction phase.**

Figure 5-1: Skill requirements in the renewable energy sector (source: own)

Further details on skill requirements are included in IASS, 2021c.

5.2 Available skills in the coal sector: Qualifications and occupations

Assessment from the previous section indicates that the renewable energy sector requires both workers with generic skills and some with highly technical skills. These occupations, however, require specialised knowledge of each technology. This section therefore assesses whether Eskom workers, coal-mining workers, and the general Mpumalanga population have the necessary skills to enter the renewable sector; and, if not, whether they can be re-skilled and/or upskilled.

Eskom workers are generally very highly skilled (see Figure 5-2 and 3-28): According to the analysis in Section 3.1, 6,537 Eskom workers and 4,337 coal-mining workers will be impacted by decommissioning of coal power plants by 2030 (IRP 2019 scenario). Eskom workers acquire higher skill levels through education (i.e., 55% with post-grade-12 qualification) and also receive on-the-job training (i.e., 36% are technicians and associated professionals). The analysis shows that, purely based on skill levels, Eskom workers could transition to the renewable energy sector through training specific to the required technology.

Compared with Eskom employees, coal miners have much lower overall skill levels (see Figure 3-27 and Figure 5-3), with 22% holding a post-grade-12 qualification. However, the on-the-job skills they acquire are technical (i.e., plant and machine operators), which could be utilised in the renewable energy sector, especially during manufacturing and construction phases. On average, the Mpumalanga population has even lower educational attainment, with only 11% holding a post-matric qualification and 30% with a matric qualification.

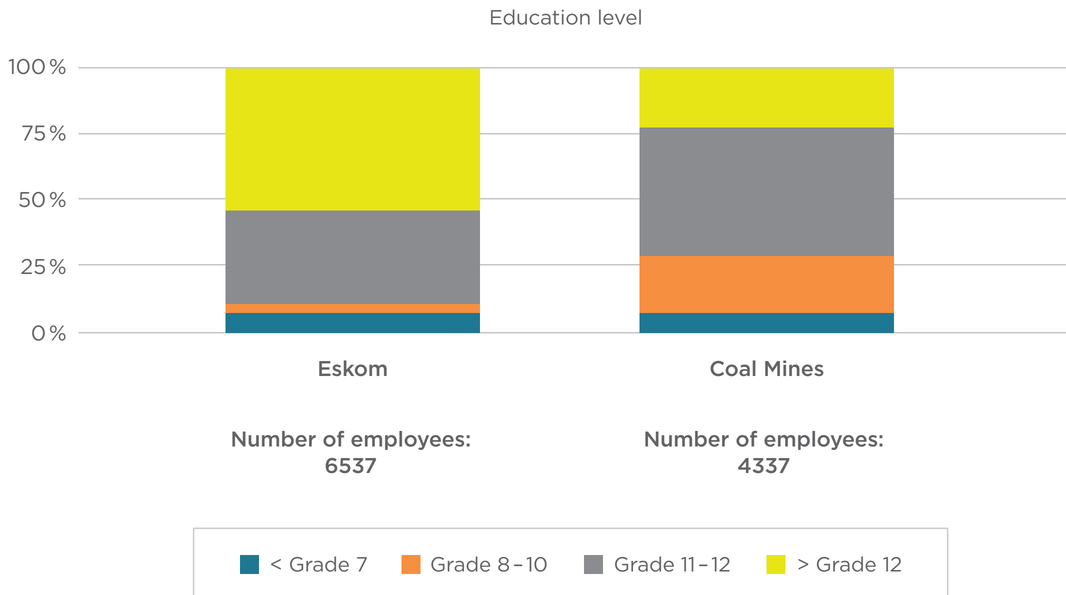

Figure 5-2: Education level among Eskom and coal-mining workers to be impacted by decommissioning of power plants under IRP 2019 (Source: Eskom, 2021 and MQA,2021)

Figure 5-3: Occupation categories among Eskom and coal-mining workers to be impacted by decommissioning of power plants under IRP 2019 (Source: Eskom, 2021 and MQA, 2021)

5.3 Towards a gender-inclusive energy sector in Mpumalanga

As indicated in Section 1.5, the electricity sector in South Africa is currently characterised by a gender imbalance. Female participation in the labour market is crucial because their economic activity raises overall household incomes (IASS, 2021b). Increased income among females in turn increases their access to, and control over, resources and can have a statistically significant impact on poverty reduction (Bravo and Contreras, 2004). Accordingly, this section examines gender disparities among participants in the South African labour market.

A gender gap analysis is used to fully consider the different needs, roles, benefits, impacts, and risks of women and men, and appropriate measures taken to address these and promote gender equality through women's empowerment. Barriers and opportunities for women working in the South African electricity sector, and in renewable energy sector, are assessed.

Eskom employs only 31% females, compared with 21% in coal mining. The under-representation of women in the mining sector is driven by its traditional image, underpinned not only by strong and persistent perceptions but also real experiences, as a sector considered unsuitable for women. Only a few 'light' or 'physically less demanding' areas of work, such as catering/cooking, cleaning, caregiving, and other similar activities are considered suitable for women.

In Mpumalanga, unemployment is higher among women than men, due in part to the demands of the homemaker role. StatsSA 2017 shows that women who have minor children and have higher levels of education are not precluded from the workforce, as they are able to afford childcare. Therefore, providing childcare facilities will be crucial for women engaged in education (i.e., TVET) or as employees in the renewable energy industry.

According to StatsSA 2017, women need to have higher levels of education than men in order to enter the labour market, a trend also observed amongst Eskom and coal mine workers. Consequently, the low local skill levels (seen throughout the province's general population) place women at an even greater disadvantage.

Even when women are able to access formal employment, gender stereotypes and cultural norms often limit them to specific roles, which tend to be lower status or lower paid positions than men (see Table 5-3); For example, domestic work is more common among females than males, with clerical work being the second most common role among employed females. In comparison, plant and machinery operator is one of the largest occupational category choices for males.

Table 5-1: Percentage share of males and females by occupation

Source: Stats SA, 2017

Occupation	Female	Male
Domestic worker	96.3	3.7
Elementary	41.9	58.1
Plant and machinery	13.6	86.4
Craft and related trades	10	90
Skilled agriculture	14.4	85.6
Sales and service	49.7	50.3
Clerk	72.2	27.8
Technician	55	45
Professional	50.8	49.2
Manager	34.3	65.7

The challenges confronting women in different parts of the province (and South Africa generally) can be summed up as follows (Nkangala DM IDP 2018/2019):

- The violence directed towards women and children remains a challenge
- High teenage pregnancy rates, which present challenges in bridging the skills gap between males and females
- Lack of diversification in the economic streams followed by women, resulting in limited opportunities
- Lack of dedicated development programmes for women
- Sexual abuse
- Limited improvements in women's quality of life and status (in both rural and urban communities)
- Lack of entrepreneurial skills development, especially in the small business sector

The emergence of the renewable energy sector represents an opportunity to achieve a more gender-inclusive energy sector in Mpumalanga and South Africa. A 2021 report by the IPP Office shows that women hold only 14% of the jobs created during construction and operational phases in South Africa, compared with 21% globally (IPP Office, 2020, IRENA, 2020, IASS, 2021b).[22]

Renewable energy projects in South Africa employ economic development (ED) managers who execute various socioeconomic- and enterprise development strategies to fulfil their obligations under the REIPPPP. A gender diversity working group has been established by the South African Wind Energy Association (SAWEA) and the South African Photovoltaic Industry Association (SAPVIA). Four ED managers who are part the group, and responsible for coaching and mentoring young women entering the renewable energy sector, were interviewed to understand the barriers and opportunities for women in the sector.

Challenges for female workers and entrepreneurs in the renewable energy sector include:

- Most plants are in remote areas, which presents a security risk for women
- Some plants do not provide separate restrooms for women
- Women engineers having to prove their capability
- No recognition of technical skill, qualifications, or knowledge
- Credentials are routinely questioned and under-mined; However, this helped, as it pushed women to know the business better.
- Access to markets and networks ("who you know") is male-dominated

[22] The IPP office also reported that construction procurement from women owned vendors represented 5% of total procurement, compared with a 4% commitment and 5% target. Operational procurement of 6% has been achieved, exceeding the 5% target.

Opportunities for women workers and entrepreneurs in the energy sector

- As a "new" sector, there is not an entrenched perception of the industry being male-dominated compared to coal mining or fossil power generation.
- Provide financial understanding and knowledge of how to manage company finances.
- Master classes provided by some organisations have excelled in providing a foundation and many more benefits concerning the practicalities of establishing a business model and plan, as well as tips and strategies on sales and marketing. The financial master class was very helpful for understanding business finance and compliance.

It is apparent that South Africa's renewable energy sector still exhibits significant gender inequality. Consequently, the industry has launched its Gender Diversity Working Group, a collaboration between SAWEA and SAPVIA that also includes WE Connect, an NPO focusing on female empowerment within the renewable energy sector. The working group provides gender coaching and mentorship. This includes a Leadership Acceleration Programme (LAP), which identifies women with leadership potential and places them on an accelerator programme to help bridge the female leadership gap in the renewable energy sector.

As a new sector, renewable energy provides an opportunity for women to participate, as there is no "male industry" perception as seen in the old energy industry. Although the renewable energy sector is currently male dominated, leading organisations in the sector are providing mentorship and coaching to enable women to take on leadership roles.

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

6. Creating an enabling environment to make Mpumalanga a clean energy hub in South Africa

This COBENEFITS study depicts the opportunities for Mpumalanga in becoming a clean energy hub. The jobs that will be lost in the coal sector can be partially replaced by jobs in the renewable energy sector. To make this happen and to achieve local value-creation opportunities, massive investment in renewable energy capacity is required in combination with initiatives to build associated local industries. In addition, the transition from fossil-based to renewable energy sources presents an opportunity to improve conditions for women working in the energy sector in Mpumalanga.

How can government departments and agencies maximise socio-economic benefits in Mpumalanga and alleviate negative externalities in the province resulting from shifts away from coal?

How can provincial and national stakeholders harness the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating employment opportunities, building a regional industrial sector, and enabling skill development and gender-inclusive career pathways?

Building on the study results and the surrounding discussions with both political and knowledge partners, we propose to direct the debate toward the following areas in which policies and regulations could be introduced or enforced to strengthen socio-economic benefits for Mpumalanga and increasing the social performance of renewable energy for communities (cf. IASS 2021d):

The Pinnacle Rock in Mpumalanga © H&T Photo Walks via Flickr, CC BY-NC 2.0

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.

High-impact action 1: Implement policies enabling renewable energy development in Mpumalanga

Institution to champion the Action	Collaborative bodies to successfully implement the Action	Timeframe of the Action
Department of Minerals and Energy	DFFE, dtic, IPPO	Short term, over the next 1–2 years

Policy interventions are required to increase the share of renewables constructed in Mpumalanga. Without massive deployment of renewables in Mpumalanga, net job losses in the province will be high. The levelised cost of electricity for renewables in Mpumalanga will be slightly higher than in other parts of South Africa due to slightly inferior resource conditions (solar radiation, wind speeds). Consequently, premium payments or dedicated procurement rounds might be required. This could be justified in part by the reduction in externality costs induced by coal-related activities while grasping the benefits of Mpumalanga's existing grid infrastructure and proximity to load centres.

High-impact action 2: Regional procurement with annual build targets

Institution to champion the Action	Collaborative bodies to successfully implement the Action	Timeframe of the Action
DMRE	dtic, IPP Office	Short term, over the next 1–3 years

The policy framework for the sector needs to include both "push" and "pull" elements. In terms of "pull" elements, regional procurement of renewable and clean energy technologies should be considered. This could be introduced as a short-term measure until the renewable energy market in Mpumalanga, including private off-take opportunities, is well established. Establish regional annual procurement rounds consisting of the respective technologies—solar PV, wind, battery storage, and biopower. In addition, put in place annual build targets to enable continuity (10+ years) and thereby sustain employment, because once the construction and commissioning of a power plant are completed, the subsequent operational phase provides fewer permanent O&M jobs. Creating a pipeline for capacity development will ensure that the high levels of employment provided by construction can be taken advantage of, as the capacity will be added over the longer term. This will create sustained annual employment in the region through construction companies and allow for the development and transfer of skills over time.

Regional procurement could be implemented as a short-term measure until the private power market is established and matures sufficiently to phase out incentives. Future work could be undertaken to fully understand the cost implications of regional procurement—to gauge the penalty for developing regional renewable energy compared to the advantages of proximity to load centres (and hence reduced losses between generator and customer) as well as utilising the region's existing grid infrastructure.

High-impact action 3: Grid development is required to facilitate renewable energy in Mpumalanga and elsewhere

Institution to champion the Action	Collaborative bodies to successfully implement the Action	Timeframe of the Action
DMRE, DPE, National Treasury	Eskom, DFFE, IPPs	Medium- to long term, over the next 5–7 years

The Generation Connection Capacity Assessment (GCCA) 2023 Phase 1, released by Eskom in July 2021, shows that certain regions (e.g., Northern Cape) that have more attractive renewable energy sources than Mpumalanga actually lack any additional transmission grid capacity (Eskom, 2023). IPPs must consider where there is transmission capacity available for connecting their projects, as this is one of the major limiting factors at present. Eskom's transmission plans do include developing the grid in areas where projects need to be connected, however, this will require significant investment and will take time. This could mean that grid-based auctions may be required to allow for capacity to be built in areas that have a lower resource base but greater transmission capacity, such as Mpumalanga. GCCA 2023 Phase 2 was released on 27 October 2021 and shows that Mpumalanga has (at 6,788 MW) the highest grid connection capacity for IPPs among all of South Africa's provinces. (Satimburwa et al., 2021).

6.1 Enabling value creation and localisation in Mpumalanga

High-impact action 4: A coordinated approach, to achieve localisation and foster value creation from renewable energies

Institution to champion the Action	Collaborative bodies to successfully implement the Action	Timeframe of the Action
Provincial government	Eskom, DFFE, IPPs, DMRE, DPE, Sasol, SAREM	Short term, over the next 1–2 years and then ongoing

A coherent clean energy industry policy needs to be established for Mpumalanga in order to create job opportunities and a framework for provincial value creation. There needs to be coordination of efforts at all levels—spanning local, provincial, and national tiers of government—with the local and provincial governments driving the initiatives and plans for the province. A coherent strategy is required between the Mpumalanga government, local municipalities, Department of Mineral Resource & Energy (DMRE), Department of Trade, Industry & Competition (dtic), and Department of Forestry, Fisheries, & Environment (DFFE) on renewable energy value chains to develop the green economy. District-level planning needs to be utilised to move the plans along, which have already been outlined at the national and provincial levels.

Potentially, there should be a roadmap for development, in which each player is assigned a role and milestones to meet, to make the initiatives a reality. This focused approach may also appeal more to international donors. The South African Renewable Energy Master Plan (SAREM) will provide for the development of such a roadmap at the national level. The President also sees a major role for the local level through the District Development Plan, versus just a focus on the national level.

The Just Transition also requires effective and responsive local government. The national government is to provide the overall framework (and funding to some extent) for the Just Transition, however, it will be at the local government level where the projects will be implemented. Thus, it is essential to have the local government tier fully on board with plans for their regions, and that they become functional and efficient partners in the implementation process.

High-impact action 5: Diversification of local content

Institution to champion the Action	Collaborative bodies to successfully implement the Action	Timeframe of the Action
dtic	DMRE, IPPO	Short-term, over the next 1–2 years

High-impact action 6: Dedicated Special Economic Zones to manufacture key components

Institution to champion the Action	Collaborative bodies to successfully implement the Action	Timeframe of the Action
dtic	National Treasury DMRE, IPPO	Short-term, over the next 1–2 years

As indicated above, the policy framework for the sector needs to include both "push" and "pull" elements. To push the provincial clean energy industry, Special Economic Zones (SEZ) can be established. The focus should be on establishing SEZs that specifically provide an attractive environment for companies that manufacture the majority of plant components. These include transformers, switchgear, and cabling, etc., which together account for 60–65% of the value of a typical plant, some of which South Africa already manufactures on a competitive basis. The Nkomazi SEZ in Mpumalanga already provides incentives for the green economy, and can ensure that these companies are prioritised.

The eMalahleni Renewable Energy Development Zone (REDZ) would be complimented by the existence of such SEZs, as it would have a dedicated supply of components for renewable energy development at attractive prices. The manufacture of smaller components makes more sense for Mpumalanga versus larger (exportable) components for which manufacturers would prefer coastal locations to take advantage of access to global markets.

High-impact action 7: Renewable energy skill-development programmes through TVET colleges

Institution to champion the Action	Collaborative bodies to successfully implement the Action	Timeframe of the Action
Department of Higher Education & Training	Department of Basic Education; Department of Science & Innovation; Eskom	Short term, over the next 5 years
	Private sectors (Manufacturing Circle/BUSA)	

6.2 Developing skills and assuring gender-inclusiveness

The renewable energy sector requires a variety of technical skill levels, with some level of training specific to each technology. Data show that only 11% of the Mpumalanga population have a post-matric qualification; however, 65% of the population have a secondary qualification, and it is believed that this group can benefit from a career path though TVET colleges, for which Grade 9 is the minimum admission requirement. The province has three public TVET colleges that provide civil- and electrical engineering-related courses, and trade-related courses (in the engineering and construction industries). These courses provide skills relevant to careers within the renewable energy sector, especially during the manufacturing and construction phases of projects.

Nevertheless, more specialised courses are needed, focused on roles in the renewable energy sector (e.g., wind turbine technicians). Such courses are provided by the South African Renewable Energy Technology Centre (SARETEC) based in the Western Cape province, and it is believed that collaboration between this training facility and TVET colleges is crucial for expanding these types of career opportunities to more people. Collaboration on developing training courses should include the Department of Higher Education and Training (DHET), OEMs, EPC contractors, and district and local municipalities, and should be implemented in two phases. In Phase 1, courses to be developed should resemble those offered by SARETEC, although admission will require a higher level of education, particularly with a university degree. Phase 2 should focus on establishing skills-development programmes and should target population groups with lower educational attainment (i.e., Grades 9–12). Phase 2 will train workers in assisting engineers and trade workers; as these workers gain experience and skills, they could enrol in the types of courses described in Phase 1.

Coal workers typically have lower formal educational attainment compared to Eskom workers, but they do have practical on-the-job training skills, thereby necessitating appropriate assessment of their abilities via Prior Learning Recognition (PLR). PLR is a process through which non-formal learning is measured for recognition across different contexts and certified against the requirements for advancement in the formal education and training system. This process will be powerful in providing these workers with formal educational qualifications (e.g., in reskilling for roles in the renewable energy sector), and should be conducted through collaboration with DMRE, relevant SETAs (i.e., MQA and MerSETA) and DHET.

High-impact action 8: Childcare facilities nearby training centres

Institution to champion the Action	Collaborative bodies to successfully implement the Action	Timeframe of the Action
DHEDT	National Treasury, Department of Basic Education, Private sector	Programmes have already started

According to the IDPs of the three district municipalities, the province has a high teenage pregnancy rate, which represents a challenge in bridging the skills gap between males and females. StatsSA 2017 shows that females without minor children reported higher labour participation rates than those with minor children (i.e., 48.3% of women with no minor children employed, compared to 40.1% of women with minor children, for women with sub-matric qualification). It is evident that childcare responsibilities are a limiting factor for career development, particularly among women. It is therefore crucial to provide childcare facilities near training centres. The DHET, in collaboration with the National Treasury, Department of Basic Education, and the private sector, should provide this service as a component of training programmes.

High-impact action 9: Entrepreneurial development for women

Institution to champion the Action	Collaborative bodies to successfully implement the Action	Timeframe of the Action
Mpumalanga DEDT, EWSETA	SAWEA, SAPVIA SALGA/municipal chapters, Gender CC; Local Municipalities, CSIR Energy Industry Support Program (EISP)	Short term, over the next 5 years

According to expert interviews and the literature review, there is a lack of entrepreneurial skills development, especially in the small business sector. This space is still male-dominated, meaning that women have less access to markets and networks. Procurement processes for developing clean technologies must therefore include gender diversity requirements. REIPPPP has been designed to enhance the participation of women through preferential procurement commitments and obligations with the DMRE. Projects have an obligation to spend a minimum of 0.6% of revenue on enterprise development (ED) and 1.5% of revenue on socio-economic development (SED) activities, exclusively in communities located within 50 km of the project site.

The power sector is still male-dominated. © Shutterstock/Unsplash

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Abbreviations

BMU	German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety
CSIR	Council for Scientific and Industrial Research
DFFE	Department of Forestry, Fisheries and Environment
DHET	Department of Higher Education and Training
DMRE	Department of Mineral Resources & Energy
ED	Enterprise Development
EoI	Expression of Interest
EWSETA	Energy & 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
PV	Photovoltaic
R&D	Research and development
REIPPPP	Renewable Energy Independent Power Producers Procurement Programme
RENAC	Renewables Academy
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 and 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's (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

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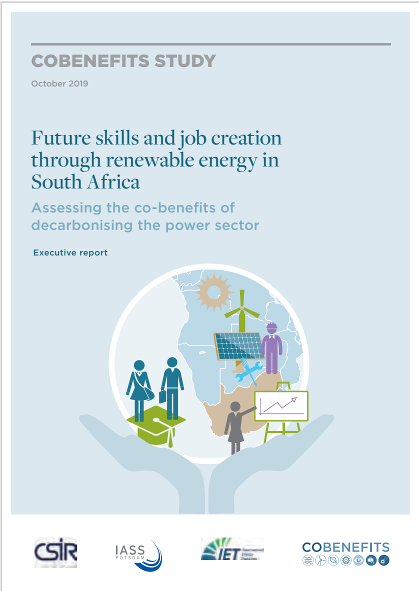

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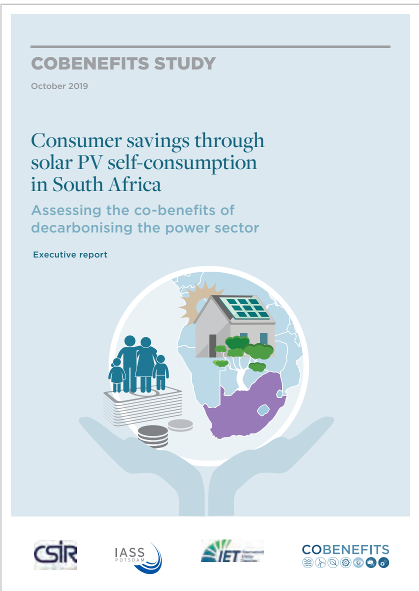

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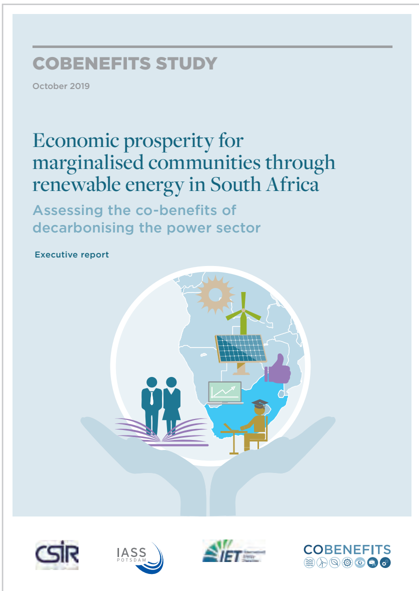

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The COBENEFITS project supports national authorities and knowledge partners in countries worldwide to connect the social and economic co-benefits of decarbonising the power sector to national development priorities and to mobilise these co-benefits 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.

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