COBENEFITS STUDY

October 2019

Future skills and job creation through renewable energy in South Africa

Assessing the co-benefits of decarbonising the power sector

Executive report

CSIR our future through science

IASS POTSDAM

IET International Energy Transition

COBENEFITS

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). This print version has been shortened and does not include annexes. The full version of this report is available on www.cobenefits.info.

This study is part of a 2019 series of four studies assessing the co-benefits of decarbonising the power sector in South Africa, edited by IASS and CSIR. All reports are available on www.cobenefits.info.

- Improving health and reducing costs through renewable energy in South Africa
- Consumer savings through solar PV self-consumption in South Africa
- Economic prosperity for marginalised communities through renewable energy in South Africa
- Future skills and job creation through renewable energy in South Africa

COBENEFITS is part of the International Climate Initiative (IKI). The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) supports this initiative on the basis of a decision adopted by the German Bundestag. The 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), IET – International Energy Transition GmbH, and the Council for Scientific and Industrial Research (CSIR).

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INTERNATIONAL CLIMATE INITIATIVE (IKI)

COBENEFITS of the new energy world of renewables for the people in South Africa

South Africa is in the midst of an energy transition, with important social and economic implications, depending on the pathways that are chosen. Economic prosperity, business and employment opportunities as well as health impacts, issues related to the water–energy–food nexus and global warming impacts: through its energy pathway, South Africa will define the basis for its future development. Political decisions on South Africa's energy future link the missions and mandates of many government departments beyond energy, such as environment, industry development, science and technological innovation.

Importantly, the whole debate boils down to a single question: **How can renewables improve the lives of the people in South Africa?** Substantiated by scientific rigor and key technical data, the study at hand contributes to answering this question. It also provides guidance to government departments and agencies on further shaping an enabling environment to maximize the social and economic co-benefits of the new energy world of renewables for the people of South Africa.

Under their shared responsibility, the CSIR Energy Centre (as the COBENEFITS South Africa Focal Point) and IASS Potsdam invited the Department of Environmental Affairs (DEA) and Department of Energy (DoE), together with the Independent Power Producers (IPP) Office, the Department of Trade and Industry (DTI), Department of Science and Technology (DST) and the South African National Energy Development Institute (SANEDI) to constitute to the COBENEFITS Council South Africa in May 2017 and to guide the COBENEFITS Assessment studies along with the COBENEFITS Training programme and political roundtables.

We particularly highlight and acknowledge the strong dedication and strategic guidance of the COBENEFITS Council members: Olga Chauke (DEA); Nomawethu Qase (DoE); Gerhard Fourie (DTI); and Lolette Kritzinger-van Niekerk, Frisky Domingues, Thulisile Dlamini and Lazarus Mahlangu (IPP Office). Their contributions during the COBENEFITS Council sessions guided the project team to frame the topics of the COBENEFITS Assessment for South Africa and to ensure their direct connection to the current political deliberations and policy frameworks of their respective departments. We are also indebted to our highly valued research and knowledge partners, for their unwavering commitment and dedicated work on the technical implementation of this study. The COBENEFITS study at hand has been facilitated through financial support from the International Climate Initiative of Germany.

South Africa, among 185 parties to date, has ratified the Paris Agreement, to combat climate change and provide current and future generations with opportunities to flourish. Under the guidance of the National Planning Commission, municipalities, entrepreneurs, citizens and policymakers are debating pathways to achieve a just transition to a low-carbon, climate-resilient economy and society in South Africa. With this study, we seek to contribute to these important deliberations by offering a scientific basis for harnessing the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating a just transition, thereby **making the Paris Agreement a success for the planet and the people of South Africa**.

We wish the reader inspiration for the important debate on a just and sustainable energy future for South Africa!

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Executive Summary

Future skills and job creation through renewable energy in South Africa

Assessing the co-benefits of decarbonising the power sector

South Africa has an abundance of renewable energy resources. This, combined with the recent drop in technology costs and the need for new power generation as coal power plants reach retirement, provides an opportunity for the country to decarbonise its electricity sector. Managing this process will allow for a just transition in coal-dependent sectors and regions, thus opening new opportunities for current coal sector employees and other job seekers.

This study analyses the employment impacts of different plans for expanding electricity generation in South Africa's power sector; this was carried out in the context of the COBENEFITS[1] project with the aim of assessing the co-benefits of a low-carbon energy transition in the country. Four scenarios for the future development of the electricity sector in South Africa were analysed: Council for Scientific and Industrial Research Least Cost planning scenario (CSIR_LC); Department of Environmental Affairs Rapid Decarbonisation scenario (DEA_RD); Integrated Resource Plan 2016 (IRP 2016); and Integrated Resource Plan Policy Adjusted scenario 2018 (IRP 2018).

This report presents the resulting employment effects within the electricity sector, primarily focusing on coal and renewable energy sources. It also provides an initial assessment of the skill attainment levels required for South Africa's energy transition, and the potential for workers to transfer from the coal sector to the emerging renewable energy sector.

The four scenarios considered two timelines: The short-term timeline up to the year 2030 which is based on the expected electricity generation mix to meet the rising demand in the country and which is aligned with the National Development Plan 2030. The long-term timeline considers the timeframe up to 2050, based on the electricity generation mix predicted to meet the projected growth in energy demand in the country within this timeframe. It also considers the predicted decommissioning timeline of coal power plants in the country by 2050. The 2018 IRP is only modelled to 2030; the timeframe between 2030 and 2050 runs optimally within the model for the net employment impacts assessed. Hence, the results from the years 2035 till 2050 for the IRP 2018 scenario are based on optimal assumptions. The IRP 2016 was used as the reference case as the IRP 2018 was released towards the end of the study.

- **Key policy message 1:** South Africa can significantly boost gross employment by increasing the share of renewables. With its decision to scale up renewables by moving from IRP 2016 to IRP 2018, employment (measured in job years) can be expected to increase by an additional 40 % in the next 10 years. But there is room for more: by following CSIR's least cost pathway, this number could even be doubled.
- **Key policy message 2:** Following the historical development in the power sector with predominant high-skilled labour, about 70 % of jobs created through the shift towards renewable energy occur in the highly skilled groups (> Grade 12). This growth is most distinct in DEA's rapid decarbonisation pathway and CSIR's least cost pathway, both reaching a share of 76 % in 2050.
- **Key policy message 3:** Coal-sector-based employment is expected to decline regardless of a shift in power generation towards renewable energy sources, with 35 – 40% decline in employment between 2020 and 2050. However, the transition process should be managed politically, to mitigate negative impacts on affected workers and communities.

[5] The term "co-benefits" refers to simultaneously meeting several interests or objectives resulting from a political intervention, private sector investment or a mix thereof (Helgenberger et al., 2019). It is thus essential that the co-benefits of climate change mitigation are mobilised strategically to accelerate the low-carbon energy transition (Helgenberger et al., 2017).

KEY FIGURES:

- By 2050, the shift from IRP 2016 to IRP 2018 will have contributed to a 17 % job increase. By this horizon more than 150,000 jobs will have been created in the power sector in net terms, i.e., including job losses in the coal sector.
- Up to 1.6 million additional jobs can be created economy-wide through the power sector transformation by 2050.
- Jobs in the coal sector will decline by 35 – 40% between 2020 and 2050, with expected reductions in global demand and exports being the main driver behind this transformation.

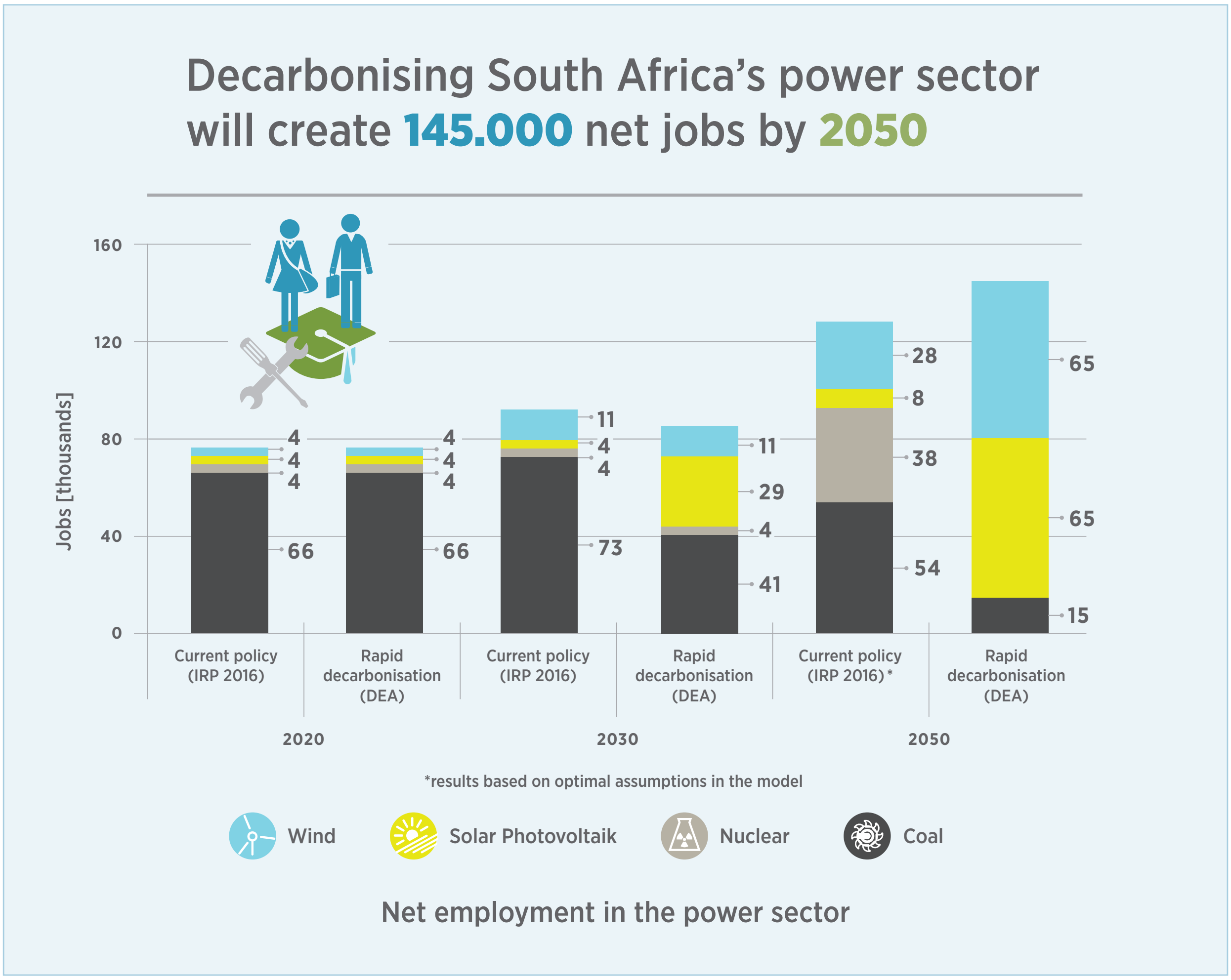
COBENEFITS South Africa (2019): Future skills and job creation through renewable energy in South Africa. Assessing the co-benefits of decarbonising the power sector

available on www.cobenefits.info

KEY FINDINGS:

- **South Africa can significantly boost employment by increasing the share of renewables.** Employment can be expected to increase by an additional 40 % in the period 2018 to 2030, accounting for 580,000 job years. By following CSIR's least cost pathway this number can be more than doubled to almost 1.2 million job years, created along the renewable energy value chain.
- **Jobs in renewable power generation are concentrated in the services, construction and manufacturing sectors.** However, employment opportunities are created in almost all sectors – including the mining sector, which experiences a net increase in employment despite job losses in coal mining.
- **With the shift from IRP 2016 to IRP 2018 an additional 1.3 million jobs are created economy-wide by 2050.** DEA's rapid decarbonisation pathway would have an equivalent impact. However, following the CSIR's least cost pathway would create an additional 300,000 economy-wide jobs.
- **With the shift from IRP 2016 to IRP 2018, new jobs created in the power sector increase by an additional 17 % by 2050**, adding up to more than 150,000 jobs (net).
- In terms of total net employment in the electricity sector, solar PV and wind together account for more than 80% of total net employment in the CSIR_LC and DEA_RD scenarios. Scenarios with higher shares of renewables also lead to the highest net employment figures.
- **By the 2030 horizon, CSIR's least cost pathway will result in the highest number of jobs in the power sector, accounting for 94,000 jobs (net)**, and the highest number of economy-wide jobs with almost 300,000 additional jobs in comparison to IRP 2018. In general, CSIR's least cost pathway performs best in terms of economy-wide jobs at both the 2030 and 2050 horizons.

- **The bulk of job creation in renewable power generation is within the high-skilled labour group**, defined as workers with an educational attainment level above Grade-12, although employment is also created in other skill groups. Across all scenarios, around 70 % of new jobs created in the power sector by renewable energy are in fact high-skilled jobs (> Grade 12). Growth in high-skilled jobs is most distinct in DEA's rapid decarbonisation pathway and CSIR's least cost pathway, both reaching 76 % in 2050.
- **The Renewable Energy Independent Power Producer Procurement Programme (REIPP-PP) has demonstrated the potential for localised job creation through renewable energy deployment in South Africa.** The localisation requirements of the REIPPPP resulted in the development of renewable manufacturing industries and capacity in South Africa. However, growth in the manufacture of essential renewable energy (RE) technologies (and the associated components) is highly dependent on commitment by government to continuous and long-term deployment of renewable energy.
- **Continued job losses are likely in the coal sector: declining global demand for coal is the largest impact factor for coal mining employment;** a decline in demand for South African coal can be observed across all scenarios. Bloomberg New Energy Finance (2018) estimates that by 2050 global coal power generation will decrease to 5% of the global power mix (from 30 % in 2017). Across the employment scenarios, jobs in the coal sector are predicted to decline by 35 – 40% between 2020 and 2050. For IRP 2018, this decline corresponds to 19,000 jobs in total.


Decarbonising South Africa's power sector will create 145.000 net jobs by 2050
Jobs [thousands]
160
120
80
40
0
4
4
4
66
4
4
4
66
11
4
4
73
11
29
4
41
28
8
38
54
65
65
15
Current policy (IRP 2016)
Rapid decarbonisation (DEA)
Current policy (IRP 2016)
Rapid decarbonisation (DEA)
Current policy (IRP 2016)*
Rapid decarbonisation (DEA)
2020
2030
2050
*results based on optimal assumptions in the model
Wind
Solar Photovoltaik
Nuclear
Coal
Net employment in the power sector

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1. Creating jobs and managing a just transition

KEY POINTS:

- South Africa has an abundance of renewable resources. This, combined with the recent decline in technology costs, provides an opportunity to increase the deployment of renewable energy in the power sector at the lowest cost to the economy.
- As Eskom's coal-fired plants reach the ends of their lifespans and are decommissioned, demand for coal in the electricity sector (the largest user of coal in South Africa) will decline. By managing this transition politically, the impacts on workers and communities in coal-dependent sectors and regions can be mitigated.
- This study assesses the gross and net employment impacts of increased renewable energy deployment in South Africa's energy mix. It also provides a comprehensive review of employment in South Africa's coal and renewable energy sectors, including skill levels and estimates of gross employment impacts, amongst others.

Declining costs and technological improvements in renewable energy (RE) have driven a shift in the global energy sector in recent years, with renewable energy sources playing an ever-more prominent role in power generation. The last five years have seen rapid growth in new wind and solar photovoltaic (PV) installations, and in 2016 total renewables accounted for about 60% of new electricity capacity (Arndt et al., 2018). The rapid global uptake of renewable energy has resulted in similar growth among ancillary industries, the combined effect of which has been to expand employment in the renewable energy sector. South Africa's rich sources of renewable energy, combined with declining renewable energy costs, provide an opportunity for a structural shift in power generation, which will assist the country in meeting its Nationally Determined Contributions (NDCs) under the terms of the Paris Agreement, while promoting economic development. While renewable energy has been included in South Africa's electricity mix, to date this has been on a relatively small scale. Recent studies by Wright et al. (2017) and Reber et al. (2018) demonstrate that a much larger share of renewables (70% or more of generation by 2050) is central to the least-cost pathway for the power sector in South Africa.

South Africa, however, has an energy system that is largely dependent on locally mined coal, and Eskom – the national state-owned enterprise (SOE) for electricity generation, transmission and distribution – is the largest user of coal in the country. The coal sector employed approximately 78,000 workers in 2015 (Quantec, 2015) and accounted for 2.3% of total GDP in 2012 (van Seventer et al., 2012). Given the high levels of unemployment in South Africa (the official unemployment rate was 26.7% during the first quarter of 2018), any transition away from coal and toward renewable energy needs to occur without increasing unemployment, but rather by delivering net-positive employment impacts. Several studies have assessed the employment implications of increased renewable energy deployment in South Africa (e.g., AGAMA, 2003; Williams et al., 2008; Rutovitz, 2009; Maia et al., 2011; Stands, 2015). However, those studies focused on gross employment opportunities related to the renewable energy value chain, and did not account for potential employment impacts resulting from changes in the energy mix (i.e., the shift from coal to renewable energy), changes in energy prices or the crowding-in or crowding-out effects of increased renewable energy deployment. Studies that have considered these elements (e.g., Caetano and Thurlow, 2014; Altieri et al., 2016; Caetano et al., 2017) only indirectly analysed the net employment impacts of a transition to renewable energy, while Burton et al. (2018) assessed the direct impacts of such a transition on the coal mining sector, but with little focus on the job creation potential of the renewable energy sector.

This study aims to fill this gap by assessing the net employment impacts of a transition away from coal and towards renewable energy. Building on Borbonus (2017), the study methodology utilises a linked energy–economic model, thus providing a consistent framework within which the renewable energy value chain is captured. The analysis focuses on solar PV and wind resources, as these are the dominant technologies defined in the scenarios analysed. Four scenarios are considered, which assess the technology mix of official electricity planning policy in South Africa as well as the least-cost technology mix. The modelling results and findings also cover other renewable energy resources that are included in the electricity generation mix in the above scenarios, such as concentrated solar power (CSP), biomass and small-scale hydro technologies. An assessment of gross employment impacts is undertaken using the International Jobs and Economic Development Impacts (I-JEDI) model developed by the National Renewable Energy Laboratory (NREL), United States. The model was modified for the South African context. 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. The underlying data used as the baseline for employment in South Africa are from the quarterly labour force survey (QLFS) as published by Statistics South Africa (StatsSA, 2018). The gross employment effects are reported according to direct, indirect and induced employment effects as defined by IRENA (2014). In contrast, the net employment effects are reported by sector, with no distinction made between direct, indirect and induced impacts, as these cut across sectors in the national accounts and are not discernible from the results.

While the net sectoral impacts of a shift to renewable energy in South Africa are important, understanding the impacts of this transition on affected sectors is also vital. This study therefore also offers an initial examination of the implications – for the coal sector and its employees – of shifting the electricity production mix away from coal power. Specifically, the study identifies the skills and quality of jobs in both the coal and renewable energy sectors, and the potential for retraining coal workers to enable them to take up employment opportunities that emerge in other sectors of the economy. Note that this study provides an initial analysis of these issues; more focused work (and data collection) will be necessary to unpack and address these issues more comprehensively.

BOX 1: DEFINING EMPLOYMENT EFFECTS

- The definitions of direct and indirect employment effects related to increased renewable energy deployment differ between studies in both the international and domestic literature (Lambert and Silva, 2012). These differences depend on which activities are considered to form part of the direct or core function of renewable energy power generation versus the indirect functions. The definition used is dependent on the modelling methodology implemented and the question being asked.
- The gross employment effect considers only the impact on employment resulting from the activity. It generally includes the direct and indirect effects but can also include the induced effects. Net employment effects account for the gross impact as well as other employment changes that occur due to the impacts that the change in activity has on the overall economy (e.g., changes in prices, crowding out investment, etc.). For example, increased labour demand from the renewable energy sector may result in higher wages if labour supply is insufficient to meet demand. This could negatively affect other sectors in the economy, as higher wages increase production costs. Increased renewable energy deployment may lead to lower coal production for local use and potentially lower coal employment. This would be captured in the net employment effect. While definitions of direct, indirect and induced jobs may be important for comparability across value chains, the overall net impact on employment should be of interest to policy makers interested in the employment impacts of decarbonising the power sector.

BOX 2: Defining skill attainment levels

- Low-skilled workers possess limited skills and lower educational attainment, e.g., a matriculation certificate or lower. These employees perform work that does not require specialised experience. This category includes truck drivers, cleaners, gardeners and those employed in rudimentary tasks
- Semi-skilled workers are persons with basic training, knowledge and experience necessary to complete specific tasks, but who lack specialised skills. These employees would have some form of post-secondary school training.
- Skilled and high-skilled workers are persons with a specialised skillset required to complete a specific task, and will most often have completed tertiary education (either vocational training or university education). This category includes white- and blue-collar professions, including administrative workers, electricians and lab technicians, computer programmers and lawyers.

2. Methodology

The assessment methodology includes a qualitative analysis of interviews with key renewable energy stakeholders as well as a review of the existing literature. A quantitative analysis is adopted to estimate the gross and net employment impacts of increased renewable energy deployment arising from specific scenarios (see figure 1). The International Jobs and Economic Development Impacts (I-JEDI) tool adapted for South Africa is used to assess the gross employment impacts, while the SATIMGE model is used to assess the net employment impacts. Four electricity generation scenarios from different government analyses are considered to evaluate the employment impacts associated with different shares of renewable power in South Africa's electricity mix.

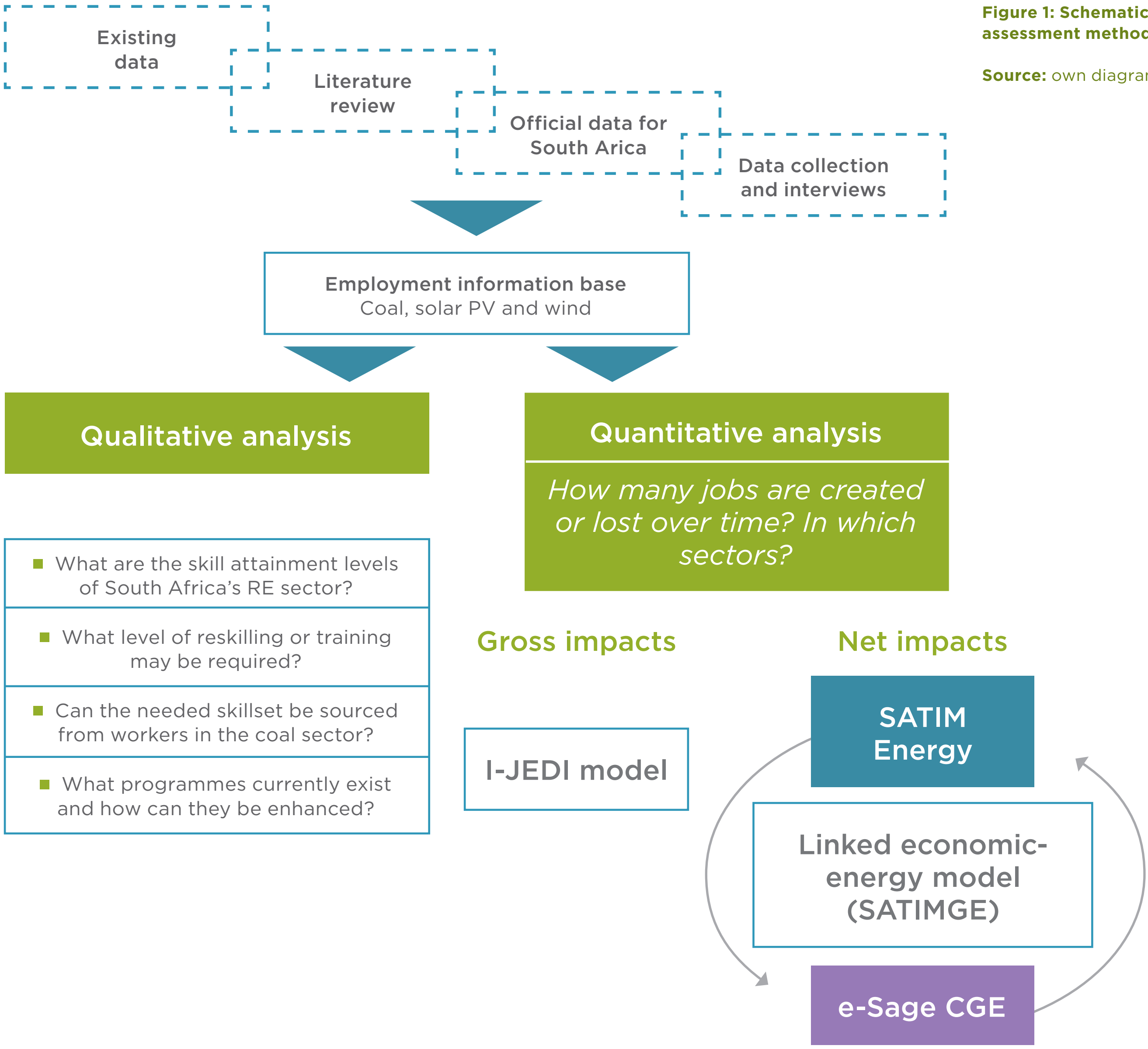


Figure 1: Schematic of assessment methodology

Source: own diagram

2.1 Qualitative and quantitative assessment methodologies

The qualitative approach uses information gathered from a literature review, and surveys with key stakeholders, to understand the value chain for renewable and coal power. Through unpacking these sectors, a better understanding of the skills and training needs can be attained. Furthermore, piecing together the value chain provides important information on the sectors that are indirectly affected by the uptake of renewable power.

The quantitative assessment utilises a South African-adapted I-JEDI model (NREL, 2016) to estimate the gross employment impacts of increased renewable energy deployment in South Africa. The South African TIMES linked general equilibrium model (SATIMGE) is used to estimate the net employment effects. The employment impacts of increased renewable energy deployment are assessed over the period 2018 to 2050. For each technology, the I-JEDI model estimates the economic impacts associated with the construction and operation of power plants, by characterising these two phases in terms of domestic (in-country) and international expenditure. The model data are then used in a country-specific input–output (I–O) model to estimate employment, earnings, gross domestic product (GDP) and gross output impacts. Total economic impacts are presented, as well as impacts per industrial sector. The model is used for the gross employment assessment as it only considers the positive direct, indirect and induced employment impacts of the value chain.

SATIMGE is a linked model that brings together a bottom-up engineering model of South Africa's energy system (SATIM) and a top-down computable general equilibrium economy-wide model (e-SAGE). The models are linked through an iterative process that mimics the planning process employed in South Africa's electricity sector, thus preserving the strengths of each model. SATIMGE is uniquely placed for assessing net employment impacts as it provides a consistent framework for energy–economic analysis. The inclusion of SATIM ensures that physical properties of the energy system are included, thus ensuring that appropriate costs and constraints are considered. The e-SAGE model provides for economic analysis of changes in the energy system, accounting for direct and indirect impacts, changes in prices and behaviour and also macroeconomic constraints in the economy. Electricity sub-sectors are included in the 2012 SAM, in which the electricity sector is disaggregated by technology using data from the 2012 energy balance for South Africa, the IRP 2016 and data from StatsSA. Operations and maintenance (O&M) employment (per GWh) is based on estimates by Pauw (2007) but updated to the most recent information; detailed O&M employment factor per energy generated for each power generation technology is shown in figure 2.

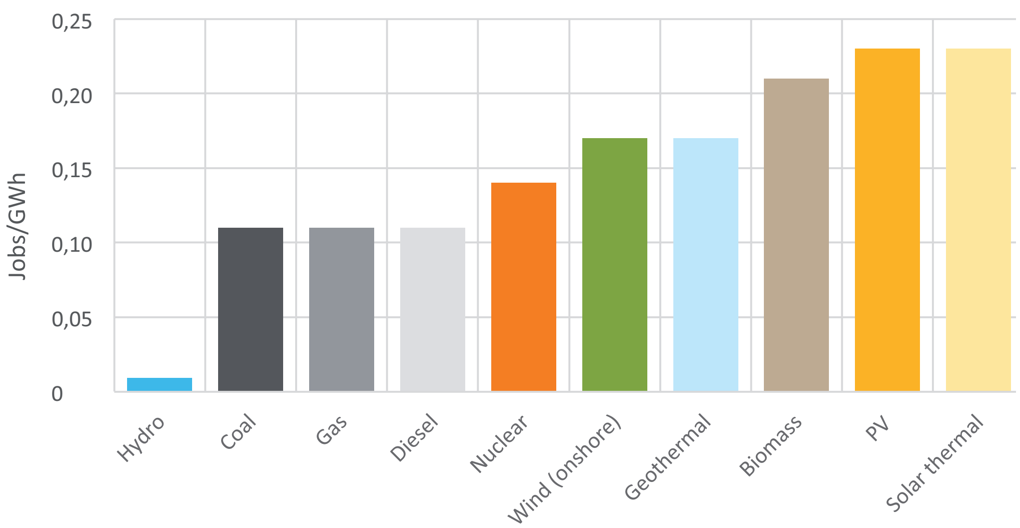


Figure 2: Operations and maintenance employment factors (source: Pauw, 2007)[2]

Source: own

[2]The numbers presented here (jobs per GWh) do not account for transmission and distribution jobs.

2.2 Scenarios and assumptions

Four scenarios were analysed for the future development of the power sector in South Africa. From these four, three government-level scenarios from the Department of Energy (DoE) and the Department of Environmental Affairs (DEA) South Africa represent the composition of South Africa's energy mix over medium- and long-term planning horizons, and form the basis for assessing the employment impacts of renewable energy deployment in South Africa's power sector and the broad economy. The power supply mix and new capacity additions from the Integrated Resource Plan 2016 (IRP 2016)[3] scenario developed by the DoE are chosen as the baseline, representing the policy-planning status quo in the power sector. The Integrated Resource Plan 2018 (IRP 2018)[4], also developed by the DoE, is an updated version of the IRP 2016 document, which shows updated medium and long-term electricity sector planning under consideration by the South African Government. It shows the increased share of renewable energy sources in the energy mix. The third government reference policy and scenario assessed is the DEA Rapid Decarbonisation scenario[5] (DEA_RD), which presents an alternative approach for rapidly reducing the greenhouse gas and harmful emissions generated from the power sector. The scenario shows an increase in the share of renewable energy in the power sector to more than 70% by the year 2050. It also has a planning horizon up to the year 2030 for the short term and 2050 for the long term. The last scenario analysed is the Council for Scientific and Industrial Research Least Cost planning scenario[6] (CSIR_LC). This scenario was developed as the least-cost alternative to power sector planning, as a formal and independent review of the IRP 2016. The scenario places no annual techno-economic limitations on expanding the shares of renewable energy sources over the planning horizon until 2050. The decommissioning timeline of coal power plants in the country used in the analysis is adopted from the IRP 2016.

Noteworthy, the use of differing underlying assumptions in each scenario means that they cannot be compared if modelled exactly. To address this, only the production shares of each technology for each scenario are modelled in SATIMGE to generate new capacity technology additions for each scenario. Thus, the new capacities obtained from SATIMGE are hence used in the I-JEDI model. The IRP 2016 assumptions[7] are used as a baseline across the other three scenarios, except for renewable technology costs which are taken from Ireland and Burton (2018); this is done to account for the significant decline in actual renewable energy costs and changes from the year the IRP 2016 was published.

[3]The IRP refers to the coordinated schedule for generation expansion and demand-side intervention programmes, taking into consideration multiple criteria to meet electricity demand. The IRP 2016 presents insights on the preferred generation technology required to meet expected demand growth pre-2030. The planning period further extends beyond 2030 up to 2050. The scenario's calculations are based on broadly different factors, such as technology cost calculations, energy policy direction and emission targets. The base case scenario (BC) is used for the analysis.

[4]The draft IRP 2018 was published for consultation in August 2018. It considered demand-growth scenarios that tested the impacts of projected load demand (at a moderate rate) on the energy mix up to 2030. Details of the scenario can be found here: http://www.energy.gov.za/IRP/irp-update-draft-report2018/IRP-Update-2018-Draft-for-Comments.pdf

[5]The DEA_RD scenario presents an alternative mitigation pathway via emission reduction in the power sector as well as the technological requirements for power generation. The scenario has a baseline set from 2015 and projected until 2050. The data for this scenario were provided directly by the Department of Environmental Affairs (as a member of the COBENEFITS COUNCIL) to be analysed in this study.

[6]The CSIR least-cost scenario was developed as an independent review of the IRP 2016 (Wright et al., 2017). The scenario places no annual technical limitations on the penetration of solar and wind technologies over the planning horizon until 2050. It shows lower emissions in the energy mix, and consumes less water than the Draft IRP 2016. Renewable energy costs are set to be compatible with the global learning curve on energy technologies. Furthermore, the scenario presents solar PV and wind energy as the largest contributors to the energy supply mix in South Africa by 2050.

[7]The moderate growth scenario of 3.2% average annual growth is used.

3. Employment opportunities for South Africa

KEY POINTS:

- A typical 86 MW solar PV power plant direct value chain created 950 jobs and 3,670 job years over the lifetime of the project.
- The construction phase had the highest share of jobs created in the value chain; 63% of total headcount jobs and 47% of total job years were obtained during this phase. Operations and maintenance (O&M) created 1,575 job years (43% of jobs years) over the life time of the project. The remainder jobs (386 job years) were created during the development and manufacturing phases of the project.
- 64% of head count jobs and 52% of job years required skilled workers to achieve the required task. 76 jobs (8% of total jobs) and 470 jobs years (13% of total jobs years) were created for unskilled labour over the lifetime of the projects assessed.

3.1 Qualitative findings on job creation under the REIPPPP

This section reports the findings from surveys and interviews conducted with industry stakeholders concerning job creation and skills development during the initial rounds of the REIPPPP. Table 1 provides a description of the various educational attainment levels applied for the survey and the adopted to measure the skill levels required in the renewable energy sector (see box 2 for a detailed explanation of each skill level).The results obtained were primarily for the solar PV value chain; the data did not account for the indirect and induced employment impacts of these projects. Table 2 provides the head count jobs (number of people employed) and job years (total number of jobs multiplied by the (maximum) number of years that those jobs are required) created according to the value chain phase for a typical 86 MW solar PV project. Stakeholders obtain and track the information provided through detailed checks and balances that include FICA registrations, payslips and timesheets for every employee contracted, ID certificates and submission of Employment Equity Declaration by Worker (EEA1) forms. The information presented does not account for indirect or induced jobs, as this information is not monitored by the various stakeholders.

Skill level	Educational attainment/ employment grade level	Description based on South Africa's education system
High-skilled graduate	> Grade 12	Tertiary or university education
Skilled	Grade 11–12	Vocational education (at least)
Semi-skilled	Grade 10–12	Secondary education
Unskilled	Grade 1–9	Primary education

Table 1: Description of educational and skill attainment levels in South Africa (adopted for the study)

Source: own

Over the lifetime of the power plant, 950 jobs and 3,670 job years were created. From data obtained, majority of the jobs are concentrated in the construction and installation (CI) phase (including transportation and logistics) and account for about 63% of total headcount jobs created and 47% of total job years. Manufacturing and development each account for 5% of total job years. O&M provides 1,575 job years of employment (43% of total job years); O&M jobs last for a period of 25 years, whereas the typical period for employment in non-O&M jobs is approximately 1.5 years to 3 years. From the results, jobs created in the direct value chain of the project are largely for skilled and high-skilled workers, with unskilled workers accounting for less than 10% of total headcount jobs created. The demand for higher education especially up to the university level (> Grade 12) is predominant during the development phase of the project.

Table 2: Jobs created and skill needs in an 86 MW PV plant (source: own data from surveys)

Source: own

Project phase	Project activity	Number employed	Skill level	Period (years)	Job years
Manufacturing	Module assembly	186	Skilled (vocational)	1	186
Development	Developer employees	10	High-skilled (university)	1.5 – 2	20
	Permitting phase (consultants)	15	High-skilled (university)	1.5 – 2	30
	Ancillary services	5	High-skilled (university)	1.5 – 2	10
	EIA process	3	High-skilled (university)	1.5 – 2	6
	From development to sale	25	High-skilled (university)	1.5 – 2	50
	EPC	15	High-skilled (university)	1.5 – 2	30
	Banking	18	High-skilled (university)	1.5 – 2	36
	Construction management team	9	High-skilled (university)	1.5 – 2	18
	Total	**286**			**386**
Construction and installation	Civils (site clearing, foundation, basic construction, etc.)	211	Semi-skilled	1.5 – 3	633
	Construction team from various contractors and EPC	65	Skilled or high-skilled	1.5 – 3	195
	Electrical	6	Skilled or high-skilled	1.5 – 2	2
	Structure erection, excluding civils	202	Semi-skilled or Skilled	1.5 – 3	606
	Grid work	52	Skilled	1.5	78
	Transportation of equipment	65	Unskilled	1.5 – 3	195
	Total	**601**			**1,709**
Operations and maintenance	Control centre (projects in process)	20	High-skilled (university)	25	500
	Grass-cutting	11	Unskilled	25	275
	Operations and maintenance	32	Semi-skilled or Skilled	25	800
	Total	**63**			**1,575**
Sum-Total	**950**				**3,670**

3.2 Estimating gross employment impacts for different power sector pathways

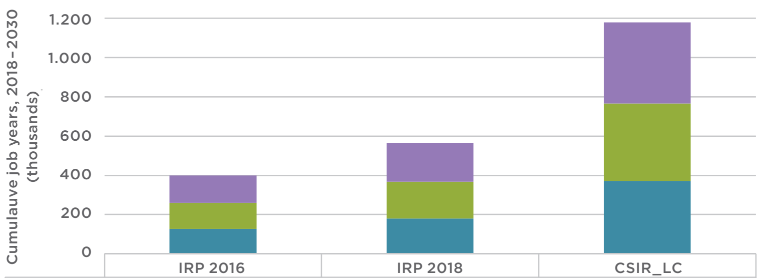
This section presents the job creation impacts of different plans for expanding electricity generation in South Africa's power sector, focusing on the areas of construction and operations and maintenance (O&M).

The total number of jobs created in the construction phase during the period 2018–2030 amounted to 399,600 job years under the IRP 2016 scenario (see figure 3). The decision by the DOE to consider a shift from IRP 2016 to IRP 2018 by scaling up renewables, employment created along the renewable energy value chain can be expected to increase by additional 40% in the period 2018 to 2030, accounting for a total of 580,000 job years (and an increase of over 165,000 job years). By following CSIR's least cost pathway this number can be doubled to almost 1.2 million job years. This substantial variance can be attributed to the difference in the share of new renewable energy capacities added over this time horizon across the three scenarios; calculations conducted in the study show that the IRP 2016 was expected to add about 14 GW of new RE capacity between the years 2018 and 2030 while 15.5 GW of new renewable energy capacities are planned under the IRP 2018. Over this same time horizon, 29.7 GW of additional renewable capacities are planned under the CSIR_LC scenario.

Figure 4 shows the cumulative job years created by both wind power and solar PV technologies for each of the scenarios analysed during the period 2018–2030. More jobs are created in the wind sector under the CSIR_LC and IRP 2018 scenarios. This can be attributed to the larger shares of wind power capacities added in comparison to solar PV in both scenarios over the analysed time horizon.

Between the year 2018 and year 2030, CSIR_LC scenario creates 27,800 job years in the O&M value chain (see figure 5). This is considerably higher than both IRP 2018 creating 10,600 jobs years and IRP 2018 with 14,500 job years.

Figure 6 and figure 7 show the breakdown of the gross employment effects in job years across selected sectors in the South African economy during the CI and O&M phases respectively for the three scenarios between the year 2018 and 2030; the sectors shown are based on the spread used in the country's SAM. These numbers account for the gross direct, indirect and induced impacts across the country (but not accounting for the net employment losses or shifts in these sectors over the time horizon). The manufacturing, construction, services and sales sectors experience the highest gross employment gains during the construction and operation phases of adding new renewable energy capacities to the power mix; this is because these sectors show greater linkages to, and are more positively affected by developments in the renewable energy value chain across South Africa.



	IRP 2016	IRP 2018	CSIR_LC
Induced	139763	198194	413100
Indirect	133778	188273	393586
Direct	126030	178918	371909

Direct Indirect Induced

Figure 3: Cumulative job years created during the construction phase by wind and solar PV year 2018 and 2030

Source: own data I-JEDI results

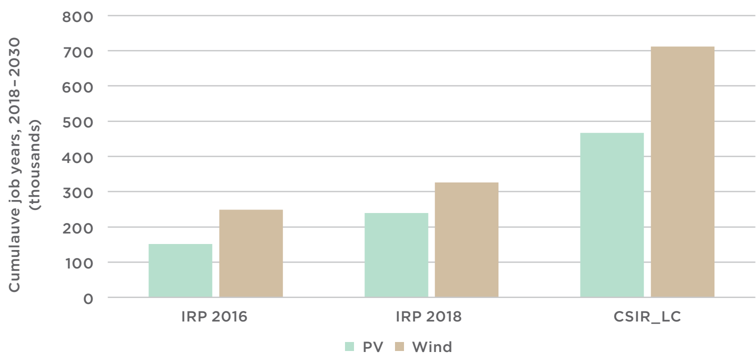
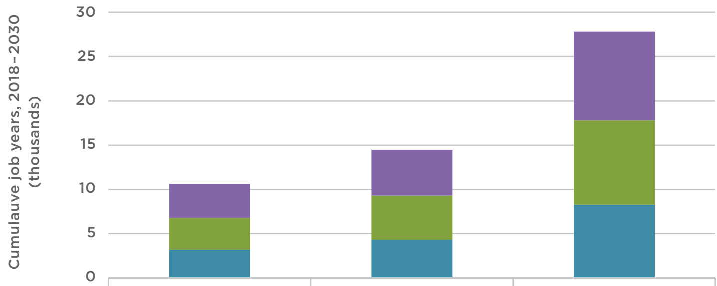


Figure 4: Cumulative job years created during the construction phase wind and solar PV between the year 2018 and 2030

Source: own data I-JEDI results



	IRP 2016	IRP 2018	CSIR_LC
Induced	3825	5189	10032
Indirect	3629	4975	9489
Direct	3179	4975	8294

Direct Indirect Induced

Figure 5: Cumulative job years created during the O&M phase by wind and solar PV between the year 2018 and 2030

Source: own data I-JEDI results

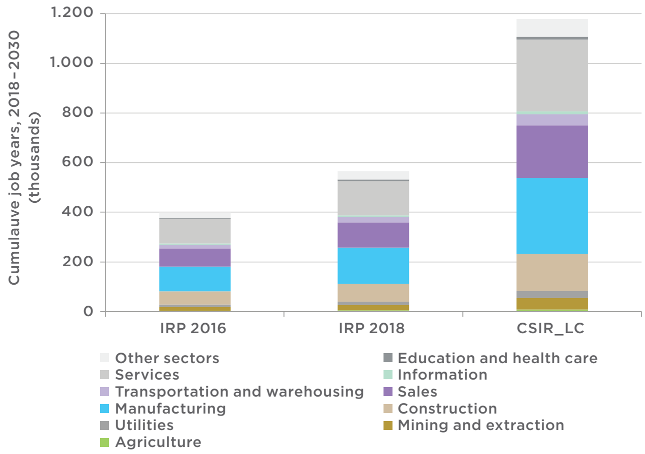


Figure 6: Broad sectoral cumulative job years induced during the construction phase by wind and solar PV be-tween the year 2018 and 2030

Source: own data I-JEDI results

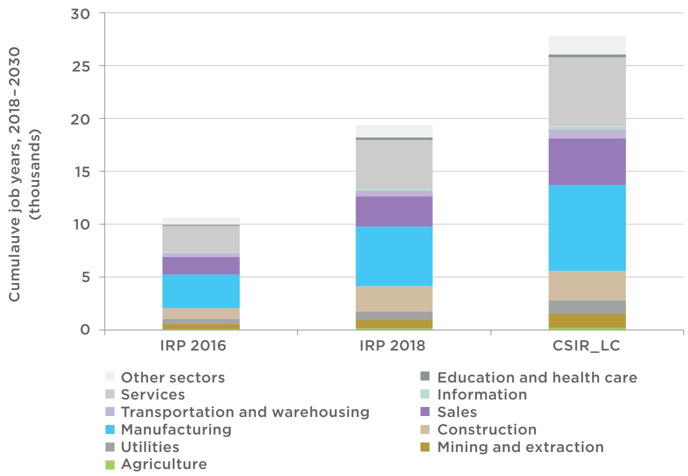


Figure 7: Broad sectoral cumulative job years induced during the O&M phase by wind and solar PV between the year 2018 and 2030

Source: own data I-JEDI results

3.3 Estimating net employment impacts for different power sector pathways

The evolution of direct jobs created

In the medium term, coal continues to play an important role in the power sector as a major employer, but this decreases over time as coal-fired power plants are decommissioned and replaced with other emerging technologies, especially renewables. The assessment conducted in this section takes into consideration the DEA_RD scenario as an additional power sector planning pathway for South Africa, and also compares accordingly with the IRP 2016, IRP 2018 and CSIR_LC.

With the shift from IRP 2016 to IRP 2018 an additional 17% of new jobs in the power sector are created by 2050, adding up to more than 150,000 jobs (net). In terms of total net employment in the electricity sector, together, solar PV and wind account for more than 80% of total net employment in the CSIR_LC and DEA_RD scenarios (see figure 8). Scenarios with higher shares of renewables also lead to the highest net employment figures. In short and medium term however, by the year 2030, CSIR's least cost pathway will result in the highest number of additional jobs in the power sector, accounting for 94,000 new jobs (net), and the highest number of economy-wide jobs with almost 300,000 additional jobs in comparison to IRP 2018 (see figure 9).

The bulk of employment in the power sector as a result of additional shares of renewable energy generation is created in the high-skilled labour group, defined as workers with an educational attainment level above Grade-12, although employment is also created in other skill groups (see figure 10). Across all scenarios, around 70% of new jobs in the power sector are high-skilled jobs, requiring at least a university education; this aligns with results obtained from focus group surveys (see Table 2). Growth in high-skilled jobs is most distinct in DEA's rapid decarbonisation pathway and CSIR's least cost pathway, both reaching a share of 76% in 2050.

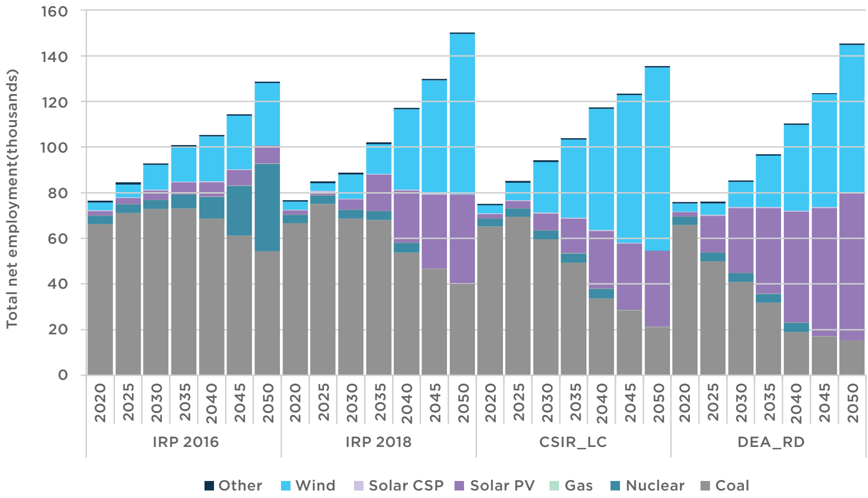


Figure 8: Evolution of net employment in the power sector by the different technologies

The results from the years 2035 till 2050 for the IRP 2018 scenario are based on optimal assumptions in the model.

Source: own data/ SATIMGE results

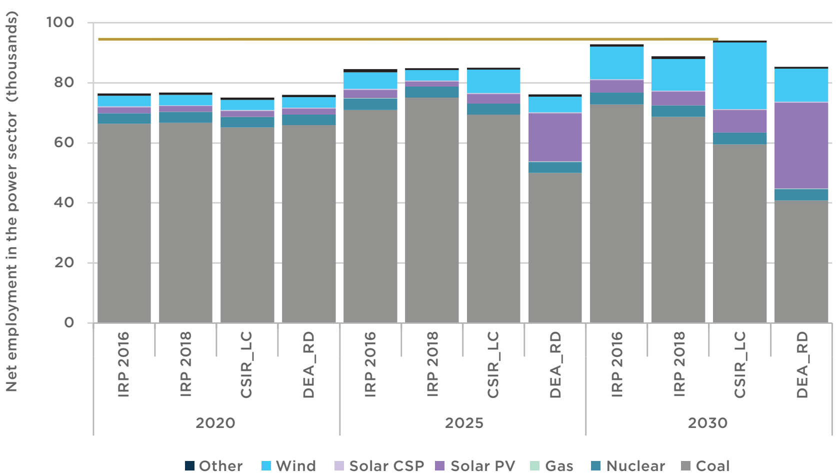


Figure 9: Net employment in the power sector by the different technologies by the year 2030

Source: own data/ SATIMGE results

Figure 10: Expected evolution of skill grade levels based on net employment impacts in the power sector

The results from the years 2035 till 2050 for the IRP 2018 scenario are based on optimal assumptions in the model.

Source: own data/ SATIMGE results

Coal sector employment impacts

Jobs in the coal sector (especially in the mining sub-sector) are estimated to decline by 35–40% between 2020 and 2050 across the scenarios, with expected reductions of global demand and exports being the main driver behind this transformation – declining global demand for coal is the largest impact factor for coal mining employment. This is also driven by the decrease in coal demanded by the power sector in South Africa, as well as an endogenous shift to increased automation use relative to "manual" labour in mining processes over the assessed time horizon. Bloomberg New Energy Finance (2018) estimates that by 2050 global coal power generation will decrease to 5% of the global power mix (from 30% in 2017). The coal demand by industrial consumers in the country for process heat and other purposes is not sufficient to offset the decline in demand from other sources (see figure 11).

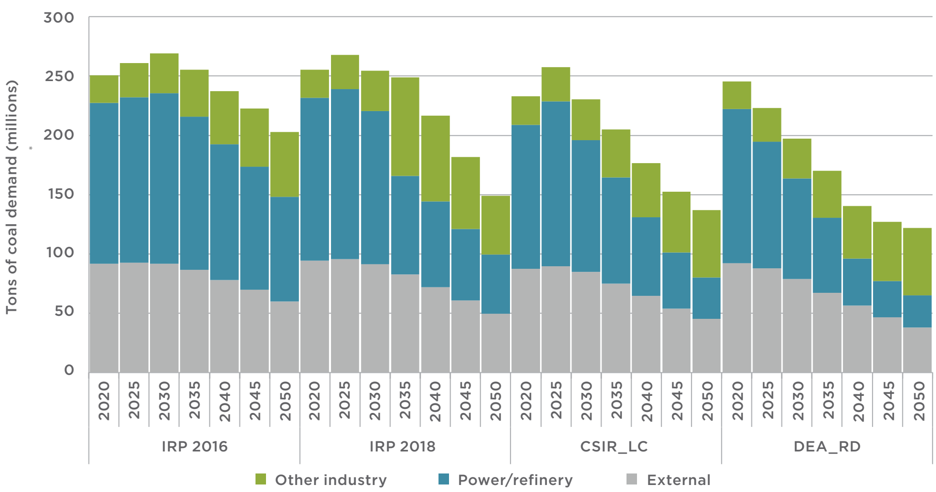


Figure 11: Estimated changes in coal demand by different consumer groups

The results from the years 2035 till 2050 for the IRP 2018 scenario are based on optimal assumptions in the model.

Source: own data/ SATIMGE results

For IRP 2018 the predicted net loss of jobs corresponds to 19,000 jobs in total by 2050. For the IRP 2016, the decline is approximately 17,000 between 2020 and 2050 (see figure 12). The CSIR_LC and DEA_RD scenarios experience a decline of 18,000 and 27,000 jobs respectively. Figure 12 also shows the evolution of skill groups and educational attainment levels with changes in the power sector and coal demand in the country. The coal demand across different consumer groups shown in 11 indicates further that the net job losses expected in South Africa's coal sector are not primarily due to the shift from coal towards renewable energy in the power sector. Two other key factors obtained are the decreasing demand from the global market, and the lack of industrial consumers to offset for reducing power sector demand. In the short term, between the year 2020 and 2030, the net job losses estimated under IRP 2018 scenario is approximately 7,000, approximately 6,000 job losses in the CSIR_LC scenario and 12,800 under the DEA_RD scenario.

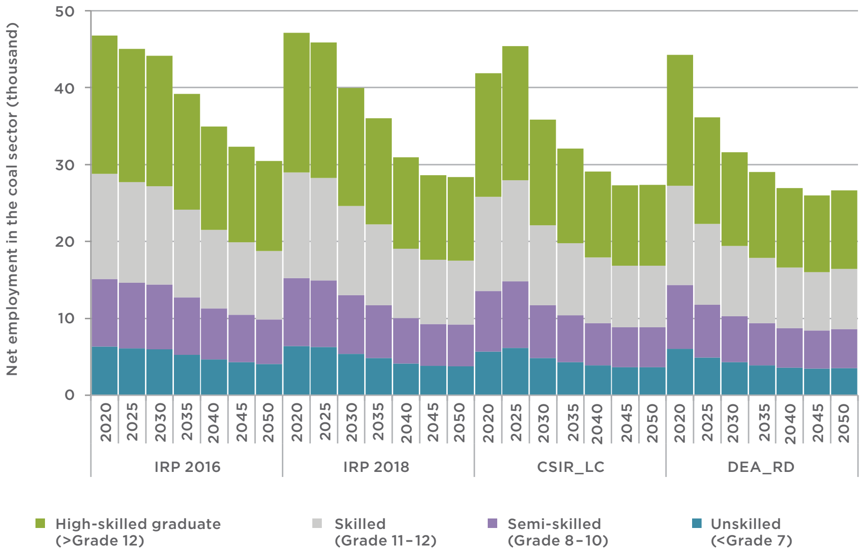


Figure 12: Evolution of total net employment in the coal sector (including mining and transport) by skill attainment level

The results from the years 2035 till 2050 for the IRP 2018 scenario are based on optimal assumptions in the model.

Source: own data/ SATIMGE results

Broad economy-wide employment impacts

Increased deployment of renewable energy in South Africa and the associated changes it creates in the economy leads to net increases in overall employment over the assessed time horizon. With the shift from IRP 2016 to IRP 2018 an additional 1.3 million jobs are estimated to be created economy-wide by 2050. DEA's rapid decarbonisation pathway would have an equivalent impact. However, following the CSIR's least cost pathway would even create an additional of 300,000 economy-wide jobs to the IRP 2018 (see figure 13). Progressively over the years and in all scenarios, the net economy-wide employment gains are obtained mainly in the service based sectors. The manufacturing sector experiences relative conspicuous net employment gains as a result of estimated lower energy prices, this occurs as a result of reduced operating costs from the new renewable energy capacities added in the power mix.

This study makes a reasonable assumption that new monetary investments in the power sector as a result of new renewable energy capacity additions in the power sector would be locally sourced. Albeit, it is appropriate to note that additional foreign investment into renewable energy value chain (this can be engendered through an efficient and effective procurement process) may be required to offset or ameliorate potential negative medium-term impacts that could occur due to potentially crowding out local investments from other competing sectors in the country. It is also assumed that existing coal-powered stations can run at their maximum availability factors of 70% (older plants) and 80% for Eskom's two new coal power stations, Medupi and Kusile. If the stations are run at unexpected lower average load factors, additional capacity and investments into renewables or peaking power plants may be required over time; this was not considered in this study.

Employment gains are concentrated in the services sectors, although new employment opportunities also arise in manufacturing and other industrial sectors (including the electricity and construction industries). Within manufacturing, electricity-intensive users such as the chemical sector and metal products are key employers. Within the services sector, the key employers are trade, financial and business services.

The economy-wide evolution of skill attainment levels is quite similar to the changes obtained in the case of the power sector (see Figure 10). Skilled and high-skilled jobs (> Grade 11) account for 60% of new jobs created by the year 2050. This evolution of skills is distinct across all scenarios especially in DEA's rapid decarbonisation and CSIR's least cost scenarios (see Figure 14).

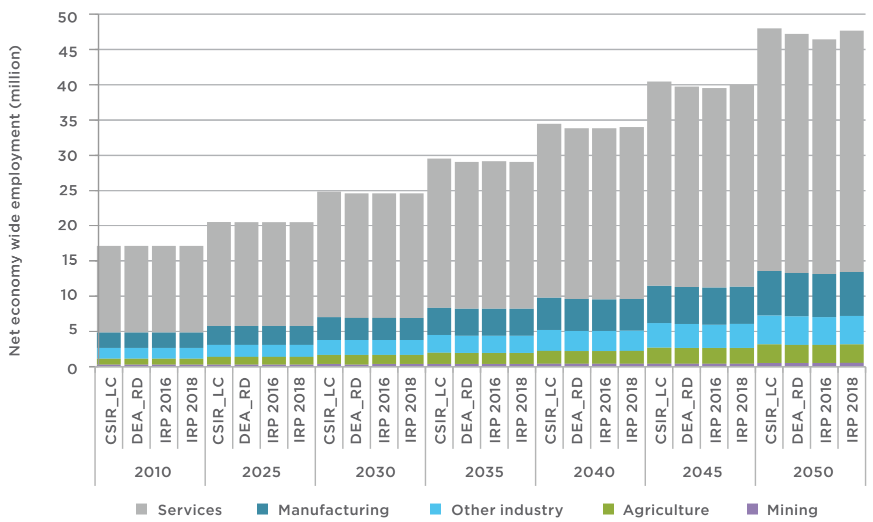


Figure 13: Economy-wide net employment impact for key economic sectors (adjusted for job losses and shifts in the economy)

The results from the years 2035 till 2050 for the IRP 2018 scenario are based on optimal assumptions in the model.

Source: own data/ SATIMGE results

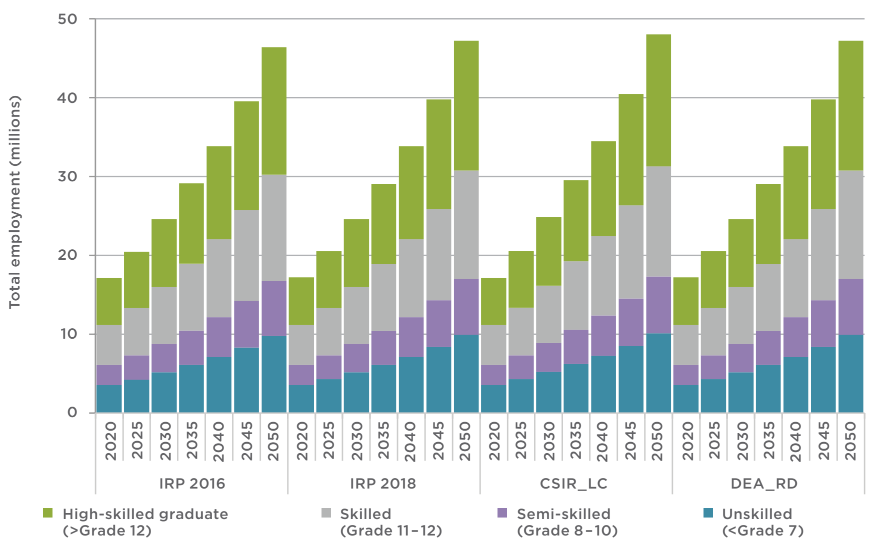


Figure 14: Economy-wide net employment impact and skill attainment levels across all scenarios by 2050

The results from the years 2035 till 2050 for the IRP 2018 scenario are based on optimal assumptions in the model.

Source: own data/ SATIMGE results

4. Creating an enabling environment to boost employment with renewables

Impulses for furthering the debate

This COBENEFITS study shows that South Africa can significantly boost gross employment by increasing the share of renewables. By 2050, more than 150,000 new jobs (+17%) will have been created in the power sector in net terms (i.e., including job losses in the coal sector). Up to 1.6 million additional jobs can be created economy-wide through the power sector transformation by 2050.

What can government agencies and political decision makers do to create a suitable enabling environment to maximize employment benefits in the South African power sector, both in terms of job creation within the renewable energy sector and in terms of alleviating the social impacts in the coal regions?

How can other stakeholders harness the social and economic co-benefits of building a low-carbon, renewable energy system while facilitating a just energy transition?

Building on the study results and the surrounding discussions with political partners and knowledge partners, we propose to direct the debate in three areas where policy and regulations could be put in place or enforced in order to benefit from the potential employment opportunities:

- Create jobs along the value chain of the RE sector
- Manage the transition in the coal sector and regions
- Built the skills required for the future power sector in South Africa

Create jobs along the value chain of the RE sector

Jobs in renewable power generation are concentrated in the services, construction and manufacturing sectors. The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) has demonstrated the potential for localised job creation through renewable energy deployment in South Africa. The localisation requirements of the REIPPPP resulted in the development of renewable manufacturing industries and capacity in South Africa.

However, growth in the manufacture of essential renewable energy technologies (and the associated components) is highly dependent on the government's commitment to continuous and long-term deployment of renewable energy. The present skills shortage in renewable energy is partly a result of the 'boom–bust' cycles that have occurred in the procurement processes; for example, as an effect of the REIPPPP, projects are often constructed simultaneously, creating sharp and short-term increases in demand for skills. A sustained and predictable pace of renewable energy procurement over time will be essential to manage these cycles. A successful transition to a low carbon power sector in South Africa will require a clear commitment from the government for a sufficiently long period (i.e., 10 years or more).

The renewable energy sector presently provides employment opportunities for some displaced coal workers following minimal training effort (in jobs such as installation, manufacturing, and sales), whereas the transition plan for displaced workers must be broader and more comprehensive. For developing countries to effectively create employment, *"a multi-prong strategy, entailing a combination of manufacturing, agriculture, services, and natural resources, is needed"* Stiglitz (2018).

Manage the transition in coal sector and regions

Continued job losses are likely in the coal sector. This trend is primarily driven by declining global demand for coal. A transition away from coal is therefore likely to take place in South Africa regardless of increased domestic deployment of renewable energy. In other words, policymakers would need to manage these structural changes even without any energy transition in South

Africa. Bloomberg New Energy Finance (2018) estimates that by 2050 global coal power generation will decrease to 5% of the global power mix (from 30% in 2017). Across the employment scenarios, jobs in the coal sector (including the mining and power sectors) are predicted to decline by 35–40% between 2020 and 2050.

Detailed data on the age- and skill-profiles of workers at each power station and mine will be needed if the transition is to be managed in an orderly manner. For example, the estimated median age of coal miners in Mpumalanga is 38 years. This means that some portion of the present workforce will be approaching retirement age by 2040 when a bulk of coal-fired power plants would be reaching the end of their assumed technical lifespan and the associated mines would be undergoing closures.

Redeployment, early retirement and retraining costs can only be assessed through more detailed information and by acknowledging the coming closures of coal infrastructure. Notwithstanding the challenges presented by such profound changes in the energy sector and the broad economy, existing systems for professional development (through the Mining Qualifications Authority and individual mining companies) provide an institutional framework for assisting workers to transfer to new sectors.

To alleviate the social impact on the energy transition in coal regions, specific measures can be taken that have proven successful in other countries around the world. In a first step, South Africa could assess the renewable energy potential in the coal regions; deploying renewables in the (former) coal regions can generate employment and economic activities in those regions. Secondly, policymakers could plan location-specific renewable energy auctions in (former) coal regions.

In order to create new economic stimulus, policymakers could create economic incentives in order to strategically move future industries to these areas (e.g. develop special economic zones in former coal regions). South Africa needs to identify new opportunities for existing sectors or engender new and emerging sectors that can serve as drivers of growth. The development of these "new" sectors could act as an absorption mechanism for workers displaced as a result of net shifts in the power sector. An example of such an opportunity may lie within the mining sector. The global increase in demand for battery technologies, driven by exponential increases in both electric vehicle ownership and increase into installed capacity of renewables has also increased demand for minerals such as lithium, cobalt, nickel, manganese, and graphite. Battery technologies also offer other opportunities for new sectors and the expansion of existing sectors in manufacturing and services. Further investigation should therefore be conducted towards enabling South Africa to become a player in this emerging sectors and delivering on the government's objective of a just transition.

Build the skills required for the future power sector

The bulk of job creation in renewable power generation is within the high-skilled labour group, defined as workers with an educational attainment level above Grade-12, although employment is also created in other skill groups. Across all scenarios, around 70% of new jobs created in the power sector by renewable energy are in fact high-skilled jobs.

The employment gains obtained are dependent on the availability of a skilled labour force. This needs to be addressed through a renewed and redirected education and training systems. While not optimal for localisation, the "importation" of key high-skilled labour could be considered as an interim measure to address potential critical skills gap that arise. Eventually, higher education, training institutions, and sectoral skill plans need to align their training programmes with the skills requirements of the sector.

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List of abbreviations

BNEF	Bloomberg New Energy Finance
CI	Construction and installation
CSIR	Council for Scientific & Industrial Research
CSIR_LC	Council for Scientific & Industrial Research: Least Cost Scenario
CSP	Concentrated solar power
DCGE model	Dynamic Computer-Generated Equilibrium model
DEA	Department of Environmental Affairs, South Africa
DEA_RD	Department of Environmental Affairs: Rapid Decarbonisation Scenario
DoE	Department of Energy, South Africa
DTI	Department of Trade and Industry
EIA	United States Energy Information Administration
EPC	Engineering, procurement and construction
ERC	Energy Research Centre
e-SAGE	Economy-wide South African General Equilibrium model
EWSETA	Energy and Water Sector Education and Training Authority
FTE	Full-time equivalent (employment unit)
GDP	Gross domestic product
GVA	Gross value added
GW	Gigawatt (1 000 megawatts)
IEA	International Energy Agency
IEP	Integrated energy plan
ILO	International Labour Organization
IPP	Independent power producer
IRP 2016_BC	Integrated Resource Plan 2016: Base Case scenario
IRP 2018_PA	Integrated Resource Plan 2018: Policy-Adjusted scenario
IRENA	International Renewable Energy Agency
IRP	Integrated Resource Plan
LCOE	Levelised cost of electricity
MW	Megawatt (unit of power)
NERSA	National Energy Regulator of South Africa
NQF	National Qualifications Framework
NREL	National Renewable Energy Laboratory, United States
O&M	Operations and maintenance
OECD	Organisation for Economic Co-operation and Development
OEM	Original equipment manufacturer
PPA	Power purchase agreement

RE	Renewable energy
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SAM	Social accounting matrix
SATIMGE	South African TIMES general equilibrium model
SETA	Sector Education and Training Authority
SOE	State-owned enterprise
Solar PV	Solar photovoltaic generation
StatsSA	Statistics South Africa
UK	United Kingdom
US	United States

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COBENEFITS cooperates with national authorities and knowledge partners in countries across the globe such as Germany, India, South Africa, Vietnam, and Turkey to help them mobilise the co-benefits of early climate action in their countries. 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 trainings, and policy dialogue sessions on enabling political environments and overcoming barriers to seize the co-benefits.

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