Briefing paper: An overview of the employment implications of the South African power sector transition

Based on research commissioned by SAWEA and undertaken by Meridian Economics in June 2018
Published: July 2018

Executive Summary

The employment implications of the South African power sector transition are highly complex, dynamic and politicised. Whilst there are numerous studies and reports which investigate these, a common understanding remains elusive and misunderstandings abound. This briefing paper presents a high-level overview of the status of current information based on a review of existing literature.

The review demonstrates that the misunderstandings is due in part to the use of nonstandard employment metrics and categorisation methodologies, poor and inconsistent disclosure of study parameters, and uncertainty about future energy sector development paths. These aspects can and should be addressed.

However, the briefing also reveals that the comparability of current employment data and analysis is further constrained by: the purpose of the study for which it was gathered or generated; whether the study is of actual or projected employment; what the particular metrics used can and can't reveal about employment; how different employment categorisation methods are used in the study; assumptions around related aspects such as localisation, multipliers and skills; the scale at which the study occurred; assumptions, data, and counterfactuals utilised in modelling; and the degree of independence of the research organisation and the nature of the funding it relies on.

As a result, any discussion that quotes high-level employment figures out of their context is largely meaningless. By cherry picking particular studies' high-level findings, contradictory employment-related arguments can and have been made.

Despite this situation, a few data points can be reported and assertions made around what is known at a high-level:

1. Coal mining drives the employment associated with coal power generation, and absorbs low skilled labour.
2. The loss of up to 35,000 coal mining 'employees' in the Central Basin appears likely due to the planned decommissioning of Eskom's older coal fired power plant over the next twenty years[1].
3. However, the current threat to jobs at Eskom's older coal stations and affected mines is primarily caused by Eskom's own build programme (Medupi and Kusile) which is stranding the older stations – not by renewable energy. This situation will of course change over time as the energy transition unfolds.
4. As of June 2017, the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) had created 32,532 direct, Full Time Equivalent (FTE) person-years of employment. It is anticipated that 109,444 direct, FTE person-years of employment will result from REIPPPP Bid

[1] SA Coal Roadmap: Outlook for the coal value chain: scenarios to 2040 (2013)

Rounds 1-4 in both construction and operation (O&M) over their 20-year Power Purchase Agreement time horizon[2].

5. Internationally it is becoming standardized to report employment in 'person-years'. However, this metric is not yet consistently used across South African studies, and in some cases analysis based on person-years of employment is reported simply as 'jobs' at the high-level. Whilst duration is unspecified in the term 'job', a 'job' (or 'employee') nevertheless conveys a sense of a timeframe beyond one year. The use of this term when reporting employment implications of power sector transition can therefore be misleading.
6. There appears to be little agreement on the ratio between direct, indirect and induced potential job figures. In addition, figures for 'gross' jobs appear significantly inflated against those produced by economy wide (or 'net') studies.
7. The net long-term employment impact of particular power generation scenario studies are specific to the particular model, scenario and assumptions used, making it difficult to compare across studies. Some studies assessed suggest that the loss of coal mining jobs will outweigh the jobs created in renewable energy, nuclear or gas, whilst others suggest the opposite.
8. Power mix assumptions[3] can all dwarf the employment implications of the ratio of coal and individual Renewable Energy (RE) technologies within any one power generation scenario.
9. Electricity demand levels is a significant driver for the economy-wide employment implications of the power sector transition; Given the highly plausible causal link between higher electricity prices in recent years and the stagnation of demand this might well suggest that choosing a least cost power sector path will create the most jobs than other options.
10. Employment metrics typically in use do not shed light on whether employment is 'meaningful' or 'decent'.

Future work should aim to standardise the metrics and methodologies used to reduce the current confusion in addition to aiming to fill a number of gaps in the field. Developing transparent and publically available datasets is another priority.

A combination of responsible use of existing studies with additional work focused on answering carefully articulated and policy-relevant questions will enable and encourage the sensible and productive debate that has thus far eluded us on this critical aspect of South Africa's energy transition.

Introduction

The South African power sector is undergoing a complex structural transition away from a model of regulated, monopolistic, centralized and coal-based electricity supply. As a highly unequal middle-income country, the employment implications of this transition are politically and socially significant. This briefing paper attempts to better understand the status of current information on employment opportunities associated with this transition and future scenarios for the sector. The study focuses on utility scale power generation, but also considers embedded generation.

Many studies have and are being conducted which are relevant to understanding the impact of the transition in the power sector on employment[4]. Taken together, these have generated a significant amount of data and information on actual and possible employment implications. However, it is nevertheless very

[2] Department of Energy consolidated IPP Quarterly report (2017)

[3] For example, around economic growth, technology penetration and learning rates, localisation, skills availability, the trajectory of the coal export price and what happens in relation to investment in natural gas (fracking), nuclear, electric vehicles and coal-to-liquids

[4] See appendix B for an annotated list identified in the course of the research for this briefing paper

hard to get a good sense of what all these studies are collectively confirming. Individually they are often misleading There are a number of reasons for this:

- Various datasets are used by the different studies, without necessarily fully disclosing either their or the study's parameters.
- A plethora of different metrics are used across the studies, making comparison difficult.
- Many of the studies are undertaken by those with particular interest in the sector, undermining the independence of their results.
- Those involved in the sector report that these are 'murky waters', and that calculating employment implications of a power sector transition is difficult if not impossible, hinting at an inherent complexity to the issue.
- There are multiple pathways and drivers through which employment impacts are realised, and different scales and timeframes at which these occur.

This briefing paper attempts therefore to articulate these complexities, contributing towards a common understanding, aiming to advance the debate and assist planning. It confirms that the value of individual studies can be appreciated as perspectives on a complex whole. It also recommends simplifications where these are useful (such as standardizing metrics), and identifies priorities for future work[5].

It is accompanied by two Appendices. Appendix A comprises a set of questions to assist policymakers and other users of employment studies to understand and draw on findings for planning. Appendix B provides an annotated list of the main individual studies considered.

Categorising power sector employment

Three different methodologies are used to categorise the incidence of power sector employment, and these are used variously across the studies. Some studies use only one, others use all three. The categorisations can overlap with each other, and also interact with the scale of the study (see section 5). Their use can contribute towards confusion rather than clarity for the (typical) non-specialist reader. The three categorisation methods are briefly described below.

'Direct', 'indirect' and 'induced'

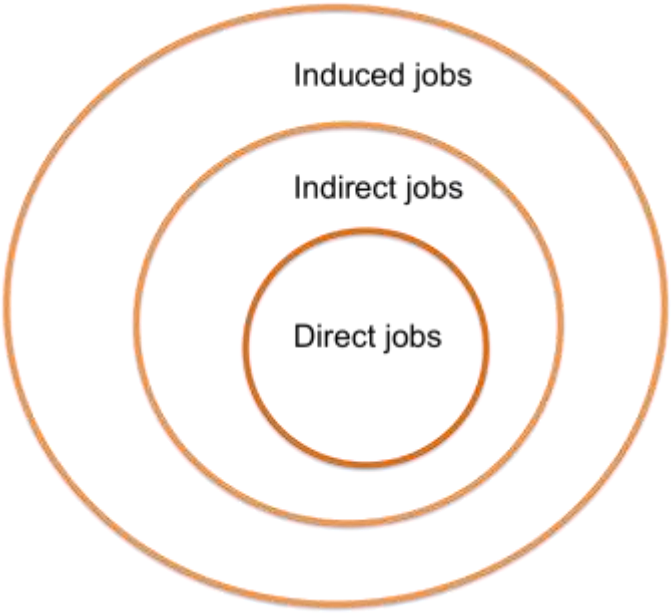
Power sector jobs are frequently categorized as 'direct', 'indirect' and 'induced'. Whilst the precise distinction between these categories differs from study to study (with one study, the Integrated Energy Plan (IEP) Appendix (DOE, 2016a) including a fourth category, that of 'supplier'), they usually denote the following[6]:

1. *Direct:* people employed by the power generation project itself
2. *Indirect:* people employed by supplying goods and services to the power generation project,
3. *Induced:* those employed to provide goods and services to meet consumption demands of additional directly and indirectly employed workers.

[5] Note that the brief seeks to assist consideration of what is and is not comparable in employment analysis. It does not particularly focus on the adjacent and entangled issues of who the jobs go to, nor the skills and localization debates. These issues may be covered in future briefing papers.

[6] Definitions as per Bacon and Kojima, 2011, although it is not always clear where the boundaries are in the data (Cunliffe, personal communication).

Figure One: Direct, indirect and induced jobs



Some studies (IEP Appendix (DOE, 2016a); Rutovitz (2010) establish multipliers as a means of estimating indirect and induced jobs.

Construction versus operation and maintenance

Power generation jobs are further categorized into those in the construction phase, and those in the operation phase (O&M). Construction jobs are often reported as jobs per MW installed capacity, with O&M jobs being reported as jobs per MWh (DOE, 2016a; Maia et al, 2011).

The categorization methods in 2.1. and 2.2. can be considered together, as in Table 1 below:

Table 1: Typical categorisation of power generation jobs at project, technology or power sector level

	Direct	Indirect	Induced
Construction	a	c	e
Operation	b	d	f
Sub-totals	a+b	c+d	e+f
		Total employment	a+b+c+d+e+f

"Net" and "gross" employment

Most commonly, the term 'gross' refers to jobs created by a particular project, technology or power sector plan, as described by 'Total employment', (a+b+c+d+e+f), in Table 1 above. Critically however, jobs lost by displacement or crowding out of other technologies and their value chains are not considered in a 'gross' jobs study. Therefore 'gross' jobs tend to be an overstatement of the overall employment effects.

'Net' employment, on the other hand, considers both jobs created and lost, i.e. (a+b+c+d+e+f) - (u+v+w+x+y+z), where (u+v+w+x+y+z) represents the direct, indirect and induced employment crowded out. The interactions though are more complex than this simplified equation suggests, requiring the use of sophisticated sector and/ or economy-wide modeling platforms to estimate.

Employment metrics and what they measure

'Employment' can be measured in a number of different ways. One way is as a total number of *jobs*, or *employees* and this is typically how employment is reported on. However such a metric is almost meaningless if the duration of these jobs is not also provided. A job could be for a day, a month, a year or more. Internationally and increasingly in South Africa, studies are starting to be formalized around the *job year*. A *job* or *employment* could therefore comprise any number of, or fraction of *job years*. The concept of 'Full Time Equivalent' (FTE) is typically used to qualify absolute employment metrics.

The term job years, however, provides no insight into the relative ability of different power generation technologies to deliver jobs. For this, *jobs per MW installed capacity*, or *jobs per MWh* is a more suitable metric.

These metrics in turn do not help to understand the investment required to generate jobs in different technologies or in different power generation sector scenarios. For this, one requires metrics such as *jobs per Rand of capital invested*. In order to assess the employment contribution relative to society at large, metrics such as *jobs per total population* are needed.

Metrics can be relative, useful for making comparisons between technologies or scenarios, or they can be absolute.

Further however, the metrics discussed above say nothing about whether the employment created is for those previously unemployed ('new' employment), or in order to address a shift of people from other industries. The metrics also reveal nothing about the skills levels of these jobs. It is important to note that there is no one measure that can capture all the aspects tied up in the concept of 'employment', and strong performance on one metric does not guarantee overall strong performance. When metrics are used without contextualizing findings in terms of what the metric can and cannot provide insight on, the analysis runs the risk of being simplistic and therefore misleading (Stands, 2015).

Meaningful employment

In addition to the problems associated with the metrics discussed above, they have been found to shed insufficient light on the 'decent' and 'meaningful' qualities of employment that South African policy aspires to in its 2011 'New Growth Path' (Stands, 2015). The concept of a 'job' is too high level to capture all that is required for a successful development-oriented power sector transition. Aspects that remain hidden include the sustainability of any one particular job, the working conditions, the level of contractual security provided. Questions that remain unanswered include: Can this job support a family? Does it require

relocation? Is there opportunity for learning and progression?

Work exploring and promoting these aspects has been done by the One Million Climate Jobs campaign, which describes decent jobs as 'jobs that are safe, provide healthy working conditions, and offer social protection, security and fair wages. Decent jobs are jobs that, at the very least, meet the International Labour Organisation's standards of 'decent work' and are in alignment with goals such as meeting the social needs of the majority of the population. In this sense they should be useful jobs' (2011, p9). Accompanying metrics to those discussed above are necessary, and qualitative data is likely to feature highly in furthering understanding.

Timeframes

Employment figures for the power sector exist in two forms. The first is data reporting on what has happened: how many jobs were created by the construction or operation of a particular plant or fleet. Whilst still subject to many of the other complexities discussed in this study, such reporting is more straightforward and easier to verify than the second form: attempts to project forward in time to understand what is likely to happen if certain projects are undertaken or policies adopted. This second form is dependent on a host of assumptions about what may happen in the future, assumptions which heavily influence the employment findings.

A significant issue with projected data is the timeframe assumed. How long will the plant construction take? How long is it assumed to be operational for? (Often the length of the Power Purchase Agreement (PPA) is used to estimate this). At a sector or system level, over what timeframe are the employment implications being considered, until 2030? Or 2050? When jobs are reported per year, the timeframe is critical to contextualise the final employment figures produced. Even relative metrics such as jobs per MWh are based on assumptions around how long the particular technology or plant will generate electricity for. The relative contribution of the various categories of employment (direct, indirect, induced, construction and operation) differ over different timeframes (IRENA, 2018).

The issue of "Scale" in different power sector employment studies

Power sector employment studies differ dramatically from each other in terms of the scale of analysis, and then consequently, will differ in terms of the types of research methods employed and the use and positioning of employment categories. It is therefore important that findings from employment studies are considered relative to their scale of analysis. Five scales of analysis can be identified and are described and then depicted in Figure 2 below:

1. *Site or plant scale*: The purpose of this scale of analysis is to explore employment issues at a particular plant. This analysis often includes qualitative data from interviews with employees, plant managers and other stakeholders. It can highlight contextual issues, and explore the specific employment related dynamics of a particular plant.

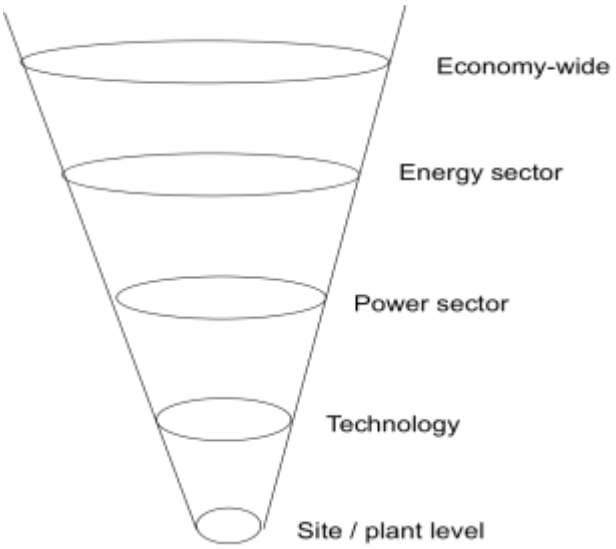
2. *Technology scale*: The purpose here is typically to compare how one power generation technology fares against another. Issues relevant here include the technological learning curves of each technology, possible ownership structures, the size of the envisaged fleet, whether jobs are temporary (in construction) or permanent (in O&M). This analysis most often uses the 'direct, indirect and induced' job categorisation to organise the research. Studies focused on the REIPPPP largely focus on this scale.

3. *Power sector scale* The purpose of this analysis is to consider various future power sector development pathways. This is done using sophisticated power generation modelling software which, inter alia, balances electricity supply and demand considering technology costs, learning curves and resource constraints. However power sector analysis cannot assess feedback between the economy and the power sector.

4. *Energy sector scale:* The purpose of this scale of analysis is to consider various forms (or scenarios) of a country's future energy sector, exploring how changes in one energy sub-sector affect other energy sub-sectors. The impact of the power sector transition on coal mining employment, for example, is strongly revealed at this scale.

5. *Economy-wide scale*: The purpose of this scale of analysis is to identify the impact of a particular policy intervention both within the power sector and throughout the economy. Economic modelling shows the net effect on jobs of a particular power generation trajectory, as it can capture jobs lost and gained throughout the system.

Figure Two: Scales of power sector employment analysis



The categorisation of employment impacts as direct, indirect and induced, is most relevant to the site, the technology and the power sector scales. What is included within these categories may also shift depending on the scale of analysis (for example, coal mining jobs are indirect at the site, technology and power sector scales, but direct at the energy sector scale). When models are used (at the power, energy and economy-wide sectors) these categorisations become less relevant as all categories are explicitly accounted for by the model.

Each scale of analysis provides a particular perspective on the employment implications of the power generation transition and has relative strengths in revealing particular aspects.

A note on the use of models and counterfactuals

Highly sophisticated energy and economic models are used in assessing employment implications at the power, energy and economy-wide scales. Whilst these models provide very useful insights into the

potential implications of different power generation pathways, they are highly dependent on the data and assumptions made, together with the internal mechanics of the model. It is often very difficult to appreciate these from how modelling findings are reported. It is worth here recalling the maxim that 'all models are wrong, some are useful'[7].

A further important aspect of models in particular but not exclusively, is that of the counterfactual used in the analysis. Comparative scenarios are often developed when using sector or economy-wide models to project employment implications of a particular investment or technology strategy. For example, a future power generation path consisting of technology mix *X* creates *Y* jobs compared to a different mix. To appreciate the model's findings and potential for generalisation, knowledge of the counterfactual (s) is necessary. The transition in the power sector globally is rapidly changing the viability of 'business as usual' counterfactuals.

The status of knowledge on the employment implications of the South African power sector transition

The paper thus far has shown that employment data is determined by:

- the purpose of the study for which it was gathered or generated
- what the particular metrics used can and can't reveal about employment
- whether the study is of actual or projected employment
- how different employment categories are used in the study
- assumptions around localisation, multipliers, skills etc
- the scale at which the study occurred
- the assumptions, data, and counterfactuals utilised in modelling
- the independence of the research organisation and the nature of the funding it relies on

As a result, any discussion that quotes high-level employment figures out of their context is thus largely meaningless, and by cherry picking particular studies, contradictory employment-related arguments can, and have, been made. To undertake meaningful comparison requires excavating each and every detail pertaining to each study. Even then, given how poorly the studies map onto each other (see Figure Three below), it is unclear how much useful information will result. Rather, a different approach is suggested; one that employs a humble, nuanced and exploratory approach in the face of a complex and emotive issue. A more effective approach requires considering carefully what methods are best for addressing particular types of questions. In response to this complexity, a set of questions to assist policymakers and other users of employment studies to understand and contextualise findings is provided in Appendix A.

Figure Three below maps the main studies identified through the research according to their scalar focus, demonstrating the diversity of the studies and the difficulty of comparing them even across just one dimension of scale.

[7] attributed to statistician George Box.

Figure Three: mapping of the main studies' scalar focus

Study	Plant	Technology	Power sector	Energy sector	Economy wide	Regional
Altieri et al, 2017:						
DOE, 2016 and 2016a: IEP						
ERC, (forthcoming): Coal Transitions						
ERC, CSIR, (forthcoming): COBENEFITS Project						
CSIR, 2017: IRP comments 2017						
IPP-Office, ongoing: REIPPPP data						
CSIR, 2017a: Wind, solar survey						
McDaid, 2016: REIPPPP review						
Stands, 2015: Masters Thesis						
Stands et al (Altgen), 2014: RE&EE Career pathways						
Single technology studies (Gibson, 2017; SABIA, 2016; SAPVIA, 2014. Coal data.)				(coal mining)		

(Dark grey indicates priority focus; lighter grey indicates additional scales included in the study.)

Acknowledging this complex situation, the few data points indicated below nevertheless provide some indication of the status of knowledge of the employment implications of the South African power sector transition within four general themes:

Coal-fired power generation

- There is very little data on coal related employment generally, and coal generated power employment in particular. Indirect coal mining jobs drives the employment potential of coal fired power generation (IEP, 2016; Caetano and Thurlow, 2014).
- Coal mining employs 87,500 people (CoM, 2018), and absorbs more unskilled labour than RE (Caetano and Thurlow, 2014). As an economic activity it has a high potential for job creation (DoE, 2016)
- Eskom has 7928 employees at its coal fired power fleet as of 2017 (Eskom, 2017)[8].
- Up to 35,000 coal mining jobs are likely to be lost by 2040 in any scenario due to the planned decommissioning of older power stations on the Central Basin coalfield (SA Coal RoadMap, 2013).
- Up to 55 000 jobs are created in coal mining if the Waterberg coal field is opened up (SA Coal Roadmap).
- Of the studies considered, only the SA Coal Roadmap (2013, thus fairly dated) and the 2016 IEP consider an expansion in coal fired power generation (a maximum of 14 MW), creating employment in mining.
- The increase in the labour efficiencies of new build coal-fired power generating plant does not appear to have been taken into account in any of the studies assessed.
- Coal mining job losses are spatially restricted to the Mpumalanga Province, where over half of the population is living in poverty. Here, unemployment rates are second highest in the country, and the occupational profile heavily skewed towards semi-and unskilled occupations (Mpumalanga Economic Growth and Development Path, 2011). Mpumalanga has only one REIPPPP project to date, a Bid Four small biomass plant.
- Currently all coal power related employment studies use the metric 'employees' or 'jobs' as opposed to the more internationally aligned metric, 'person-years' which is predominantly used to report RE employment. This has significance for any employment comparisons made between the two sectors.

The REIPPPP

- As of June 2017, the REIPPPP had created 32,532 direct FTE person-year jobs.
- It is anticipated that 109,444 direct FTE person-year jobs will result from bid windows 1 to 4 over their 20-year PPA lifespans (Eberhard and Naude, 2017).
- McDaid et al (2016) estimate that a further 50,000 FTE person-year indirect and induced jobs will result from REIPPPP Bids 1-4.
- The REIPPPP data is admirably multi-faceted and provides the most nuanced quantitative assessment of employment of all the studies.
- The REIPPPP data reflects the technology mix and MW capacity achieved through the competitive auction process at a particular point in time. This composition of the REIPPPP generation fleet has been determined by a number of criteria relevant to each bid window, including cost, local content etc. Because of this, the REIPPPP employment data is constrained in its ability to reveal aspects such as the employment potential of any one RE technology utilizing economies of scale, or the relative cost of employment creation of different technologies.

[8] Information secured by the Centre for Environmental Rights through an application under the Public Access to Information Act.

Technology scale RE

- There appears to be little agreement on the ratio between direct, indirect and induced potential job figures for RE at a technology level.
- Technology scale RE studies, including those based on the REIPPPP data, estimate far higher job creation potential for RE than the figures coming from power, energy or economy-wide models, confirming that figures for 'gross' jobs tend to significantly inflate the economy-wide employment implications of RE.
- Studies comparing the job creation potential of individual technologies are heavily context and metric specific.

Energy, power sector and economy wide scales

- The overall, long term employment impact of particular power generation scenarios can only be known within the context of the particular study presented.
- Some suggest that the loss of coal mining jobs will outweigh the jobs created in RE, nuclear or gas (DoE, 2016; Coal Roadmap, 2013; Caetano and Thurlow, 2014). More recent studies focusing on least cost optimisation models seem to be suggesting a net positive effect (CSIR, 2017).
- Assumptions around economic growth, technology penetration and learning rates, localisation, skills availability, the trajectory of the coal export price and what happens to natural gas (fracking), nuclear, electric vehicles and coal-to-liquids can all dwarf employment implications.
- Structural economic change appears to hold potential to significantly impact employment pathways over the long term, suggesting the importance of considering the demand side of the power sector transition (Altieri et al, 2016; Burton et al, 2016)

Two studies underway are anticipated to add significantly to the knowledge currently available. The Energy Research Centre (UCT) Coal Transitions modelling project runs least cost and decarbonisation scenarios to 2050 with a significantly expanded coal sector. Jobs impacts in coal and RE to 2050 will be included in the model outputs. The COBENEFITS project being undertaken by ERC and CSIR is a similar modelling exercise which will expand the current assumptions for RE (see Appendix B). This project will generate a public database of employment figures, which will contribute towards greater transparency and accessibility of employment data in the sector.

Gap analysis

The main drivers of the current confusion and frustration around the employment implications of the South African power sector transition have been argued here as being:

1) a lack of standardization of metrics, employment categorization methods, and power sector plans (counterfactuals); and
2) a lack of appreciation of the inherent complexity of the topic and standardised methodological approaches to address these.

Standardising metrics and employment categorization methods could be relatively easily addressed by the sector. This imperative has been raised locally and internationally. Importantly, standardisation should not be confused with simplification. There is no need to reduce the number of metrics and categories that usefully shed light on different aspects of employment. Updating and confirming an IRP is a political prerogative, and one that is anticipated to be addressed in the second half of this year.

A number of studies raise the issue of complexity. It is inappropriate to attempt to oversimplify this complexity. Instead, continuing to reveal additional aspects of it will contribute to a greater overall understanding. Specific gaps or areas currently underrepresented include:

- An initiative to provide a frame for transparent disclosure of both employment metrics and categorization methods for employment research;
- An expression of coal power jobs in FTE person-years;
- An independent and methodologically transparent assessment of the particular employment-related strengths of different technologies across multiple dimensions (such as continuity, costs, economies of scale, skills, working conditions etc);
- An investigation into the relative strength of the different key drivers of employment effects, including structural economic change, general economic performance, ownership models, technological drivers, international trends, and regulatory or policy impacts;
- A power, energy or economy-wide investigation into the employment implications of disruptive market events such as sector liberalization, smart-grid technologies and strong uptake of embedded generation and storage;
- Demand side employment opportunities, such as those in energy efficiency technologies such as solar thermal, and how these compare across the multiple dimensions of employment in expanded generation capacity;
- Consideration of the current suite of metrics used to quantify employment, and how these align with an expanded understanding of poverty and inequality and their alleviation;
- Further qualitative investigation of meaningful employment creation dimensions at a plant level, including both where employment will be lost and gained.

Conclusion

A number of South African studies which are relevant to understanding the employment implications of the South African power sector transition have and are being conducted. Taken individually, most provide important insights into pieces of the puzzle. However, given a lack of standardization in the use of both employment metrics and categorization methodologies, together with the inherent complexity of the subject matter, attempts to draw employment data conclusions from these studies as a whole currently tends to lead to confusion.

Nevertheless, some high-level findings of the employment implications of the power sector transition can be drawn through this literature review. These include a sense of the limitations of particular findings and clarity on what cannot be concluded at this point. A gap analysis was undertaken identifying a number of priority areas for future research and initiatives. Standardisation of metrics and methodologies, and developing transparent and publically available datasets stand out here.

Investigation of a number of specific content areas currently overlooked would add great value to the knowledge base required for effective planning.

Throughout, care must be taken to maintain and expand both the complexity of the analysis and the number of perspectives from which the issue is viewed and understood. The employment implications of the power sector transition are highly complex and dynamic, validating suitably complex and diverse analysis to enhance useful understanding of these.

Glossary

CGE	Computable General Equilibrium
CSIR	Council for Scientific and Industrial Research
DoE	Department of Energy
ERC	Energy Research Centre
EE	Energy efficiency
FTE	Full Time Equivalent
GHG	Greenhouse gas
IEP	Integrated Energy Plan
ILO	International Labour Organisation
IPP	Independent Power Procurement
IRP	Integrated Resource Plan
O&M	Operations and maintenance
PAIA	Public Access to Information Act
PPA	Power purchase agreement
RE	Renewable Energy
REIPPPP	Renewable Energy Independent Power Plant Procurement Programme
SATMGE	The ERC's South African linked energy and economy model

References

Altieri, K. E., Trollip, H., Caetano, T., Hughes, A., Merven, B., Winkler, H., … Hughes, A. (2016). Achieving development and mitigation objectives through a decarbonization development pathway in South Africa. *Climate Policy*, Sup 1(August 2017), S78–S91. http://doi.org/10.1080/14693062.2016.1150250

Alternative Information Dissemination Centre (2011). One million climate jobs a just transition to a low carbon economy to combat unemployment and climate change.

Bacon, R. and Kojima, Masami (2011). Issues in estimating the employment generated by energy sector activities. A report to the Sustainable Energy Department of the World Bank.

Burton, J., Caetano, T., Hughes, A., Merven, B., Fadiel, A., & McCall, B. (2016). *The impact of stranding power sector assets in South Africa Using a linked model to understand economy- wide implications*. Cape Town, South Africa.

CSIR (2017) Comment on 2016 IRP

CSIR (2017a) Energy research at the CSIR. Jobs impact of solar and wind energy. SATRI Symposium on energy choices and the protection of worker's interests in South Africa. Boksburg, 17 May 2017

CSIR (2017b) International jobs and economic development (I-JEDI) impact model. Modelling the renewable energy jobs potential of the draft 2016 IRP. CSIR energy centre. Just energy transition roundtable. 28 November 2017. PNtuli.

Chamber of Mines http://www.mineralscouncil.org.za/sa-mining/coal accessed 14 June 2018.

DoE (2015). The State of Renewable Energy in South Africa

Department of Energy (DoE) (2016) Integrated Energy Plan (IEP)

DOE (2016a) IEP Annexure B: Macroeconomic assumptions.

Eberhard and Naude (2017) The SA Renewable Energy IPP Procurement Programme: Review, lessons learned and proposals to reduce transaction costs

Eskom (July 2017). Untitled SAP Printout of employment at 15 power stations, obtained by the Centre for Environmental Rights through a PAIA (Public Access to Information Act) process.

Gibson, S. Altgen presentation: South African Job Opportunities in Renewable Energy: 17 May 2017.

Gibson, S. (2017). Assessment of training skills needs for the wind industry in South Africa: Comparing 2012 estimates and compiling new estimates in the light of sector developments (Funded by GIZ)

IPP Office (2017): The IPPPP. An overview. As at June 2017

IRENA, 2018

Maia, J., Giordano T., Kelder, N., Bardien, G., Bodibe, M., Du Plooy, P., Jafta, X., Jarvis, D., Kruger-Cloete, E., Kuhn, G., Lepelle, R., Makaulule. L., Mosoma, K., Neoh, S., Netshitomboni, N., Ngozo, T., Swanepoel, J. (2011). Green Jobs: An estimate of the direct employment potential of a greening South African economy Industrial Development Corporation, Development Bank of Southern Africa, Trade and Industrial Policy Strategies

McDaid L. 2016. Renewable Energy Independent Power Producer Procurement Programme Review 2016: a critique of process of implementation of socio-economic benefits including job creation

Mining Review Africa (5 April 2018) South African Minister of Energy announces REIPPPP Projects. Accessed https://www.miningreview.com/south-african-minister-energy-announces-reipppp-projects/

Mpumalanga Economic Growth and Development Path (2011).

Polity (28 March, 2018). NUMSA: NUMSA in court to fight IPP roll out. Accessed http://www.polity.org.za/article/numsa-numsa-in-court-to-fight-ipp-roll-out-2018-03-28

Rutovitz, J. 2010. South African Energy Sector Jobs to 2030: How the Energy [R]evolution will create sustainable green jobs. Prepared for Greenpeace Africa by the Institute for Sustainable Futures, University of Technology, Sydney, Australia

South African Biogas Industry Association (SABIA). (May 2016). Biogas Industry in South Africa: An Assessment of the skills need and estimation of the job potential. By Altgen Consulting

South African Coal Roadmap: Outlook for the coal value chain: scenarios to 2040. Technical Report (2013).

South African Photovoltaic Industry Association (SAPVIA). Localisation and the Road Beyond REIPPPP 2015 (Phase 1) (December, 2014). (Prepared by Stream Equity, ALTGEN Consulting, Chris Ahlfeldt, Frank Spencer).

Stands, S., (2015). Utility-Scale Renewable Energy Job Creation: An investigation of the South African Renewable Energy Independent Power Producer Procurement Programme (REIPP). Unpublished Masters (MPhil) Thesis. Stellenbosch: Stellenbosch UniversityStands Masters thesis retrieved from http://scholar.sun.ac.za/handle/10019.1/96791

Stands, Moodley and Gibson (November, 2014). Renewable Energy and Energy Efficiency Career pathways (November 2014). AltGen Consulting on behalf of EW SETA, Northern Cape Urben TVET College, PEETS and University of Johannesburg.

Worthington, R. (2015). Challenging the State: Renewable energy opportunities and electricity in South Africa in 2015. A publication of the AIDC.

Personal communications:

Sarah Stands, Independent Consultant. 30 May 2018 Skype conversation.
Holle Wlokas, Complex Systems in Transition, Stellenbosch University (23 May 2018, meeting)
Tara Caetano, Energy Research Centre, University of Cape Town (21 May 2018, meeting and email correspondence)
Guy Cunliffe, Energy Research Centre, University of Cape Town (23 May 2018, meeting)
Ntombifuthi Ndluli, CSIR (31 May 2018, telephone call)
Jesse Burton, Energy Research Centre, UCT (24 May 2018 at workshop, and email correspondence)
Alison Hughes, Energy Research Centre, UCT. (email correspondence)
Sean Gibson, Altgen Consulting. (Email correspondence).

(In addition, the author attempted, unsuccessfully, to contact both NUMSA's policy research unit and the AIDC (Million Jobs Campaign) for input)