Socio-economic benefits of renewable and storage technologies in South Africa

Authors: Abram Marema – Researcher, Boitumelo Tlokolo – Researcher and Aradhna Pandarum – Acting Research Group Leader (Presenter)

Council for Scientific and Industrial Research (CSIR): Energy Industry

1. Introduction

Globally, South Africa is ranked as the 12th largest emitter of greenhouse gases. This is predominantly due to the fact that the energy sector in the country is currently dominated by coal with the inclusion of a small share of renewable energy technologies. This brings about an increasing need to reduce greenhouse gas (GHG) emissions, especially in the electricity sector, to address climate change.

South Africa is a signatory of the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC), wherein it has committed to Nationally Determined Contributions (NDCs) in an effort to honor its' commitment to reduce emissions and contribute a fair share to the global effort to move towards net-zero emissions by 2050. Furthermore, at the Conference of Parties (COP) 26, South Africa secured a funding pledge of $8.5bn (~R128bn) from the UK, the US, France, Germany and the EU for the main purpose of cutting carbon emissions through the retirement of coal-fired power plants and investment in low carbon energy technologies. However, it has become prudent that during this transition to low carbon technologies, civil society must be at the centre of related decisions and actions [1].

With the intention of combatting some of the challenges relating to unemployment, poverty and inequality, the technologies selected for a 'just' transition must contribute towards poverty reduction, gender and social inclusion, and job creation. This can be done by the creation of new industries and skills, economic growth, improvement of livelihoods, and the creation of a more equal, resilient and sustainable economy.

The Renewable Energy Independent Power Producer Programme (REIPPP) and the elimination of the requirement for licensing of embedded generators are significant enabling factors for the deployment of renewable energy (RE) technologies in the country. Battery storage technologies, in combination with renewables, have the potential to create a firmer source of energy and are therefore also increasingly being installed. However, statistics around the social and economic benefits of these technologies being deployed in South Africa are not fully understood. This paper details some of the findings around what such potential benefits are and includes a case study for the deployment of renewable and battery storage technologies in the municipal jurisdiction of City of Cape Town (COCT) municipality.

2. Literature Review

This section provides a literature review of the benefits of the deployment of different sources of renewable technologies. That includes job creation, economic value added, skill development, gender empowerment and health attributes which are explored in their respective sections below. Note that the job creation data is quantified in terms of direct, indirect, and induced jobs where direct jobs are directly related to the power plant e.g., installer of PV modules for solar PV. Indirect jobs are associated with activities indirectly related to the power plant e.g., steel maker required for structures. Induced jobs are those that arise from economic activity in the area, but not directly related to the power plant e.g. restaurant chef in the plant area [2].

2.1. Job creation and value add

2.1.1. Renewable energy technologies

Table 1 below details the various sources of literature that was reviewed and the findings therein for the potential job creation and economic value add for renewable technologies. The adopted methodology for derivation of such data is also expanded on.

Table 1: Findings from literature review for social and economic benefits for renewable energy technologies

Study/source	Methodology	Technologies	Findings
[3] **IASS/CSIR/UCT (2019)**	I-JEDI[1] modelling coupled with scenarios i.e., Integrated Resource Plan (IRP) 2016, IRP 2018 (draft), and CSIR Least Cost (LC) with varying % of RE deployment.	RE	Job creation for deployment of 14GW, 15.5GW and 29.7GW capacity during period 2018-2030 in IRP 2016, IRP 2018 (draft), and CSIR LC, respectively: - ~399 600, 580 000 and 1.2 million job years [d] during the construction phase of and ~10 600, 14 500 and 27 800 jobs years during the operations and maintenance (O&M) phase.
[4] **Merven et al. (2019)**	Adopted SATIMGE[2] modelling coupled with two scenarios namely: constrained RE and unconstrained RE	Solar and wind	By 2050, unconstrained RE scenario results estimated ~2.5 to 3 million potential job creation and 5% to 6% real GDP. Real GDP increase in the unconstrained scenario is driven by lover overall level of investment required over the period and lower electricity price. Total investment in the electricity sector is assumed to be higher under the constrained scenario due to the use of more expensive technologies and that lowered employment growth as compared to unconstrained scenario.
[5] **National Business Initiative (NBI) et al. (2021)**	Pathway scenario's, namely: IRP constrained and low emissions.	RE	For 2020-2035 the estimated job creation was: - 1 million net job years for low emissions pathway and - 0.8 million net job years for IRP constrained pathway.
[6] **Eberhard & Naude (2017)**	N/A	RE	109 444 direct job years are expected from bid window 1 to 4, of which, solar and wind expected to account for about 43.1% and 39.7%, respectively with the remaining proportion 17.2% for other RE technologies.
[7] **SAPVIA & CSIR (2021)**	I-JEDI modelling for scenarios: Base case, IRP 2019, accelerated and high road. Accelerated scenario caters for accelerated decarbonization of the power system as compared to the IRP2019. High road scenario adds embedded generation in 2019 which is then supplemented with the accelerated scenario case for utility scale capacity addition.	Solar (small scale embedded generation, and utility scale)	4 *013 and 13 302 FTE jobs have been created in 2013 and 2014, respectively.* Future scenarios: - IRP 2019: 38 056, 33 891 and 34 726 FTE jobs created in 2028, 2029 and 2030, respectively. - Accelerated: 32 000 – 38 000 FTE jobs created each year for 2023-2030. - High road: 33 000 – 40 000 FTE jobs created each year for 2023-2030. - Embedded and utility scale to create 39 and 17 FTE jobs per MW.

1 International Jobs and Economic Development Impact model – developed by NREL but modified for local context
2 SATIMGE is a linked energy-economic model for South Africa that combines the South African TIMES (SATIM) model and eSAGE model. SATIM model is a full sector energy systems optimization model and eSAGE model is an energy-hybridized recursive dynamic computable general equilibrium for South Africa [25].
c The FTE job is a unit to measure employed persons and accounts for part-time and full-time workers in a comparable way.
d Job year is one job for a period of one year

Study/source	Methodology	Technologies	Findings
[8] GreenCape, (2021)	N/A	SSEG rooftop solar PV	500 MWp SSEG rooftop has the potential to create ~1 250 jobs per annum.
[9]**Semelane et al. (2021)**	Adopted four scenarios including 45%, 65%, 80% and 100% LCRs (local content requirements) applied for 6 814 MW utility-scale solar PV installed capacity.	Solar PV (utility scale market)	- 100% LCR: ~249 315 FTE direct and indirect jobs estimated for 2020-2030 during construction and O&M phases with ~$8 billion GDP potential growth translating to ~$2.38 billion increase compared to the base case scenario (45% LCR). - 45% LCR: ~165 609 FTE direct and indirect jobs, with the potential to generate~$5.62 billion GDP.
[10] **Escience Associate et al. (2013)**	N/A	Solar PV (Utility scale and small scale)	- Solar PV utility scale projects to create ~5.83 FTE jobs/MW during construction phase and ~0.35 FTE jobs/MW in the O&M phase. - C&I market (dependent on size of installations) to create between ~5.3 and 8 FTE jobs/MW during construction and installation phases, respectively, translating to an average of 6.7 FTE jobs/MW. - Residential market to create between 6.1 and 9.2 FTE jobs/MW (average of 7.7 FTE jobs/MW).
[12] **Independent Power Producer Office (IPPO), (2021)**	N/A	RE technologies	A total of 63 291 direct job years have been created in Q3 of 2021/22. These comprise of 48,110 jobs-years (76%) created during construction and 15,182 job-years (24%) during O&M phase. The operational capacity totaled to 5611 MW for the same quarter. Additionally, 50% of local content was procured locally.

In addition to the studies reviewed above, a recent study conducted by the CSIR in collaboration with IASS and EIT deduced the results shown in Table 2 below [2]. The study adopted I-JEDI model to quantify the job numbers and gross output value across various scenarios for the period 2019 – 2030. The scenarios modelled included IRP 2019, accelerated repurposing, ambitious repurposing, and super high road. For each scenario, the following local content were assumed: moderate (national levels, based on data from DTIC, industry associations, and general online searches) and high (an increase of local content of 5% p.a. from the moderate scenario).

Table 2: Estimated jobs and gross output values across various scenarios for the period 2019 -2030

			Technology							
			Distributed PV		**Wind**		**Solar PV**		**Biomass**	
			Construction	**O&M**	**Construction**	**O&M**	**Construction**	**O&M**	**Construction**	**O&M**
Scenario	**Super high road**	**FTE jobs**	1 237	861	20 009	6 489	35 404	3 605	1 279	3 152
		GVA (RBn)	R11	R0.6	R165.5	R5	R97.7	R 2.7	R36	R2.9
	Accelerated	**FTE jobs**	1 237	861	14 693	2899	28 323	5126	960	2 366
		GVA (RBn)	R11	R0.6	R81.5	R2.2	R139	R3.8	R27.1	R2.2
	IRP 2019	**FTE jobs**	1 237	861	11 376	2 315	7081	1036	320	789
		GVA (RBn)	R11	R0.7	R65.5	R1.8	R28.8	R0.8	R9	R0.6

The literature review summarized above, which covers mainly the job and economic value creation associated with renewable energy technologies have revealed that the deployment of these technologies mostly in a form of solar and wind energy have the potential of contributing to economic growth and job creation. Utility scale solar PV has the potential to create between 2-7 FTE jobs/MW per annum and generate R82 000 - R95 000 GDP/MW per annum [8] [9]. This is based on a 45-65% local content assumption. On average, SSEG has the potential of creating between 3-8 FTE jobs/MW per annum. Within the solar PV value chain sectors such as construction, utilities sale and manufacturing have the potential to create more jobs [9]. Additionally, significant assumptions used when modelling job creation and economic value add in the country are based on localization of the components across the entire value chain, effective reskilling of SA workforce, access to international green finance, competitive cost of capital, and strengthened collaboration between public sector, private sector and civil society [2,3,9,13]. Furthermore, the adoption of different methodologies can result in varying results. Majority of the reviewed studies have not reported their findings in MW/job or GDP metric, which makes it difficult to compare these studies.

2.1.2. Battery storage

Battery energy storage systems (BESS) have the potential to create 15 -20 direct employment opportunities during construction, however, these jobs are temporary and can be created over a six to eighteen month period [14][15]. Potential jobs which arise during the fabrication and manufacturing phases are also expected to support the emerging industry. Local storage manufacturing facilities are necessary to support production of materials and equipment consequently the energy storage value chain [14].

Investing in energy storage technologies, especially battery storage and clean molecules such as green hydrogen, is key to unlocking new opportunities to provide a secure electricity supply and more jobs in South Africa’s energy sector [16]. However, there is a need for national efforts to foster the nascent energy storage technology industry which could provide jobs, new infrastructure, and even export-oriented industries. As more RE is integrated into the energy mix, there will be greater local demand for battery storage.

2.2. Skills development, gender empowerment, and health attributes

The deployment of renewable energy technologies offers the opportunity for skills development, gender empowerment and improved health in the renewable energy value chain. This section will elaborate on the nuances of how this can be achieved.

2.2.1. Skills development

For developing countries, one of the key challenges faced while trying to accelerate the energy transition is the lack of skills required for deploying renewable energy technologies. The major hindrance for the successful deployment of the technologies in South Africa is the lack of adequate RE skills [17]. Since the deployment of RE technologies is set to increase, this is a suitable time for the country to develop and improve skills across the society through investment in education and training in relevant fields of engineering, science, environmental management, economics, finance and business management [17]. This will help develop highly skilled labour force thus creating opportunities for participation in the renewable energy sector (of which 70% of new jobs created in the sector are of the same level) [3]. It is a further advantage as most of these skills are cross-cutting and generally technology agnostic to the most degree.

Mismatch between skills available and required by employers was found to be prevalent in the City of Cape Town (COCT) [20]. As the COCT plans to move towards a more decarbonized economy, the upskilling and reskilling of the workforce to be able to participate in low carbon technologies becomes more necessary to contribute to job retention. Focusing specifically on wind energy, the study asserted that wind turbine manufacturing segment of wind energy value chain requires highly skilled labour force in occupations such as project managers, engineers, and technicians, among others. The Western Cape province is starting to make progress and benefit from less technical sophisticated components of wind energy value chain, including towers required for wind turbines. Individuals with an engineering background can be targeted for upskilling and future absorption when economic activities across the wind energy value chain are completely mobilised. Apart from wind energy, the solar PV value chain, that ranges from manufacturing of components such as solar modules, inverters, mounting structures, transformers, to construction and installation, operation, and maintenance, requires highly skilled resources. Many local activities in area related to component assembly, testing and wiring activities for inverters. However, such activities account for a small portion of the development process of solar PV.

As an initial activity for skills development, projects need to be dedicated towards the development of skills to equip local communities for employment in renewable energy sector. Such skillsets should include installation, and O&M of solar energy, among others [18]. Community participation in a form of local ownership and beneficial development can be promoted by the rollout of renewable energy technologies [18]. Furthermore, there's a need to develop skills specifically in high end occupations such as IPP project management, energy finance, engineering for municipal mini-grid solutions and legal aspects of licensing, wheeling and power purchase agreements (PPAs) [17]–[19].

Significant amount of training and skills development programs will also be required for the development and possible manufacturing of battery storage systems, especially if SA plans on leveraging this sector [15][17]. SA is endowed with raw materials required for manufacturing of battery storage technologies particularly vanadium flow batteries. Furthermore, the expected penetration of electric vehicles (EVs) and LIBs (local and global) will offer a full exploitation of upstream segment of battery storage [14].

2.2.2. Gender Empowerment

The implementation of climate action presents the opportunity for promoting female participation [20]. High female participation in climate action related occupations, particularly in low carbon energy and transport sectors has been reported. However, on average female participation appears to be low on occupations related to coal value chain which are at risk. This implies that should the trajectory of high female participation in climate action related occupations continues, new expected jobs resulting from the transition towards low carbon economies will be more gender equitable [80]. Additionally, implementation of various climate actions is highly expected to have a net-positive impact on employment equity for females. According to IRENA, RE technology has a higher share (32%) of women employed compared to the oil and gas sectors (22%). Traditionally, the energy sector has been male dominated, despite women representing half of university students [21].

2.2.3. Health

The deployment of cleaner technologies such as wind and solar PV will help eradicate health issues brought about by fossil fuels [22] . In South Africa, there are as many as 2 080 deaths annually that are caused by exposure to pollution from power plants [23]. Furthermore, health cost externalities from Eskom power plants range between R0.05 to R0.15 cents per kWh, costing Eskom between R11 billion to R30 billion per annum, with only an increase projected in future. These costs can be reduced through the deployment of renewable energy deployment [23].

2.3. Conclusion from literature review

The literature reviewed illustrates a lack of standardization of metrics and employment categorization methods relating to social and economic benefits. The general reporting of job creation considers a combination of total number of potential jobs and full time equivalent (FTE) job-years which are not easily comparable to each other. It is also unclear if some of the reported total jobs are inclusive of direct, indirect, and induced potential jobs figures for RE technologies.

The standardization of metrics used to measure and report employment as well as the format in which they are reported is strongly recommended. Some progression has been made with some local studies adopting the international accepted metric of "person-years" which is predominantly used to report RE employment. The FTE job-years per megawatt (MW) installed capacity or MWh is a more suitable metric, as it provides more insight into the relative ability of different RE technologies to provide employment opportunities.

Other socio-economic aspects such as GDP, skills have also been explored within the literature although not as extensively as employment. It should be noted that due to the emerging nature of battery storage technology, quantitative numbers for potential job creation were limited.

3. Case study

This section details the methodology and results from computation of the expected social and economic benefits during the potential deployment of a combination of large-scale wind and solar plants as well as small scale embedded generation and battery storage within the jurisdiction of the City of Cape Town municipality.

3.1. Methodology

The I-JEDI model (created by the National Renewables Energy Laboratory (NREL)) was used to quantify potential job creation and economic growth from deploying solar PV and wind technologies. The model in an input-output (I-O) model which requires inputs such as project size (MW), exchange rates, cost component data, local content for various equipment and segments of the value chain and social accounting matrices. The input data was sourced from a combination of desktop research as well as primary research through stakeholder engagements with specific technical companies.

The outputs derived from the model include jobs numbers (direct, indirect, and induced), earnings, gross output value and gross domestic product (GDP). The model is capable of quantifying positive and negative impacts associated with the deployment and decommissioning of different power generation technologies but is limited to solar PV (utility scale and small scale) and wind. Therefore, the job creation for battery storage system deployment was calculated using data obtained from an international study conducted by the Solar Foundation [24].

3.2. Results

The representation of results for the jobs created are given for periods of both construction and operations and maintenance (O&M) phases. Construction jobs are created in a single year and cease to exist once construction is complete, while O&M jobs are regarded as permanent (exist over the lifetime of the plant) and have a cumulative effect if the installed capacity is increased. The model assumes certain jobs should have already been created over the years prior to construction, therefore the construction jobs are phased back to previous years. Furthermore, the jobs are also calculated on a full time equivalent (FTE) basis which makes the number of employed persons comparable although they may work different hours.

The results given for the case study is based on the least cost plan developed for 2024 to 2040, which assumes building additional generation capacity (solar PV, wind turbine, battery storage) only if it is economically viable to do so. The capacities installed for each technology in each year for this plan is depicted in Table 3 below. The potential jobs and contributions to GDP are subsequently detailed below.

Table 33: Installed capacities for wind, solar PV, distributed PV (DPV) and battery energy storage systems (BESS) technologies for the period 2024 -2040 as part of the least cost plan for case study

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032
PV	100	100	100	100	100	100	100	100	100
DPV	10	10	10	10	10	10	10	10	10
Wind	-	100	100	100	100	100	100	100	90
BESS	-	10	80	120	20	-	-	360	-
Year	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	
PV	90	90	100	90	90	90	90	100	
DPV	9	9	10	9	9	9	9	10	
Wind	90	90	100	90	90	80	80	80	
BESS	-	-	30	100	170	30	30	50	

For the deployment of a total of 1640 MW solar PV (details illustrated in Figure 1 and Figure 2 below):

- A total of 1 864 construction FTE jobs created comprising of 575 direct, 623 indirect and 666 induced,
- A total of 711 O&M FTE jobs created comprising of 212 direct, 259 indirect, and 240 induced,
- Total GDP growth of R 897.9 million and R 309.7 million, is created respectively during the construction and O&M phases.

For the deployment of 1 490MW wind (details illustrated in Figure 1 and Figure 2 below):

- A total of 1 803 construction FTE jobs created comprising of 568 direct, 603 indirect and 631 induced,
- A total of 2 100 O&M FTE jobs created comprising of 643 direct, 686 indirect, and 771 induced,
- Total GDP growth of R 755.4 million and R 1 915.18 million, is created respectively during the construction and O&M phases.

For the deployment of 163MW small scale solar PV (details illustrated in Figure 1 and Figure 2 below):

- A total of 207 construction FTE jobs created comprising of 69 direct, 64 indirect and 74 induced,
- A total of 14 O&M FTE jobs created comprising of 6 direct, 3 indirect and 5 induced,
- Total GDP growth of R 95.2 million and R 5.4, is created respectively during the construction and O&M phases.

For the deployment of 1GW battery storage (details illustrated in Figure 3 below):

- A total of 1 151 direct construction FTE jobs and 2 311 induced jobs created.

Additionally, it should be noted that O&M jobs exceed construction jobs due to the difference in the localisation potential. This implies that job growth rate is linked to localisation potential. Therefore, by increasing the local content, total construction jobs will be further increased.

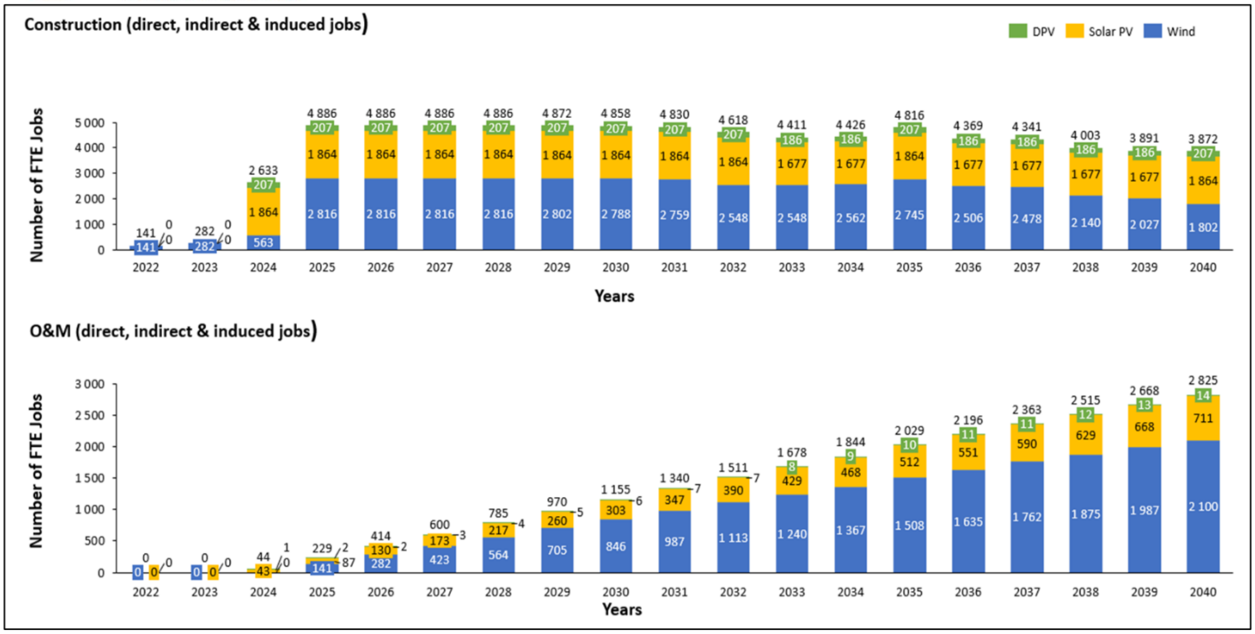

Figure 1: Potential job creation of the least cost plan for the implementation of wind, solar PV and distributed PV in the City of Cape Town jurisdiction using I-JEDI modelling (2024-2040)

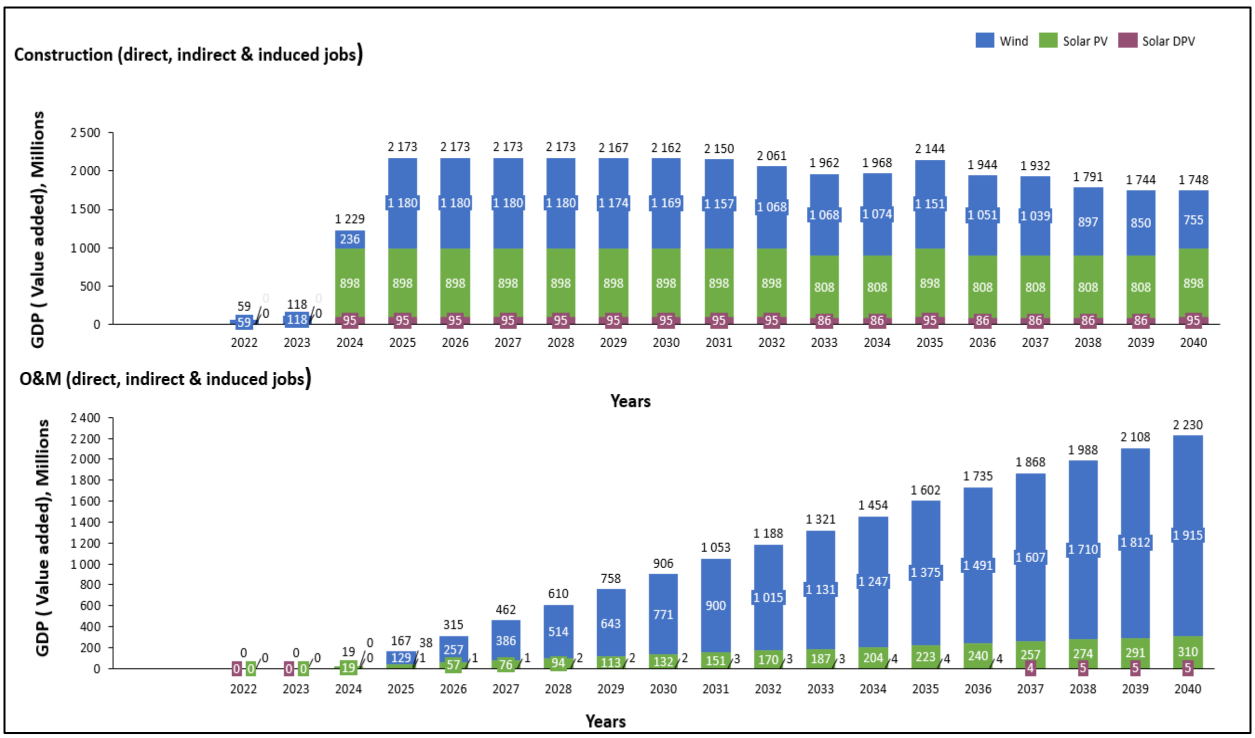

Figure 2: Potential economic value add – Gross Domestic Product (GDP) of the least cost plan for the implementation of wind, solar PV and distributed PV in the City of Cape Town jurisdiction using I-JEDI modelling (2024-2040)

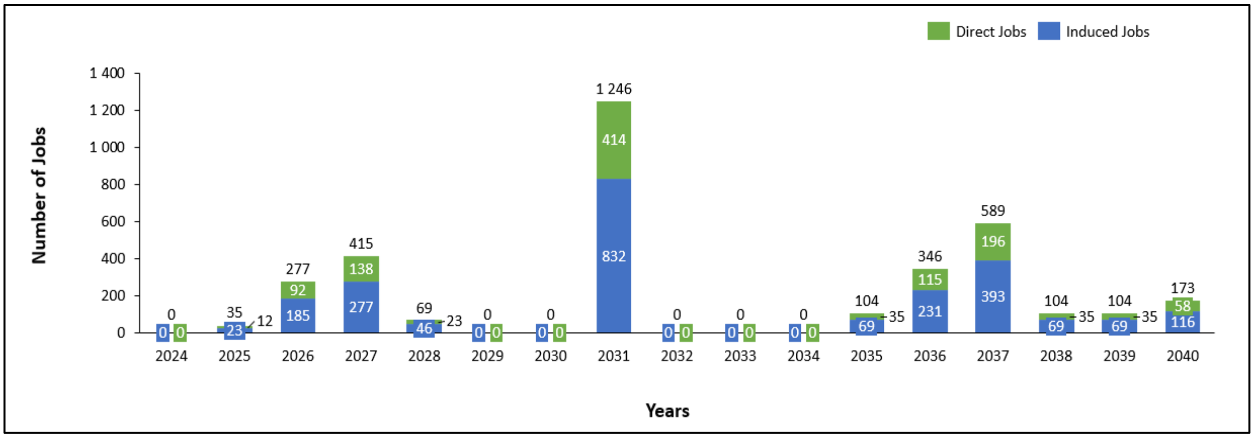

Figure 3: Potential job creation of the least cost plan for the construction of battery energy storage systems in the City of Cape Town jurisdiction (2024-2040)

3. Conclusion

This paper highlights findings obtained from an extensive literature review as well as a practical case study which was aimed at understanding what social and economic benefits are attached to the installation and deployment of renewable and battery storage technologies in South Africa.

In the case study for City of Cape Town, the social and economic benefits relating to job creation and economic value add for renewables has been modelled using the International Jobs and Economic Development Impacts (I-JEDI) tool with informed assumptions regarding local content distribution of equipment of these technologies. The results indicate that a total of 3873 and 2427 full-time equivalent (FTE) jobs can be created during construction phase and operations and maintenance phases of these projects, respectively for a total of 3.67GW of wind, solar and distributed solar PV from 2024 to 2040. The total economic value-added during construction and O&M phases of these projects amount to ~R4bn. Note that these numbers do not include implementation of battery storage technology due to the limited available information and models relating to the technology. Manual calculations for total number of job creation have been performed and are detailed in the report.

It is evident from the literature as well as the case study that the deployment of renewable and battery storage technologies has significant potential to improve the unemployment rate and contribute to the economic growth of the country. However, the quality of these jobs and the salary scale offered is not yet fully understood. Furthermore, it can be said that the job creation expected from deployment of renewable technologies as informed by the IRP 2019 will not result in a complete replacement of the coal sector workforce. Skills development and/or upskilling is also a key activity to create the supply of jobs and skills required for deployment of these technologies. This must be implemented and planned with consideration of ensuring gender equality and social inclusion.

It is firmly recommended that other opportunities such as entrepreneurial development and economic diversification be considered to ensure a JUST transition in the country.

4. References

[1] PCC, “Framework for a Just Transition in South Africa. Draft for public comment,” 2022. [Online]. Available: https://pccommissionflow.imgix.net/uploads/images/A-Just-Transition-Framework-for-South-Africa-2022.pdf

[2] CSIR, IET, IASS, Prime Africa, Enertrag, and Navitas Energy, “From coal to renewables in Mpumalanga : Employment effects , opportunities for local value creation , skills requirements , and gender- inclusiveness Assessing the co- benefits of decarbonising South Africa ’ s power sector,” 2022. [Online]. Available: https://www.cobenefits.info/wp-content/uploads/2022/01/COBENEFITS-Study_From-coal-to-renewables-in-Mpumalanga.pdf

[3] IASS, CSIR, and UCT, “Future skills and job creation through renewable energy in South Africa Assessing the co-benefits of decarbonising the power sector,” no. October, pp. 3–32, 2019, [Online]. Available: https://www.cobenefits.info/resources/cobenefits-south-africa-jobs-skills/

[4] B. Merven, F. Hartley, and C. Arndt, “Quantifying the Macro- and Socio-Economic Benefits of a Transition to Renewable Energy in South Africa,” no. January, 2019, [Online]. Available: https://sa-tied.wider.unu.edu/sites/default/files/pdf/SATIED_WP26_January_2019_Hartley_Merven_Arndt_Ireland.pdf

[5] NBI, BUSA, and BCG, “Just Transition and Climate Pathways Study for South Africa: Decarbonising South Africa’s Power System,” 2021. [Online]. Available: https://www.nbi.org.za/wp-content/uploads/2021/08/NBI-Transition-Chapter-Decarbonising-SA-power-11-Aug-2021.pdf

[6] A. Eberhard and R. Naude, “The South African Renewable Energy IPP Procurement Programme,” *Rev. Lesson Learn. Propos. to Reduce Trans. Costs*, no. April, 2017, doi: 10.13140/RG.2.2.11612.80007.

[7] CSIR and SAPVIA, “Solar PV Industry Jobs Report,” 2021. [Online]. Available: https://www.sapvia.co.za/wp-content/uploads/2021/05/SAPVIA-PV-Industry-Jobs-Study-Report-COMBINED.pdf

[8] GreenCape, “Energy Services Market Intelligence Report,” 2021. [Online]. Available: https://www.green-cape.co.za/assets/Energy_Services_MIR_2021_31_3_21.pdf

[9] S. Semelane, N. Nwulu, N. Kambule, and H. Tazvinga, “Evaluating economic impacts of utility scale solar photovoltaic localisation in South Africa Evaluating economic impacts of utility scale solar photovoltaic localisation in South A ... Evaluating economic impacts of utility scale solar photovoltaic locali,” *Energy Sources, Part B Econ. Planning, Policy*, vol. 00, no. 00, pp. 1–21, 2021, doi: 10.1080/15567249.2021.1894513.

[10] Escience Associate, Urban-Econ Development Economist, and C. Ahlfeldt, “The localisation potential of Photovoltaics and a strategy to support the large scale roll-out in South Africa,” p. 171, 2013, [Online]. Available: http://awsassets.wwf.org.za/downloads/the_localisation_potential_of_pv_and_a_strategy_to_support_large_scale_roll_out_in_sa.pdf

[11] SAPVIA, DTI, and WWF, “Photovoltaic Electricity: The localisation potential of Photovoltaics and a strategy to support the large scale roll-out in South Africa,” 2017.

[12] Independent Power Producers Office (IPPO), “Independent Power Producers Procurement Programme (IPPPP) An Overview,” no. June, p. 72, 2021, [Online]. Available: https://www.ipp-projects.co.za/Publications

[13] AIDC, “Challenging the State : Renewable Energy opportunities and electricity in South Africa in 2015,” 2015. [Online]. Available: http://aidc.org.za/download/climate-change/04REnergySAlowlogo.pdf

[14] P. Frink, J. Hargreaves, J. Enslin, U. Govender, and K. Kritzinger, “South Africa Energy Storage Technology and Market Assessment,” 2017. [Online]. Available: https://www.crses.sun.ac.za/files/research/publications/technical-reports/USTDA_Public+Version+1.pdf

[15] Savannah Environmental, G. Raath, and J.-A. Thomas, “(Bess) and Associated Infrastructure At Gunstfontein Wind Energy Facility , Northern,” 2021. [Online]. Available: https://sahris.sahra.org.za/sites/default/files/additionaldocs/1.Gf BESS Final BA Report.pdf

[16] SANEA, “ENERGY STORAGE TECHNOLOGIES WILL UNLOCK A ‘NEW GOLD RUSH’ FOR

SOUTH AFRICA,” 2020. [Online]. Available: https://cdn.ymaws.com/southafricanenergyassociation.site-ym.com/resource/collection/E2FD5238-2E40-4BAE-B1CB-5D7982995120/WEB_-_SANEA_Opinion_Piece_-_ENERGY_STORAGE_SAs_NEW_GOLD_RUSH.pdf

[17] C. Mugodzva, “The Economics and Imperatives of Renewable Energy: Impact on South Africa’s Competitiveness,” *Educor Multidiscip. J.*, vol. 3, no. 1, 2019, [Online]. Available: https://journals.co.za/doi/pdf/10.10520/EJC-1b3499ed99

[18] CIF, “Supporting Just Transitions in South Africa,” no. September, pp. 1–52, 2020, [Online]. Available: https://www.climateinvestmentfunds.org/sites/cif_enc/files/knowledge-documents/supporting_just_transitions_in_south_africa.pdf

[19] ILO, “Skills for Green Jobs in South Africa,” International Labour Organization 2018, 2018. [Online]. Available: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_706955.pdf

[20] F. Capazario, M.; Kaziboni, L.; Kensett, M.; Venter, “Economic and Labour Market Assessments to Advance Local Just Transitions in South Africa, C40 Cities Climate Leadership Group,” 2021.

[21] IRENA, “Renewable Energy: A Gender Perspective,” 2019. doi: 10.5040/9780755620074.ch-011.

[22] L. Krugel, Jayne Mammatt, and C. Poschl, “What a ‘ just transition ’ means for jobs in South Africa,” *PWC*, pp. 1–20, 2021, [Online]. Available: https://www.pwc.co.za/en/assets/pdf/what-a-just-transition-means-for-jobs-in-south-africa.pdf

[23] IASS, CSIR, and Prime Africa, “Improving health and reducing costs through renewable energy in South Africa,” 2019. [Online]. Available: https://www.cobenefits.info/wp-content/uploads/2019/03/COBENEFITS_SA_Health_Executive_Report_190322.pdf

[24] The Solar Foundation, “Solar + Storage Jobs,” 2016. [Online]. Available: http://www.ourenergypolicy.org/wp-content/uploads/2016/07/Solar-Storage-Jobs-A-Discussion-Paper.pdf

[25] B. Merven, F. Hartley, and J. Schers, “Private transport modelled in SATIMGE and the socio-economic impacts of electric vehicles in South Africa,” no. June, 2020, [Online]. Available: https://sa-tied.wider.unu.edu/sites/default/files/pdf/SA-TIED-WP-121.pdf