Learning Pathways In The Context Of A Just Energy Transition

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EXECUTIVE SUMMARY

South Africa faces the dual challenge of environmental degradation and socio-economic disparities. A Just Energy Transition (JET) presents an opportunity to ensure that, as a shift to sustainable energy is made, the burdens and benefits are fairly distributed, particularly among employees and communities at risk. The research focused on where intermediate jobs, stemming from the JET, will be created in the highest numbers to reduce unemployment in the country.

Channels must exist for acquiring essential knowledge and skills to foster an inclusive and sustainable energy and skills system embedded in a JET. This highlights the urgent need for research on learning pathway trajectories and a clearer understanding of learning pathways that promote better employment prospects for young South Africans. Potential job areas include electric vehicles, renewable energy (solar, wind and battery storage) and energy efficiency.

The project's objectives were thus to investigate the nature of learning pathways at the intermediate level to:

- Improve learner progression within education and training
- Improve connections between education and work
- Improve the development and use of skills at work within the energy sector
- Illuminate the institutional processes necessary to ensure effective systems of work and learning for the selected occupational streams (electric vehicles, renewable energy, and energy efficiency) and the broader low-carbon transition
- Clarify the institutional processes necessary to ensure effective systems of work and learning for the selected occupational streams
- Provide information on articulatory mechanisms, signposts, and safety nets needed.

The methodology was thus framed to elucidate three factors integral to pathways: the occupational progression—key jobs and how they were connected in a value chain; the educational progression and how qualifications and training opportunities are articulated to allow seamless progression into work; and the 'real life' transitions people are making to construct the nature of learning pathways.

The scope of work encompassed a comprehensive exploration, over five years, of intermediate jobs and occupations in South Africa connected to the country's energy transition. The project mapped out learning trajectories across key energy value chains closely linked to the JET; this provides a structured and adaptable framework in the South African skills ecosystem to enable transitioning within and across intermediate roles.

The analysis showed that overall, the learning pathways in the three technological areas (plus storage) have structural differences and are at different stages of maturity. Although interconnected in key areas, they are fragmented and lack adequate policy and coordination.

Occupations require more diverse skills than before, with the blurring of sectoral boundaries and customer needs. This requires a shift in educational provisioning and ensuring that the pathway constraints such as finance are addressed. The career pathway facilitation should go beyond qualifications to assist the learner along the journey to work integration. This could be done by officially registering learnerships and work experience so students can move to higher-level positions. This starts with rigorously monitoring the quality of education to improve employability and entry into the market and ensure that employers can access suitable, trained, and qualified people.

It is evident from the research that skills learning pathways in the JET areas studied are changing rapidly and are fragmented with barriers to educational progression. The following can however transform learning pathways:

- Policy to drive demand sufficiently by focusing on the different impacts in the three areas and prioritising technology enablement and localisation.
- Technology to transform the learning pathways, some of which don't exist.
- Emerging skills at high and intermediate levels (for example, artificial intelligence and the inter

- net of things) are required to drive the need for the job clusters discussed in this report. High-level emerging skills are key to unlocking intermediate-level job growth in emerging skills.
- Localisation efforts to drive demand, even though value chains are a complex mixture of local and international components.
- The hybridisation of occupations (technical and soft skills) and more interlinked occupations within clusters or streams of occupations.
- Upskilling of the occupational family and, in some cases, upskilling laterally across sectors. There is also a shift in some areas to more construction jobs bringing uncertainty due to temporary employment rather than full time jobs. Those with lower-level qualifications could become multi-skilled, leading to higher-level qualifications.

Barriers to learning pathways were identified as:

- Level of foundational education in STEM (primarily) subjects for technical jobs
- Uncertainty in demand due to either a lack of policy or strategy
- Pace of implementation of projects related to the Just Energy Transition and skills programmes, impacting market entry or career progression and certainty of work duration for short-term/project-based jobs
- Legislating qualifications for compliance reasons to ensure accessibility
- Accessibility and quality of required educational provisioning, including slow progress in updat-ing and recertifying curricula and qualifications for specialised training programmes, including upskilling for rapid technology advancement and other changes
- Quality and knowledge of academic staff
- Provision of infrastructure in education institutions (including IT)
- Availability of RPL programmes
- Availability and quality of mentorship
- Availability and quality of hands-on experience, including incentives for certification of formal, recognised on-the-job training and learnerships
- Limited access to structured internship programmes and opportunities for compulsory learnerships for certification
- Knowledge of issues such as basic safety training and specific brand/product training required
- Lack of soft skills impacting the pace of progression
- Financial constraints impacting time taken for career progression
- Opportunities for vertical career moves; when vertical progression takes place, it is generally into managerial positions rather than technical ones
- Availability of time for training for individuals already in employment
- Need for multi-skilled individuals or clusters of interrelated occupations

The multi-entry, multi-exit learning pathways model:

Interventions to facilitate a multi-entry, multi-exit learning pathways model with easy and rapid progression, which addresses the barriers, were identified for each of the three areas studied. These interventions coalesced around the following and are termed "intervention clusters":

- Policy and national strategy
- Qualification reviews to develop more broad-based qualifications to allow flexibility in career pathways
- Upskilling and supporting TVET lecturers/ infrastructure
- Supporting mentorship and work-based learning
- Bridging interventions to aid in entry into the pathways but also further progression
- Collaboration across various industry players to increase impact
- Future proofing qualifications in recognition of the fast-changing technology landscape

The interventions were assessed using a set of principles:

- There should be no duplication of efforts, but rather the building on, amplifying and supporting of collaborative partnerships
- They should align and support JET IP efforts as a major strategic driver for the country
- The interventions must focus on the system rather than individual components; pathways are critical
- They must have an impact.

This analysis resulted in a set of recommendations as follows:

No	Recommendation	Intervention cluster addressed	Justification
1	Give impetus and guidance to the JET IP activities around skills, such as the JET IP Desk, which is currently being set up using the high-level framework of interventions	• Policy and national strategy • Collaboration across various industry players to increase impact • Future proofing qualifications in recognition of the fast-changing technology landscape	The framework can be used to ensure a transformative approach, where the ecosystem is unblocked in key areas to allow better career progression. The National JET Skills Advisory Forum can be utilised to give input and guidance to the proposed strategy interventions
2	Support the increase in quality of educational provisioning by doing a systems-led series of pilot programmes to work with TVET colleges, businesses and SETAs	• Upskilling and supporting TVET lecturers/infrastructure • Supporting mentorship and work-based learning • Collaboration across various industry players to increase impact • Future proofing qualifications in recognition of the fast-changing technology landscape	This will allow GIZ to be the convenor of several efforts, pulling together funding and replicable learnings. It can link to the Skills Development Zones (SDZs) envisaged in the JET IP skills chapter and help establish and support them where appropriate. It encourages a demand-led skills approach
3	Support an expanded and coherent RPL	• Bridging interventions to aid in entry into the pathways but also progression • Collaboration across various industry players to increase impact	This is a significant barrier to entry for many South Africans and requires a focused approach that makes RPL more accessible, affordable, and developmental in nature. This will have a significant transformative effect on the ability of young people and adults, particularly those in townships, to gain recognition for their skills, become more mobile in the labour market, have opportunities for income generation, and progress towards a trade qualification.There are intrinsic challenges with RPL, particularly with the attempted RPL models (largely influenced by poor assessor training). Other models piloted in SA and elsewhere are better suited to address the challenge.

4	Partner with the Department of Communications and Digital Technologies (DCDT) to facilitate the implementation of the National Digital and Future Skills Strategy	• Bridging interventions to aid in entry into the pathways but also progression • Collaboration across various industry players to increase impact • Future proofing qualifications in recognition of the fast-changing technology	The first Digital Skills Implementation Plan ends in 2025. Engaging now with implementation planning for 2026-2030 provides an efficient mechanism for systemic inclusion of the JET skills priorities from basic education through TVET to universities.
5	The development of a JET Skills Atlas by the JET IP Skills Desk and Advisory Forum. The current qualifications framework and approach required for JET skills and skills clusters can be reviewed.	• Qualification reviews to develop more broad-based qualifications that allow flexibility in career pathways • Upskilling and supporting TVET lecturers/infrastructure • Collaboration across various industry players to increase impact • Future proofing qualifications in recognition of the fast-changing technology	This will address the barriers of financial requirements for continual retraining and upskilling due to technology changes. It can also provide the basis for developing training for job clusters and for SMMEs where a variety of skills may be needed. It can also address the Organising Framework for Occupations (OFO) alignment issue and ensure that qualifications can be quickly and efficiently developed or reviewed.

The energy sector's barriers and fragmented skills pathways can only be addressed through radical collaboration. This will address the lack of coordination and integrated planning and is a mixture of collaboration and co-creation of solutions from top-down, strategic, and bottom-up perspectives that lead to sustainable current and future sig-nificant positive outcomes and benefits. Only by taking this holistic approach can the identified gaps in the learning pathways be adequately addressed.

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1. Introduction

This project builds on the research work that Wits University did for the South African National Energy Association (SANEA) on the South African Energy Skills Roadmap, which is widely lauded as a comprehensive guide to future work in the energy skills area. The roadmap's recommendations emphasised a multidimensional approach to skills development that focused on aligning the energy skills development system with the anticipated labour force needs, focusing on jobs to support a JET (SANEA, 2023).

Understanding learning pathways is crucial for the success of JET work. This would provide insight into the channels for acquiring essential knowledge and skills necessary for an inclusive and sustainable energy and skills system.

Sanders and Peake in a Harvard Business Review Article define a learning pathway as "A designated sequence of activities, often from different sources and in different formats, devised to develop the skills and behaviours of colleagues. This can be achieved by stitching together disparate educational resources into rich, diverse, cohesive, and enlightening learning journeys" (Sanders & Peake, 2022). In today's changing world with the major technology shifts that go with them, these dynamic and ever-changing learning pathways apply not only to market entrants but to lifelong learning. Learning pathways are particularly important for the energy transition given the high levels of unemployment and the need for new energy skills. This combination, if not handled correctly, could result in job losses and imported skills rather than local development.

There is little representation of environmental occupations in South Africa at intermediate and elementary skill levels. This highlights the urgent need for research on pathway trajectories enabling broad access, mobility, and progression. This project sought to present a clearer understanding of learning pathways to promote better employment prospects for young South Africans as a transition is made to a more sustainable and decarbonised economy.

The focus was thus on the areas where intermediate jobs will be created in the highest numbers to support the drive to reduce unemployment in the country. Potential work streams include electric vehicles, renewable energy (solar, wind and battery storage) and energy efficiency.

A sophisticated anticipatory skills development, working with labour market intelligence (beyond technical skills and across the complete energy ecosystem), and strengthening skills system innovations across the energy value chain is required.

2. Objectives and Scope of work of the project

The objectives of the project, over a five-year period across the value chain in South Africa which excluded decommissioning, were to:

- Investigate the nature of learning pathways at the intermediate level to help create a better flow of learners within education and training, improve connections between education and work, and improve the development and use of skills at work within the energy sector.
- Illuminate the institutional processes necessary to ensure effective work and learning systems for the selected occupational streams, such as electric vehicles, renewable energy, energy efficiency, and the broader low-carbon transition. This will provide information on articulatory mechanisms, signposts, and safety nets needed.

3. Contextual Analysis

South Africa's energy-intensive economy is heavily dependent on fossil fuels, primarily coal. The carbon intensity of exports will negatively impact this and the country's international competitiveness; potential border tax adjustments are being considered by the European Union (EU), for example (Damsté et al., 2024).

The country is the biggest contributor to greenhouse gas emissions in Africa and is vulnerable to the impacts of climate change. As much of South Africa's greenhouse gas emissions come from the energy sector, it is a key focus.

3.1 Just Energy Transition

Building on this definition of an energy transition is that of **a JET, defined as:**

> *"a shift from our current energy system to one that is better in terms of sustainability, environmental impact, climate change, human health, economics, employment and social equity. A Just Energy Transition (JET) aims to make the process of shifting to a better energy system as fair and 'just' as possible. The justice part focuses on looking after people in the current energy system (such as workers in the coal sector) who could be negatively affected (such as job losses) by this energy transition." (90by2030, 2024).*

Not only is the energy sector changing technologically, but also in how and where energy is generated and consumed, how it is managed and traded, who uses it, and for what purpose (WEF, 2024).

3.2 South Africa's plan to reduce greenhouse gas emissions

South Africa's Nationally Determined Contribution (NDC) details what the country believes it can achieve and by when. In the update required as part of the Paris Agreement in 2021 at COP 26, it was highlighted that South Africa would need financial and technological support to reach net zero, as well as adaptation measures (Republic of South Africa, 2021).

A large proportion of the reductions will come from the energy sector, and thus, the NDC outlines the reduction in fossil fuels as defined in the Integrated Resource Plan (IRP) and its implications for the economy. Furthermore, the NDC includes opportunities for more renewables, green hydrogen, and power-to-X (PtX) products in the longer term (Republic of South Africa, 2021).

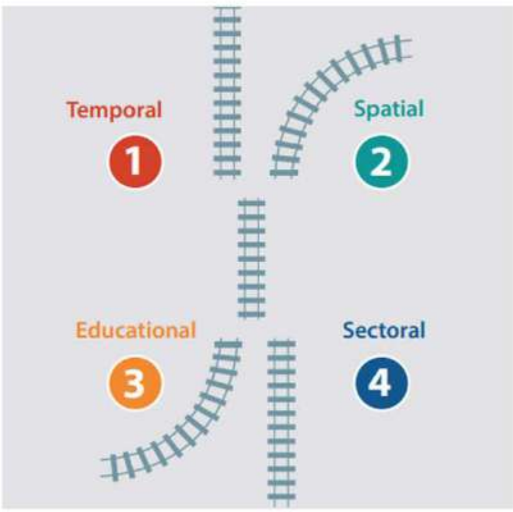
At COP 26, a $8.3 billion pledge was made by various countries to help finance this transition. The following year in 2022, the South African Government presented the JET Investment Plan (JET IP) to detail how this money should be used. The following were prioritised:

Table 1: High-level JET IP financing requirements

JET IP funding requirements 2023-2027	ZAR	USD billion
Electricity sector	711.4	47.2
New Energy Vehicles (NEV) sector Green hydrogen (GH_2) sector Skills development	128.1 319.0 2.7	8.5 21.2 0.18
Municipal capacity	319.1	21.3
TOTAL	1480.3	98.38

Source: (Presidency of South Africa, 2023)

Figure 1: Misalignments that lead to unjust transitions.



1 **TEMPORAL MISALIGNMENTS** occur when job losses precede job gains on a large scale. Examples are the closure of mining activities that do not necessarily coincide with new activities in renewable energy or energy efficiency.

2 **SPATIAL MISALIGNMENTS** occur when new jobs are emerging in other communities or regions and are a challenge for people who lost jobs and might have the right qualifications and skills, but have financial, family or property ties to the region where they live.

3 **EDUCATIONAL MISALIGNMENTS** occur when the skills levels or the occupation required under the energy transition have not been developed or needed under the previous energy system. Addressing them requires careful planning and foresight of the skills requirements ahead.

4 **SECTORAL MISALIGNMENTS** occur because of changing value chains and supply chains under the energy transition. Shifting from fossil fuel power generation to, for instance, solar energy shifts inputs from fuel extraction to the semi-conductor industry. If both are located domestically, we see a shift from one industry to another, and the job headcount depends on labour productivity. If the new value chain heavily depends on imports, job impacts move outside the country.

Source: (Renewable Energy and Jobs Annual Review 2021)

3.3 Implications for Energy-Related Skills

This significant shift in technologies utilised for energy production and distribution, as well as the shift from large, centralised power generation and oil refining to smaller, distributed energy production and use, has meant that:

- New jobs or skills will be required
- Higher volumes of certain skills will be required over time
- Upskilling and reskilling will be required for jobs that may be lost.

Indeed, career opportunities and pathways will be available: the World Economic Forum (WEF) calculated that the money spent in closing this gap may result in a global GDP increase of $6.5 trillion by 2030 (Sanders & Peake, 2022). While the JET is ambitious, the transition must be implemented and considered correctly. The International Renewable Energy Agency (IRENA) has defined under what circumstances misalignments occur: (figure 1)

3.4 Learning Pathways - conceptual framing of this research

Wheelahan (2009) outlined two important purposes of pathways. Firstly, pathways increase the effectiveness and efficiency of education systems. This means, the author argued, that individuals need to move between "different types of qualifications and different occupational sectors with ease" to reduce time and costs to individuals and governments. The second purpose is linked to equity and social inclusion: pathways, as a mechanism, aim to give access and opportunity to disadvantaged individuals (Wheelahan, 2009).

The literature outlines five main elements of pathways. These are:

- A set of interrelated experiences providing for progression
- Education and training should have a sense of continuity even when individuals cross institutional and sectoral boundaries
- Young people should have access to a range of different pathways and should be able to move from one to another without losing ground.
- There is a need for effective credit transfer and articulation arrangements to provide smooth bridges between pathways
- Signposts (information and career advice) are needed at the start of each pathway and at each junction between pathways (McKenzie, 2000; McKenzie & Hillman, 2001).

Ramsarup (2018) argued that "putting pathways at the centre of an education and training system helps to bring many parts of the system into direct relationship with each other and thus helps us raise questions on how qualifications and curriculum provide for educational progression." The notion of learning pathways is thus an important conceptual idea for understanding wider systemic articulation concerns.

A study of learning pathways also provides empirical insights into how various qualifications may or may not articulate, and how the changing context shapes choices and needs related to available qualifications, how they are used, and how they relate to more traditional qualifications-led articulation learning pathways. This complex notion of learning pathways as neither completely individualistic nor wholly structurally determined informs the framing of learning pathways used in this study. It recognises that structures precede human actions and that agents may influence structures and exercise reflexivity as they 'make their way through the world'. Based on this emergent view of human development, the perspective on learning pathways used in this study will recognise that systemic and structural factors shape learning pathways in certain ways, but agents (the individual learner or other corporate agents) may shape the learning pathways in certain ways too. Hence traditional supply and demand approaches to understanding were insufficient to raise the complexities associated with pathway construction, articulation and efficacy.

The methodology was thus framed to illuminate three layers integral to pathways:

- The occupational progression: key jobs and how they were connected in a value chain
- The educational progression: qualifications and training opportunities and how they are articulated to allow seamless progression
- An attempt to understand the 'real' transitions

people were making as an important lens in constructing the nature of the learning pathways.

This work illuminated the institutional processes necessary to ensure effective systems of work and learning (quality, articulation, learning pathways) for the selected occupational streams and the broader low-carbon transition. It provides information on the articulatory mechanisms, signposts, and safety nets needed.

4. Methodology

4.1 Scope of the Learning Pathway Mapping

The scope of work encompasses a comprehensive, five-year exploration of intermediate jobs and occupations related to the energy transition. The project will map out learning trajectories across key energy value chains closely linked to the JET, to enable transition within and across intermediate roles. It provides a structured and adaptable framework located in the South African skills ecosystem. The following sectors are relevant:

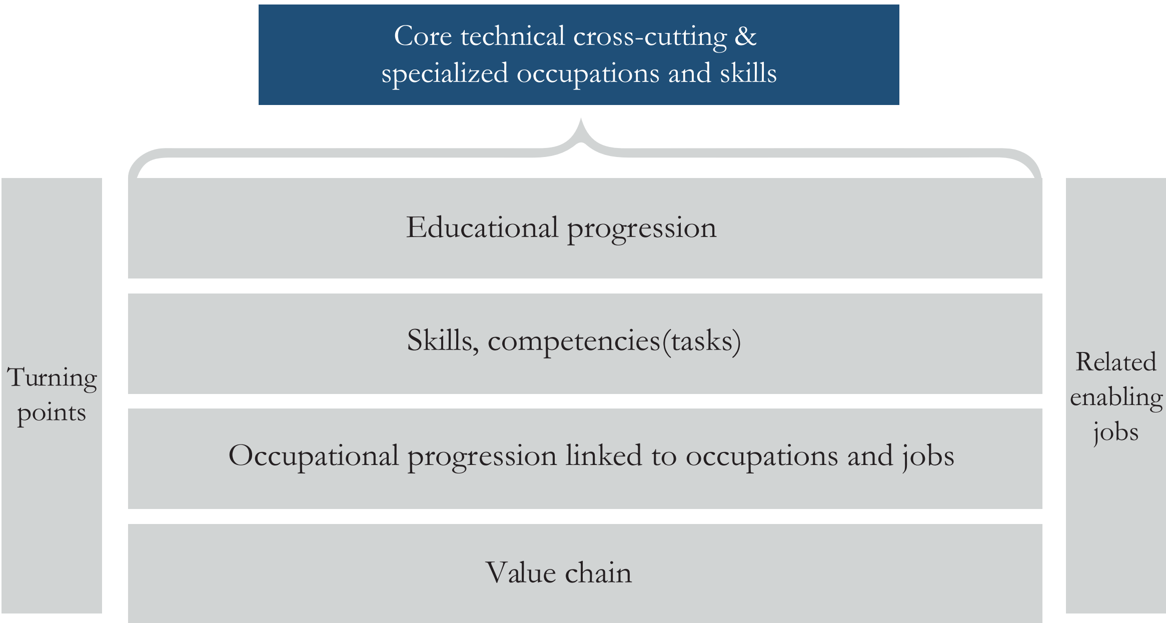
- **Renewable energy - Solar Photovoltaic (PV), Wind Energy and Battery Storage:** The solar PV and wind energy value chains are key to the just energy transition in South Africa as they are abundant renewable energy sources, can create jobs and enhance economic development, and reduce reliance on fossil fuels. Understanding learning pathways in these value chains is instrumental in building the necessary skills and knowledge for a successful and equitable transition to renewable energy. Energy storage is key to addressing intermittency in renewable energy and links to electric vehicles.
- **Electric vehicles:** As the world transitions toward cleaner and more sustainable practices, participating in the Electric Vehicle (EV) value chain allows South Africa to position itself as a player in the global green economy. The sector could potentially contribute to environmental sustainability, job creation and economic opportunities (linked to manufacturing, battery production, charging infrastructure development, and maintenance services), and innovation and technological advancements.
- **Energy efficiency**: Rising energy prices coupled with the pressing need to decarbonise and reduce resources will make energy efficiency critical. Given that it is generally quick to implement and relatively low-cost, it is a low-hanging fruit that can and should be implemented as a matter of urgency. Energy efficiency is a cross-cutting issue across many sectors and in the energy production process itself. When combined with other services such as solar PV installation, it has the potential to create many jobs.

Although the three technological areas (plus storage) were examined separately, the interlinkages and skills ecosystem implications were identified and analysed to ensure sustainable and implementable recommendations for GIZ.

4.2 Detailed Methodology

The project started by understanding and investigating the jobs and occupations in key energy-related value chains. This was done by mapping vertical and horizontal occupational progression considering the changes in the energy sector. Skills and competencies were identified to determine upskilling and reskilling needs. Full and part qualifications were mapped, with the intent of identifying current supply and demand, as well as existing gaps. The overall methodology is detailed in the figure below and takes an ecosystem approach, including more than the demand and supply equation. It includes people in the system and their stories as well as enablers and constraints of the system.

Figure 2: Project methodological approach



4.2.1 Mapping of Occupational Progression Pathways

The detailed steps that were undertaken were as follows:

STEP 1—Backcasting to determine growth demand targets for the energy transition and to identify pathways to reach these targets. The insights into the highest number of intermediate-skilled jobs that can be generated in a JET context were drawn from existing work, desktop research and labour market studies. The process included:

- Envisioning the desired future state in terms of growth demand targets for priority occupations related to the adoption of electric vehicles, renewable energy and energy efficiency
- Identifying the necessary strategies to achieve the growth demand targets in relevant sectors and occupations
- Working backwards to determine the specific learning pathways that different occupations would need to make horizontal and vertical job moves within and across the sectors.

STEP 2—Mapping existing full and part qualifications related to selected sectors as part of the JET in South Africa.

Current qualifications that exist were identified with a focus on intermediate skills. This included a rapid analysis for informal training/capacity building related to these sub-sectors/occupations. Specialists in these areas were interviewed, and desktop literature surveys were carried out. The method and data sources for each of the three areas are outlined in the table below.

STEP 3—Gathering case studies and real-life learning pathway stories. Providing some micro-level data to complement the macro-systemic pathway information is essential. The interview questionnaire is included in Appendix 1. The interviews were analysed to determine the learning pathways individuals followed, the constraints and enablers of this process, and the pivot points.

The specialists mentioned in Step 2, together with other stakeholders and searches on LinkedIn, helped to identify interviewees.

Once the interviews were completed, each interviewee was given an individual learning pathway, and constraints, enablers, pivot points, and other insights were analysed.

Commonalities among the interviewees for each technical area were compiled, and linkages between the different technologies were identified.

STEP 4— JET Learning pathway mapping. In constructing the options, feeder jobs, bridging into higher skills or workplace training, and potential routes to specialisations, an overall multiple entry and exit model was developed. This was achieved by:

- Prioritising the key technologies that have the potential to create the highest number of intermediate jobs in the short and longer-term
- Identifying the implications of these technologies for future work by unpacking the changes to job tasks and occupational roles and determining when the demand is roughly expected
- Translating the changes expected in jobs and occupations
- Identifying the pathway options for each technology, linking the technologies.

STEP 5—Plotting the key pathway elements. The main enablers and constraints for intermediate-level learning pathways were identified. These included, for example, credit transfer and articulation arrangements to provide smooth bridges between pathways and institutional and sectoral boundaries, signposts (information and career advice), exit routes, and entry routes.

STEP 6—Interventions to facilitate a multi-entry, multi-exit learning pathways model with easy and rapid progression and which address the barriers were identified for each of the three areas studied, plus overarching or cross-cutting interventions.

STEP 7—A workshop was conducted with key stakeholders and specialists to test the robustness of the analysis and identify any gaps and contributions to recommendations and conclusions.

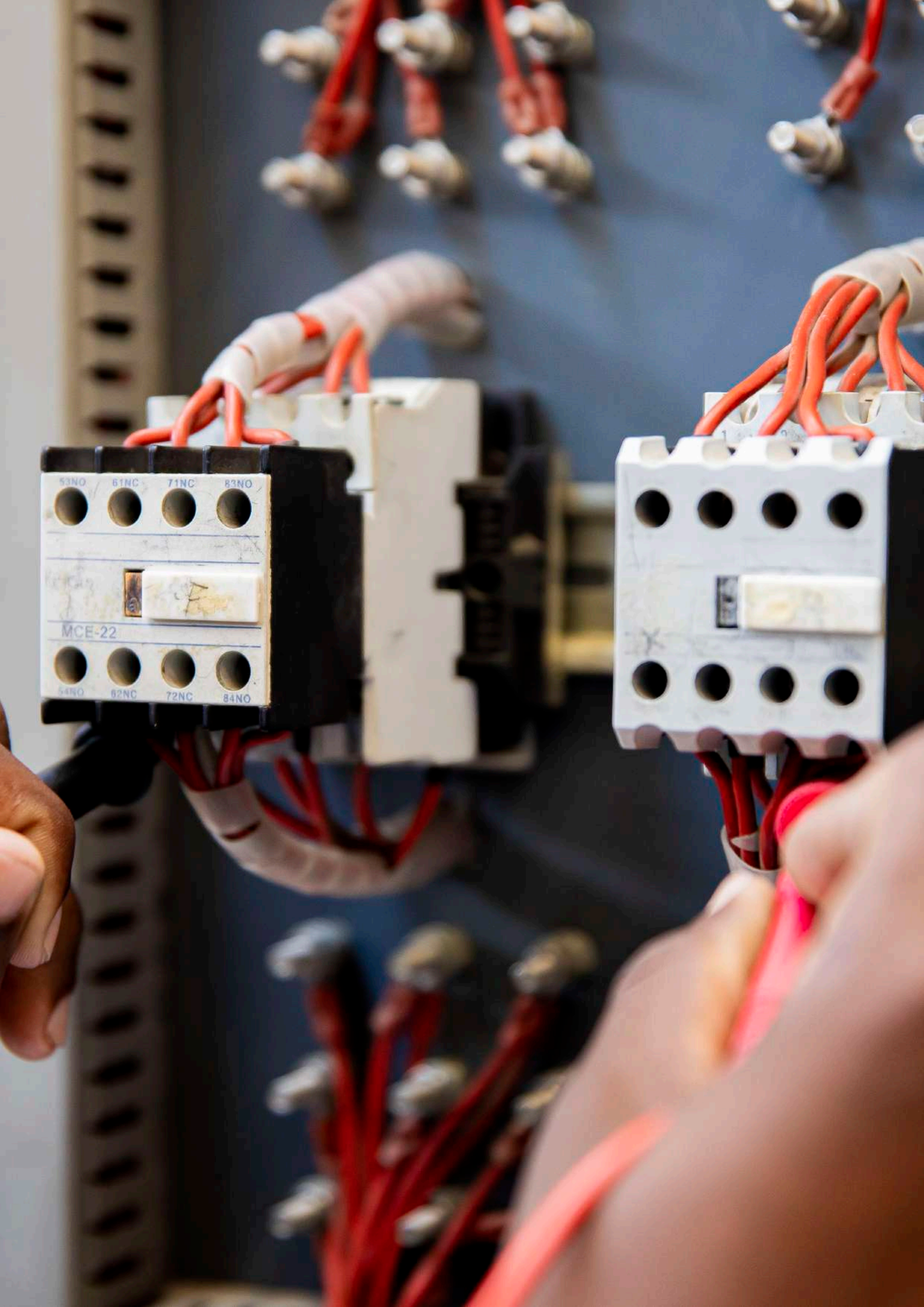
STEP 8—The interventions were then consolidated and reviewed through a series of "lenses": policy, time, ability to address barriers, and their place in the career progression process.

STEP 9— A final report with key recommendations was then developed using a set of principles to help define the most impactful interventions.

Table 2: Methodology and data sources for all three areas included in the study

Step	Electric Vehicles		Wind, Solar and Batteries		Energy Efficiency	
	Method	Data sources	Method	Data sources	Method	Data sources
Describe the (current and emerging) value chain	Description of the value chain and location of the SA value chain in the international context.	SAAM 2035 studies SAAM 2035 White Paper	Value chain analysis	Draft SAREM 2030, WWF/TIPS	Value chain analysis	Research
Identify how many jobs will need to be filled and where in the value chain	Growth demand is derived from industrial policy targets for vehicle production and localisation. Replacement demand estimated from age	SAAM 2035 merSETA SSP and research Stats SA Quantec	Growth demand derived from emerging trend data sourced from regulatory frameworks (policies, Environmental Impact Assessments (EIAs) and grant documents), market analysis, and technological trends. Further, data was sourced from strategies and reports on potential localisation	SAREM, TIPS, LSF, QLFS, IRENA, B&M Analysts (LSF)	Growth demand derived from education providers (throughput)	National Cleaner Production Centre EWSETA Institute of Energy Professionals Africa
Map occupations against the value chain	Disaggregate occupational data by value chain segments, triangulate with industry data	Industry data merSETA WSP template merSETA survey data	Review definitions and descriptions and source definitions and descriptions for gaps	OFO/O-Net/other sources	Disaggregate WSP data by value chain segments, triangulate with survey and industry data	Industry data Interviews with key players EWSETA QCTO
Prioritise occupations for learning pathway analysis	Identify at-risk, transitioning and emerging (at basic, intermediate and high skill levels), then prioritise employment and industrial impact	Analysis of findings 1 – 3 above	Divide occupations into transitioning and emerging (at different levels); Prioritise against the biggest (employment and industrial) impact	Analysis of findings 1 – 3 above	Divide occupations into at-risk, transitioning and emerging (at different levels) and prioritise against employment and industrial) impact	Analysis of findings 1 – 3 above
Summarise tech changes and skills implications	Comparative analysis of ICE/NEV technologies Comparative analysis of production processes	SAAM 2035 White Paper, research studies	Literature Review	NBI/BCG/BUSA Pathways Study on Renewable Energy	Comparative analysis of technologies Comparative analysis of production processes	Research studies

Analyse learning pathways	Compare job descriptions, OFOs, and qualifications for existing vs future skills needs in priority occupations	OFOs, O-Net, Job descriptions Qualifications Occupational and professional body data	Compare job descriptions, OFOs, qualifications for existing vs future skills needs	OFOs, O-Net, Job descriptions Qualifications	Compare job descriptions, OFOs, qualifications for existing vs future skills needs	OFOs, O-Net, Job descriptions Qualifications
Suggest supply-side focus areas and scope	Enrolment and achievement data Description of Informal and non-formal pathways, micro-credentialing shifts taking place	FETMIS, HEMIS, tracer studies ECSA Annual Reports Research reports, interviews	Enrolment, retention, achievement	Suggest supply-side focus areas and scope	Enrolment, retention, achievement Description of Informal and non-formal pathways, micro-credentialing shifts taking place	Research reports, interviews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5. Results

5.1 Mapping of qualifications and initial occupation progression pathways - Electric Vehicles[1]

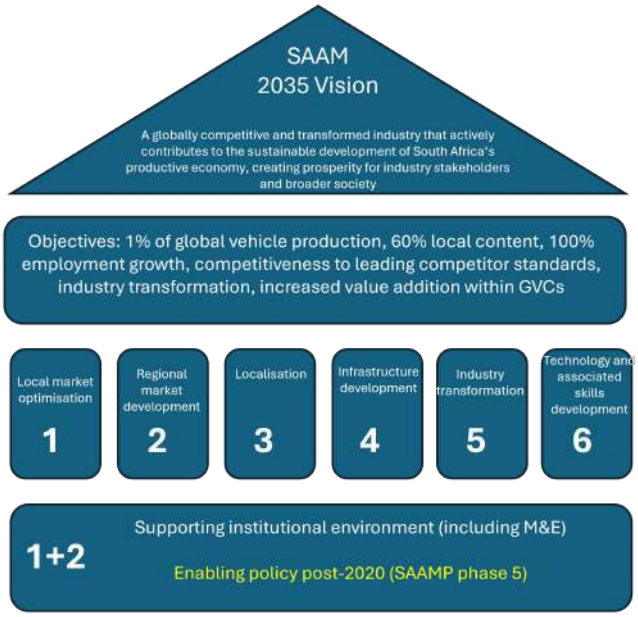
5.1.1 Description of the automotive value chain as a context for pathways

Major changes are underway in the automotive value chain globally and in South Africa. These are driven by climate change mitigation strategies, technological innovation, consumer preferences, sector restructuration, and contestations in global value chains. The focus on regionalisation is key because of the policy intention to develop a regional battery chain segment and because the automotive sector labour market is partly regional.

The draft SA Automotive Masterplan 2035 (SAAM) illuminates the value chain and the projected number of new jobs, including where and what they might be. It also outlines where the pathway analysis should focus.

Within this context, the SAAM 2035 pillars are to optimise domestic markets, develop regional markets, localise manufacturing, develop infrastructure, transform the automotive industry, and develop the skills necessary to achieve technological changes.

Figure 3: The South African Automotive Masterplan 2035.



Source: Barnes et al 2018.

SAAM 2035's objectives further elaborate on the pillars (Table 3). In the November 2023 White Paper, these have been translated into 10 policy goals with a set of 16 policy actions to be implemented over specific timelines between 2023 and 2035. These include 10 actions in support of the development of cost-competitive EV productive capacity in South Africa and six in support of the development of a cost-effective local market for EVs.

<?> "(D)emand and supply patterns are changing from a dominance of internal combustion engine (ICE) vehicles to a mix that incorporates battery electric vehicles (BEVs); plug in hybrid electric vehicles (PHEVs); hybrid electric vehicles (HEVs) and fuel-cell electric vehicles (FCEVs). In this paper, these categories are subsumed under the heading of electric vehicles (EVs) for ease of reading" (Electric Vehicles White Paper 2023:1).

Table 3: SAAM 2035 Objectives.

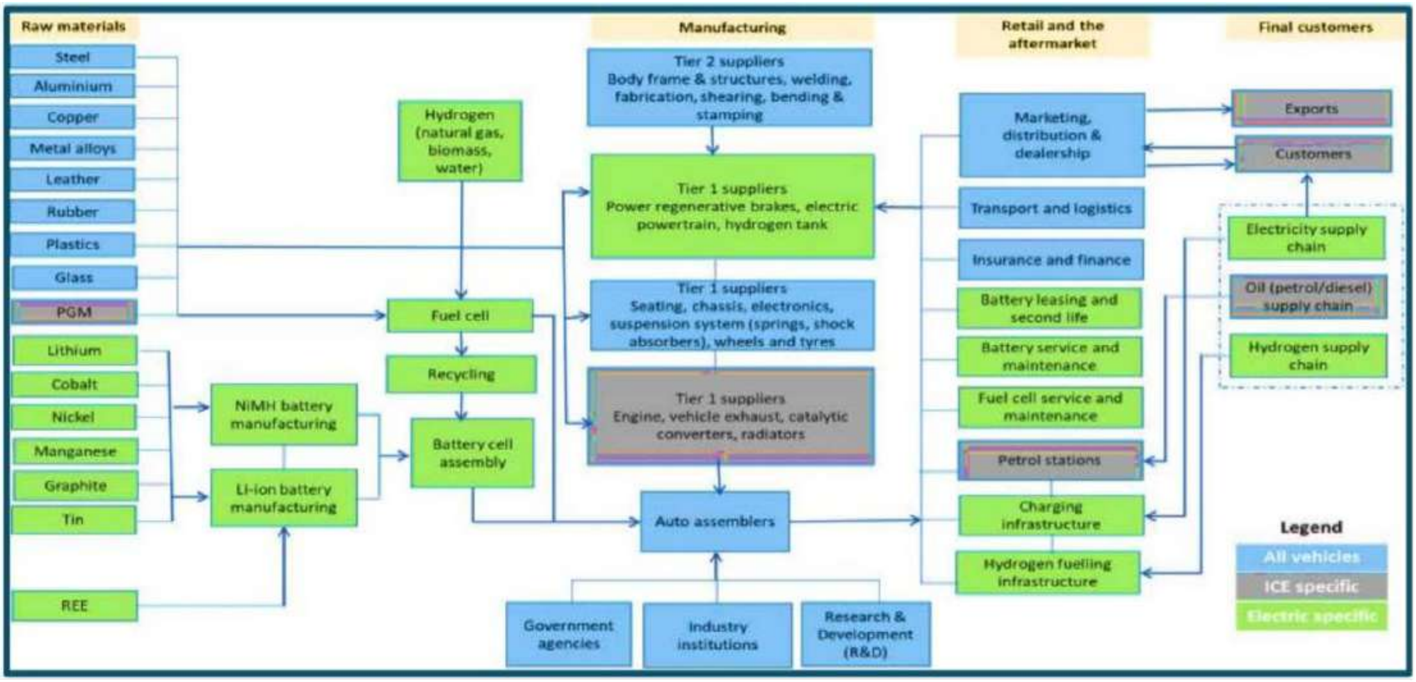
Objectives:	Estimated Impact on SA Auto Industry
1.Grow SA vehicle production to 1% of global output	• CBU production to 1.39 million units annually (129% higher than 2015 levels). • Increase in value of vehicle production to R314 billion
2.Increase local content in SA assembled vehicles to up to 60%	• Increase of R135.4 billion on 2015 local content levels • Local content increase of 21.3% per vehicle produced (55% increase) • Increase automotive component aftermarket & export production at the same pace as local content growth
3.Double employment in the auto value chain	• Employment growth of 112,000 • Aggregate employment from 112,000 to 124,000
4.Improve auto industry competitive levels to that of leading international competitors	• Sustainable automotive industry based on comparative price and non-price competitiveness versus leading international competitors • Sustained export competitiveness
5.Transformation of the South African automotive value chain	• 25% Black-owned involvement at Tier 2 and Tier 3 component manufacturer levels, as well as in dealership networks and authorized repair facilities • Amplified skills development of Black South Africans Enhanced employment equity at senior management, artisan, and • professional employment levels across the automotive value chain
6.Deepen value addition within SA auto value chains	• Growth in R&D and other innovation metrics within the South African automotive value chain

The automotive value chain encompasses:

- raw materials
- component manufacture
- vehicle assembly
- retail and aftercare
- vehicle use and infrastructure
- disposal and reuse.

The diagram below summarises the value chain, highlighting some differences between ICE and EV value chains.

Figure 4: The Automotive Industry Value Chain in Transition.



Source: EV White Paper 2023.

For purposes of this project:

- Raw materials are not included (by agreement with project management). While the overall intent of SAAM 2035 and ACTFA promotes increased beneficiation of raw materials at national, regional and continental levels, this is unlikely to impact employment and skills in the raw materials segment. It will, however, impact the components segment.
- Data sources and types differ for components, assembly, retail and aftercare. Significant employment growth is anticipated mostly for components, due to the localisation targets in SAAM 2035 and the ACTFA strategy of repositioning the continent within the global value chain. (The White Paper's target is to increase employment in component manufacturing from the current 43% to 60%). There is a specific focus on batteries and another on localisation of charging infrastructure components. Assembly, retail, and aftercare mostly reflect the transition of existing employees to work with EVs.
- Data for vehicle use and infrastructure are high-level and, at this point, sometimes speculative). The same is true for battery manufacturing and recycling.
- Recycling is a major potential new job growth area. The EV sector, in particular, is recycling-focused. Furthermore, tyre recycling and beneficiation of recycled waste material was the focus of REDISA, which has now been taken up by the CSIR and other waste economy segments. The waste economy is currently not automotive-specific, and there are no local strategies or capabilities for recycling EV materials (apart from batteries). However, vehicle recycling requires specialised vehicle salvage technicians, recycling plant opera

- tors (shredder and crusher operators), materials recovery technicians (metals, plastic, glass, rubber), hazardous materials specialists, and environmental compliance officers. Only a few SAQA qualifications exist in the waste recycling space. These are at levels 2-3, mostly targeted at waste pickers and municipal workers. The qualifications do not reflect EV specialisations such as battery recycling.

The EV White Paper states the differences between various emerging vehicle technologies under the term "EV" for ease of reading. While the policy focused on Electric Vehicles (EVs), the trend shows a deeper interest in hydrogen-powered vehicles (FCEVs). As the case study data illustrates, the transition from EVs to FCEVs is varied and dynamic, which has implications for skills planning. For example:

- Electric vehicles are powered by electric motors, typically rechargeable lithium-ion batteries. The powertrain includes battery packs, electric motors, inverters, and transmission systems. Hydrogen-powered vehicles use fuel cell stacks to generate electricity onboard by combining hydrogen fuel with oxygen from the air. The powertrain includes fuel cell stacks, hydrogen tanks, air compressors, and power control units.
- Electric vehicles store electrical energy in rechargeable lithium-ion batteries, typically in the vehicle's underbody or within dedicated battery packs. Hydrogen-powered vehicles store hydrogen gas in high-pressure tanks, typically made of carbon fibre or composite materials.

The knowledge and skills required to manufacture, assemble and service both types of vehicles share similarities but have differences. Given the pace and uncertainty of technological change and possible choices between OEMs, this pathways study focuses on cross-cutting foundational skills.

The generic "EV" descriptor fails to represent the emergent and strategically delicate state and private sector strategies on different vehicle categories. The White Paper has a specific policy objective to develop and implement a framework for fleets to transition to SA-produced new energy vehicles (including government-owned), public transport, corporate fleets, and mining equipment. Motorcycles (increasingly used, for example, in retail delivery) are another opportunity. South Africa adopted a set of non-tariff barriers to motorcycle imports in 2013 (NCRS 2013).

As the case study data illustrates, corporates sometimes retrofit existing vehicles to become hybrid. These emergent choices will also impact skills needs and priority interventions.

Further, changes in the automotive industry are wider than simply a shift in the energy source. The global trend is toward CASE (Connected, Autonomous, Shared and Electric) vehicles. New components have new uses for new industries. An Uber-type share service, for example, has digitised monitoring of road conditions and vehicle performance, among other specifications. Many of the "emerging occupations" lie in these areas, too.

One of the 16 policy goals in the White Paper is focused on skills. This is headlined "Develop an EV Certificate Programme in Collaboration with the Industry". Responsibility is allocated to merSETA, DHET, DEL and industry. The timeframes are by 2025. The purpose is "skills development for job retention". In detailing this policy goal, five interventions are broadly sketched in the White Paper:

- Upskilling existing employees for designing, engineering, manufacturing, and carrying out aftermarket services for EVs and related components and systems
- Introduction or adaptation of tertiary programmes to equip new entrants with the skills of the future
- Broader ecosystem training on working with EV high voltage components
- Develop performance and safety testing and certification capabilities
- Reskilling of those involved in "at risk" occupations.

This report complements the EV White Paper with partial, more delicate occupation-level and pathway analyses to uncover enablers and constraints.

5.1.2 Overview of Institutional Architecture

While an analysis of supply and demand is heuristically helpful, an ecosystem analysis is necessary to contextualise the interventions.

The automotive industry has historically operated within global value chains where OEMs function in "walled gardens", controlling upstream and downstream value chain activities from home countries across global networks. This applies to South Africa too. However, two factors disrupting this are the digitalisation of the automotive industry, and the SAAM 2035 policy intention to localise more component manufacturing.

Disruptive digitalisation is leading to some sector restructuring. Technology and insurance companies with deep pockets are increasingly penetrating specific niches. For example, sensors in vehicles are articulated with cloud computing and predictive analytics in parametric and alternative risk financing insurance models (in which South Africa is a world leader). The physical act of driving is increasingly integrated with monitoring driver behaviour in fleet management and is incipiently interfaced with management information systems on road infrastructure. There are pockets of innovation in South Africa, laterally and vertically across the value chain.

While current emerging occupations are at higher levels (and therefore excluded from the scope of this study), a "just transition" promises that while employment attrition will occur, other new employment opportunities will arise, mostly in the emerging occupations. These occupations must receive further attention, with the automotive industry participating in formulating Phase 2 implementation planning for the Digital Skills Strategy.

The SAAM 2035 policy aims to localise up to 60% of component manufacturing. As illustrated in Table 4 below, in 2023, there were 84 component manufacturing companies in South Africa. The bulk of these (accounting for more than 80% of employment) are in components that are not heavily digitalised (although sensor technologies are changing this). South Africa does not produce more software-dependent components such as onboard communications or entertainment systems.

Table 4: SA Component Manufacturing Segments, Size and Employment Share.

Component Category	Number of Companies	Share of Total Employment
Metal Forming and Pressing	29	24.5%
Automotive trim	18	10.4%
Foundry, Casting and Forging	9	9.8%
Plastic moulding	6	9.7
Machining	5	2.3%
Cables	4	0.9
Rubber moulding	3	1.9%
Windshields	2	6.6%
Batteries	2	9.6%
Trading	2	11.9%
Wiring harnesses	1	0.2%

Filters	1	8.3%
HVAC (heating, ventilation and aircon)	1	3.1%
Electronics	1	0.9%

Source: Monaco and Wuttke (2023: 18)

DTIC notes that "as the shift to new energy vehicles (NEVs) intensifies, there are many areas of uncertainty for both OEMs and component suppliers" (DTIC/ASCII 2022: 1). The Automotive Component Supply Chain Competitiveness Initiative argues that "local manufacturers have existing manufacturing capabilities to transition to NEV component manufacturing. Such component manufacturing includes aluminium high-pressure diecasting, laser welding, aluminium welding, aluminium stamping, forging, sintering, crimping, copper extrusion and PCB production" (DTIC/ASCII 2023: 1). They identify several components with high potential:

- Electric Motors and Transmission (e-Axle)2.
- Power Electronic Devices
- High Voltage Wiring Harnesses
- Batteries.

The occupations involved in manufacturing these components have not yet been mapped, and qualifications have not been developed or reviewed to assess the required changes.

5.1.3 Labour market trends and issues influencing occupational learning pathways

Identifying occupations with the biggest employment potential entails rudimentary labour market analysis. This includes some analysis of growth demand, replacement demand, and relevant labour market demographics to identify transformational imperatives.

a) Growth demand

The components and assembly sectors employ 116,683 people directly, 239,000 indirectly, and another 214,309 in related jobs (White Paper 2023).

- 83 362 are in component manufacturing
- 33 321 are in vehicle assembly (average monthly employment)
- 75 000 are employed in retail, with another 70 000 in the sale of parts and accessories
- 267,000 are in aftermarket
- 144 000 are employed in the fuel retail market (including 70 000 petrol attendants across 5000 petrol stations).

Vehicle assembly employment has declined by 9.8% since 2010, with an even steeper decline in component manufacturing. Employment was fairly stable across other value chain segments.

SAAM 2035 projects doubling employment to 224,000 by 2035 and, thus, 112,000 **new employees as a result of the industrial strategy.** The projections are derived from an analysis of increased sale and export target volumes, the average value of these, the value of production, and local content increases. **Note that this relates only to components, assembly, and aftercare. The projections did not include employment impact in raw materials, vehicle infrastructure, and recycling.**

Table 5: Calculating Employment Growth for SAAM 2035.

Production	2015 (base)	2020	2025	2030	2035
Light Vehicles (4.5% CAGR for PVs, 3.5% for LCVs)	583,999	735,669	900,044	1,101,746	1,349,373
M&HCVs (3.0% CAGR)	24,303	27,353	31,710	36,760	42,615
Total vehicle production	608,302	763,022	931,754	1,138,506	1,139,988
Avg. Value of SA produced vehicles (constant)	225,804	225,804	225,804	225,804	225,804
Value of Production (Rm)	137,357	172,293	210,394	257,079	314,317
Local content (%) (2.2% annual improvement)	38.70	43.18	48.19	53.77	60.00
Local content value (Rm)	53,157	74,403	101,382	138,231	188,589
Employment (productivity adjusted - 61%)	112,000	129,570	151,882	182,355	224,000

Source DTIC, 2023.

Employment growth projections are commonly derived from projected growth in output. However, productivity improvements, capitalisation, capacity utilisation, and labour elasticity coefficients must be factored into. The SAAM 2035 model incorporates productivity improvements. Capitalisation, capacity utilisation and labour elasticity were not taken into consideration. For these purposes, it is worth noting that:

- Capacity utilisation dipped below 70% during the pandemic but is up to over 80% again
- The impact of capitalisation has not been estimated
- The SAAM 2035 projections for employment growth are, therefore, likely overstated.

Infrastructure entails the construction of charging stations for NEVs. An estimated 4,000 charging stations are needed to service the projected number of EVs on the road in SA by 2035 (of a current base of roughly 300). It is possible to model the total employment impact, but these jobs lie largely in the construction industry and are not considered for this report. Similarly, growth in employment of charging station attendants is likely to be incrementally offset by attrition in petrol station attendants.

Due to the high value of materials, the shift to EVs (particularly battery recycling) will likely create job growth in the waste economy. Again, these are not regarded as core occupations in the automotive industry itself.

Figure 5: Estimating Charging Station Infrastructure..

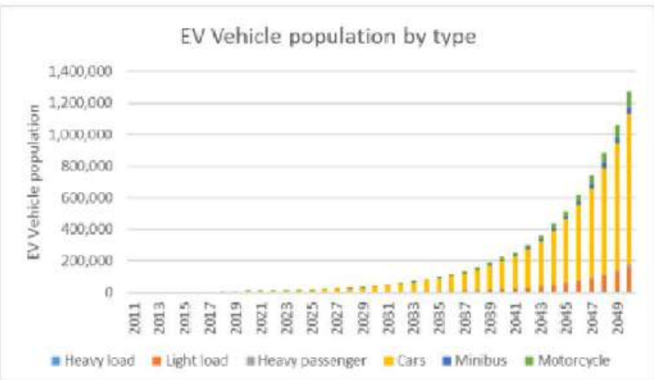
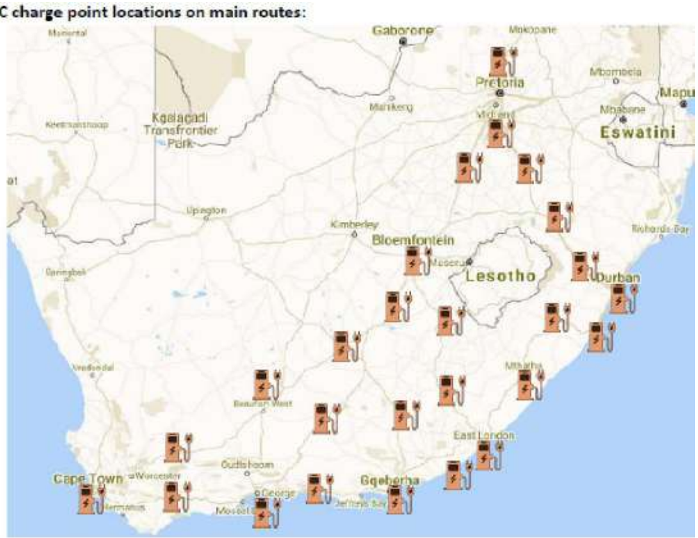


Figure 8: Electric vehicle uptake by vehicle type

Source: City Energy - Managing Electric Vehicle Uptake in the City of Johannesburg

- Recommendation by the International Energy Agency (IEA) is **1** public charging station per 10 electric vehicles
- Based on COJ's South African EV carpark prediction by 2035 there should be 40000 EVs.
- This should result in 4000 public charging stations
- This project objective is not to satisfy the above, but to assist in the stimulation of EV charging infrastructure

Proposed DC charge point locations on main routes:



Source: Bladergroen, 2022.

b) Replacement demand.

Estimating replacement demand typically requires analysis of retirement, mortality, morbidity, emigration, immigration, and inter-occupational mobility. Only retirement demand, that factors in the number of people who will retire and hence need replacing, is considered here, illustratively concerning the component manufacturing and vehicle assembly segments. Data for estimating other replacement demand variables is not disaggregated to industry level.

As reflected in the diagram below, there is a significantly higher median age profile for employment in components and assembly. Very few workers are below 30. The 30-39 age group represents 35.5% of workers. The 40-49 age group represents 45.8% of workers. Significant numbers are over the age of 50 (heavily concentrated in the professional and managerial bands).

This is significant for several reasons. First, retirement demand could add another 13,000 jobs that need to be filled to the growth demand forecasts (albeit over 10-15 years, not all within the next 5 years). Second, interview data for a merSETA 2021 study reported that older workers often cannot keep up with "tech time" and new technologies and frequently approach unions to negotiate a voluntary severance package. Thus, the retirement demand may emerge more rapidly than before, and not only among those over 50. Third, the age profile of employees, when overlaid on educational achievement levels, poses troubling questions about the general education foundations needed to transition to the new skill sets required by the shift to EVs/NEVs. This is even more pronounced concerning the informal sector, which constrains the possibilities for drawing them into the EV transition.

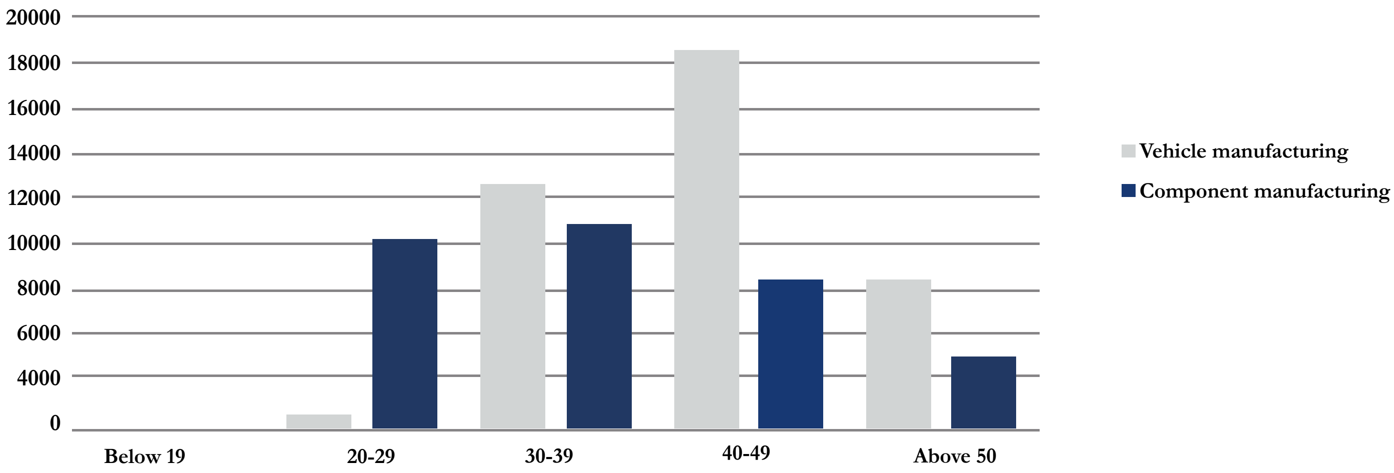
c) *Transformational imperatives*

The EV White Paper is explicitly framed as a "just transition", conceptualised around distributive, restorative and procedural justice. This has implications for human capital development. Transformational imperatives are a central stumbling block in negotiations between businesses, labourers, and the state. Industry is working out an industry transformation charter, and incentive schemes will likely be tied to the transformation of ownership and employment as much as localisation. Skills development will feature as a central element. Employment equity is being driven through BBBEE scorecard targets, but will not be discussed in this report. The AITF, the Automotive Supply Chain Competitiveness Improvement Initiative, the Retail Motor Industry, and NAACAM are driving the transformation of ownership. In all segments:

- Parts of the retail and aftercare segment aim to drive their expansion into township and rural economies through franchising
- The OEMs (vehicle assembly) have a history of growing their supply chains from global RDI capabilities to local component manufacturing.

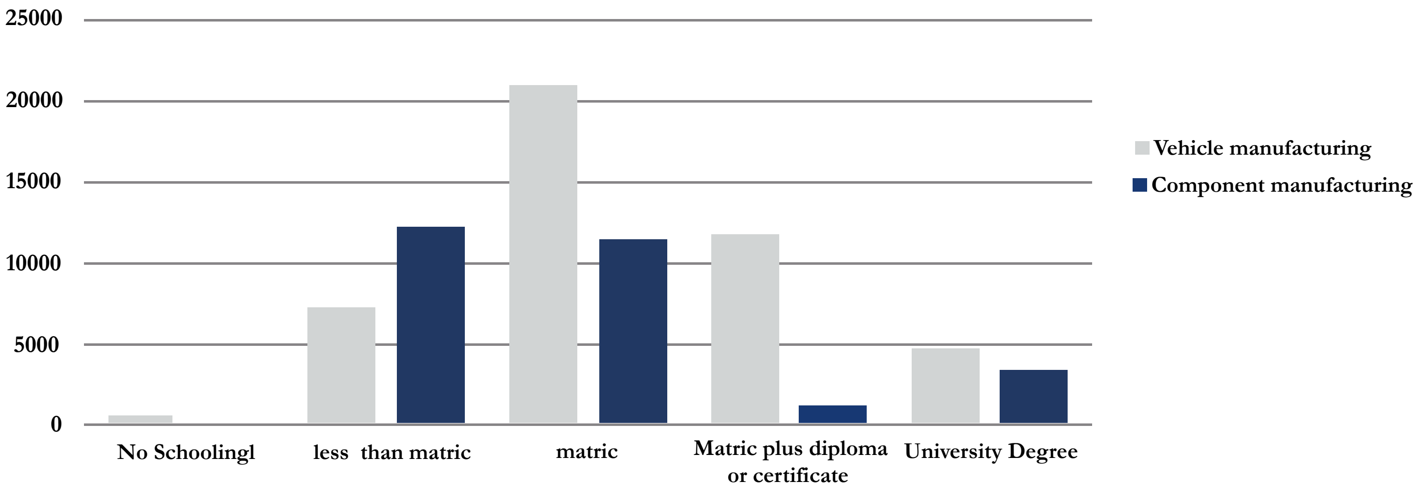
The spatial dimension of transformation is being driven in Gauteng through 'Chamdor Automotive Hubs' in townships. Some challenges lie in bringing 'markets on the margins' (Phillip 2018) into a relationship with the 'walled gardens' of the automotive value chain. Skills-related challenges are illustrated by the example of auto mechanics. Under half of those working as auto mechanics in township and rural areas are in the informal sector. Part of the transformation agenda is to upskill, qualify and formalise them to service EVs. The Tshepo 1m project includes examples of mobilising insurance industries to steer a percentage of repairs to such centres. The challenge lies in the educational achievement levels of what NUMSA terms 'bush mechanics'. Since a post-matric level 4 qualification is required to achieve industry regulatory standards, a significant level of upskilling is required (probably through RPL and top-up training). Different RPL models may be required, and informal sector trades people would require funding, market opportunities and innovative strategies to in-centivise their participation.

Figure 6: Age breakdown in the automotive industry in 2020.



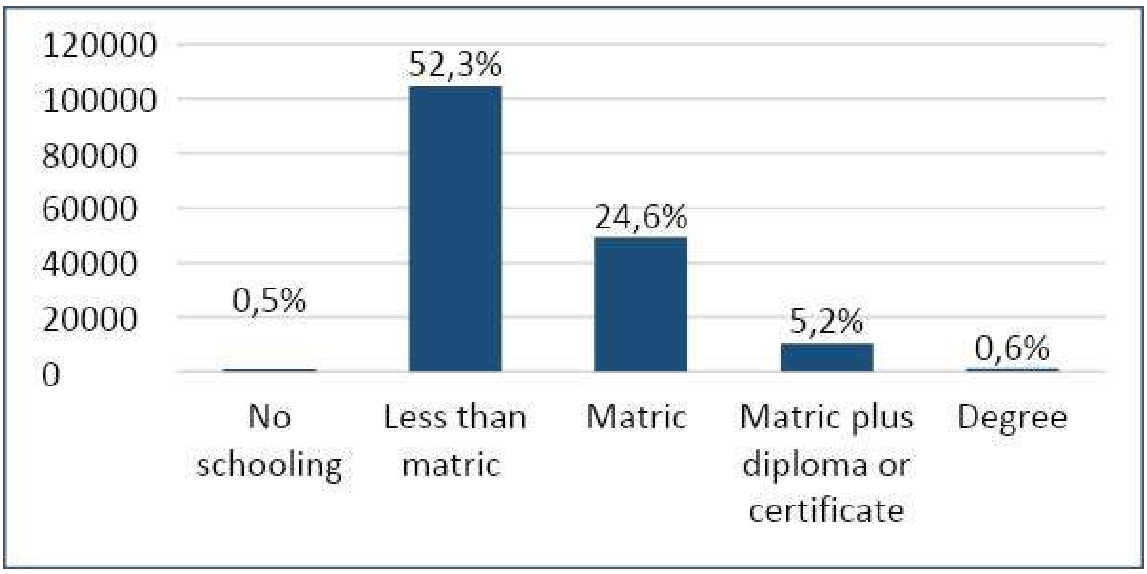
Source: merSETA SSP, 2021.

Figure 7: Education levels in the automotive industry workforce in 2020.



Source: Statistics SA.

Figure 8: Education levels of auto mechanics in 2020



Source: StatsSA, 2020.

5.1.4 Occupations across the value chain

A total of 64 "core" occupations exist across the value chain (as summarised in the tables below[1]). Few are at risk, and some new occupations are emerging, but the bulk are 'in transition.'

Occupations at risk are excluded from this study. However, given the low rate of adoption of EVs in South Africa, these occupations are not immediately at risk. However, there is likely to be incremental attrition of aggregate employment in these occupations.

Emerging occupations are a major focus of employment growth. For example, there is a global shortage of 2 million cybersecurity specialists (South African data is not available disaggregated to industry level). Pathway mapping for emerging occupations should be a priority since there is inadequate supply and a gap between most educational provisions and these occupations. This report notes that these occupations may be "catalytic" in unlocking employment growth more widely. However, most are at advanced levels and hence excluded from this study.

Transitioning occupations are where the bulk of the occupations lie. In this case, it is not that workers will need to transition to a different occupation. The occupation itself requires substantial new skill sets (currently poorly provided for). The bulk of new jobs also fall into this category. ILO (2020) estimates that 60–65% of automotive occupations will have up to 30% of their tasks automated, and digital literacy will become central to the retraining.

2 These are drawn from the merSETA Workplace Skills Plan template. A known weakness of the WSPs is that they reflect existing OFOs. Many of the occupations across the automotive value chain - in particular "emerging" occupations - are inadequately reflected in the OFOs. The EV Masterplan will require EV charging station technicians (to build and repair charging stations) in the vehicle use segment; telematics specialists (in the aftermarket segment); and a range of materials specialists (in component manufacturing). The OFO codes and qualifications for these do not yet exist. A core recommendation in this report is thus to develop better anticipatory skills planning mechanisms for a just energy transition.

Table 6: Basic, Intermediate and Advanced Core Occupations at Risk, Transitioning or Emerging in Components and Assembly

Component Manufacturing and Vehicle Assembly				
	Category	**Basic**	**Intermediate**	**Advanced**
1	Occupations at risk		a. Fuel Manager b. Diesel Mechanic	
2			a. Draughtsperson b. Manufacturing technician c. Industrial engineering technician d. Maintenance planner e. Metal machinist f. Mechatronics technician g. Welder h. Toolmaker i. Metal machinist j. Fitter and turner k. Automotive engine mechanic l. Mechanical fitter	a. Engineering manager b. Industrial Engineer c. Production engineer d. Mechanical engineer e. Metallurgical engineer f. Engineering supervisor g. Production/operations h. Industrial Engineering Technologist i. Production engineering technologist j. Mechanical engineering technologist k. Metallurgical engineering technologist l. Environmental engineering technologist m. Production/operations supervisor
3	Occupations emerging			a. Autonomous vehicle operator (robotics) b. Sensor integration specialist c. Sensor data analyst d. Sensor engineer e. Cybersecurity analyst f. Cybersecurity compliance officer g. AI and machine learning analyst h. Cloud computing i. Chemicals analyst j. Advanced materials developer k. Computer scientist

Table 7: Basic, Intermediate and Advanced Core Occupations at Risk, Transitioning or Emerging in Retail

Retail				
	Category	**Basic**	**Intermediate**	**Advanced**
1	Occupations at risk			
2	Occupations in transition		a. Insurance investigator b. Insurance loss adjuster c. Vehicle damage quantifier d. Commercial sales rep e. Sales rep f. Motor vehicle examiner g. Retail buyer h. Automotive parts salesperson	a. Quality systems manager b. Sales and marketing manager c. Director of marketing d. Customer service manager e. Advertising and public relations manager
3	Occupations emerging			a. Cybersecurity analyst b. Cybersecurity compliance officer c. Cloud computing d. Computer scientist

Table 8: Basic, Intermediate and Advanced Occupations at Risk, Transitioning or Emerging in Aftercare

Aftercare				
	Category	**Basic**	**Intermediate**	**Advanced**
1	Occupations at risk		a. Automotive Engine Fitter b. Diesel Electrical Fitter c. Diesel Fitter-mechanic d. Diesel Fuel Injection Technician e. Diesel Injector f. Engine Management and Fuel Injection System Mechanic g. Field Service Technician (Diesel) h. Fuel Injection Mechanic i. Truck Mechanic	
2	Occupations in transition	a. Machine operators	a. Mechanical Engineering Technician b. Vehicle Mechanic c. Service Mechanic d. Automotive Mechanic e. Motor Mechanic f. Motorcycle and Scooter Mechanic g. Motorcycle / Motorbike Technician h. Scooter Mechanic i. Automatic Transmission Mechanic j. Automotive Mechanician k. Mechanical Service Advisor (Vehicles) l. Garage Mechanic m. Auto Engineer / Mechanic n. Brake and Clutch Mechanic / Repairer / Fitter	a. Engineering Manager b. Industrial Engineer c. Engineering Supervisor d. Mechanical Engineer e. Mechanical Engineering Technologist f. Engineering Foreman

Table 9: Basic, Intermediate and Advanced Core Occupations at Risk, Transitioning or Emerging in Vehicle Use and Infrastructure

Aftercare				
	Category	**Basic**	**Intermediate**	**Advanced**
1	Occupations at risk		a. Petroleum Draughtsperson b. Petroleum Transfer Technician c. Petroleum Distribution Agent d. Draughtsperson	
2	Occupations in transition	a. Service Station Attendant	b. Petroleum Transfer Technician c. Service Station Salesperson d. Computer Engineering Mechanic / Service Person e. Engineering Production Systems Worker	
3	Occupations emerging			

5.1.5 Priority Occupations

Based on analysing how many new jobs there are, in which value chain segments, and what occupations these represent, this study suggests:

- Almost all employment growth and some anticipated employment change is in component manufacturing (including batteries). Some are anticipated in vehicle assembly due to new plants.
- Employment change but not growth is not anticipated in materials, retail and aftercare, or use
- Employment change and growth will occur in transport infrastructure and the waste economy. However, these occupations fall into construction and raw materials and are not "core" in the automotive industry
- Emerging occupations fall mostly into the advanced category, whereas this study focuses on intermediate skills. However, these should be a priority focus for further work.

Due to the localisation strategy, the main employment growth is projected to lie in component manufacturing. Hence key questions are:

- Which components are being/are likely to be manufactured in SA (or the region, given the ACTFA/SADC collaborations to build regional/continental value chains)?
- Which occupations are involved in the manufacturing of these?
- What skills sets are required, and what are the pipelines/pathways for these?

Components required for EVs (in the White Paper sense of the term) include:

- battery packs or fuel stack cells
- new motor technologies and power electronics
- charging and charge management systems
- power distribution systems
- regenerative braking controllers
- sensors
- brake-by-wire systems
- vehicle control systems
- vehicle bodies and chassis (lightweight materials, chassis components and body panels)
- HVAC systems
- safety systems
- infotainment and connectivity (touchscreen display, navigation, Bluetooth and smartphone integration)
- driver assistance systems (cruise control, lane keeping, parking assist and autonomous driving)
- energy recovery systems
- high voltage interlock loop systems to isolate components
- new electric power steering and suspension systems
- low resistance and more aerodynamic tyres
- telematic systems (interfaced with insurance or fleet management)
- exterior body structures and on-board energy management systems. These are all increasingly interfaced with IOT/cloud computing/AI and predictive analytics.

Within the current global value chain, the South African components sector is focused mostly on low-tech tier 1 and 2 component manufacturing, with niche (local and export) markets in some high-tech components. All other technologies are mostly imported or manufactured under licence. Monaco et al. (2023) suggest there is a relationship between OEM sourcing strategies and local productive capabilities. In skills terms, focusing on the emerging high-end skills may cascade into employment growth at the intermediate level (and simultaneously help SA build a stronger Tier 1 components industry. The White Paper lists areas of component manufacturing decline and growth and notes that "components at risk account for 67% of total automotive exports, or R69 billion worth of exports in 2022. There is also an expected decline in the ICE-specific components used in the domestic market when its transition commences. The challenge for the component manufacturing industry is finding alternative markets for the ICE-specific components, improving competitiveness to support increased localisation and exports of components used by ICE vehicles and EVs, and establishing capabilities and competitiveness in the new EV components" (White Paper: 33).

Developing a local/regional battery chain, localising charging infrastructure components, Electric Motors and Transmission (e-Axle)2, Power Electronic Devices, and High Voltage Wiring Harnesses are the current fo cus of policy interventions in the components sector (but further work on localising component manufacturing is taking place under ASCII).

Component manufacturing occupations are likely to be similar to those currently in the components and assembly sectors. The bulk of intermediate occupations will undergo significant changes in the knowledge and skills required, and (high-skill) emerging occupations will play a catalytic role.

The "priority occupations" are thus the core, intermediate, and technical occupations in the component and vehicle manufacturing segments. Based on an analysis of the changing technologies and associated skills changes, these can be clustered into 3 main sets:

5.1.6 Change drivers impacting on employment and skills in the value chain

This study analysed the changing skills requirements for a spectrum of priority occupations across all 3 sets. The primary change drivers relate to the shifting nature of technologies and materials used in EVs and the changing production processes.

EVs and ICEVs may share many materials, especially in non-propulsion components. However, the unique requirements of electric propulsion, such as battery technology and electric motors, drive the adoption of specific materials in EVs. Additionally, the push for sustainability and weight reduction in the automotive industry is influencing material choices in both types of vehicles.

Table 10: Clusters of Priority Occupations

Priority Intermediate-Level Occupations Within the Intermediate Band		
	Cluster	**Occupations**
1	Core automotive engineering, metallurgical and mechanical/ mechatronic technicians	a. Manufacturing technician b. Industrial engineering technician c. Mechatronics technician d. Automotive engine mechanic
2	Non-automotive specific traditional trades	a. Mechanical fitter b. Welder c. Toolmaker d. Metal machinist e. Fitter and turner f. Metal machinist
		a. Draughtsperson b. Production/operations supervisor c. Maintenance planner

Table 11: Differences in Materials Used in ICEVs/EVs

Internal Combustion Engines	Electric Vehicles
Battery Materials: Traditional lead-acid batteries are common in ICEVs, and the materials include lead, sulfuric acid, and various plastics for the casing.	Battery Materials: Lithium-ion batteries in EVs use materials such as lithium, cobalt, nickel, manganese, iron, and graphite for electrodes. The battery casing may be made of aluminium or composite materials.
Motors: Internal combustion engines involve materials like cast iron, aluminium, and various alloys for components such as the engine block, cylinder heads, and pistons.	Electric Motors: Materials like copper and aluminium are used for the construction of electric motor components, including the rotor and stator.
Vehicle Structure: Typically use steel for the chassis and body components, which may result in a heavier overall vehicle weight.	Vehicle Structure: Often incorporate lightweight materials such as aluminium and high-strength steel to reduce overall vehicle weight and enhance efficiency.
Interior Materials: Utilize conventional materials for interior components, such as plastics, leather, and meta	Interior Materials: May use materials like those in ICEs, including various plastics, fabrics, and metals for interior components.
Thermal Management: Similar materials are used for traditional engine cooling systems.	Thermal Management: Cooling systems in EVs may use materials like aluminium and copper for radiators and heat exchangers.
Brake Systems: Use conventional friction brakes with components like cast iron rotors and brake pads.	Brake Systems: Often equipped with regenerative braking systems that use materials such as copper for electrical components. Traditional brake components include materials like cast iron.
Wiring and Connectors: Similar materials are used for wiring and electrical connections.	Wiring and Connectors: Use materials like copper and aluminium for electrical wiring and connectors.
Exhaust Systems: Have exhaust systems made of materials like stainless steel or mild steel.	Exhaust Systems: Do not have exhaust systems as they do not produce tailpipe emissions.
Fuel Systems: Use materials such as steel and plastic for fuel tanks and fuel lines.	Fuel Systems: Lack traditional fuel systems as they are powered by electricity stored in batteries.
Sustainability: Also incorporating sustainable materials but with a greater focus on conventional mate	Sustainability: Increasing efforts to use sustainable and recyclable materials, including recycled plastics and natural fibres.

The differences between knowledge and skills required for ICE vehicles and EVs are summarised in table 12 below.

Table 12: Differences in knowledge and skills for ICE/EVs

Internal Combustion Engines	Electric Vehicles
Fuel Systems Understanding combustion processes and diagnosing issues in traditional internal combustion engines. Repairing and maintaining components like pistons, cylinders, and crankshafts. Knowledge of carburettors or fuel injection systems. Tuning and troubleshooting fuel delivery systems.	Battery Systems: Knowledge of high-voltage battery packs. Diagnosing and replacing battery modules.
Ignition systems Understanding and troubleshooting ignition systems. Replacing spark plugs and ignition	
Exhaust Systems Repairing and replacing exhaust components. Addressing issues related to emissions and catalytic converters.	Software and Controls: Familiarity with vehicle control software and firmware. Diagnosing software-related issues.
Transmission and Drivetrain: Repairing and maintaining transmissions, clutches, and differentials. Understanding gear ratios and power transmission.	Electric Drive Systems: Understanding electric motors, inverters, and power electronics. Diagnosing and repairing issues related to electric drive systems.
Cooling Systems: Diagnosing and fixing cooling system issues. Replacing radiators, water pumps, and thermostats.	Regenerative Braking Systems: Understanding regenerative braking systems. Diagnosing and addressing issues related to regenerative braking.
Electrical Systems Basic understanding of electrical systems, including starter motors and alternators. Troubleshooting and repairing electrical components.	Charging Systems: Understanding electric vehicle charging infrastructure. Diagnosing and repairing charging-related issues.
Safety Protocols: Following safety protocols for combustion systems. Understanding and implementing safety procedures during maintenance.	

5.1.7 Educational Provisioning

The automotive priority occupations fall into three main sets:

- Various categories of engineering technicians (the WSP template documents only manufacturing, industrial and mechatronic engineering technicians, but industry job advertisements also include software engineers, electrical engineers and environmental engineers)
- Various non-automotive specific trades (the WSP template includes fitters and turners, welders, tool and die makers, and machinists) and automotive-specific (auto mechanics)
- Management, supervisory and support occupations.

The first two clusters (various categories of engineering technicians and various trades) have very common patterns in the qualifications, providers, and learners across each cluster. Each is exemplified below through an occupation-specific focus.

The providers indicated in the table immediately below deliver educational provisions for industrial engineering technicians.

Table 13: Educational provision for Industrial Engineering Technicians

Providers	Location	Names of Courses
Cape Peninsula University of Technology	WC	
Central University of Technology	FS	
Durban University of Technology	KZN	
Mangosuthu University of Technology	KZN	
Nelson Mandela University	EC	
Stellenbosch University	WC	
Tshwane University of Technology	Gauteng	
University of Johannesburg	Gauteng	
University of South Africa	Gauteng	
Vaal University of Technology	Gauteng	
Walter Sisulu University	Eastern Cape	
Monash	National	**National Diploma in Industrial Engineering**

.*Table 14: Educational Provision for Automotive Mechanics*

Providers	Location	Names of Courses
Ekurhuleni West TVET C	Gauteng	
College of Cape Town	WC	
Central Johannesburg TVET College	Gauteng	
South West Gauteng TVET College	Gauteng	
Ekurhuleni East TVET College	Gauteng	
Tshwane North TVET College	Gauteng	
Coastal KZN TVET College	KZN	
Northlink TVET College	WC	
West Coast TVET College	WC	
Majuba TVET College	KZN	
East Cape Midlands	EC	
Buffalo City	EC	**Occupational Certificate in Automotive Mechanic Level 4**

The public TVET providers indicated in the table immediately below deliver educational provisions for automotive mechanics. However, each OEM also has its own academy, which is accredited to deliver automotive mechanic qualifications (sometimes in partnership with a TVET).

Provision for both sets of occupations is highly uneven across the country. Typically, higher education and TVET programmes located within the OEM ecosystem have strong relationships with the OEMs, are well-supported with infrastructure and staff development, and offer learners good opportunities for relevant workplace experience. Providers not close to OEMs have challenges in relation to all these factors.

Also, undergraduate curricula for the technician categories are better aligned to automotive industry applications (for example, industrial engineering) than those that are not located near manufacturing hubs.

A central issue in qualifications and provisioning is that the world of work in automotive industries is conducted by 'families' of interrelated occupations. Thus, automotive mechanics are supported by teams of vehicle painters, automotive body repairers, tyre and wheel alignment workers, and others. These have their own qualification pathways from levels 2–4, with a more common horizontal progression from one role to other roles than vertical progression toward full auto mechanic status. Much of the learning is on the job, with one worker teaching another.

The same applies to engineering technicians, where workplace eco-systems rely extensively on technicians working with and learning from engineering technologists and professional engineers.

5.1.8 Learning Pathway Mapping

This study provided an in-depth analysis of two occupations to exemplify the learning pathway transitions required in the automotive industry. Both are examples that illustrate characteristic features of the cluster they represent.

- The first "core" skills set is the engineering-related occupations. This is especially important for components and assembly. Automotive industrial engineering technicians, mechanical engineering technicians, production engineering technicians, and (to a lesser extent) mechatronic engineering technicians have almost identical pathways and challenges. Automotive industrial engineers were selected as an exemplar.
- There are also comparable similarities across various artisan categories for the artisan cluster. As for the engineering technicians, they are also core to the automotive industry but, in this case, are more relevant to the aftercare segment. Automotive motor mechanics were selected as an exemplar. Again, the pathway issues for automotive mechanics are similar to those for other trades.

Pathway mapping—as per the conceptualisation in section 2 of this report—improves efficiency (through enabling articulation) and social inclusiveness. The table below analyses the elements of both the technician band and the trades band.

Table 15: Elements of both the technician band and the trades band.

Pathway Element	Technician band	Trades band
Inter-related experiences	· Progression takes place through very well-defined and regulated processes · Various categories of engineering technicians lack an automotive-specific set of protocols/guidelines	· Some tradespeople begin with full qualifications and work experience before doing their trade certificate. Vertical progression thereafter takes place mostly through movement into management or supervisory roles. Possibilities exist for vertical progression from some trades to technician (for example in mechatronics) · Progression takes place through multiple routes both horizontally and vertically within "families" of occupations. Learners and workers often start with part qualifications (such as spray painting, tyre-fitting, and panel beating) before broadening to other skills. However, low RPL/ARPL route uptake suggests that few progress vertically.
Sense of continuity	· The major gap lies in candidate support within the automotive industry to enable technicians to gain relevant work experience required for professional registration · This is underpinned by a lack of workplace experience opportunities, a shortage of mentors, and funding for various elements of the candidate support system	· Continuity is typically structured by workplace contexts. In larger enterprises, roles tend to remain specialised. In smaller enterprises, workers are usually required to perform a variety of roles (but often without holding the formal qualifications for these)
Movement between	· Vertical progression is constrained by the inability to progress to the technologist level without candidate support. · Horizontal progression is enabled by maintaining the current generic categories (with automotive as an industry-specific application of e.g. industrial engineering)	· There is substantial horizontal progression but very limited vertical progression
Credit transfer	· Credit transfer is enabled through the current qualifications' architecture	· Credit transfer is currently being handled through a "generic qualification", which allows different learners and employers to select knowledge and skills required in the workplace flexibly
Signposts	· Career guidance signposts exist at the professional body level (but could be strengthened, and there are gaps between what the signposts indicate and the real-world opportunities).	· Career guidance signposts are provided only at the level of full qualifications. The pathways between and up from part qualifications are poorly signalled or supported by skills interventions.

The analysis supports the general findings that:

- Learning pathways for the transitions taking place in automotive-specific intermediate technical occupations are not yet fully codified in qualification frameworks.
- The core difference between these occupations and the newly transitioned occupations lies in the materials, vehicle technologies, and production processes for both.
- To support the transition, there are company-specific and industry-level interventions, such as providing skills training and building proximal public provider capacity.
- In the case of the engineering disciplines, graduate throughput rates are likely adequate, but candidate support after graduation is a huge need.
- In the case of artisans, there are probably still higher numbers of graduates required. But relevant work experience is also a factor.
- Overall, a skills-biased shift in employment is taking place. Reskilling and upskilling will be a focus for existing employees and the pipeline.

Table 16: Learning Pathway Analysis for Industrial Engineering Technicians

1	**Industrial Engineering Technician**
Issue	Description
Job Title	Industrial Engineering Technician Source: MerSETA Workplace Skills Plan
Job Description	An Industrial Engineering Technician supports industrial engineers in optimizing production processes, improving efficiency, and ensuring the quality of manufacturing operations. This entails: • Documenting test results, using cameras, spreadsheets, documents, or other tools. • Setting up mechanical, hydraulic, or electric test equipment in accordance with engineering specifications, standards, or test procedures. • Reading and interpreting blueprints, schematics, work specifications, drawings, or charts. • Inspecting or testing parts to determine nature or cause of defects or malfunctions. • Monitoring computer-controlled test equipment according to written or verbal instructions. Source: Adapted from O-Net, compared with sample job advertisements Note: The scope of job descriptions varies widely, depending on the industry specialisations and company structures and processes

Occupational Codes	OFO 2021-214102 Industrial Engineering Technician An industrial engineering technician investigates and reviews the utilisation of personnel, facilities, equipment and materials, current operational processes and established practices to recommend improvement in the efficiency of operations in a variety of commercial, industrial and production environments (in this case, automotive Source: ECSA Discipline-Specific Training Guide for Industrial Engineering Technicians R-05-IND-PN, 2019. Note: In SA, automotive engineering technicians are regarded as a specialisation within industrial engineering technicians. O-Net 17-3027.01 Automotive Engineering Technician Assist engineers in determining the practicality of proposed product design changes and plan and carry out tests on experimental test devices or equipment for performance, durability, or efficiency Source: O-Net
Qualifications	National Dip (Engineering), Dip (Eng Tech), Adv Cert (Engineering) type qualification, or a Dublin Accord recognised qualification. E.g. SAQA ID 112692: National Diploma in Industrial Engineering Level 6 Source: ECSA Discipline-Specific Training Guide for Industrial Engineering Technicians R-05-IND-PN, 2019. Note: There has been a proliferation of specialisations, qualifications and industry standards
Current pathways	• register as a candidate industrial engineering technician. • obtain relevant work experience under a professional registered industrial engineering technologist or professional registered industrial engineer. • write a professional exam; and • register as a professional industrial engineering technician Sources: • Engineering Needs and Numbers in the SADC Region, 2018. • ECSA Discipline-Specific Training Guide for Industrial Engineering Technicians R-05-IND-PN, 2019. • ECSA Annual Report 2022/23. Note: There are currently 6232 registered candidate professional engineering technicians. Of these, 2333 have been registered candidates for less than 3 years, 906 for 4-5 years, and 2813 for more than 6 years. This suggests that there are inadequate work experience opportunities, not enough mentors and not enough funding to support candidates.

<table>
<tr>
<td>Supply-side analysis</td>
<td>There has been a proliferation of qualifications, programmes, providers and specialisations. This is further complicated by not all providers/programmes being accepted by ECSA. South Africa has 60,000 engineering technicians and technologists who graduate annually. (Technologists and technicians are not disaggregated in the data, nor are automotive engineers distinguished from others.) These represent 9% of those in practice. As a proxy for potential absorption, many more people are graduating than being absorbed. Thus, the core pathway concerns are:

• more learners are graduating than can be absorbed (but the general foundational training does not always meet required industry standards)
• TVET colleges and universities proximate to OEMs are already being capacitated with equipment, staff training and student experience around the new technologies, equipment and production processes. This may not be adequately focused on the component manufacturing segment where employment growth is anticipated.
• For existing employees, employers are already borrowing and adapting programmes and materials to enable transitions (or developing these in house or partnering with public and private providers).
• The major gap lies in work experience during the candidate phase. This includes a shortage of experienced mentors, work experience opportunities and funding. ECSA has therefore negotiated with DHET and some SETAs to provide a separate funding category for candidate support and has accredited some workplaces to begin structured work experience for candidates. The scale of this is still small, and no automotive-specific workplaces are participating.

Sources:

• Engineering Needs and Numbers in the SADC Region, 2018.
• ECSA Annual Report 2022/23.

Note: Engineering-related professionals operate within a regional, continental and even global market. The same broad themes reported in relation to SA are also true regionally.</td>
</tr>
</table>

Table 17: Learning Pathway Analysis for Automotive Motor Mechanics

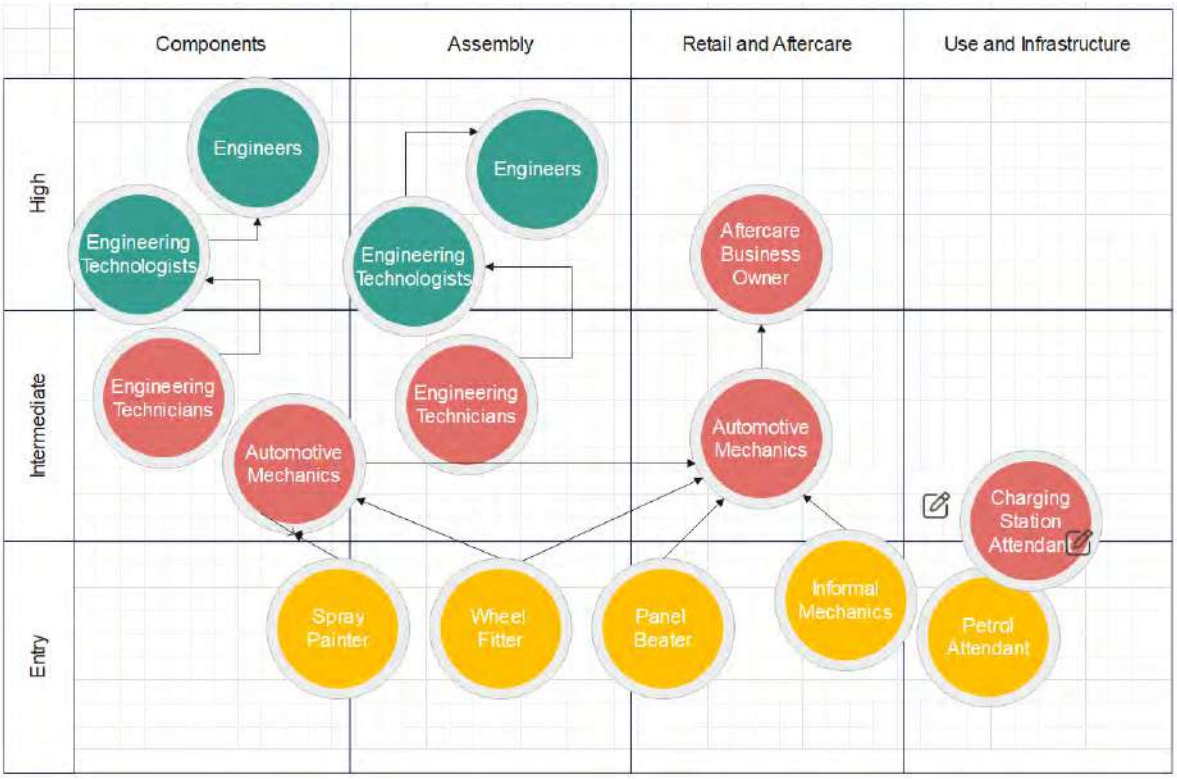
2	Automotive Motor Mechanic
Issue	Description
Job Title	Automotive Motor Mechanic. Source: MerSETA Sector Skills Plan Note: Alternative Titles include Motor Vehicle Mechanic, Motor Vehicle Repairer, Automotive Technician, Motor Diagnostic Technician, Diesel Mechanic.
Job Description	• Align vehicles' front ends. • Align wheels, axles, frames, torsion bars, and steering mechanisms of automobiles using special alignment equipment and wheel-balancing machines. • Change spark plugs, fuel filters, air filters, and batteries in hybrid electric vehicles. • Conduct visual inspections of compressed natural gas fuel systems to identify cracks, gouges, abrasions, discolouration, broken fibres, loose brackets, damaged gaskets, or other problems. • Confer with customers to obtain descriptions of vehicle problems and to discuss work to be performed and future repair requirements. The knowledge and skills needed to be an automotive mechanic differ significantly across ICE vehicles and EVs. Source: Job descriptions, O-Net Note: Relevant industry bodies illustrate the range of industries and workplaces where automotive mechanics are employed. These include: • RMI (Retail Motors Association) • MIWA (Motor Industry Workshop Association) • SAMBRA (SA Motor Body Repair Association) • SAVABA (SA Vehicle and Bodybuilders Association) • TEPA (Tyre, Equipment and Parts Association) • VTA (Vehicle Testing Association)

Occupational Codes	• OFO 2021-6531. Motor vehicle mechanics and repairers fit, install, maintain, service and repair engines and the mechanical and related equipment of passenger cars, delivery trucks, motorcycles and other motor vehicles. • OFO 2021-653101. Maintains, tests and repairs diesel and petrol road vehicles (less than 8 tons) and the mechanical parts thereof, including transmissions, suspension, steering and brakes. • OFO 2021-653103. Maintains, tests and repairs the mechanical parts of motorcycles, including scooters. • OFO 2021-653109. Diagnoses, adjusts, repairs, or overhauls automotive engines. Source: 2021 OFO Codes By contrast, O-Net has codes specific to Electric Vehicle Technicians and a spectrum of specialisations within this (e.g. O-Net: 49-2096.00). ● Electric Vehicle Technicians work on vehicles powered solely by electricity. They perform routine maintenance like other mechanics; however, Electric Vehicle Technicians must have extensive knowledge of how lithium-ion batteries and automotive systems interact. In addition, they may replace hydraulically assisted systems with electric-powered systems, such as power-steering pumps or air-conditioning compressors, to improve fuel economy. Source: O-Net
Qualifications	There is a spectrum of entry-level qualifications at levels 2, 3 and 4. These sometimes reflect partial specialisations (e.g. spray painter, body repairer) or more general entry level studies. Relevant level 5 qualifications are: SAQA ID: 78526 National Certificate: Automotive Repair and Maintenance SAQA ID: 97990. Occupational Certificate: Automotive Motor Mechanic Level 5. Source: SAQA Note: Vehicle technology is evolving so rapidly that the time it takes to review existing qualifications or develop new ones means the qualifications will likely be obsolete by the time the process is complete. QCTO has adopted fast-track mechanisms, but industry is currently pursuing a generic qualification that allows flexible micro-credentialing instead.

Current pathways	Automotive mechanics are a highly diversified workforce. In some formal workplaces, roles such as spray painting or body repair may be specialised. In formal and informal workshops, a single person may perform various functions. The learning pathways are equally diversified. Automotive mechanics typically enter through TVET college training at Levels 2, 3 and 4 before progressing to the Level 5 qualifications. Routes may be via formal artisanships, RPL or accelerated artisan development programmes. However, many people also learn purely on the job, through skills programmes and short courses, or through combinations. Horizontal progression typically takes place through broadening the range of vehicles or the range of tasks performed on vehicles. Vertical progression is typically from part qualifications to full qualifications, then into supervisory and management roles.
Supply-side issues	As noted above, the SA OFOs and qualifications do not yet reflect the changing skill sets required for EVs. However, the industry has collaborated with merSETA in developing a generic EV qualification against which employers and providers can flexibly certificate programmes using a micro-credentialing approach. Also, TVETs and universities near OEMs are increasingly providing training that is more relevant to EVs, so are company academies, and AIDC is rolling out targeted support. 108,000 automotive motor mechanics are employed in the formal sector and 93,000 in the informal sector. LMIP reports 12,503 diesel mechanics graduates over the decade to 2021 and 8,658 automotive motor mechanics. While the LMIP statistics do not reflect the full spectrum of entry pathways, these figures are below the industry's anticipated aggregate retirement demand projections. This is likely confirmed by the repeated occurrence of both occupations in the Occupations in High Demand list. However, the Indlela trade passes for the same period reflect only 1563 passes for diesel mechanics and 795 passes for automotive motor mechanics (respectively slightly more and less than 10% of graduations). This may be for many reasons. Source: Labour Market Intelligence Project Supply and Demand of Artisans 2021.

The pathways for each cluster described in the analysis above are captured in the figure below.

Figure 9: Skills pathways for EV



5.1.9 Insights from Pathway stories:

The pathways reveal some interesting insights as follows:

Four electric vehicle (EV) learning pathways were explored, involving participants with diverse professional backgrounds. Among them, three are battery electric vehicle (BEV) service technicians within the mining sector, while one participant works as a high voltage technician (EV technician) in the automotive industry.

The analysis of the EV pathway revealed that all four participants had educational backgrounds in electrical engineering. One participant held a higher certificate in electrical engineering, another had an advanced diploma in electrical engineering, and one possessed a higher diploma in electrical and electronics engineering and a red seal in mechanical engineering. Lastly, the fourth participant obtained a Bachelor of Technology degree in electrical engineering.

In the electric vehicle learning pathways, participants either initiated their careers within the sector or transitioned into it. For instance, one participant commenced their career in the EV sector through an apprenticeship for a higher certificate in electrical engineering at a company which manufactures battery-electric mining vehicles. This was their job in the EV sector, and their responsibilities included converting diesel locomotives to electric ones. Subsequently, they transitioned to a new role as a field service technician before returning to the EV sector as an EV service technician in the mining sector, responsible for servicing and maintaining BEV mining vehicles.

Another participant, after obtaining a Bachelor of Technology degree in electrical engineering, progressed through various roles such as electrician, electrical engineering technician, electronic technician, site manager, and finally, field service technician. They transitioned from the mining sector to the BEV sector as a BEV service technician, focusing on servicing and maintaining BEV mining vehicles.

The third participant, with an advanced diploma in electrical engineering, began their career in the manufacturing sector of the mining industry, manufacturing mining equipment. Later, they transitioned into the BEV sector as a BEV service technician in the mining sector, responsible for servicing and maintaining BEV mining vehicles.

Lastly, a participant with an advanced national diploma and a red seal in mechanical engineering started their career as a customer service executive and a diagnostic service technician at an automotive service dealership. Subsequently, they transitioned within the same company to a new role as a high-voltage technician (EV technician), specialising in providing customer service, technical support, and servicing and maintaining EVs. They acquired upskilling to be a high-voltage technician through work-based training specifically tailored to the products used by the company.

Among the participants, only one from the automotive sector required upskilling from a customer service executive and a diagnostic service technician to a high voltage technician to enter the EV sector. The remaining three participants seamlessly transitioned into the EV mining sector with their existing electrical qualifications and experience, only getting EV work-based training on product-specific machinery/vehicles. However, they expressed that the training provided at TVET colleges and on-the-job training was basic, offering limited knowledge and training on the actual batteries used by BEVs. This limitation hinders their ability to fully work on BEVs, emphasising the need for more comprehensive BEV training programs in TVET colleges. Furthermore, all participants in the pathway noted that they do not engage in work directly related to the battery itself, as this would necessitate expertise in battery technology, a skill they currently lack. Additionally, they mentioned that the batteries used in the vehicles are typically imported.

The insights from the pathway stories also revealed that individuals in the EV sector often make horizontal job moves within their organisation or industry, typically shifting to roles at a similar hierarchical level or skill set as their previous positions. Only one participant from the pathways made a vertical job transition from a customer service executive and a diagnostic service technician to a high voltage technician.

Furthermore, the EV learning pathways demonstrated various motivating factors prompting individuals to transition into the sector, including the shift from internal combustion engine vehicles (ICE) to EVs and the increasing adoption of EVs in various sectors in South Africa, along with the perceived career opportunities presented by an emerging sector in need of skilled professionals. One participant transitioned into the EV sector as there was a demand for an EV service technician; hence, the participant was approached for the position via LinkedIn.

Additionally, the pathways highlighted that being employed at large companies enabled participants to access EV-specific training. However, such training often focuses on specific brands/products utilised by the company rather than offering comprehensive industry-wide training.

Lastly, the electric vehicle learning pathways revealed that participants aspire for vertical career advancement within the energy efficiency sector in the future, with the majority aiming for specific areas of specialisation such as mechatronics engineering, robotic engineering, and automation. Only two participants specifically cited aspirations to further upskill in battery technology. The participants identified barriers hindering the realisation of these career goals, including the need for additional upskilling and accumulating the necessary years of experience. However, constraints such as financial limitations and time constraints emerged as significant obstacles hindering participants from achieving their future job aspirations.

Additional insights from narratives:

- There is no occupational designation for EV technicians or clear learning pathways, as companies seem to hire someone who is the closest fit.
- Employment is demand-led, i.e. people enter the EV sector because of available job opportunities (e.g. a participant was contacted by the company for the job as an EV service technician via LinkedIn)
- The transition to EVs is happening in stages. ICE vehicles are being converted to BEVs, and thus, skills are being developed in stages.
- EV training is product-specific, and there is no broader training
- Skills gap: EV battery-specific training—none of

- the participants worked on the battery itself as they did not have the necessary skills to do so.

Interviews were also conducted to map a local ecosystem in a small town far from an automotive manufacturing centre. These interviews reported:

- There are 11 automotive-related companies in the town. One provides second-hand sales. One is a major tyre-fitting and repair franchise. The others compete (and sometimes collaborate) around vehicle repair and maintenance.
- Only the franchise has a formally qualified automotive mechanic. Their staff are trained on the job and supervised by the qualified mechanic (but also are sometimes formally trained without certification) by the franchise itself.
- The vehicle repair and maintenance companies – including two township companies – have extensive work experience in body repair, painting and engine replacement/maintenance but no formal qualifications.
- The franchise brings in qualified people from a related franchise in a neighbouring town when required.
- The franchise relies on insured vehicles; the other companies rely on their reputation and price competitiveness.
- All companies know about EVs, but say there is no current customer base, and they will learn the skills when required. However, there is no local training provider; it is the top person they will send when required, but they cannot pause their business operations to send staff for training.

5.1.10 Learning pathway gaps and interventions

Gaps identified in the analysis of the two exemplar clusters are:

- One of the 16 White Paper interventions is skills development. This is focused exclusively on a collaboration between merSETA, DHET, and industry to develop and implement a certificate programme specifically for reskilling existing workers and mitigating potential job loss. This report potentially complements the White Paper intervention through a more delicate analysis of skills interventions for areas of employment growth and through a more specific learning pathway analysis.White Paper intervention through a more delicate analysis of skills interventions for areas of employment growth and through a more specific learning pathway analysis.
- The shifting skills required to work in the automotive industry derive partly from hybridising occupations in production processes. This is not mirrored by a hybridisation of curricula at TVET or higher education level, where increased collaboration across faculties or departments is required.
- This study's major focus has been identifying interventions to support learners entering emerging job opportunities. The above analysis suggests that almost all current employees will require significant skills development to learn the new knowledge and skills to produce or service EVs. The only available interventions currently are informal or non-formal courses delivered in-house and Continuous Professional Development programmes. Outside of the micro-credentialing approach, there is no coherent sectoral strategy to provide long-range learning and career path planning.
- The education and training pipeline for (all categories of) engineering technicians is producing adequate numbers of graduates. However, work experience opportunities are in short supply to bridge graduates through candidacy to professional registration. Funding is inadequate, and there are not enough mentors.
- The education and training pipeline for the trades cluster (exemplified by automotive mechanics) is still not producing enough graduates. Moreover, the qualifications and courses do not yet reflect the shifting knowledge and skills sets for EVs. Curriculum planning for TVETs will need to balance the short-term market (which remains focused on ICE) with the transition to EVs.
- The significant number of (unqualified) mechanics operating in the informal sector provides opportunities for RPL and top-up training. However, the demand for this will likely depend on incentivising their businesses to formalise. Also, these mechanics are currently exclusively focused on ICE, and interventions to equip them with an understanding of EVs will also be needed. Interventions proposed for various categories of engineering technicians are:

- The automotive industry should engage ECSA on

- automotive-specific standards for industrial engineering technicians and technologists
- Funding for candidate support should be increased across relevant SETAs
- Automotive companies should be encouraged to apply for ECSA accreditation to provide candidate support programmes. This may also require recruiting retired industrial engineers to provide mentoring.
- Providers delivering foundational industrial engineering technician training that does not meet industry standards should not be accredited until they can.
- Provide financial support to discipline-focused voluntary associations to promote their respective disciplines effectively and increase the enrolment of students in fields such as industrial engineering, mechanical engineering, and software engineering.
- Recruit discipline-specific retired engineers or internationally recruit experienced engineers to serve as mentors
- Funding to enable discipline-specific voluntary associations to incentivise retirees to act as external mentors to engineering technician candidates.
- Assign funding to the development and the roll-out of various short courses at the postgraduate level that are aligned to the common skills gaps.
- Assign funding towards a coordinated approach towards the realignment of the technical undergraduate courses to address specific skills shortages in the broader field of engineering technicians. Often, these overlap with other engineering disciplines, catering for industry-specific solutions.
- Subsidise the salaries of academics in scarce skill disciplines across all schools of engineering to ensure greater parity in remuneration between academia and industry. The shortage in academic staff currently spans more than two generations.
- Reconsider the policy dictating that the funding of engineering schools is linked to graduation numbers. Schools are encouraged to lower entry criteria, with subsequent increases in enrolments and drop-outs before graduation. This puts tremendous strain on both lecturers and facilities.

Interventions proposed for the trades clustered under the automotive mechanic family of occupations are:

- Current training levels for automotive mechanics should be sustained and expanded
- Current interventions (such as employer/provider partnerships) should be expanded
- Current efforts to transition TVET curricula and capacity toward emergent EV technologies (e.g. through AIDC) should also be expanded
- Indlela capacity to conduct trade tests for EV mechanics/technicians should perhaps be evaluated
- The scope and effectiveness of generic qualifications and micro-credentialing should be tracked and reviewed more regularly than QCTO processes for qualification review
- RPL and top-up training should be explored as interventions to build the capacity of informal sector workshops to participate in the transition or address the shortfall in graduation rates.

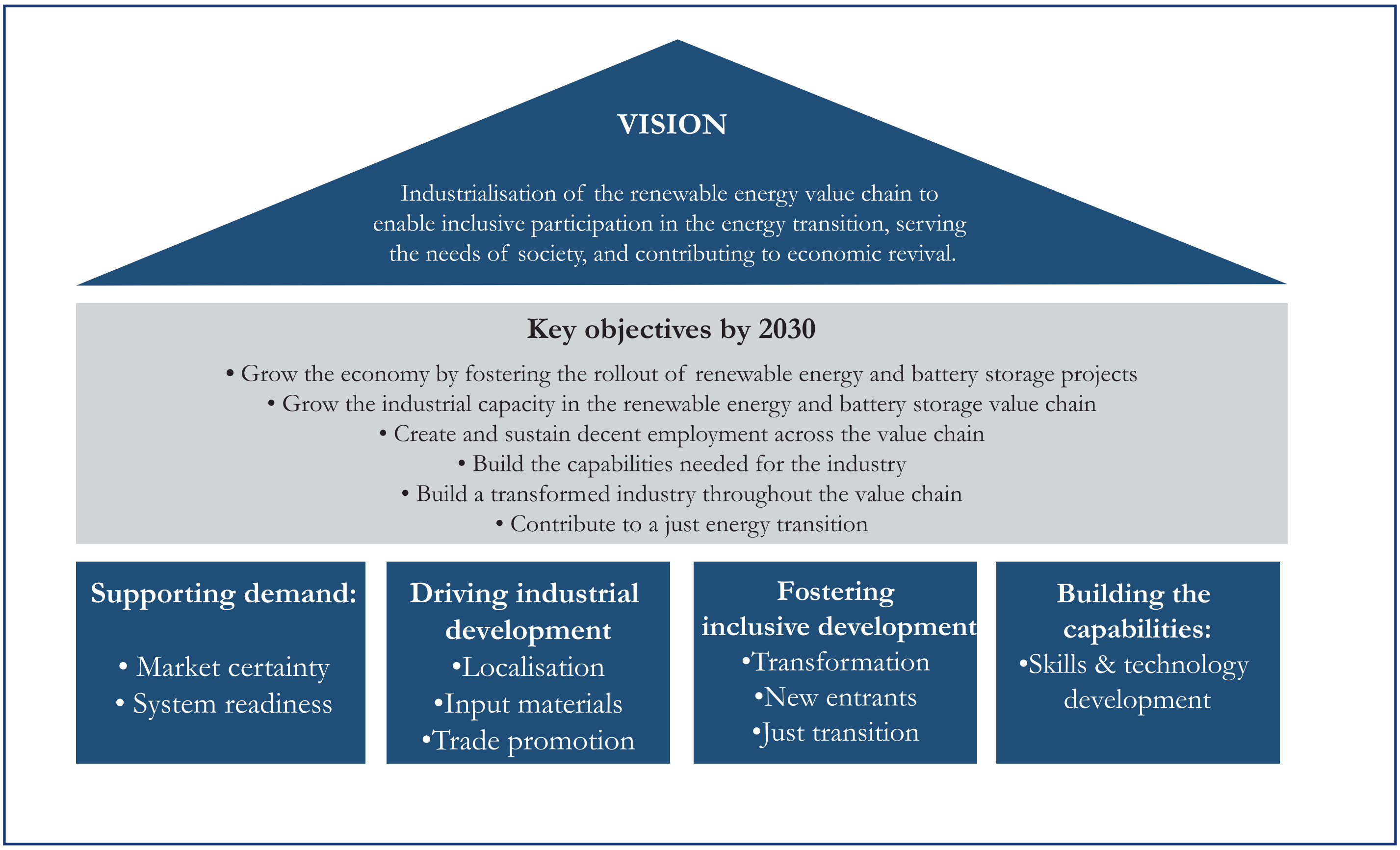
Across both occupational clusters, increased collaboration across faculties or departments should be explored (perhaps informed by a baseline study) to mirror the hybridisation of occupations in production processes.

5.2 Mapping of qualifications and initial occupation progression pathways - Wind, Solar PV and Battery Storage

IRENA (2022) predicts the global renewable energy market will reach between 5.4TW and 10.8TW by 2030, off a base of 700 GW in 2022. In South Africa, renewable energy technologies are similarly on a significant growth trajectory in line with the dual challenges of achieving energy security and simultaneously decarbonising the energy sector. The draft South African Renewable Energy Masterplan (SAREM) 2035 provides the industrial policy lens for realising the growth potential of the wind, solar PV, and battery storage value chain.

While SAREM has not explicitly set targets for employment creation, it outlines catalytic interventions with four pillars, including actively driving demand for renewable energy in local value and supply chains, focusing on SMMEs, and then fostering inclusive development and building capabilities to respond to this demand. The latter involves mapping and building skills, activating skills through on-the-job training and creating conditions for commercialising new innovations. While the focus of SAREM is on the localisation and industrialisation of the value chain, the projected demand for renewable energy technologies has a knock-on effect on downstream installation, operations, maintenance and decommissioning/recycling. The latter is a key area of focus regarding the potential for inclusive employment creation.

Figure 10: SA Renewable Energy Masterplan



SAREM 2035 indicates that localising 70% of components and 90% of balance of plant (BoP) and operations and maintenance (O&M) in the solar PV and wind value chains, combined with battery storage, can create 36,500 new direct jobs by 2030. For solar and wind projects, blue-collar or mid-level technical skills play a role in manufacturing, installation, operations and maintenance. Skilled technicians, such as high voltage electricians, welders, solar PV installers, and wind turbine service technicians, will be the most sought-after mid-level skills (GreenCape, 2022).

SAREM 2035 indicates that companies in the renewable energy and battery storage value chains face several skills challenges and see the lack of skills and the skills mismatch as a primary constraint for industrial development. This is rooted in the disconnect between occupational demand and the scope and quality of skills supply from the various Post-school Education and Training institutions.

5.2.1 Description of the Solar PV, Wind and Battery value chains as a context for pathways

The solar PV, wind and battery energy storage value chains are described in high level terms in the tables below (excluding raw materials):

Table 18: Solar PV Value Chain

Main Materials	Main Components	Assembly	Installation	Operations and Maintenance	Decommissioning and End-Of-Life
Glass, Silver Paste, Synthetic Polymers, Concrete, Steel	PV Module components PV Mounting and Training components Cabling components Inverter components	PV Modules PV Mounting and Tracking Cabling Inverter	Utility and large-scale Civil Balance of Plant Electrical Balance of Plant Small-Scale Embedded Generation	Parts Repair Parts Replacements Grid Control and Monitoring	Repair Reuse Recycle Safe Disposal

Table 19: Wind Energy Value Chain

Main Materials	Main Components	Assembly	Installation	Operations and Maintenance	Decommissioning and End-Of-Life
Permanent Magnets, Synthetic Polymers, Glass/ Carbon/ Composites, Concrete, Steel	Nacelle Components Rotor Components Cabling Components Tower Components	Nacelle Rotor Cabling Tower	Wind Turbine Civil Balance of Plant Electrical Balance of Plant	Lubricants Parts repair Parts Replacement Grid Control and Monitoring	Repair Reuse Recycle Safe Disposal

Table 20: Battery Storage Value Chain

Precursor Material	Component and Cell Manufacturing	Battery Assembly	End Market	Battery Reuse and Recycling
Aluminium Foil, NMC Powder, LFP Powder, Lithium Powder, Coated Graphite, Copper Ore	Cathode Electrolyte Anode Separator	LIB Cell Modules, Casings and Cooling BMS and BIS	EVs BSS Consumer Electronics	Remanufacturing Discharge and Disassemble Back mass recycling

While the decarbonisation of the energy sector and the inevitable decommissioning of power stations will create significant demand for renewable energy and battery storage over the medium term, the increased need for energy security is a key driver of demand for renewable energy in the short term. Cost reductions, diverse financing mech anisms, an enabling regulatory framework, and financial incentives such as the Section 12BA tax deductions have all contributed to this rising demand.

While private demand for wind energy is picking up, the big spike in wind farms connecting to the grid will likely be from 2025, with manufacturing processes kicking in 1-2 years before the wind farm is commissioned and connected to the grid (B&M Analysts, 2023).

Demand for solar power is projected to increase substantially to 34GW (off an 8GW base in 2023) in the 2023-2026 period and then remain between 30GW and 40GW between 2026 and 2038. Due to the current energy crisis, newly installed capacity is likely to peak at 11GW in 2025 and decline to 1.7GW by 2030 (Reddy & Radmore, 2024).

Installed battery capacity is projected to grow aggressively off a low base of 1.6GWh until 2030, driven by private demand due to the grid's instability, and will level out around 0.3-0.4GWh after that.

Each of these value chains faces challenges in localising upstream manufacturing. The wind energy industry suffers from inconsistent market demand and implementation delays, resulting in muted investment interest. Solar PV has been subjected to high numbers of unregulated and inexpensive imports, creating a market price that is not conducive to localised production. There are difficulties in localising high-value battery storage components protected by intellectual property owned by foreign companies. However, there are components across all three value chains that have the potential for localisation within the SAREM timeframe.

While SAREM does not address downstream economic opportunities, given the projected demand for renewable energy, there are significant market opportunities in the short—to medium-term deployment of the technology, with increasing opportunities in operations and maintenance and decommissioning/recycling over time.

5.2.2 Institutional architecture for renewable energy

Being a nascent sector, there are weaknesses in compliance, regulation and mechanisms for monitoring quality across renewable energy value chains, particularly in the energy transition and sustainability context. In Solar PV, there are concerns about the quality of the components being imported and how Solar PV systems are installed. The pathway stories speak specifically to issues around skills, which invariably impact the quality of installations. The absence of clear regulations and standards for Solar PV / Battery Storage has resulted in defects and poor-quality installations. This has had a knock-on effect for the insurance industry, which has begun to drive a process to address this in terms of minimum standards. An effective regulatory framework and institutional structure is needed to move the sector towards improved standards and quality.

A shift to a stronger regulatory environment would have important implications, not only for quality of products and installations, but of more relevance here to the quality of skills. In the absence of regulation, there is limited incentive for businesses to invest in formal skilling of their workforce. As indicated below, much work has already been undertaken and there is continued work to develop recognized programmes and qualifications for these technologies. Forcing companies to adhere to an accepted set of quality standards would influence demand for these products in the market and encourage companies to upgrade and formalize the capacity of their workforce. The role of industry associations, such as SAWEA and SAPVIA in promoting quality across the value chain and supporting companies to meet the required standards will be crucial to this process. These industry associations then also play a critical role in facilitating access to programmes that can support this process as well as informing gaps in the skilling system that need to be addressed for this purpose, be it from a curriculum or institutional perspective.

5.2.3 Labour market trends and issues influencing occupational learning pathways

There is a dearth of available labour market data in renewable energy value chains. The analysis below draws some assumptions based on international literature and available local labour market data, combined with snapshot interviews conducted with a convenience sample of wind and solar industry employers.

a) Growth demand

The growth in demand for jobs in renewable energy industries depends on the path South Africa adopts on its decarbonisation journey to 2050. IRENA (2023) estimates that jobs in the renewable energy sector will increase from around 23,900 in 2023 to 83,700 by 2030 and 128,400 by 2050 under the Present Energy Scenario (1.5ºC-2ºC) (IRENA, 2023). Under the 1.5ºC scenario, it is estimated that 500,000 jobs could be created by 2050, with around half of these in solar technologies, particularly Solar PV and concentrated solar power (CSP). In this scenario, IRENA predicts that wind energy would create 21,000 jobs.

However, the Global Wind Energy Council (2022) estimates that the installation of 1 GW of onshore wind capacity could, on average, create 130,000 jobs in development, construction and installation over a five-year period and 12,000 jobs annually during a 25-year operations and maintenance phase (IRENA & ILO, 2023). Based on projections of wind generation in South Africa reaching 16GW by 2030 (off a base of 3-4GW) and up to 23GW by 2040-45 (B&M Analysts, 2023), there are both opportunities for employment creation and pressure to ensure there is the necessary skills base to realise this opportunity.

Based on trends in the EU, the bulk of employment is in deploying the technology for the solar PV industry. While there is a growth of jobs in the EU solar industry, 80% of the 465,600 jobs are in the deployment of the technology, while manufacturing accounts for 44,200 people, operations and maintenance accounts for 40,000 and recycling accounts for 14,000 jobs (SolarPower Europe, 2022). As the peak of demand for new deployment is reached, demand for operations/maintenance and recycling skills may increase.

However, opportunities also manifest in the area of microgrids, which have the potential for significant acceleration as a means to increase energy access in developing countries. Findings from a Kenya study suggest that powering 1.1million houses through microgrids can create around 35,000 temporary jobs in the preparatory and construction phases and 10,000 permanent jobs in operations and maintenance (IRENA & ILO, 2023).

The installed capacity for battery storage grew from 500 MWh to 1.2 GWh in 2023, representing a market value of R9 billion, and is expected to reach 6.5 GWh and a market value of R32.5 billion by 2030 (Reddy & Radmore, 2024). Battery storage will somewhat track the demand for solar PV and other technologies. The scope of employment creation will depend on the level of upstream localisation for the production of lithium-ion batteries (LIBs) and vanadium redox flow batteries (VRFBs) , although the indications are that such localisation will be limited to downstream LIB assembly and manufacturing of modules, casings, and cooling components and battery management systems (B&M Analysts, 2023). Downstream, the scope of recycling and re-using batteries will be an increasing issue, but it is unlikely that local capacity will be established for this by 2030.

However, battery storage is an integral part of solar PV installations, so increasing demand for installation will invariably increase demand for battery storage.

b) Institutional barriers to demand creation

Realising the renewable energy and battery storage industry's potential to create employment will depend on the extent to which market conditions are conducive to demand growth and whether the skills system is sufficiently agile to support the opportunities created by this market growth.

Growth in solar PV demand is undermined by limited capacity among engineering procurement construction (EPC) companies, resulting in too few companies that can service the demand, particularly for larger installations. The limitation in capacity is likely to be more pronounced outside of the metropolitan centres and in the informal economy. There is also a lack of regulatory mechanisms to ensure EPC companies meet quality and safety requirements. Finally, growth in demand depends on the availability of financing instruments, insurance, and grid integration within municipalities and Eskom. Providing holistic and integrated support to enterprises in these various areas could be an important means of supporting market growth.

Although there is increasing demand for Lithium-Ion batteries, growth in the market is undermined by the low availability of skills to support the design and installation of new battery systems. This situation is worsened by weaknesses in the regulatory environment, which hampers safety, as well as delays in imports arriving from China.

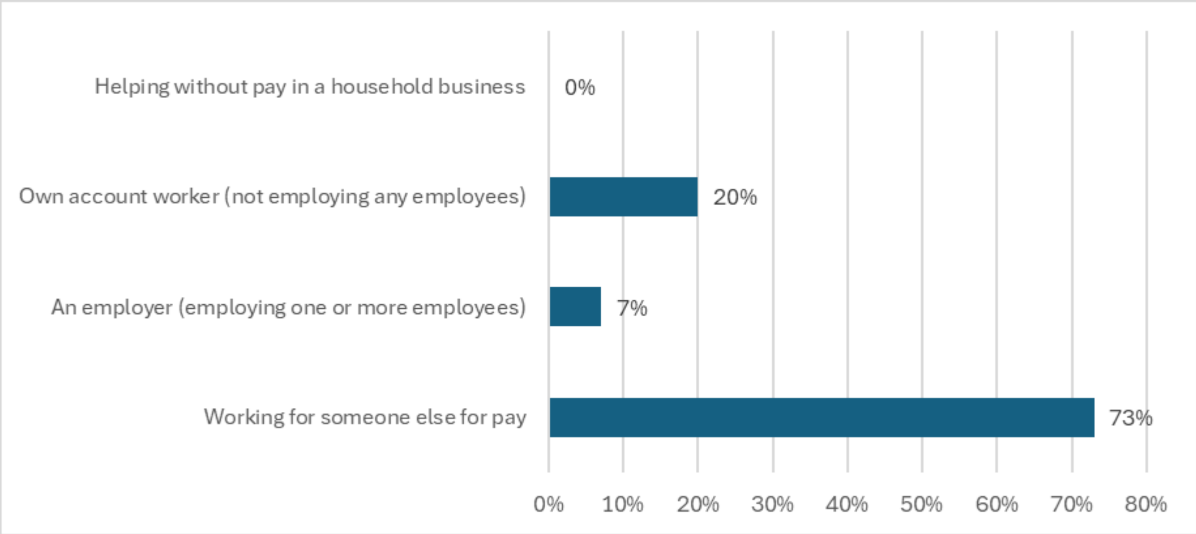
c) Ensuring transformational and inclusive access to economic opportunities

Regardless of the extent of market development upstream, unlocking inclusive opportunities in installation, operations and maintenance, and end-of-life/recycling will require active interventions into upskilling, qualifying, and formalising individuals and small businesses, particularly those in township communities and linking them to emerging and/or established value chains and supply chains.

As indicated in the occupational mapping below, the electrical trade dominates wind and solar PV installation, operations and maintenance, although other construction-related trades will feature strongly in installing both wind farms and utility-scale solar PV facilities. The scope of transformational challenges is best understood in the context of the large proportion of electricians who are informal and single-person (own account) operators. An analysis of the electrical contractors' industry in 2017 by TIPS found that 82% of the 44,285 reported electrical businesses were informal, and 69% were own account workers (GIZ/SD4GE, 2019).

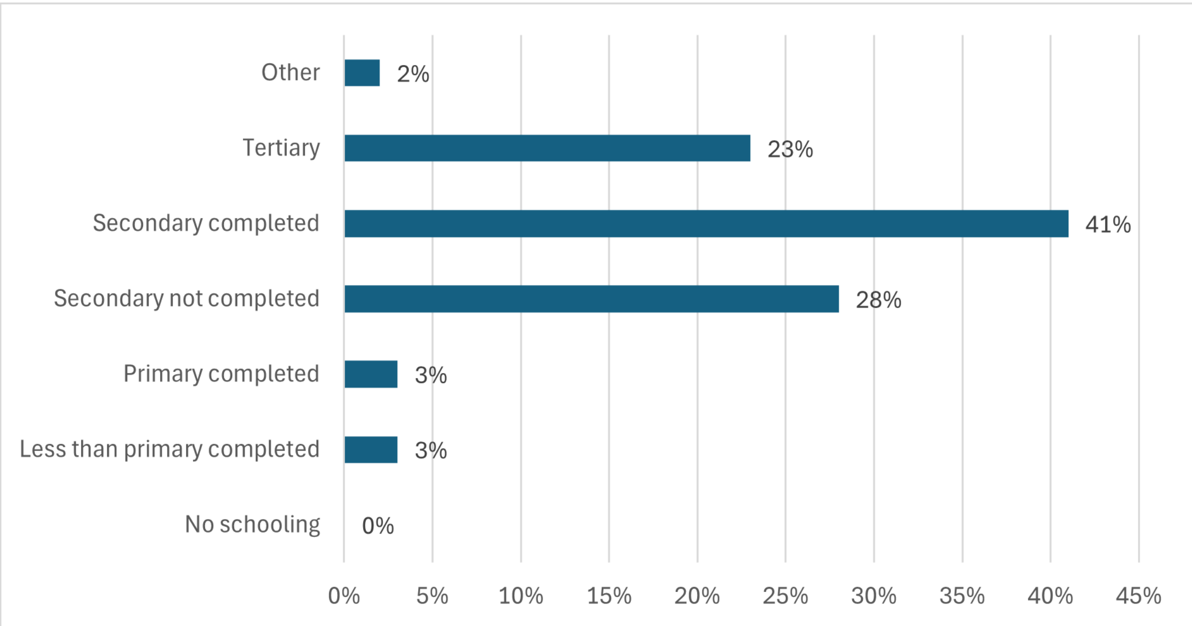
The study highlighted the skills and challenges faced by the industry. A survey of a sample of formal electrical business owners for this study highlighted the importance of on-the-job training and the desire for more skilled and knowledgeable staff; both are a significant challenge in informal and own account businesses, which are not conducive to good quality training. The 2023 Q4 QLFS data indicates that of the 212,000 people working in the electrical industry, 20% are own-account workers and 73% work for someone for pay. Only 7% report working for an employer. The implication is that a relatively small number of workplace learning environments are available.

Figure 11: Main work context of workers in the electrical industry



Source: StatsSA, QLFS 2023 (Q4)

Figure 12: Highest education level of electrical workers



Source: StatsSA, QLFS 2023 (Q4)

Furthermore, according to the National Bargaining Council for the Electrical Industry (NBCEI), almost half of the people working in the electrical industry in 2019 were categorised as 'Electrical Assistants', which is an entry-level graded worker who is unlikely to access a learning pathway to being an electrician. Therefore, there are large numbers of workers in the electrical industry who have no recognised qualifications. Only 12% of those in the industry are registered electricians and above. 33% of workers are on a learning pathway towards the electrical trade, either through the apprenticeship route or the Elconop route (an employer-driven training route unique to the electrical industry), although most of these workers were still at the early stages of their learning progression.

Using the 2023 Q4 QLFS data, an analysis of people working in the electrical industry indicates that 41% of workers have completed secondary education (Grade 12), and 34% have less than Grade 12. Only 23% have some form of tertiary or post-school education (which would include an electrical trade qualification).

In summary, the various data sets cited above suggest that a significant effort will be needed to grow and expand the skills base in the electrical industry, which is crucial in supporting the development of the solar, wind and battery storage value chains. While the electrical industry is not the only support industry for these chains, it represents a microcosm of the skills challenges the country faces in achieving a JET and guides the planning needed to prepare the labour force to participate in the transition meaningfully.

d) A focus on mid-level occupations across the Solar and Wind value chain

For this research, the focus is on mid-level skills/occupations. Some consideration is also given to occupations that provide a pathway to these mid-level occupations and supervisory roles, which can be progression routes for individuals in these roles.

Being relatively nascent industries in the South African contexts and many other contexts across the globe, the full set of occupations that make up these value chains is still being developed. However, many existing occupations have relevance and applicability for the three value chains. At the upstream level, the key challenge will be adapting the current skills and qualifications to meet the emerging and evolving technologies in the manufacturing and assembly parts of the value chain. In installation, operations and maintenance, there is scope for growth in labour-intensive occupations, particularly during the large-scale roll-out of solar and wind farms.

In their engagements with industry stakeholders, B&M (2023) found that finding and retaining staff in SA is becoming increasingly challenging, with many opting to work overseas. From a localisation point of view, skilled technicians will be critical for manufacturing, maintenance and refurbishment work as component warranties and lifespans expire. However, the report does not indicate the quantum of skills required.

5.2.4 Occupations across the value chains

For the purpose of this research, the focus is on mid-level skills/occupations. Some consideration is also given to occupations that provide a pathway to these mid-level occupations and supervisory roles, which can be progression routes for individuals in these roles.

The tables below identify 33 mid-level occupations across the three value chains. Being relatively nascent industries in the South African contexts and many other contexts across the globe, the full set of occupations that make up these value chains is still being developed. However, many existing occupations have relevance and applicability for the three value chains.

Few current jobs are at risk; some new occupations are emerging, and many are "in transition". Many emerging occupations are found in the installation, operations, maintenance and end-of-life/recycling components of the solar PV and wind energy value chains. Occupations in transition depend on the extent to which upstream localisation of processing of minerals and manufacturing of components for the three value chains occurs, as imagined in the SAREM 2035. However, the nature of these transitions will require marginal reskilling in the workplace. However, the skills sets associated with these emerging technologies will need to be clearly defined so that the skills gaps can be better understood and the provisioning for these skills gaps can be addressed. Such skills gaps could be addressed through shorter skills programmes, particularly for the new products being introduced.

Emerging occupations are a major focus of employment growth, as indicated in the growth in demand analysis above. While there are new qualifications and learning pathways in place for solar PV and wind turbine technicians, the quantum of these occupations is yet to be established. Existing qualified tradespersons, particularly but not exclusively in the electrical field, can be upskilled for these roles.

In their engagements with industry stakeholders, B&M (2023) found that it is becoming increasingly challenging to find and retain staff in SA, with many opting to go work overseas. From a localisation point of view, skilled technicians will be critical for manufacturing, maintenance and refurbishment work as component warranties and lifespans expire. However, the report does not provide any indications of the quantum of skills required.

Solar PV

The manufacturing and assembly of Solar PV components requires a range of transitioning occupations which are core to production/assembly processes, including:

1. Mechatronics Technicians
2. Electricians
3. Welders
4. Glaziers
5. Toolmakers
6. Production Operators / Assembler
7. Production Process Controller

Occupations 1-5 are all registered trades and have 3-4 year qualifications registered with QCTO. Occupations 6-7 are recognised through the completion of 1-year qualification at Levels 3 and 4 respectively.

In the area of Installation, Operations and Maintenance, the OFO offers 3 emerging occupations in the Solar PV industry:

1. Concentrated Solar Power (CSP) Plant Process Controller (OFO Code 2021-313106) –

2. Solar Photovoltaic Service Technician (OFO Code 2021-313108)

3. Solar Installer (OFO Code: 2021-642602

The registered qualifications for the Solar PV Technicians differentiates between a Technician for a PV farm technician (PV farm servicing), and a Standalone Technician, which incorporates roof-top and other off grid solar installations.

In addition, the MerSETA has also registered a part-qualification for a Solar Photovoltaic Standalone System Mounter at NQF Level 4 which offers progression to the Solar Photovoltaic Serve Technician at NQF Level 5.

A Standalone Solar PV installation business will typically have a Solar PV Technician/Installer and a team of PV System Mounters as well as Electrical Assistants [3](OFO 2021-862918). The latter provide support to the Electrician in the equipment room where the cables are brought from the panels and connected to batteries and the live circuits.

However, a survey of the solar industry in North America by the North American Board of Certified Energy Practitioners (NABCEP) found that installers are increasingly offering services beyond just solar panel installation, including emerging occupations such as Energy storage installation, EV charger installation, Electrician services, and roofing work with a specialisation in Solar PV installations (a transitioning occupation to ensure roofs are safe to hold PV installations) (SolarReviews, 2023). This implies that Solar PV companies will require access to a broader range of specialised Electrical skills and potentially a Carpenter and Roofer. Electricians can transition into EV charger and Energy (Battery) Storage installations.

In addition, there are emerging challenges around how Solar PV installations integrate with other technology installations in existing buildings, such as security systems, CCTV, smart appliances etc. The integration of these various technologies requires a sound understanding of systems integration to avoid conflicts and overload. Advanced skills in systems integration can be added to the solar technician qualification.

3 These electrical assistants should be differentiated from those reported by the NBCEI, as these are more likely to have formally recognized skills aligned to a part-qualification or skills programme.

Utility-scale Solar PV Installation requires a construction team, including construction operators. In addition, the floating solar farms are potentially on an expansion trajectory, there is no specific training specific for this but the pontoons will require specific product training.

[3]The O-NET provides for a Solar Energy Installation Manager, which is a first-line supervisor of construction workers. The South African equivalent of this role would probably be a Supervisor of Construction Processes which is not currently an occupation on the OFO but is a Level 4 qualification, with a variety of elective/ specialisms including General Structures Construction, Concreting, Concrete Reinforcing, Access Scaffolding and formwork etc. This role could transition to a Solar Energy Installation Supervisor role, especially for larger installations. Electricians also play an important role in maintaining Solar PV installations (both stand-alone and farms), in terms of regularly inspecting and maintaining electrical components, including checking wiring connections, inverters, transformers, and monitoring systems, and ensuring that all connections are secure and functioning properly.

The work of the Solar PV Technician in the maintenance of the Solar PV installation is complemented by the work of Energy Efficiency Technician (Energy Auditors) (OFO 2021-311303) and Energy Performance Certificate Practitioners, which are emerging occupations, who audit, analyse and report on the energy performance of a building, particularly in the public, commercial and industrial property sectors. The EPC is a top-up for a qualified artisan or graduate for an engineering qualification at a TVET institution.

Up to 96% of a solar panel can be recycled, with the most complex task being the separation of the silicon wafers from the glass protective layer. With a lifespan of 25-30 years, the immediate demand for recycling will be low but will ramp up in line with the large-scale roll-out of the solar PV installations, lending itself to large-scale employment creation in the medium-term. This will depend on the development of localised e-waste recycling businesses and value chains.

For the electronic components of the PV Panel, a qualified E-Waste Operations Controller oversees sustainable processes and practices to fulfil the entire recycling chain from collection, repurposing and beneficiation of suitable parts and components in accordance with circular economy-based pollution prevention and resource conservation principles. The Waste Electrical and Electronic Equipment (WEEE) Manual Dismantler (Materials Recycler, OFO Code: 2021-524901) tests, assesses, dismantles and depollutes ICT equipment, large and small household appliances (excluding temperature exchange) and consumer and entertainment electronic equipment. Both of these are emerging occupations with distinct learning pathways.

Wind Energy

The manufacturing and assembly of Wind Energy components requires a range of transitioning occupations which are core to production/assembly processes, including:

1. Mechatronics Technicians
2. Electricians
3. Welders
4. Toolmakers
5. Machinist
6. Production Operators / Assembler
7. Production Process Controller

Occupations 1-3 are all registered trades with 3–4-year qualifications registered with QCTO.

Occupations 6-7 are recognised through the completion of a one-year qualification at Levels 3 and 4, respectively.

In the area of Installation, Operations and Maintenance, the OFO offers 3 occupations in the wind energy industry:

1. Wind Turbine Power Plant Process Controller (OFO Code 2021-313105)

2. Wind Turbine Service Technician (OFO Code 2021-313110)

There are a range of complementary plant process controller occupations in hydro, gas, and fossil fuels. As such, while there is no specific qualification yet for the Wind Turbine Plant Process Controller, there is clear articulation/transitioning from these other occupations.

The wind turbine service technician is an emerging occupation requiring a based trade qualification in electrics, fitting and turning millwright, or mechatronics. The installation of a Wind Turbine, be it onshore or offshore, requires a construction team, which will invariably include:

1. Rigger / Assistant Rigger
2. Electrician
3. Welder
4. Fitter
5. Construction Supervisor
6. Construction Plant Operator
7. Machine Operator and Assembler

The first four are registered trades. Similar to the solar energy installation manager, the supervision of construction processes qualification has relevance—it is not currently an occupation on the OFO but is a Level 4 qualification, with a variety of electives/specialisms, including general structures construction, concrete, concrete reinforcing, access scaffolding, and formwork. this role could transition to a wind energy installation manager role.

Wind farm operations and maintenance require a wind service turbine technician and an electrician, who are supported by a power plant (wind farm) operator.

Wind turbines have the potential to be fully recyclable. While blades have not been recyclable at scale to date, various smaller-scale innovations are in place to recycle blades, and the first fully recyclable blades are in development. There are also drives to make wind turbines fully recyclable over the next two decades.

Wind Turbines have a lifespan of around 20 years, and it is estimated that there will be 2 million tonnes of wind turbine waste by 2050.

For the electronic components of the PV Panel, a qualified E-waste operations controller oversees sustainable processes and practices to fulfil the entire recycling chain from collection, repurposing and beneficiation of suitable parts and components in accordance with circular economy-based pollution prevention and resource conservation principles. The Waste Electrical and Electronic Equipment (WEEE) Manual Dismantler (Materials Recycler, OFO Code: 2021-524901) tests, assesses, dismantles and depollutes ICT equipment, large and small household appliances (excluding temperature exchange) and consumer and entertainment electronic equipment.

Battery Storage

There are no occupations registered on the OFO or O-NET for battery manufacturing. There is a qualification registered on the OFQUAL in the UK for battery manufacturing technicians, which is potentially an emerging occupation and involves individuals who prepare for and conduct processes in one stage of cell or battery manufacture, with four areas of specialisation across the battery production process:

- Electrode technician
- Cell assembly technician
- Ageing, formation and testing technician
- Module and pack technician

B&M (2023) identified the most feasible opportunities for localisation in the LIB battery assembly and manufacturing modules, casings, and cooling components. This is due to the existing capacity and capabilities, and the sector is considered competitive. The authors estimate that LIB casings, modules, and cooling components will represent around 30% of the total value within the LIB assembly storage sector by 2030. The manufacturing base has sufficient excess capacity to respond to this demand, which could create close to 3,000 direct jobs.

However, there is little scope for localisation of cell production linked to mineral beneficiation. This implies that the bulk of employment will most likely be in battery assembly rather than battery production.

Opportunities in battery recycling to create new batteries or other products will ramp up after 2030 as batteries reach the end of their initial life.

Table 21: Solar PV Occupations

	Manufacturing / Assembly	Installation	Operations and Maintenance	Decommissioning and End-Of-Life
Solar PV	· Mechatronics Technicians · Electricians · Welders · Glaziers · Toolmakers · Production Operators / Assembler · Production Process Controller	· Solar PV Technician · Solar PV Installer · Solar PV Mounter · Electrician · Electrical Assistant · Energy (Battery) Storage Installer · Construction Supervisor · Construction Plant Operator · Crane Operator · Roofer · Carpenter	· Solar PV Technician · Electrician · Energy Efficiency Technician (Energy Audit Technician) · Energy Performance Certificate Practitioner	· E-Waste Operations Controller · Waste Electrical and Electronic Equipment (WEEE) Manual Dismantler

Table 22: Wind Energy Occupations

	Manufacturing / Assembly	Installation	Operations and Maintenance	Decommissioning and End-Of-Life
Wind	· Mechatronics Technicians · Electrician · Welders · Toolmakers · Machinist · Production Operators / Assembler · Production Process Controller	· Wind Turbine Technician · Rigger / Assistant Rigger · Electrician · Welder · Fitter · Construction Supervisor · Construction Plant Operator · Machine Operator and Assembler · Crane Operator	· Wind Turbine Technician · Electrician · Plant Operator	· E-Waste Operations Controller · Waste Electrical and Electronic Equipment (WEEE) Manual Dismantler · Metalworker/Fabricator

Table 23: Battery Storage Occupations

	Refinement and Processing	Component and Cell Manufacturing	Battery Assembly	Battery Reuse and Recycling
Battery	· Process Operators · Process Technicians	· Battery manufacturing technicians · Electricians · Fitters · Electrical Instrumentation Technician.	· Battery Assembly Technicians	· Battery Assembly Technician · Process Operators · Process Technicians

5.2.5 Priority Occupations

The projected growth trends in Solar, Wind and Battery storage suggests:

- There will be increased demand for employment in installation as these technologies are deployed on a scaled-up basis into the market, including solar installers, mounters, electricians, and electrical assistants, as well as construction-related jobs for larger installations.
- Therefore, employment growth for site supervisors, technicians, and electricians is also likely in the operations and maintenance of such facilities to optimally extend their life.
- To ensure inclusive access to opportunities emerging from this ramped-up deployment, the increased development of formal electrical and other relevant trade skills through upskilling and recognition of prior learning, as well as formal training of electrical assistants that are aligned to the electrical trade, is critical as a basis for increasing the number of qualified electricians/electrical assistants that can access opportunities as these new technologies are deployed.
- Employment growth in the manufacturing and assembly of solar, wind, or battery technology will depend on local market trends and the extent to which upstream localisation can be realised. This growth is inclusive. Much of this will involve retraining existing artisans, operators, and assemblers or on-the-job training of new artisans, operators, and assemblers through apprenticeships and skills programmes.
- Employment growth will occur in the waste economy as PV panels, wind turbines, and batteries reach their end of life or become viable for recycling. E-waste recyclers will be important occupations in the next few years.

The priority occupations are thus focused in the short term on those needed to lay the foundation for deploying the technologies into the market. The quantum of the skills needed and the localities in which they will be in demand will require deeper analysis and proactive tracking over time. In the medium- to long-term, a more detailed analysis of skilling and reskilling will be needed to assess what emerging industrial role-players in the upstream manufacturing and assembly of the technologies will require. This could inform the development of specialised curricula for retraining or training of artisans, operators and assemblers.

Table 24: Priority occupations in renewables and battery storage

Priority Occupations		
1	Wind Energy	Electricians, Riggers, Wind Turbine Technicians
2	Solar PV	Electricians, Electrical Assistants, Energy Installers, PV Mounters, PV Technicians
3	Battery Storage	Electricians, Battery Assembly Technicians

5.2.6 Change drivers impacting on employment and skills in the value chain

The shift to renewable energy represents South Africa's best chance to resolve its energy crisis and become competitive in a global economy increasingly defined by green market conditions. This aligns with the country's commitment and contribution to reducing global carbon emissions. The unlocking of wind and solar energy assets creates the potential for large-scale job creation and mitigating the negative effects of climate change on job losses. In the context of South Africa's high levels of inequality, poverty and unemployment, the net-zero carbon transition must be "just" so that communities and workers impacted by the transition are not left behind.

It is estimated that the large-scale deployment of renewable energy would enable an almost 60% reduction in South Africa's emissions, with renewables becoming the main source of energy across all sectors (NBI, 2022). If South Africa is able to localise key elements of the renewable energy value chain, a renewable-dominant power system can create 2.4 million net positive jobs by 2050. The inevitable energy transition and the ramping up of renewable energy are critical drivers for investing in skills. The transition provides the opportunity to address some fundamental issues undermining inclusive growth in the South African economy, including the growth of SMMEs and better planning and implementation around demand-led skilling.

Adopting decarbonisation-oriented production and developing products that contribute to broader decarbonisation will impact the production processes and the skills needed for the new technologies introduced along the valuechains. To ensure the workforce is sufficiently skilled and that marginalised communities are not further excluded from industrialisation and localisation, the focus of the TVET and skills system must be on ensuring widespread access to relevant green skills and learning pathways.

The priority occupations outlined above refer to those that larger companies employ through wage employment as well as those that operate their own business and require formal upskilling for themselves as well as their workforce, complemented by enterprise development support. Beyond the formal sector workforce, opening the three value chains through increased investment in localisation should be matched with investment in developing artisanal SMEs to enable optimal access to emerging opportunities. As such, the TVET and skills systems need to deliberately respond to not only the demand of the larger companies in the formal sector in its transitioning process but equally to SMEs. These include those in the informal sector/township economy that have the potential to grow and increase their market presence in these value chains while simultaneously becoming effective workplaces for the training and employment of young people in the identified occupations.

5.2.7 Educational provisioning

As indicated in the table below, a range of education and training providers have emerged in the solar PV industry, particularly in Gauteng and Western Cape, in response to the already significant uptake and projected uptake in solar PV installations over the next few years. There are far fewer providers in the wind energy industry, the most important being SARETEC in Western Cape, and minimal in battery storage. Public TVET Colleges are gearing up to qualify solar PV installers, but only a few have the necessary infrastructure and capacity to achieve accreditation and deliver these programmes. The development of institutional capacity for the delivery of programmes linked to jobs within these value chains should be done off the basis of a careful mapping of the scale of demand-side opportunities to ensure that the investment in institutional development is going to result in programmes that will contribute to optimal labour market transitions. This speaks to the spatial nature of the market for these technologies. Ideally, the development of skills must speak to local demand, which is guided by market conditions.

Table 25: Educational provisioning for renewables and battery storage

Education provider	Provincial location (HQ)	Solar	Wind	Storage	Course type	NQF level	Course length
TVET colleges							
Ekurhuleni East TVET College	Gauteng	IRM: Plumbing & Solar Water Heating, Solar PV Installer / Technician			Short course		
Ekurhuleni West TVET College	Gauteng	Solar PV Installer / Technician			Short course		10 days
Umfolozi College	KwaZulu-Natal	Renewable Energy Workshop Assistant			National Certificate (Vocational)	NQF levels 2-4	3 years
Capricorn TVET College	Limpopo	Solar Energy Fundamentals			Short course		
Gert Sibande TVET College / RES4Africa / EWSETA	Mpumalanga	Solar PV Installer / Technician			Short course		
Gert Sibande TVET College	Mpumalanga	Solar PV Installer / Technician (still in development)			National Certificate		
Nkangala TVET College / RES4Africa / EWSETA	Mpumalanga	Solar PV Installer / Technician			Short course		
False Bay College	Western Cape	Solar PV Technician			Short course		
Northlink TVET College	Western Cape	Solar Thermal Renewable Energy Technology					
West Coast College	Western Cape	Solar PV Technician					
Private colleges / other training academies etc							
MSC Artisan Academy	Eastern Cape	Design & Operation of Photovoltaic Systems			Short course		
MSC Artisan Academy	Eastern Cape	Install & Maintain PV Rooftop Systems			Short course		
MSC Artisan Academy	Eastern Cape	Solar Thermal Systems Technology			Short course		

MSC Artisan Academy	Eastern Cape		Understanding Wind Energy Technology		Short course		
SP Wind	Eastern Cape		Basic Safety Training		Short course		
SP Wind	Eastern Cape		Basic Technical Training		Short course		
Africa International Training	Gauteng	Solar Plumbing Inspector			Short course		1 week
Africa International Training Facilities	Gauteng	Solar Plumbing Installer			Short course		1 week
Ekurhuleni Artisans Skills & Training College	Gauteng	Solar Power			Short course		5 days
Institute for Capacity Development	Gauteng		Fundamentals of Wind Energy		Short course		
Lilovattech	Gauteng	Beginner & Intermediate Solar Installation			Short course		
Lilovattech	Gauteng	Full practical training			Short course		
Nepoworx Renewable Energy Institution	Gauteng	Solar Photovoltaic Service Technician			National Occupational Certificate	NQF level 5	
Sinetech	Gauteng	Solar Design & Installation Course			Short course		
We Train You	Gauteng			Battery Maintenance	Short course		2 days
Africa Skills Private College	Western Cape	Solar PV Service Technician			Short course		
Green Solar Academy	Western Cape	Compliance for PV Systems			Short course		1 day
Green Solar Academy	Western Cape	Financing of PV Systems			Short course		1 day
Green Solar Academy	Western Cape	PV Mounter			Short course		2 days
Green Solar Academy	Western Cape	PV Sol Design School			Short course		
Green Solar Academy	Western Cape	PVA Prep Course			Short course		1 day

Green Solar Academy	Western Cape	Solar 101			Short course		3 days
Green Solar Academy	Western Cape	Solar Power Designer for Commercial PV systems			Short course		3 days
Green Solar Academy	Western Cape	Sunrise (Solar PV basics)			Short course		2 days
Green Solar Academy	Western Cape	SuperSolar-School			Short course		5 days
Industry Training Centre	Western Cape		GWO Blade Repair		Short course		
Nepoworx	Western Cape	PV Greencard			Short course		5 days
Nepoworx	Western Cape	Solar PV Designer Software			Short course		2 days
Nepoworx	Western Cape	Solar PV Fundamentals			Short course		2 days
Nepoworx	Western Cape	Solar PV Project Finance			Short course		2 days
Nepoworx	Western Cape	Solar PV System Mounter			Short course		2 days
PQRS Solar PV Training	Western Cape	Commercial Solar PV Design and Installation			Short course		
PQRS Solar PV Training	Western Cape	Solar PV Products and PV Systems			Short course		
PQRS Solar PV Training	Western Cape	Solar PV Exceed			Short course		2 days
PQRS Solar PV Training	Western Cape	Solar PV Excel			Short course		2 days
PQRS Solar PV Training	Western Cape	Solar PV Sales			Short course		1 day
Solar Training Centre SA	Western Cape	SF Food & Energy (Agri-voltaic) Course			Short course		4.5 days
Solar Training Centre SA	Western Cape	SSEG Technical & Financial Course			Short course		5 days
Solar Training Centre SA	Western Cape	STC Installers Course			Short course		5 days

Terra Firma Solutions	Western Cape	Solar PV Feasibility Assessment			Short course		
Terra Firma Solutions	Western Cape	Solar PV Installation			Short course		
Terra Firma Solutions	Western Cape	Solar PV Operations and Maintenance			Short course		
Industry / Sector associations							
Electrical Contractors Association (ECA)	Gauteng	Solar PV			Short course		
South African Institute of Electrical Engineers	Gauteng		Anatomy of Wind Turbines		Short course		2 days
South African Institute of Electrical Engineers (SAIEE)	Gauteng	Photovoltaic Solar Systems			Short course		2 days
South African Wind Energy Association (SAWEA)/ EWSETA	Gauteng		Wind Industry		Internship		
Southern African Energy Efficiency Confederation	Gauteng	Solar PV Greencard Installer			Short course	Certificate	5 days
SETA learning programmes							
merSETA	Gauteng	Hot Water System Installer (Solar Water Installer)			National Occupational Certificate	NQF level 4	
merSETA	Gauteng	Solar Photovoltaic Standalone Service Technician			Higher Occupational Certificate	NQF level 5	
merSETA	Gauteng	Solar Photovoltaic Standalone Systems Installer			National Occupational Certificate	NQF level 4	
merSETA	Gauteng	Solar Photovoltaic Standalone Systems Mounter			Part Qualification	NQF level 4	

merSETA	Gauteng		Wind Turbine Service Technician		National Occupational Certificate	NQF level 5		
Traditional universities								
Nelson Mandela University, AMTC	Eastern Cape		Wind Energy Technology & Systems		Short course		4 days	
University of KwaZulu-Natal	KwaZulu-Natal	Mechanical Engineering (Solar Energy Thermodynamics			Postgraduate			
University of Venda	Limpopo	Computational Physics for Solar Energy Harvesting			Masters / PhD			
University of Venda	Limpopo	Physics: Renewable Energy			Honours			
University of Venda	Limpopo	Renewable Energy: Solar energy			Masters / PhD			
North West University	North West	Photovoltaic Installation (Solar PV)			Short course		5 days	
North-West University	North West	Solar Technician						
Stellenbosch University, CRSE	Western Cape	Advanced Photovoltaic Systems			Short course		5 days	
Stellenbosch University, CRSE	Western Cape			Energy Storage Systems	Short course		5 days	
Stellenbosch University, CRSE	Western Cape	Solar Thermal Energy Systems			Short course		5 days	
Stellenbosch University, CRS	Western Cape		Wind energy		Short course		5 days	
University of the Western Cape	Western Cape			Energy Storage & Fluid Treatment	Postgraduate			
Universities of Technology								

Tshwane University of Technology, TICE	Gauteng	Solar Technology					10 weeks
Durban University of Technology, ETS	KwaZulu-Natal	Design, Installation & Maintenance of a PV System			Short course		
Durban University of Technology, ETS	KwaZulu-Natal	Installation & Maintenance of a Solar Water Heater			Short course		
Durban University of Technology, ETS	KwaZulu-Natal	Planning Large Scale Grid-Connected Photovoltaic			Short course		
Durban University of Technology, ETS	KwaZulu-Natal	Small Scale Grid-Connected Photovoltaics			Short course		
Durban University of Technology, ETS	KwaZulu-Natal	Solar Photovoltaic Installation			Short course		
Durban University of Technology, ETS	KwaZulu-Natal	Solar Photovoltaic Fundamentals			Short course		
Durban University of Technology, ETS	KwaZulu-Natal	Solar Thermal Fundamentals			Short course		
Durban University of Technology, ETS	KwaZulu-Natal		Wind Energy for Engineers and Technicians		Short course		
Mangosuthu University of Technology	KwaZulu-Natal	Electrical Engineering: Solar Cells & Photovoltaic (module)			National Diploma		4 years
Mangosuthu University of Technology	KwaZulu-Natal		Electrical Engineering: Wind Technologies (module)		National Diploma		4 years
Cape Peninsula University of Technology, SARETEC	Western Cape	Basics of Solar PV Systems			Short course		2 days

Cape Peninsula University of Technology, SARETEC	Western Cape		Operation & Management of Wind Farms		Short course		
Cape Peninsula University of Technology, S	Western Cape	Solar PV Installer			Short course		5 days
Cape Peninsula University of Technology, SARE	Western Cape	Solar PV Green Card Assessment			Short course		2 days
Cape Peninsula University of Technology, SA	Western Cape	Solar PV Small Grid-Tied System Basic Design			Short course		3 days
Cape Peninsula University of Technology, SARE	Western Cape		Wind: Basic Safety Training		Short course		
Cape Peninsula University of Technology, SARETEC	Western Cape		Wind Energy for Engineers and Technicians		Short course		
Cape Peninsula University of Technology, SAR	Western Cape		Wind Energy for Generalists		Short course		
Cape Peninsula University of Technology, SARETEC	Western Cape		Wind Farm Project Development		Short course		
Cape Peninsula University of Technology, SARET	Western Cape		Wind Turbine Service Technician		Short course		5 months

5.2.8 Learning Pathway Mapping

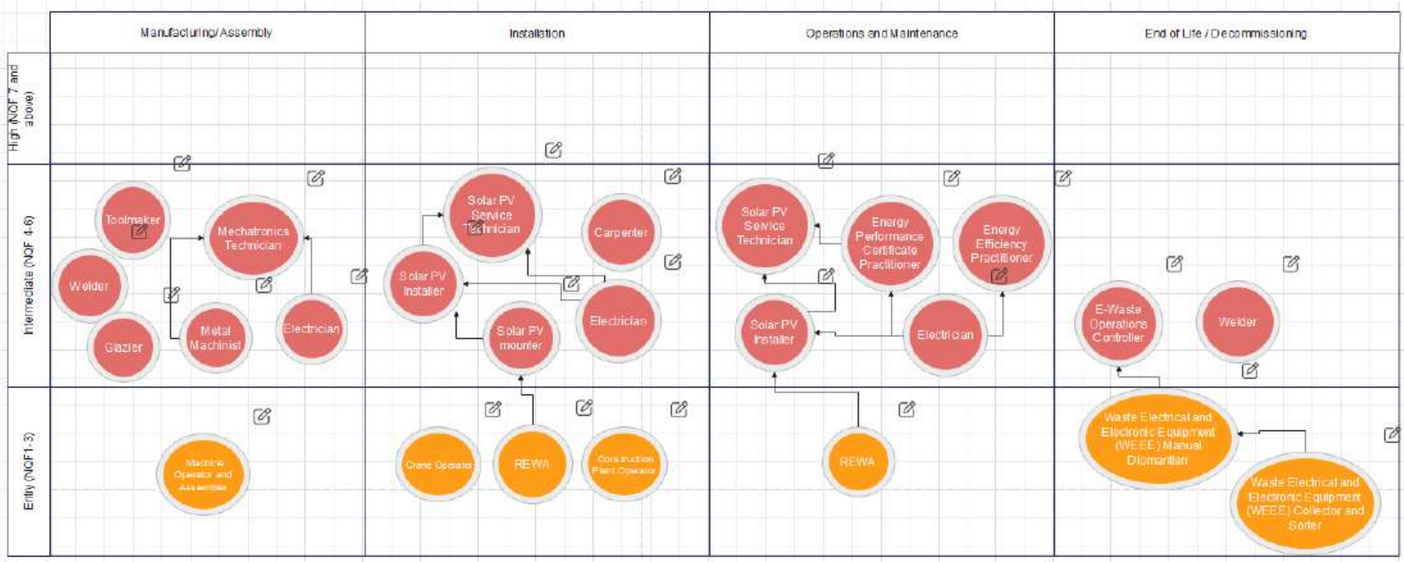
The learning pathways for intermediate/mid-level occupations in the renewable energy-industries are as far as possible mapped against the OFO and existing qualifications. However, cognisance must be taken of the range of emerging occupations that do not currently exist on the OFO and/or for which there are no qualifications registered with QCTO/SAQA. There is also a mismatch between the stated occupational role and the qualification (for example, people will use the generic title of solar installer without being a qualified solar installer or working in a clearly defined solar installer role). This makes it difficult to accurately measure or project the demand for these occupations.

As such the learning pathways identified below also make provision for newly recognised occupations, borrowing from other occupational categorisation systems (most notably the O-Net system). These newly recognised occupations address some of the limitations of the current pathways and form the foundation for the development of new programmes and qualifications for skills that are in demand.

It is also important to recognise that many of the skills sets/occupations across the value chains, specifically in the upstream manufacturing/assembly of components, will be similar in nature for both wind and solar PV. From a supply perspective, TVET Colleges and private training institutions will generally support training against the generic trades.

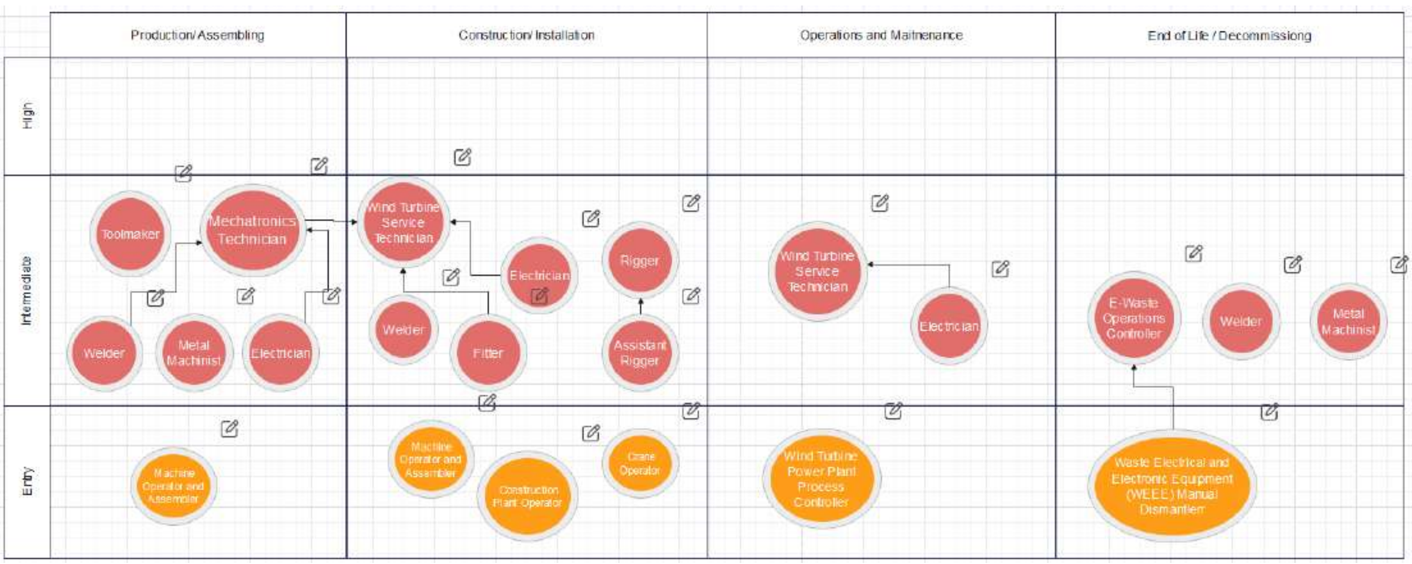
a) Learning pathways for Solar PV

Figure 13: Learning pathways for Solar PV



b) Learning pathways for Wind Energy

Figure 14: Learning pathways for wind energy



c) Learning Pathways for Battery Storage

With the exception of the fitter and electrical trades, the occupations identified in the battery storage value chain do not currently exist on the South African framework for occupations and, therefore, do not have obvious learning pathways. More data is needed to support the development of a clear understanding of the jobs and skills needs in this value chain.

5.2.9 Insights from Pathway Stories

Learning Pathways stories for Solar PV:

In the exploration of learning pathways within the solar sector, 12 participants with diverse professional backgrounds were interviewed. Among them, six individuals held the title of solar installer, each providing valuable insights into the study. Their duties range from commissioning grid systems for residential installations, focusing on cost-effective solutions, to managing client relationships and employing online monitoring systems for proactive maintenance. Proficient in installing inverters, solar modules, and panels of various sizes on different roof types, they also excel in commercial-level solar PV installations. Moreover, their expertise extends to offloading and protecting equipment, such as batteries, while trunking for organised electrical wiring. In essence, solar installers are integral to deploying and maintaining solar technologies, driving the transition towards sustainable energy solutions.

Additionally, one participant was a solar installer assistant, overseeing the materials and the entire solar system installation process, from site preparation to connecting machinery. Another participant specialised as a solar technician, while one contributed as a solar technician assistant. These are both crucial roles to ensure the effective operation and maintenance of solar systems. They are responsible for installing all components, including inverters and batteries, and wiring them together. Their duties encompass installing solar panels and backup power systems for various settings, including residential, commercial, and industrial properties. Their skills are central to implementing reliable and sustainable energy solutions. Further enriching the data were individuals with specialised roles, including a commissioning technician responsible for ensuring the seamless integration of solar technologies, along with technical duties such as installation and maintenance, a lead solar technician, with expertise and vision, oversees projects, handling engineering tasks and overseeing the commissioning of solar systems, and a freelancer bringing a versatile perspective to the conversation is engaged in project-based work.

The analysis of the solar pathway reveals a diverse educational background, with engineering qualifications being dominant. Four participants held national diplomas in electrical engineering, indicating a strong foundation in electrical principles and practices. Furthermore, one participant possessed a higher certificate in electrical engineering; another held a higher certificate in civil and building construction. Additionally, one participant held a national diploma in mechanical engineering. Four participants pursued short courses to enhance their skills, with one completing a Working at Heights course and three undertaking solar installation courses.

Several participants entered the solar sector from different occupational backgrounds. Among them, several individuals with backgrounds in electrical work made notable transitions. For instance, one participant started as a junior electrician trainee, transitioned to a solar technician, and eventually transitioned to freelancing. Another participant began as an apprentice electrician, worked as a general worker, and later became a solar installer. Similarly, another participant started as an electrician intern and then transitioned to solar installer. Furthermore, another participant started as an assistant electrician and progressed to a solar electrician, then transitioned through roles as a solar installer, solar technician, and back to a solar installer.

Furthermore, others entered the solar field from different starting points. For example, one participant with a background in IT administration shifted to become a solar installer. One participant shifted from a construction background to working as a general worker and transitioned to becoming a solar installer. Similarly, another participant with experience in security transitioned from being an assistant technician to working as a solar installer assistant. Moreover, participants with diverse backgrounds, such as cathodic protectors, moved to solar technicians, and development manager found their way into roles as solar technicians and transitioned to lead solar engineer technicians. In summary, these job transitions highlight the dynamic nature of career progression within the solar industry, with individuals moving between various roles and levels of responsibility, drawing from diverse backgrounds and experiences. The insights from the pathway stories revealed that people in the solar energy sector make horizontal job moves because they move within their organisation or industry, typically shifting to a role at a similar hierarchical level or skill set as their previous position.

The learning pathways unveiled various motivating factors prompting individuals to transition into the solar energy sector. Among the prominent motivations highlighted by participants, a notable theme emerges concerning the new technology. Several respondents were fascinated with the innovative technology, indicating a genuine interest in technological advancement. Additionally, the pervasive load-shedding issue in South Africa is a powerful motivator for many individuals, prompting them to seek employment within the solar sector. For example, participants noted that their experience of load-shedding prompted their move into the solar sector. A participant said that completing academic studies without access to electricity motivated them to transition.

Additionally, familial influence emerges as a recurring theme, with several participants entering the solar energy sector through connections with relatives already working within the industry. This familial connection not only provides an entry point but also highlights the importance of social networks in shaping career trajectories. Moreover, economic considerations, such as limited employment opportunities in other industries, emerged as a motivating factor for some participants, highlighting the promise of long-term stability and growth. Other factors include the desire to gain experience in solar energy to establish one's company or engage in subcontracting activities reflecting entrepreneurial aspirations among participants, indicating a broader ambition to leverage industry expertise for professional development.

Lastly, external factors, such as the economic fallout from the COVID-19 pandemic, contribute to participants' career decisions. Some individuals turn to the solar energy sector because of job loss in other industries. Participants indicated that they entered the solar energy sector due to retrenchment from previous jobs. In summary, the motivations driving individuals to enter the solar energy sector differ, encompassing factors ranging from personal interest in technology to economic considerations.

Furthermore, three participants highlighted completing a solar installation course as crucial to entering the solar energy sector. This course provided them with hands-on experience and practical insights into the complexities of solar energy systems, enhancing their readiness for roles within the industry. Additionally, one participant attained a wireman's license, another crucial enabler. In addition to technical training, first aid and firefighting certifications emerged as important enablers, enhancing participants' safety competencies and ensuring compliance with industry regulations. Two participants were further enabled by their technical knowledge. In summary, the pathways of these participants highlighted the diverse pathways into the solar energy sector, enabled by a combination of educational background, specialised training, and industry-specific certifications. By gaining these enabling factors, individuals could successfully transition into roles within the solar energy industry, contributing to its growth and sustainability while fulfilling their career aspirations.

Participants in the solar energy sector encounter various challenges in their workplaces and academic pursuits. Despite the enabling factors that facilitated their entry into the industry, several challenges emerged. Five participants highlighted the precarious nature of labour in the sector, where many jobs are project-based and lack full-time employment opportunities, leading to prolonged periods of unemployment for some individuals. Financial constraints also pose a significant challenge, particularly regarding the affordability of necessary training programs such as the **Solar PV Green Card,** creating barriers to skill development and career development.

The challenge of soft skills deficiencies was a recurrent theme among participants in the solar sector, significantly affecting their interactions with clients, colleagues, and management. Five participants highlighted communication barriers with clients, citing difficulties in effectively conveying information and understanding client needs and concerns due to a lack of service customer skills. For instance, one participant indicated a lack of customer service skills taught in formal education, resulting in an inability to manage client emotions and expectations adequately. This limitation hindered their ability to foster positive relationships with clients and advocate for the benefits of solar power. Moreover, participants faced challenges in communicating with management, with one individual noting difficulties in obtaining accurate information due to responses from management personnel. Additionally, diverse professional backgrounds among colleagues, such as construction and electrical industries, led to conflicting perspectives and communication breakdowns, exacerbating workplace conflicts and impeding collaboration efforts. Furthermore, the transition from mechanical to electrical engineering posed communication challenges for some participants. This shift in industries compounded existing communication barriers and required individuals to navigate unfamiliar terminologies while acquiring new skills and knowledge.

The challenge of bridging the gap between theory and practice emerged as a substantial challenge for six participants in the solar sector. Despite receiving theoretical knowledge in training institutions, individuals_found it challenging to apply it in practical work settings. For example, one participant noted an absence of practical skills training in university programmes, compared with the hands-on training provided in colleges. Consequently, participants were ill-equipped to handle real-world tasks upon entering the workforce, requiring them to learn essential skills on the job. This discrepancy between theoretical learning and practical application posed considerable challenges for participants as they struggled to translate theoretical concepts into actionable tasks in the workplace. Many individuals expressed frustration at the lack of preparation for practical scenarios encountered in their roles, highlighting the inadequacies of their formal education in providing relevant, job-specific skills. As a result, participants often do their own research to fill the gaps and acquire necessary skills, further delaying their ability to perform effectively in their roles.

Technical challenges, including wiring and installation placement issues, hindered project completion and quality assurance. The rapid pace of technological development within the industry exacerbated these challenges, requiring individuals to enhance their skills continually. Two participants noted difficulties acquiring the necessary skills due to the fast-paced nature of technological developments and new products. Furthermore, one participant emphasised the absence of internships in the fast-moving solar industry, which further adds to the challenge of adapting to new technologies. Internships traditionally serve as valuable opportunities for hands-on learning and practical experience, enabling individuals to gain exposure to industry practices and develop relevant skills. However, the absence of structured internship programmes in the solar sector deprives individuals of these learning opportunities, making it even more challenging to stay informed of technological developments and new products. Furthermore, the lack of readily available information and resources exacerbates these difficulties, necessitating self-teaching and resourcefulness to overcome knowledge gaps and access reliable equipment.

In addition to workplace challenges, some participants face academic challenges, including a lack of preparedness for certification exams like the Solar PV Green Card and limited time to study due to work commitments. Some individuals identify mentorship and guidance in the energy sector as crucial needs. Additionally, inadequate mentorship and guidance within the workplace hindered skill development and practical training opportunities.

The solar energy learning pathways show that most participants aspire for vertical career advancement within the solar energy sector in the future and particular managerial roles such as site managers and operations managers. Conversely, some participants aspire for horizontal career advancement, exemplified by ambitions to become qualified solar installers/technicians. This role requires additional qualifications such as electrical engineering, a wireman's license, and a Solar PV Green Card. Moreover, four participants wanted to establish their own companies, recognising the entrepreneurial opportunities within the solar energy sector. This endeavour requires obtaining a Solar PV Green Card and business skills to navigate the complexities of entrepreneurship. Additionally, some individuals aim to specialise in other areas such as energy efficiency, wind energy, battery storage, and green hydrogen. However, participants identified various barriers hindering the realisation of their career goals. The need for additional upskilling and accumulating requisite years of experience emerges as primary challenges. Moreover, financial limitations represent significant obstacles, impeding individuals from accessing the necessary training and resources to advance their careers. Despite these constraints, participants demonstrate resilience and determination to overcome barriers and pursue their aspirations within the evolving solar energy sector.

Learning Pathways Stories for Wind Energy:

In exploring learning pathways within the wind sector, six participants with diverse professional backgrounds were interviewed. Among them, four individuals held the title of wind turbine technician, each providing valuable insights into the study. They specialise in the technical intricacies of turbines, ensuring optimal performance through maintenance and operational expertise. Furthermore, one participant was an installation technician in the construction phase, which encompasses tasks ranging from mechanical to electrical work during the construction phase, focusing on turbine installation. Another participant was a wind technician in the construction phase, focusing on service, maintenance, and annual planning, emphasising service troubleshooting.

The analysis of the educational background within the wind energy sector reveals a diverse foundation rooted in engineering disciplines. One participant holds a national diploma in mechanical engineering, providing a solid groundwork in mechanical principles essential for tasks such as turbine assembly and maintenance. Similarly, two participants possess a national certificate in mechanical engineering, indicating proficiency in mechanical systems relevant to wind turbine operation. Furthermore, two participants hold higher certificates in fitting and turning. In addition, one participant holds a higher certificate in electrical and electronics engineering.

The job transitions within the wind energy sector show diverse occupational backgrounds. Participants commonly transitioned from various technical roles into wind energy-related positions. For instance, one participant started as an air conditioning installer (technical assistant), progressing to become a technician before transitioning into the role of a wind turbine technician. They subsequently transitioned into the role of an Installation Technician in the construction phase. Similarly, another participant started as a Mechanic in the automotive sector before transitioning into the role of a wind turbine technician. From there, they advanced to become a wind technician in construction. Electrical apprenticeship served as a stepping stone for another participant, who transitioned into the role of a wind turbine technician. Additionally, participants with backgrounds in mechanical fitting embarked on the journey towards becoming wind turbine technicians. Moreover, another participant with expertise in hydraulics and pneumatics transitioned to a wind turbine service technician before progressing to the role of turbine technician. In summary, the insights from the pathway stories revealed that people in the wind energy sector make horizontal job moves because they move with their industry, typically shifting to a role at a similar hierarchical level or skill set as their previous position.

The learning pathways unveiled various motivating factors prompting individuals to transition into the wind energy sector. For many, the prospect of working in a new, upcoming sector held promise for career growth and advancement, motivating individuals to explore opportunities within wind energy. Additionally, the lack of employment opportunities in other industries was a crucial motivator for participants seeking employment in the wind energy sector. Faced with limited options elsewhere, individuals turned to the wind energy industry. A notable finding is the three participants' interest and fascination with the emerging industry. Their longstanding curiosity and enthusiasm for renewable energy drove them to pursue careers in the wind energy sector, aligning with their values and sustainability aspirations. Moreover, mentorship has emerged as a significant factor in facilitating career transitions into the wind energy sector. Participants who had mentors providing guidance and support found it easier to navigate the transition process. Financial incentives also played a role in motivating individuals to enter the wind energy sector. Some participants indicated money as a driving force behind their decision.

The enablers enabling participants' entry into the wind energy sector encompass a range of factors, including training, mentorship, and technical expertise. Training and experience were foundational pillars for many participants, equipping them with the requisite skills to thrive in the sector. Three participants highlighted the significance of their training and experience in providing them with the necessary competencies to excel in wind energy-related roles. Mentorship emerged as a critical enabler for two participants, who benefited from guidance and support from mentors familiar with the wind energy sector. Furthermore, participants identified specific training programs that enabled their entry into the wind energy sector. Three participants indicated that basic safety training from the Global Wind Organisation (GWO) was a foundational component of their preparation for roles within the industry. Additionally, participants undertook various technical training courses, including advanced rescue training, generator alignment, working at heights, first aid, fire-fighting, and manual handling, further enhancing their skill set and readiness for employment in the wind energy sector.

Wind energy sector participants encounter various challenges in their workplaces and academic pursuits. Despite the enabling factors that facilitated their entry into the industry, several challenges emerged. One of the predominant challenges identified by three participants is the precarious nature of labour in project-based work, often resulting in extended periods of unemployment. This uncertainty contributes to financial instability. Contractual constraints, such as clauses preventing job transitions, present additional challenges for participants seeking career advancement within the wind energy sector. These restrictions limit professional growth and opportunities for individuals to pursue new roles and responsibilities. Financial barriers emerged as a significant constraint for four participants, hindering their ability to upskill and pursue further training opportunities. Limited access to resources for professional development limits career development. One participant highlighted that offshore training is not easily accessible in South Africa, limiting opportunities for skill development and specialisation in offshore wind energy projects. Acquiring visas for overseas work poses a considerable challenge for participants seeking international employment opportunities.

Furthermore, safety capabilities are essential when working with wind turbines, particularly due to the elevated heights involved in turbine maintenance and operation. Two participants highlighted the inherent risks associated with working at heights, emphasising the need for PPE and training to mitigate potential risks. Travelling to remote work sites and adapting to new environments presents logistical and mental challenges for participants, particularly in terms of prolonged periods away from family and familiar surroundings. Moreover, skills gaps pose a significant barrier for two participants, with educational institutions often prioritising theoretical knowledge over practical skills relevant to the wind energy sector. Another challenge highlighted by the participants is the lack of guidance and mentorship within companies, which poses challenges for participants in navigating the complexities of the wind energy sector. Communication issues and teamwork challenges compound the complexities of working in the wind energy sector, affecting collaboration and productivity. Weather disruptions, such as lightning and adverse conditions, pose operational challenges for participants working on turbines, leading to downtime and delays in project timelines.

The wind energy learning pathways show that most participants aspire for vertical career advancement within the sector in the future, with many participants aiming for specific roles such as site planner, operations and project manager. These roles require further training such as supervision training, and business management short courses. Conversely, three participants aspire for horizontal career advancement, with ambitions to become offshore wind turbine technicians. This role requires additional qualifications, such as sea survival training. Moreover, other career aspirations include pursuing further studies, with participants seeking qualifications such as a degree in electrical engineering and generator alignment training.

5.2.10 Learning pathway gaps and interventions

There are significant gaps in available data that clearly explain the demand for skills in the renewable energy value chains. This then impacts the scope of qualification and learning pathways that are available for new entrants and existing workers in these value chains.

However, there is an indication that the deployment of these technologies will not be consistent across the country, which will, in turn, impact the available markets for enterprise participation and growth. Building on the analysis of the status of individuals in the electrical trade, there is a need to clearly understand the scope of intervention that is going to be needed to address the skills base for the renewable energy value chain, particularly in the context of the JET.

Understanding the nature of the job, the skills required, and the scope of interventions needed to address these skills will inform a holistic skilling strategy to support the development of these value chains.

The proposed interventions are as follows:

- The emerging data suggest an increasing demand for skills in the end-of-life/decommissioning phase of the value chains. Together with EWSETA, develop a qualification for renewable waste recycling – particularly solar PV waste.
- To develop a coherent, demand-led strategy for skilling, there is a need to conduct a detailed mapping of the demand for RE skills across geographic localities and the institutional capacity and requirements to deliver on these at a localised level, including resourcing and accreditation. This can support more targeted interventions to gear up skills institutions (particularly TVET Colleges) to deliver on these skills (whether for reskilling, upskilling or skilling of new labour market entrants).
- The mapping of renewable energy skills will rely on a coherent and industry-accepted set of occupations with clearly defined skill sets and articulation pathways. These occupations should reflect the emerging and evolving reality of the sector and ensure that all roles are factored in.
- Given the number of people working in many of the technical trades who are un- or under-qualified, a coherent strategy for recognising and upskilling people working in relevant trades is needed to create a pool of formally skilled individuals who can adapt and engage in opportunities emerging through the RE value chain. This can be achieved through RPL and ARPL across critical sectors where many individuals are working but are not formally skilled.
- The strategy for upskilling should be accompanied by a strategy for supporting entrepreneurship and SMME development to enable those that can generate income independently as an account worker or have the ability or appetite to establish a business to be equipped to do so sustainably. This will assist in opening up more expansive opportunities for participation in RE markets in the value chains to ensure the realisation of the JET.
- The battery storage sector is the least understood of the three value chains, but there are high expectations for localisation and growth of industries along the value chain. A research project is required to unpack the skills and jobs required for the localisation of battery manufacturing in South Africa in alignment with the TIPS study on "Opportunities to develop the lithium-ion battery value chain in South Africa" report in the following identified areas:
  - 1. Mineral refining
  - 2. Cell manufacturing
  - 3. Battery manufacturing and assembly
  - 4. Battery recycling.

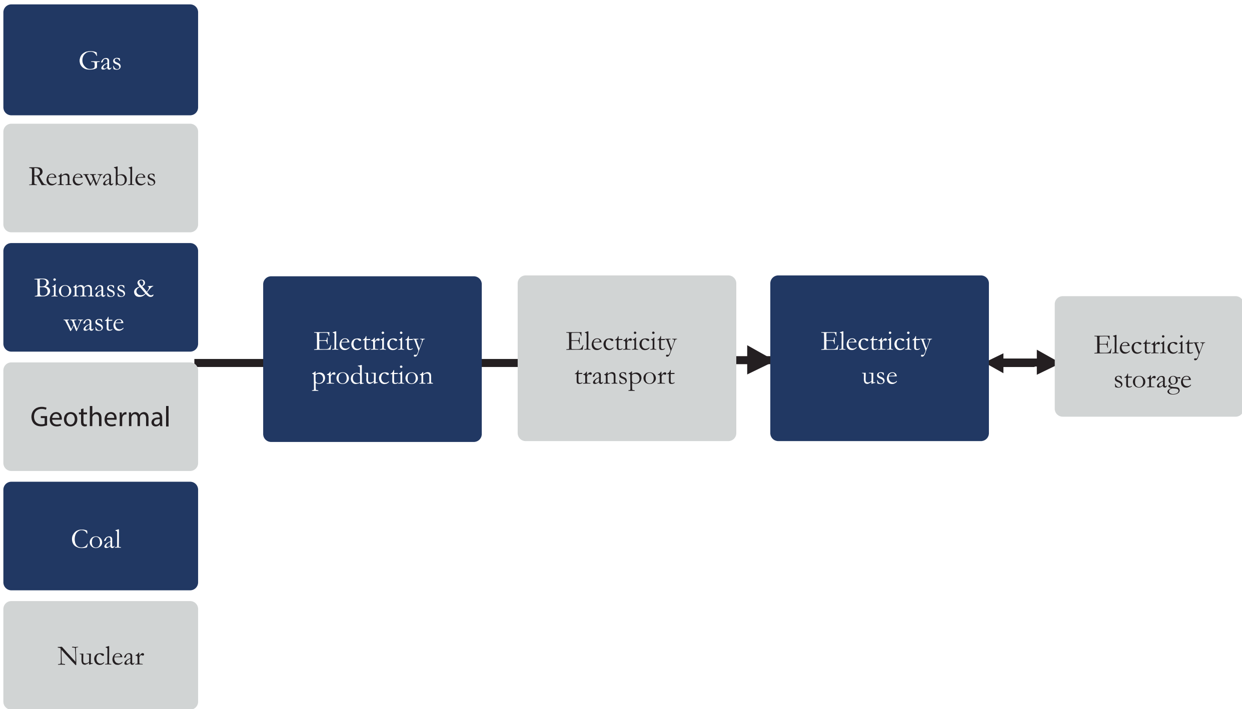
5.3 Mapping of qualifications and initial Occupation Progression Pathways: Energy Efficiency

5.3.1 Description of the energy efficiency value chain as an occupational context for pathways

As energy efficiency cuts across many different value and supply chains, with sometimes varying skills requirements, it was decided to focus on the energy efficiency technology value chain rather than the energy value chain itself, although the two are related. Although there are efficiency improvements to be had in all forms of energy, it was decided to focus on electricity, given that this is the major focus for South Africa in an increasingly electrified world.

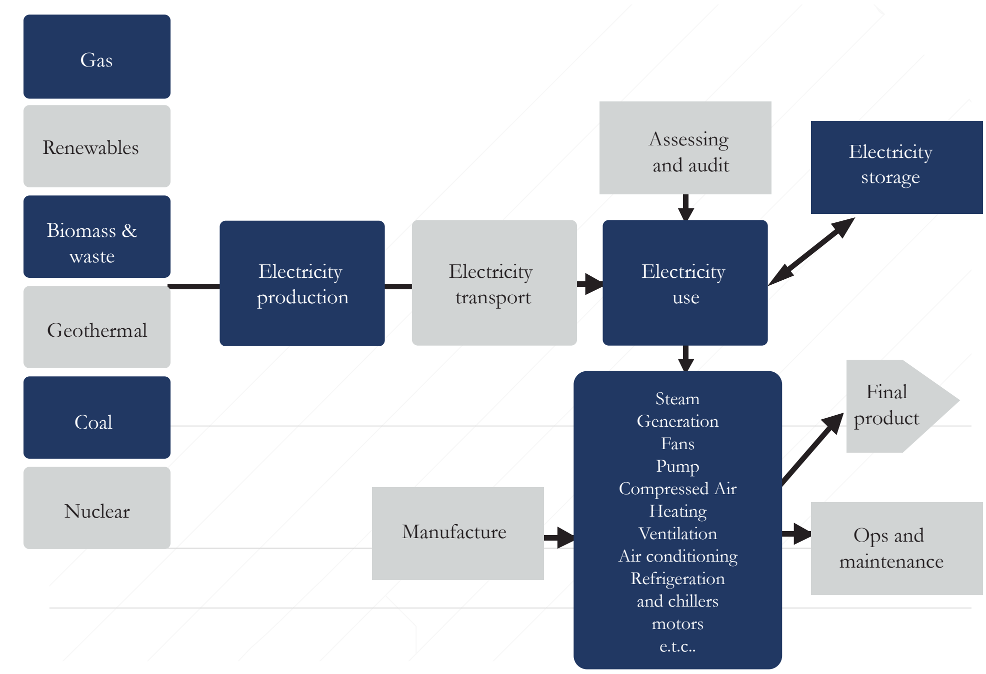
Figure 15 below depicts the electricity value chain. Energy efficiency can be implemented at various points along the value chain, including in production, transport, and storage.

Figure 15: Electricity value chain



However, if energy efficiency in the use of electricity is included as an additional value chain, it expands, as shown in Figure 16 below.

Figure 16: Electricity value chain including energy efficiency



The various utilities generally deal with energy efficiency in the electricity value chain. The focus of this research was decided to be that part of the value chain depicted by the grey blocks in Figure 17 above.

The use of electricity or broader energy takes place across all sectors and the major areas that are generally considered include:

- Buildings - residential, commercial and public
- Industry - manufacturing, processing, chilling, heating etc
- Agriculture - motors for pumping water, harvesting, drying etc
- Transport efficiency (including distribution in the value chain)

5.3.2 Overview of institutional architecture

Given the complex value chains described above, the institutional architecture of energy efficiency is a mixture of interventions primarily driven by climate change-related policy but with individual and company behaviour adjustments. The role players are very diverse, and oftentimes, the owners of systems are not invested in their energy efficiency. This disjuncture manifests as building developers not paying the energy bill and the buyer or renter not incentivised to install initially expensive but more energy-efficient systems. Energy users such as office workers are also not incentivised to use less energy, and behavioural and technical solutions must be found. Thus the role of government in developing policy to incentivise this change in behaviour is critical but needs to be multifaceted to address the diversity of energy uses. Given rising energy prices, direct industrial, commercial and residential users are incentivised for change and skills development to optimise systems and be more energy efficient. But again, if not hardwired into the system, change can rely on behaviour change. This uncertainty can result in educational provisioners in energy efficiency-related certificates and qualifications training and learners being unable to find employment. In some countries, stricter energy efficiency policies and implementation are an effective mechanism for increasing the deployment of energy efficiency technologies and processes and, thus, jobs. In South Africa, the Department of Minerals and Energy Resources is the lead Government department, but there are also links to the Department of Fisheries, Forestry and Environment (climate change link) and the Department of Trade, Industry and Competition (localisation and international competitiveness). The South African Bureau of Standards also plays a critical role in setting standards that can be adopted in local and national regulations.

Other role players in the system include the players in the PSET system and business associations that increase awareness. Mediators include organisations such as the SETAs (several of them given the breadth of energy efficiency including EWSETA, MERSETA and PSETA) and organisations such as the National Cleaner Production Centre, which is mandated to drive green growth and improve energy efficiency in the industry in particular. These bodies provide important bridges between policy developers and businesses, as do municipalities, who are, in many cases, the energy suppliers, and they ensure regulations and standards are enforced. The institutional architecture is therefore quite fragmented with many moving parts and agendas. Skills provision reflects this fragmentation and the lack of consolidated information, including skills needs.

5.3.3 Labour market trends and issues influencing occupational learning pathways

Globally, Energy efficiency is known to create jobs due to the labour-intensive nature of installing new, more efficient equipment or retrofits (IEA, 2020). This varies depending on energy prices, energy security, the level of policy support, and the energy and carbon intensity of the energy sector.

Table 26: IEA report on efficiency-related jobs post Covid-19 in various countries

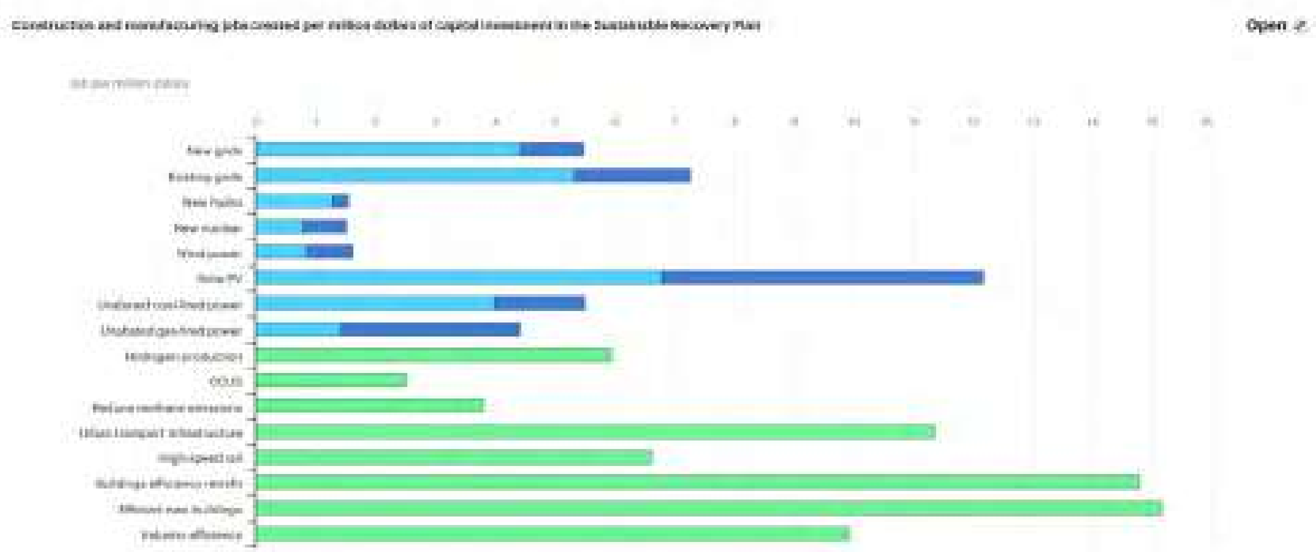
Estimated energy efficiency jobs in selected countries and regions

Country	Efficiency-related jobs (pre Covid-19 crisis)
United States	2.4 million
Europe	1 million - 3 million
China	729 000 - 730 000
Canada	472 000
Australia	60 000 - 236 000
Brazil	33 000 - 62 000

Note: Definitions of energy efficiency jobs differ between regions and the numbers provided in this table are therefore not directly comparable or additive. United States: as of February 2020; China: as of 2018, energy service companies only; Europe: as of 2020, buildings sector only (preliminary estimates subject to change); Canada: as of 2019; Australia: as of 2019; Brazil: as of 2018. Sources: NASEO and EFI (2020), The 2020 U.S. Energy & Employment Report; Wang Qingyi (2019), 2019 Energy Statistics; BPIE (Unpublished), Working Paper: Examining the impact of Covid-19 on building efficiency employment in Europe; ECO Canada (2019), Energy Efficiency Employment in Canada; EEC (2019), Energy efficiency employment in Australia; Mitsidi (2019), Job creation potential in Brazil from 2018 to 2030 (in Portuguese).

The figure below shows that energy efficiency creates more jobs than other clean technologies, but policy intervention is essential to stimulating uptake (IEA, 2020).

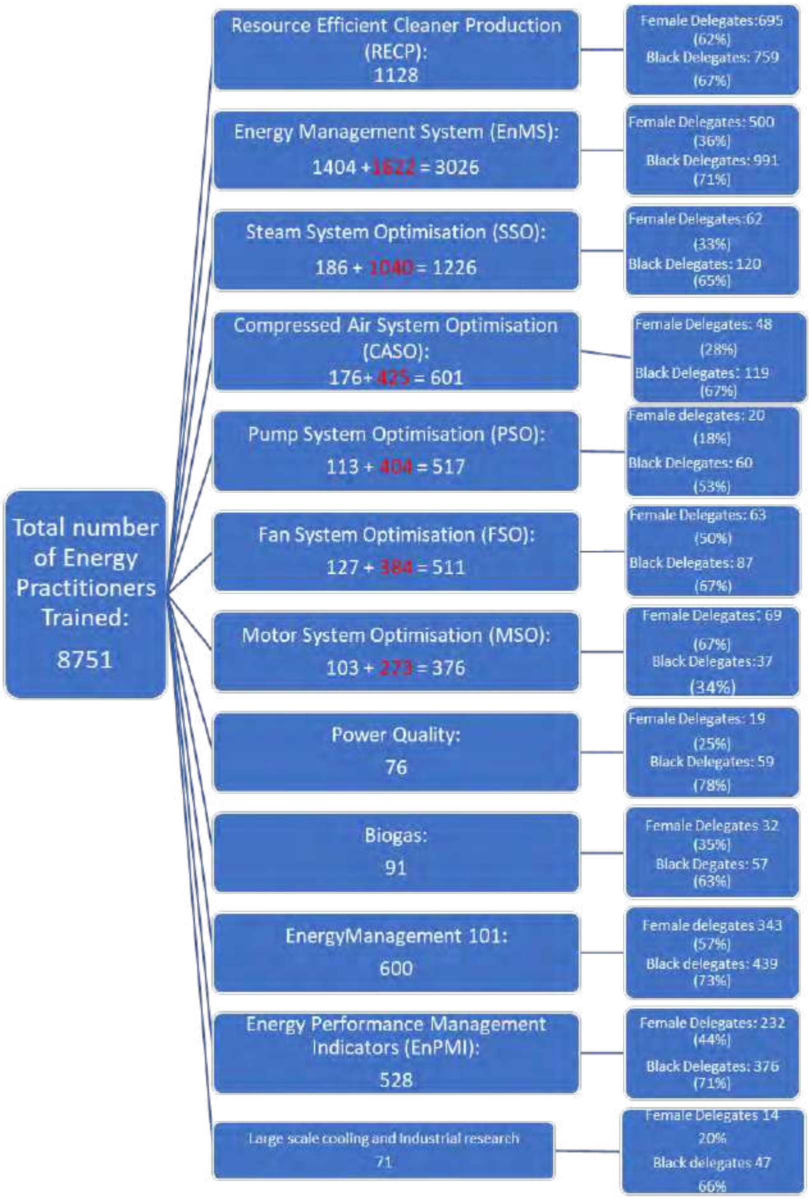
Figure 17: Jobs per million dollars of capital investment in energy technologies in Covid-19 recovery plans



There is little labour market analysis for energy efficiency jobs in South Africa. The following was identified through training providers:

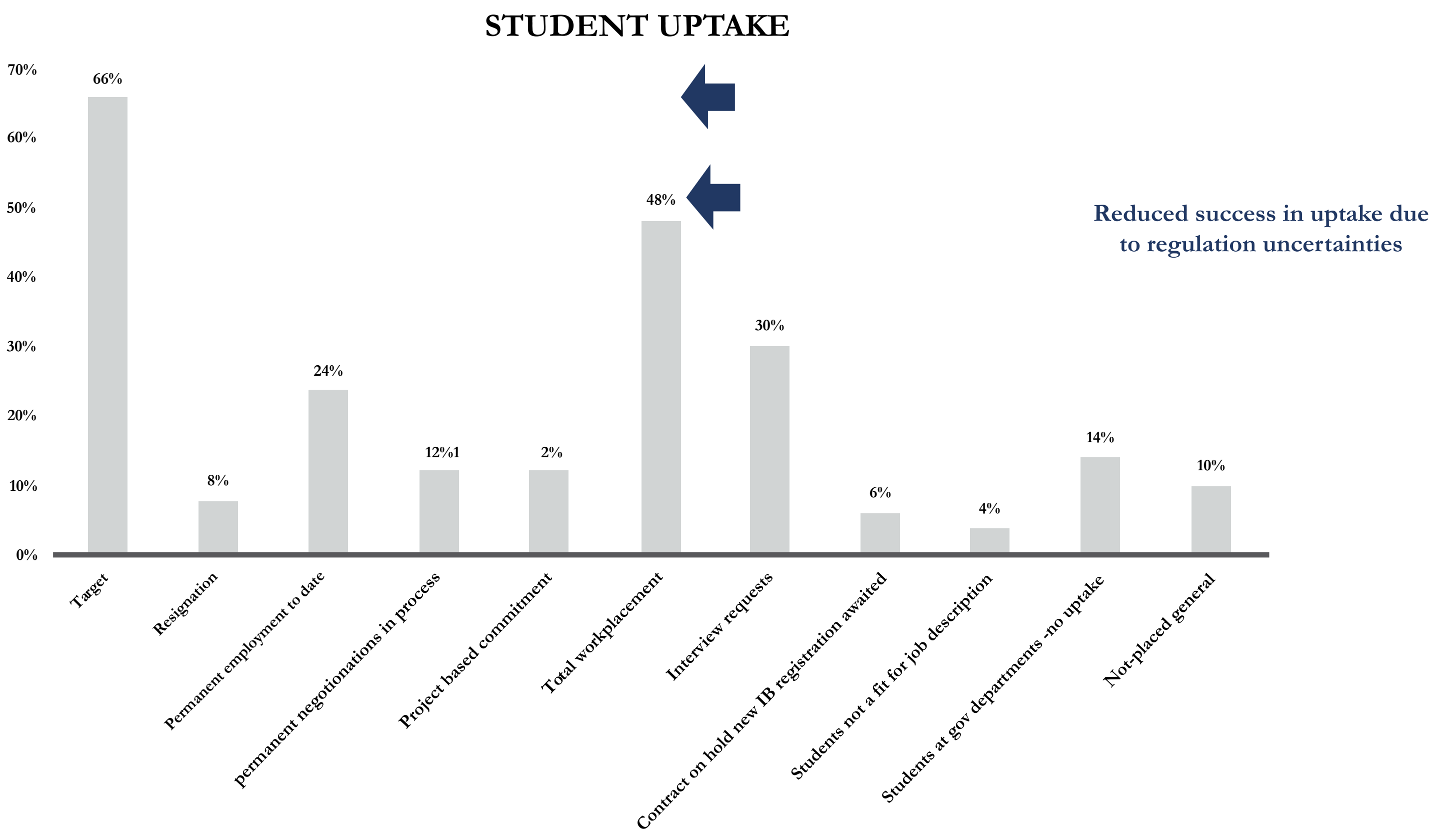
- Training, mostly for certificates of competency, at the National Cleaner Production Centre (NCPC) for their Industrial Energy Efficiency Programme has resulted in more than 6 300 professionals being trained, almost 300 experts certified and almost 200 local trainers certified over a 12-year period.

Figure 18: Number of NCPC trained Energy Practitioners



At the IEPA, for the Energy Practitioner Certificate Skills Programme (EPC), the following graph indicates the number of students who found jobs after qualifying, which was less than expected due to regulatory uncertainty:

Figure 19: Student uptake of EPC-certified practitioners from IEPA

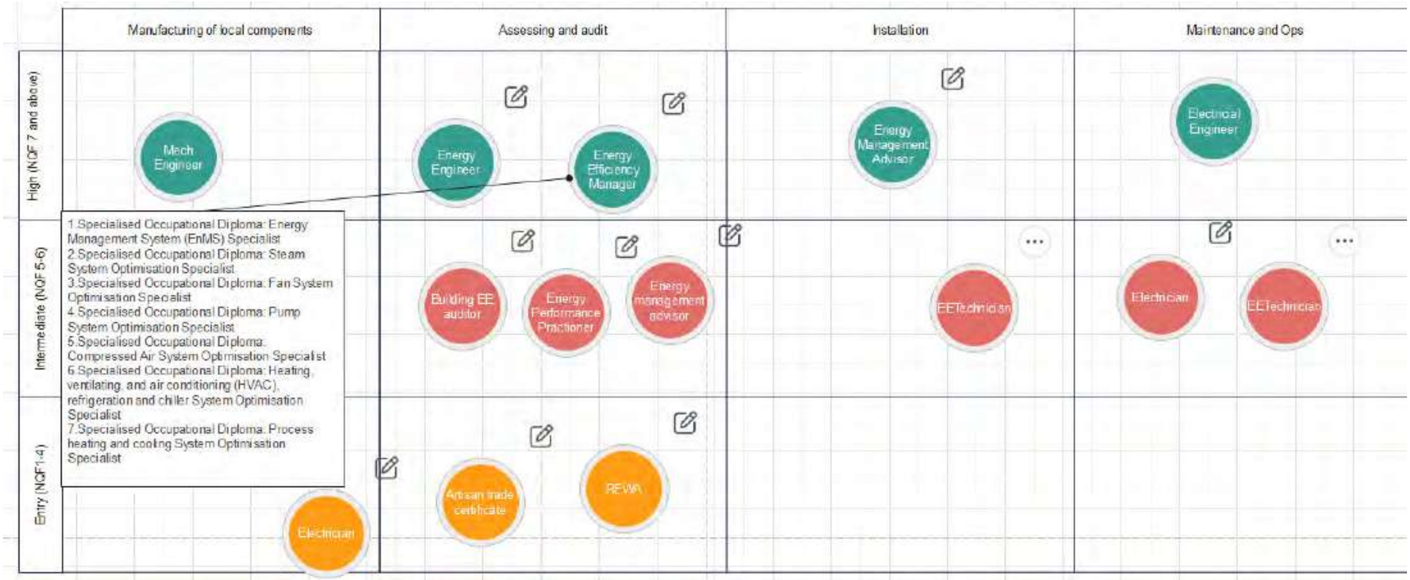


5.3.4 Occupations across the Energy Efficiency Value Chain

All qualifications related to energy efficiency were mapped across the value chain. Some qualifications have been delayed and are currently in progress. The focus was on intermediate level jobs (NQF 5-6) but both entry level (NQF 1-4) and high level (NQF 7-9) were also included as part of potential pathways.

Those occupations registered with the QCTO are indicated by the ☑symbol

Figure 20: Qualifications mapping for energy efficiency



These are mirrored in the table below, along with additional qualifications that could be assumed for manufacturing in the energy efficiency sector in South Africa, evidence of which could not be found.

Table 27: Qualifications mapping for energy efficiency

Manufacturing / Assembly	Assessing and audit	Installation	Maintenance and operations
Mechatronics Technicians Electrician Welders Toolmakers Machinist Production Operators / Assembler Production Process Controller	Electrician REWA Artisan trade certificate Energy building auditor Energy performance practitioner Energy management advisor EE Technician Energy Engineer Energy efficiency manager Electrical engineer	Electrician Energy performance practitioner Energy management advisor EE Technician Energy Engineer Energy efficiency manager Electrical engineer	Electrician Energy performance practitioner Energy management advisor EE Technician Energy Engineer Energy efficiency manager Electrical engineer

Specialised Occupational Diploma: Energy Management System (EnMS) Specialist

Specialised Occupational Diploma: Steam System Optimisation Specialist

Specialised Occupational Diploma: Fan System Optimisation Specialist

Specialised Occupational Diploma: Pump System Optimisation Specialist

Specialised Occupational Diploma: Compressed Air System Optimisation Specialist

Specialised Occupational Diploma: Heating, ventilating, and air conditioning (HVAC), refrigeration and chiller System Optimisation Specialist

Specialised Occupational Diploma: Process heating and cooling System Optimisation Specialist

The analysis shows that the occupational pathways bridge right across entry to high-level jobs and that many occupations are already registered with the QCTO or are under development. An electrician qualification appears to be the base qualification for many pathways.

5.3.5 Insights from Pathway Stories:

Six energy efficiency learning pathways were explored, involving participants with various professional backgrounds. Two were energy performance practitioners (EPCP), one specialising in solar energy, two were energy performance technicians, and one was a certified energy auditor (CEA).

The analysis of the energy efficiency pathway showed that all six participants had an educational foundation in engineering. Specifically, one participant held a national certificate qualification in electrical engineering, while two possessed national diplomas in electrical engineering. Additionally, one participant held a Bachelor of Technology degree in chemical engineering, and another held a national mechanical engineering diploma.

Participants from diverse occupational backgrounds were found to have entered the energy efficiency sector. Among them, three individuals with experience in electrical engineering made the transition from electricians. Additionally, one participant, originally a panel beater, shifted from a mechanical engineering background, while another, who had been a processing engineer trainee, moved from a chemical engineering background. Lastly, one participant transitioned from a previous role in retail. The learning pathways unveiled various motivating factors prompting individuals to transition into the energy efficiency sector. These included the influence of prevailing policies and Sustainable Development Goals (SDGs), the ongoing challenges of load shedding and the electricity crisis in South Africa, a deep-seated passion for sustainability and reducing CO2 emissions, and a keen interest in the career opportunities presented by an emerging sector. A key finding from the learning pathways was that individuals with an electrical background exhibited a strong inclination to shift into the energy efficiency sector. They noted that occupations within this sector were predominantly electrical-focused, making the transition feel seamless for many participants due to their existing knowledge and familiarity with electrical concepts.

Five participants made their entry into the energy efficiency sector by enrolling in an Energy Performance Certificate Practitioner (EPC) skills programme. Upon completing the programme, they secured positions as EPCP interns within various companies. Once within the energy efficiency sector participants transitioned from Energy Performance Practitioners to Energy Efficiency Technicians, Energy Coordinators or Energy Audit Technicians within the same company. Another participant entered the energy efficiency domain by undertaking a Certified Energy Auditor in Training course (CEAIT) and is currently an Energy Auditor. The insights from the pathway stories revealed that people in the energy efficiency sector make vertical job moves because they move within their organisation or industry, as the job moves involve an expanded scope of work, enhanced skill set, increased responsibility and increased career advancement opportunities.

Five of the participants expressed that the technical skills they acquired in the EPC training programme equipped them with the necessary technical skills and knowledge demanded on the job. However, the majority of the participants noted that they faced challenges with report writing upon completion of energy audits as well as in effectively communicating with colleagues, clients, and exercising leadership skills. This highlights the necessity for a greater emphasis on the development of soft skills within the training curriculum. Furthermore, one participant expressed dissatisfaction with the mentorship provided at their company, citing insufficient knowledge and inadequate training from mentors. This often led to the allocation of general tasks instead of specific, skill-building work. Additionally, the participant highlighted a lack of access to resources, including equipment necessary for energy audits, due to limited funding and restricted access to buildings. These challenges hindered their practical, work-based training and limited their opportunities to apply and practice their theoretical knowledge.

The energy efficiency learning pathways show that the participants aspire to vertical career advancement within the energy efficiency sector in the future, with the majority of the participants aiming for a specific role such as to become a Certified Energy Manager (CEM) with the exception of three participants. Two of the participants aspire to branch out into specific areas of specialisation, particularly the solar sector within energy efficiency and one participant aspires to start up their own energy efficiency consultation company. The participants identified barriers hindering the realisation of these career goals, including the need for additional upskilling and accumulating the necessary years of experience. Constraints such as financial limitations and time constraints emerged as significant obstacles hindering participants from achieving their future job aspirations.

5.3.6 Priority occupations

The following priority occupations were identified

- EE Auditors as more people will require energy systems management and energy audits are the first step in this process as well as helping organisations prioritise energy efficiency activities
- EPC Practitioners as they are the basis for the majority of other skills pathways, together with electricians
- An emerging priority occupation is that of energy systems optimisation and management as it is required for optimisation of use before the installation of renewables and storage, as well as for the integration of those systems into the overall energy system at eh point of installation. In addition battery charging facilities for EVs are oftentimes installed with solar installations, or as stand-alone charging systems and also need to be integrated into the electrical system of the site.

5.3.7 Change drivers impacting on employment and skills in the value chain

The major change drivers impacting on employment and skills in the energy efficiency value chain include:

- Energy price escalations – driving a need to reduce usage and therefore cost
- Loadshedding – to help avoid loadshedding by reducing demand
- Climate change mitigation – to reduce emissions and avoid carbon taxes and possibly sell carbon credits in the voluntary carbon market
- Environmental benefits – to reduce related environmental impacts such as water usage and air pollution
- To minimise the cost of self-generation – if energy management and efficiency are optimised then the size of self-generation plants can be smaller and therefore lower cost

The policy drivers include:

- The Energy Efficiency Strategy which was approved in 2008 and which sets an energy intensity reduction target of 12% by 2015 and sectoral energy efficiency improvement targets
- The National Building Regulations (updated 2011) which translated into SANS 10400XA; Application of the NBRs, Energy Use in Buildings (2011) and SANS 0204; Energy Efficiency in Buildings (2011). These regulations apply to new build and upgrades the require planning permission and not existing buildings
- There are also voluntary standards whilst not policy, are driven through SABS and accredited certifying entities such as ISO 50001 which is

aimed at "establishing, implementing, maintaining and improving an energy management system, to assure conformity to its stated energy policy, and to demonstrate conformity to ISO 50001:2011 (SANS 50001:2011).

- Compulsory specifications for light bulbs that outline minimum energy-efficiency standards that effectively ban incandescent and fluorescent lights (Vermeulen, 2023)
- The12L tax is "available to South African manufacturers that are approved by the Department of Trade, Industry and Competition for making significant investments in qualifying manufacturing assets. A minimum investment of R30 million to R50 million is required, depending on the nature of the project. The manufacturer must invest in new manufacturing assets in either a new (greenfield) project or an expansion (brownfield) project. Additional benefits are available for projects located in special economic zones." One of the recognised categories is that of Improved Energy Efficiency where improvements of 12.5% to 15% are achieved relative to the baseline for a 12-month period.

The final driver noted which links specifically to career pathways is that of the increasing need for energy optimisation studies to be done before Solar PV plants are installed in order to not over-spec the plant and save on capital costs. In addition, the need to integrate the solar PV plants into the other systems also requires a blend of expertise including energy systems management and energy systems integration. Thus energy systems integration and management are emerging priorities.

5.3.9 Educational provisioning

The table below indicates the current training related to energy efficiency in South Africa.

Table 28: Educational provision data for energy efficiency related training

Education provider	Provincial location (HQ)	Course name
TVET colleges		
Ekurhuleni East TVET College/ SANEDI	Gauteng	Energy Performance Certificate (EPC) Practitioner Skills Programme
Ekurhuleni West TVET College	Gauteng	Energy Efficiency
Ekurhuleni West TVET College	Gauteng	Energy Management
Capricorn TVET College	Limpopo	Energy Efficiency
College of Cape Town/SANEDI	Western Cape	Energy Performance Certificate (EPC) Practitioner Skills Programme
Private colleges/other training academies etc		
BSI Group	Gauteng	ISO 50001: Energy Management Implementation
BSI Group	Gauteng	ISO 50001: Energy Management Requirements
BSI Group	Gauteng	ISO 50001: Energy Management Internal Auditor
BSI Group	Gauteng	ISO 50001: Energy Management Lead Auditor
BSI Group	Gauteng	ISO 50001: Energy Management Lead Implementer
BSI Group	Gauteng	ISO 50001: Energy Management Masterclass
BSI Group	Gauteng	ISO 50001: Energy Management Requirements On-demand
DQS Academy	Gauteng	ISO 50001 Energy Management: Foundation
DQS Academy	Gauteng	ISO 50001 Energy Management Lead Implementer

Education provider	Provincial location (HQ)	Course name
NCPC-SA	Gauteng	Compressed Air System Optimisation
NCPC-SA	Gauteng	Energy Management 101 (EM101)
NCPC-SA	Gauteng	Energy Management System Implementation
NCPC-SA	Gauteng	Energy Performance Measurement Indicators (EnMPI)
NCPC-SA	Gauteng	Fan System Optimisation (FSO)
NCPC-SA	Gauteng	Large scale Cooling & Industrial Refrigeration System Optimisation
NCPC-SA	Gauteng	Motor System Optimisation (MSO)
NCPC-SA	Gauteng	Pump System Optimisation
NCPC-SA	Gauteng	Steam System Optimisation
SABS Training Academy	Gauteng	Introduction to Energy Efficiency Management Systems ISO 50001
SABS Training Academy	Gauteng	ISO 50001: Understanding and Implementation of Energy Efficiency Management Systems
SGS South Africa	Gauteng	ISO 50001: Energy Management Systems: Internal Auditor
The Knowledge Academy	Gauteng	ISO 50001 Energy Management Systems
We Train You	Gauteng	Industrial Energy Efficiency and Savings
SBS Training	Western Cape	Introduction to Energy Audit and Energy Management
Industry / Sector associations		
AEE	Gauteng	Certified Energy Manager
AEE	Gauteng	Certified Energy Auditor
IEPA	Gauteng	Business Energy Professional
IEPA	Gauteng	Energy Auditor
IEPA	Gauteng	Energy Manager
IEPA	Gauteng	Energy Performance
IEPA	Gauteng	Industrial Energy Professional
IEPA	Gauteng	Lighting Efficiency Professional
IEPA	Gauteng	Measurement & Verification Professional
SAEEC	Gauteng	Business Energy Professional
SAEEC	Gauteng	Energy Auditor
SAEEC	Gauteng	Energy Manager
SAEEC	Gauteng	Energy Performance Certificate (EPC)
SAEEC	Gauteng	Fundamentals to Energy Management
SAEEC	Gauteng	Industrial Energy Professional
SAEEC	Gauteng	Lighting Efficiency Professional
Traditional universities		
University of Johannesburg/RC	Gauteng	Energy Efficiency Audit Technician
University of Pretoria	Gauteng	Electrical Engineering (Energy management module)
University of Pretoria	Gauteng	Electrical Engineering (Energy optimisation module)
University of Pretoria	Gauteng	Electrical Engineering (Energy systems & optimisation module)
University of Pretoria	Gauteng	Energy Efficiency & Demand Side Management
University of Pretoria	Gauteng	Energy Efficiency & Management in Buildings
University of Pretoria	Gauteng	Industrial Energy Optimisation
University of Witwatersrand, AELC	Gauteng	Decarbonising Energy (module)
University of the Witwatersrand	Gauteng	Energy Efficiency & Renewable Energy for Buildings (module)
University of the Witwatersrand	Gauteng	Environmental and Energy Economics

University of the Witwatersrand	Gauteng	Sustainable and Energy Efficient Cities
University of KwaZulu-Natal	KwaZulu-N	Power Electronics 2
North West University, CRCE	North West	Energy Management
University of Cape Town	Western Cape	Energy Efficiency and Sustainability
University of Cape Town	Western Cape	Integrated Energy Systems
Universities of Technology		
Vaal University of Technology	Gauteng	Electrical Engineering: Energy Management & Energy Efficiency (modules)
Vaal University of Technology	Gauteng	Electrical Engineering (Power): Energy Management (module)
Vaal University of Technology	Gauteng	Engineering: Energy Efficiency (incl. Renewable Energy module)
Durban University of Technology, ETS	KwaZulu-Natal	Building Energy Audit & Training Programme (BEAT)
Durban University of Technology	KwaZulu-Natall	Introduction to Energy Auditing & Assessment
Cape Peninsula University of Technology	Western Cape	Energy: Energy Efficiency & Management (modules)
Cape Peninsula University of Technology	Western Cape	Smart Energy: Energy Efficient Agriculture & Human Settlements

AEE = Association of Energy Engineers

IEPA = Institute of Energy Professionals Africa

SAEEC = Southern African Energy Efficiency Confederation

RC = University of Johannesburg/Resolution Circle

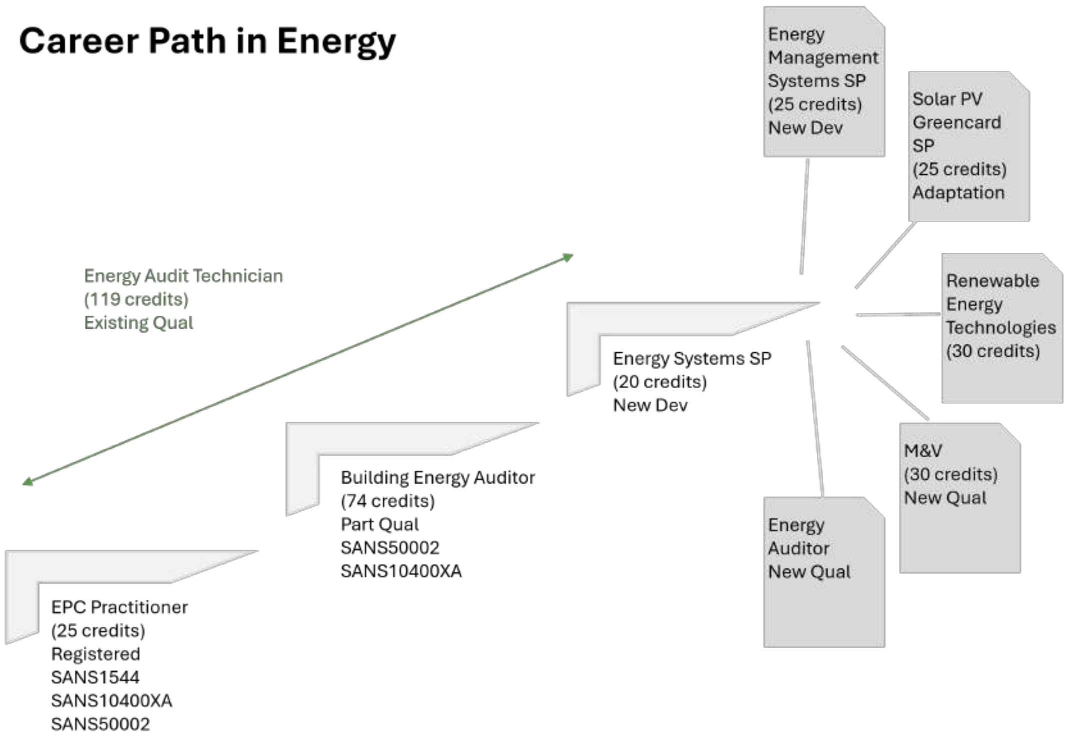
Source: (Mathe and De Lange, 2022).

The data shows that there are a wide variety of service providers for energy efficiency related training from a mixture of sectors from higher education to industry associations. The university offerings are short courses or modules embedded in tertiary qualifications. Some of the programmes are aligned with the formal qualifications identified in the mapping outlined above, whilst others are short courses. TVET colleges also offer a number of courses and qualifications.

As energy efficiency is oftentimes a specialism, training that provides CPD points for engineers to keep up their certification is another mechanism used by various organisations.

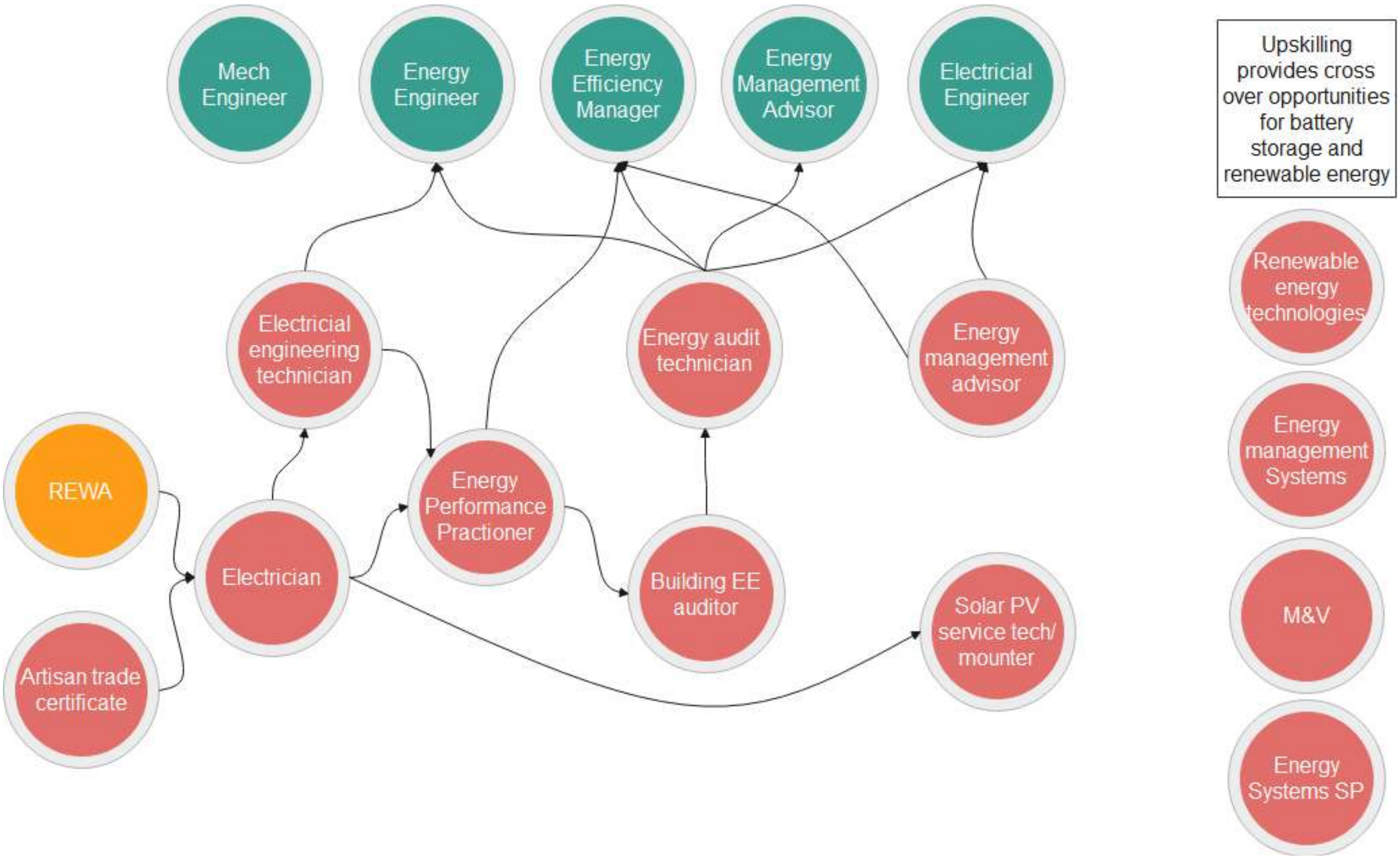
The learning pathways are varied as detailed below as defined by the IAEE, and will depend on the context. If upskilling is required to an existing job that could involve on the job training or a specialist course or qualification, or it could be broader in nature in training entrepreneurs to be business owners including a multiple service offering Energy Service Companies (ESCOs).

Figure 21: Potential career path in energy efficiency and then broader ESCO offerings



The figure above and the qualifications mapping indicates that there are various options for entry into the energy efficiency career path, but also options for diversification or exit into other sectors. The diagram below indicates the potential pathways for energy efficiency under the different context described above. This model aids in identifying the gaps and potential interventions.

Figure 22: Various career and skills pathways in energy efficiency



This multi entry exit model shows that given the variety of different energy efficiency applications and the opportunities to link energy efficiency with renewables and storage, many lateral expansions of knowledge and expertise are possible, as well as upward mobility into high level jobs such as electrical engineering or managerial positions. These would however require quite onerous steps-ups and time commitments in terms of qualifications, particularly for the degree qualifications. Management or management advisor positions may be more attainable with shorter training interventions around finance and HR management etc.

The REWA and artisan trade certificate entry points allow for RPL and open a considerably expanded pathway. The additional diploma qualifications under development will expand the career prospects even further, although many of them are deep specialisations in specific technologies or processes which may constrain the number of future pathways or more lateral moves to be able to then progress. 5.3.10 Learning pathway gaps and interventions

The gaps that were noted in this analysis include the following:

- The demand for energy efficiency skills does not match the issues facing South Africa such as load-shedding, energy price increase and affordability and carbon intensity
- Part of this lack of demand is attributed to the policy environment which has been slow to mandate energy efficiency standards and regulations that would drive the uptake of various technologies and processes.
- Skills pathways are being done in isolation and the

development of ESCOs that are more resilient to market changes by providing a diversity of services are not a focus, although some moves are being made in this direction
- Alignment of the various role player's initiatives is not happening meaning that there could be overlaps and duplication

Proposed interventions include:

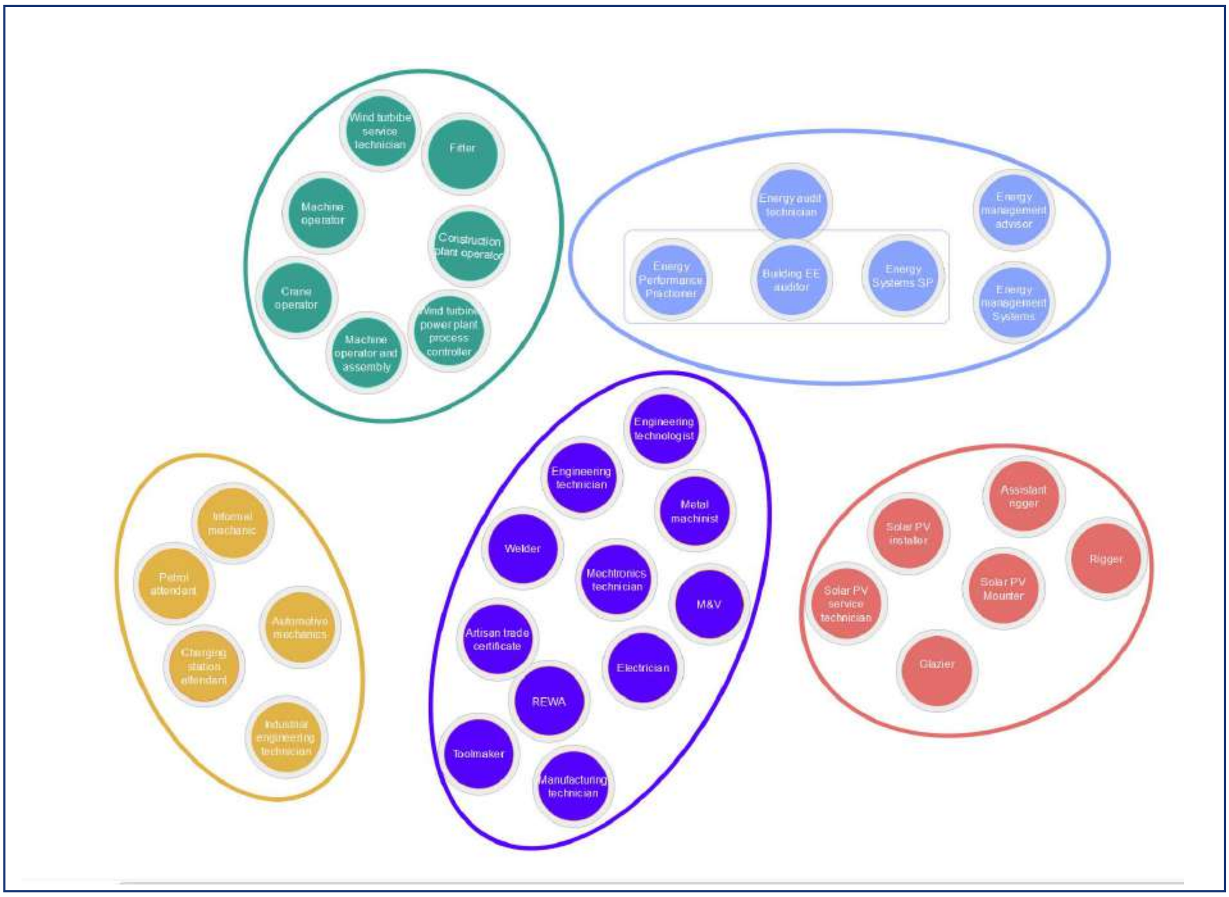
- Developing a programme for SMME ESCO development, building on existing work but adding in other skills such as finance, HR, procurement and soft skills like problem solving and linking energy efficiency, renewable energy and battery storage skills
- Together with DMRE and SANEDI propose an awareness programme for organisations to do energy audits and run a parallel development programme. This could be initially supported through a government procurement programme for government facilities
- Partner with industry associations to fast track energy efficiency qualifications and the use of CPD points to upskill individuals
- Together with the EWSETA, help fast track the Energy Systems skills programme and review and possibly expand it to include energy systems integration, battery installation as well as energy management and optimisation
- Conduct research into the skills required for localising the energy efficiency value chain and the required skills
- Develop a structured programme for electricians to get apprenticeships in organisations focussing on energy efficiency and renewable energy
- Analyse government policy to identify where regulations can scale energy efficiency implementation and map which skills would be required as a result.

5.4 Common learning pathways map

The learning pathways also show some commonalities and differences. If the majority of the occupations that have a pathway connection are mapped then a complex and interconnected picture emerges.

The number of qualifications that are common to all three areas is 11 and could be an area of focus for GIZ going forward. It shows that there is a great deal of overlap and that due to the broadening of job requirements and clusters of jobs emerging, broad-based qualifications are needed that can work across a variety of sectors.

Figure 23: Integrated qualifications analysis for electric vehicles (yellow), renewables (green and red) and energy efficiency (light blue), with dark blue being common to all three.



5.5 Pathways in the energy sector: Collective analysis and insights from the three focus areas

5.5.1 Collective analysis

Policy:

Policy across all three areas is in place but is fragmented and not always fully aligned with each of the three areas and other critical policy interventions, such as South Africa's Nationally Determined Contribution submitted to the United Nations Framework Convention on Climate Change as agreed in the Paris Agreement. Much of the policy is focused on technology enablement and localisation opportunities, with skills developments being allocated to thePSET system or business and little interconnections between the two in terms of planning. Another common issue identified was that policy implementation is slow, a general concern in South Africa.

The EV pathways are developed in a structured and regulated environment, mostly in large companies where individual career paths can be scoped and monitored. Large-scale reskilling and upskilling programmes can, therefore, be designed around a particular manufacturer's technology but also in common areas. In the EV sector, almost all current employees will require skills development, which is being carried out piecemeal with no sectoral-wide strategy.

Solar PV and wind skills development are driven primarily by market demand as the policy has enabled growth in the sector, together with load-shedding, energy price increases and carbon mitigation gaining momentum. As a result, many smaller companies are emerging and much of the training is not linked to formal qualifications. Energy efficiency has been a much slower growth market with regulation and policy pressure lagging behind renewables. Skills demand in this sector is therefore tending towards being latent or at least under potential.

There is a critical need for energy efficiency policy to drive demand and skills uptake.

Institutional architecture:

The institutional architectures of the three areas have many differences, but also some commonalities. The biggest differences are the levels of maturity and regulations between the three sectors with energy efficiency behind the other two in regulation and market growth, EVs being the most regulated and renewables driven by market demand with some relatively new enabling policy. The role players are also different as every energy user is a potential player in the energy efficiency and renewable/battery market, and only a few big manufacturers are producing EVs with limited uptake in SA over the next few years, but expectations that this will increase globally.

All three areas have different levels of integration between the core and the periphery of the industry, with large OEMs in EV (and to a lesser extent renewables) being controlled and directed often from other countries or major metropolitan areas, with the possibilities for enterprise development essentially operating as "markets on the margins". All three areas also have quality and safety issues, which result in linkages to the insurance industry. Government role players are varied, with DMRE and DFFE being common across all three to some degree, but many others also play a role, such as DTIC, DoT, National Treasury, and DHE. The South African Bureau of Standards also plays a critical role in setting standards that can be adopted in local and national regulation.

Other role players in the system include the players in the PSET system, business associations that increase awareness and mediators/funders, including organisations such as the SETAs (a number of different ones given the breadth of scope of the three areas). These bodies potentially play a mediation role (although they cannot generally play this role effectively) in the energy ecosystem between policy developers and businesses, as do municipalities, who are, in many cases, the suppliers of the energy, as well as ensuring regulations and standards are enforced. Their inability to play this mediation role is one of the critical weaknesses of the skills systems.

Therefore, the institutional architecture is quite fragmented, with many moving parts and agendas. Skills provision reflects this fragmentation and the lack of consolidated information, including skills needs.

Value Chains:

All three sectors have complex value chains with a mixture of local and international components. DTIC developed industrialisation and master plan strategies for the EV and renewables sectors to increase the localisation of the value chain, including local component manufacturing. The success of these strategies will impact the skills and occupations required as well as the volumes thereof.

There is little localisation for energy efficiency and battery storage, and thus, there is an opportunity for the country to develop local value chains. However, enabling policy, increased investment in manufacturing plants, and skills development are needed. The Renewable Energy Master Plan includes the mention of battery manufacturing as part of a localisation strategy for the $400bn market expected by 2030 (Mudekwa, 2023).

Bridging into work: Addressing bridging into work is critical as it identifies vital systemic challenges associated with the transition of new learners from high school into the further education processes and then graduates from the learning environment into the workplace.

Bridging into work can be challenging and impacted by various, diverse factors, including not only educational ones but also financial constraints, discrimination and bias, demand for skills, social issues and geospatial issues. In all three areas, it was found that one of the major barriers to entry into the work or education system from high school was the lack of certain critical skills such as basic maths and IT knowledge and expertise. Once in the system, other barriers to bridge into new positions include the quality of the education provisioning and the availability and quality of work integrated learning (WIL) internships, learnerships, artisanships etc. These are critical barriers for learning pathways and oftentimes not recognised (Raelin, 2008).

Labour market context: occupational context:

In all three areas occupations were found not to be discrete but interlinked with many opportunities for horizontal progression (and few opportunities or many barriers for vertical progression) and clusters of occupations available. More attention therefore needs to be paid to families of occupations for example in the EV sector a cluster encompassing a spray painter to a wheel alignment occupation, or the solar PV mounter, solar PV installer and electrician. There are also possibilities for articulation between the informal and shadow economies and the formal industry sector (although this has historically proved very difficult to achieve).

In response to technological and market change upskilling of the occupational family as a whole is therefore required and in some cases upskilling laterally, but across sectors. A clear example here is the case of entrepreneurs starting an Energy Service Company where they offer a variety of services from energy audits and efficiency improvements to Solar PV and EV charging facilities and integration into the household electrical system as customers' needs become more integrated and require a "one stop" service. Oftentimes this means that occupational progression could be from a lower level qualification as part of a series of multi skilling interventions, ultimately leading to a high level qualification. Career aspirations of participants in all three sectors aspire to vertical career progression, aiming for roles that have a higher level of responsibility, authority, or pay scale, but within a similar role or function within the same industry.

Labour market context: occupational change:

Occupational change requires new knowledge shifts. A hybridisation of occupations is sometimes occurring. For example, digital and IT knowledge and systems integration is increasing across all three areas as digitalisation and the interconnected energy ecosystem evolve. This is a cross-cutting shift for many occupations. This is also true of many of the soft skills, where occupations that are customer-facing need new skills around communication and problem-solving. In addition, the policy drive to localise energy and related value chains means that occupations in manufacturing and new technologies such as energy storage will be required. The policy enablers for localisation are varied and are much more advanced in EVs and Solar PV with wind and energy efficiency lagging behind and energy storage in its infancy.

The pace of occupational change requires more agility from the skills system and more economical and efficient expenditure (since almost all employees require some upskilling or reskilling). In addition, small and medium-sized businesses, which make up the bulk of enterprises in the installation, operation, and maintenance of the renewable energy value chain, do not generally engage in formal on-the-job training and do not make use of the skills levy. It also depends on existing demand and how this evolves will depend on the technology, the pace of conversion to new technologies such as EVs and solar and national competitiveness. Solar energy is a much bigger driver than wind energy, given the emerging residential and commercial markets. Electricians must legally sign off installations, requiring a formal certification process. The solar market is becoming increasingly price competitive and there are challenges with quality, necessitating stronger regulation and the increased need for a well-trained workforce. There is an existing demand for energy efficiency, but how long this will last and whether demand will plateau over time remains to be seen. It does, however, appear that the market is beginning to pick up in response to other drivers, such as renewables and energy systems optimisation, management and integration, which are evolving.

In each area, priority occupations emerged that are critical enablers in the learning pathways. Some of these, like electricians, are common across the three areas. Still, others are specific, like energy auditors, which are linked, in some cases, as a precursor to solar PV installations. Interventions should focus on these priority occupations to unlock some of the constraints and barriers.

Implications for Skills Planning:

The complex and changing nature of the labour market raises several challenges for effective skills planning. Effective skills anticipation relies on reliable occupational data that keeps track of labour market trends. Planning for skills development necessitates agile institutional conditions that recognise and respond to emerging skills demands. South Africa falls short in both of these areas in that the occupational data is not collected in a manner that accurately reflects the realities of the labour market. The various institutions that are established to drive the planning of skills development are limited in their ability to fully understand the demand for skills, particularly in SMMEs and the informal economy.

As such, skills planning in South Africa tends to take a highly static and aggregated approach, limiting the capacity of the skills system to offer young people meaningful pathways to employment and career progression within emerging green and digital sectors, and different geographical localities. Invariably, the public education and training system falls behind in providing demand-led skilling as the private sector takes up the immediate opportunities offered by these emerging and rapidly evolving sectors with more speed and agility. The skills system needs to be equipped with better tools and capacity for measuring and monitoring labour market demand, and this needs to be used to better guide expansive and inclusive skilling.

Provisioning and qualifications:

Given the regulated nature of the EV sector, there is some data on enrolment and numbers of people being trained and for which qualification. The renewables and energy efficiency sectors have less regulation, and few public education and training institutions are offering specific programmes in this regard. Thus, the data is not as readily available, and even if it is, there is some information on tracer studies as to which trainees get jobs and where. The SETAs have done some work in this regard but are fragmented and time-bound. Therefore, there is a significant gap in credible data to allow adequate provisioning planning.

Labour market signals and qualitative data suggest a shortage of skills for emerging occupations, particularly at the higher levels. Pockets of excellence exist in the higher education system, and there is a concerted effort under the National Digital Skills Strategy to grow these across the skills pipeline. Schools have introduced coding at the basic education level; teacher development and ITC infrastructure are being expanded; robotics and additive manufacturing are being integrated into TVET and higher education provision; and various industry councils have been established under the Presidential Commission on 4iR.

Overall, there is an adequate supply of traditional energy qualifications at all levels (the number of qualifications, not the number of graduates) across the three areas. However, the pipeline for the trades cluster is not producing enough graduates, for example, automotive mechanics.

It is, however, the case that in all three areas, the transitioning occupations are where substantial new skill sets will be needed and where education and training providers will need to update and recertify curricula and qualifications to reflect this. This is a delicate balance between introducing new areas and market demand for those skills. What is missing is the inclusion of some new technologies or approaches e.g. energy systems management and recognition of the need for multi-skilled individuals or clusters of interrelated occupations. As a result the need for provisioning on new qualifications and training for occupations that understand and manage a plethora of energy issues are emerging, e.g. the energy manager or the energy system manager which may not be all technical and will include a number of other soft and technical skills such as problem-solving and finance or procurement. Currently, educational provisioning consists of multiple training interventions, instead of a comprehensive and coordinated offering, which can be done in its entirety or as individual skills offerings. In other words, learning pathways for some occupations are not at this stage codified into qualification frameworks, e.g. EVs and energy efficiency. There is an increasing shift toward micro-credentialing strategies (e.g. EVs) based on generic qualifications in some cases.

For EVs, the educational provisioning response for auto mechanics at Community and Technical Vocational Education and Training (TVET) Colleges appears adequate, and the OEMs all have their own in-house training programmes. However, this is spatially uneven - colleges not located near manufacturing hubs do not benefit from the infrastructure, teacher training or workplace experience in the same way as those that are. TVET Colleges are gearing up for the delivery of Solar PV qualifications, but only a few have the necessary infrastructure and capacity to achieve accreditation and deliver these programmes. Investment in institutional development needs to be carefully considered to deliver optimal results. The development of skills must speak to local demand, and TVET colleges, in some cases, are not responding to nor providing appropriate training for current and future local demand, e.g. the Northern Cape, where the local TVET college provides no solar training. The skills pipeline from basic education is also poor. This impacts the throughput of students in the relevant courses at the tertiary education level.

In all three areas, there is a proliferation of short courses and, in some cases, concerns about the quality of the training and or whether the legal requirements are being enforced. For example, an electrician is required to sign off on a solar PV installation, but anecdotal evidence indicates that this is not always the case. In many cases short courses do not provide a certified qualification or training intervention and the accreditation of providers appears to be problematic. This can have a significant impact on learning pathways as a barrier to getting to the next career step.

Electricians and engineering technicians are key pivot points or bridges into work and the bigger pathways landscape, with many options available in all three sectors, primarily through skills programmes, short courses, and some qualifications. They do, however, struggle with the compulsory learnership required to become a certified electrician or to bridge graduates to professional registration, as companies do not or cannot take enough learners, resulting in many being unable to finish their qualifications. There are also insufficient funds for this bridging and a lack of experienced mentors, impacting the quality of learning.

Pathway enablers:

Enablers for entry into the energy sectors include foundational education, specialised training programmes, mentorship, and technical expertise. Basic safety training, technical courses, and hands-on experience are crucial in preparing individuals for roles within the industry. Work-integrated learning strategies should be prioritised in this context to enable bridging into work.

Motivations for an individual entering the energy sector include the emerging career opportunities presented by the transition, the growing emphasis on sustainability and energy efficiency driven by policies and environmental concerns, fascination with emerging technologies, economic considerations such as job stability, and familial connections within the industry. External factors such as load shedding and the impact of the COVID-19 pandemic also influence career decisions.

Pathway constraints and barriers:

There are unqualified participants in the informal sector, and RPL programmes and top-up training are needed to bring them into the formal sector. It is particularly difficult to transition these participants given some technology changes, e.g., the shift from ICE to EVs. Participants in all three sectors face challenges with the adequacy of training programmes, with some expressing dissatisfaction with the level of practical, hands-on experience and the emphasis on specific brand/product training over comprehensive industry-wide knowledge. Moreover, participants in all sectors emphasised the lack of soft skills. Participants encounter challenges related to job insecurity, financial constraints, safety concerns, communication issues, and teamwork issues. Moreover, the precarious nature of project-based jobs and the need for continuous upskilling, given the rapid technological advancement, create a high degree of uncertainty.

Common barriers to career advancement include additional upskilling, the necessary years of experience in the sector, financial limitations, and time constraints. Participants also face challenges related to limited access to resources, mentorship for professional development, and opportunities for practical training. The absence of structured internship programmes and mentorship within companies further impedes skill development and career progression. The lack of mentorship at all stages of career progression, particularly during early stages and internships, was highlighted as critical. In addition, the mentorship quality required attention, with mentors possibly requiring retraining on new methodologies and technologies. Incentives to be a mentor and be mentored may also need investigation.

Occupational progression:

EV, energy efficiency, solar and wind sectors attract individuals with engineering backgrounds, particularly in electrical and mechanical engineering, ranging from Higher certificates to National Diplomas. These participants commonly transition from various technical roles into energy-related positions, drawing from backgrounds in electrical work, mechanical fitting, and other technical fields. The transition often involves acquiring new skills, mostly on the job and adapting to the specific requirements of the renewable energy sector. However, in the solar and wind sectors, participants without engineering backgrounds transition into the industry by acquiring specialised short courses relevant to the sector with limited opportunities for career progression.

Participants made a combination of horizontal and vertical job moves in all three sectors. In both the solar and wind sectors, participants made horizontal job moves, e.g. solar installer to solar technician. In the energy efficiency sub-sector, some participants made vertical job moves e.g. moving from EPCP to energy manager. Not unexpectedly, participants in all three sectors aspire to vertical career progression; they aim for roles with a higher level of responsibility, authority, or pay scale but within a similar role or function within the same industry. However, this poses challenges, given the considerable training required to move vertically. An Energy Management Systems qualification is a bridge for vertical career progression in the energy efficiency sector.

These nascent industries are, therefore, already witnessing multiple entry points into, and mobility points within, learning pathways across the value chains, particularly from an upskilling and reskilling point of view. This is an important element of the just transition and the skills system should create enabling conditions for flexible entry and progression. It is necessary to take cognisance of these multiple entry points to make it easier for curriculum planning and provisioning and to enable inclusive access for those particularly affected by the shifts in labour market demand due to the decarbonisation of carbon-intensive value chains.

5.5.2 Overarching insights from analysis - learning pathway enablers and barriers

Enablers and barriers are often different sides of the same coin, depending on whether they are in place. These issues that can be enabling or constraining include the following:

- Level of foundational education in STEM (primarily) subjects for technical jobs
- Uncertainty in demand due to either a lack of policy (or strategy eg localisation)
- Pace of implementation, impacting market entry or career progression and certainty of work duration for short-term/project-based jobs
- Legislating qualifications for compliance reasons that need government support to ensure accessibility
- Accessibility and quality of required educational provisioning including slow progress in updating and recertifying curricula and qualifications for specialised training programmes including upskilling for rapid technology advancement and other changes
- Quality and knowledge of academic staff
- Provision of infrastructure in education institutions (including IT in education institutions).
- Availability of RPL programmes
- Availability and quality of mentorship
- Availability and quality of hands-on experience including incentives for certification of formal, recognised on-the-job training, learnerships etc.
- Limited access to structured internship programmes and opportunities for compulsory learnerships for certification
- Knowledge of issues such as basic safety training and specific brand/product training required in some sectors
- Lack of soft skills impacting the pace of progression
- Financial constraints impacting time taken for career progression
- Opportunities for vertical career moves as when vertical progression takes place it is generally into managerial positions rather than technical ones
- Availability of time for training
- Need for multi-skilled individuals or clusters of interrelated occupations

6. PROPOSED INTERVENTIONS FOR GIZ

6.2 Summary of Interventions

The analysis of the pathways reveals the need for formalised, transversal or integrated interventions. The interventions were originally proposed per sub-sector:

Table 29: Summary of proposed interventions per sub-sector

Category	Interventions EVs	Interventions for RE and battery storage	Interventions for energy efficiency
Policy	Engage ECSA and other bodies on elaborating relevant technician categories Increase funding for candidate support and other forms of work-integrated learning	Develop a strategy for supporting entrepreneurship and SMME development. Support the development of policy to better regulate quality and compliance in RE installations	Analyse government policy to identify where regulations can scale energy efficiency implementation and map which skills would be required as a result Update of the current strategy
Institutional architecture	Promote increased collaboration between industry associations across value chain segments in relation to skills	Partner with the insurance industry and industry associations to promote and support increased quality through enterprise and skills development	Partner with industry associations to fast-track energy efficiency qualifications and the use of CPD points to upskill individuals
Value chain	Increase focus on circularisation (many more pro-poor jobs in this space)	Support development of business cases for investment in local manufacturing within the RE/Battery value chain for emerging black-owned enterprises	Develop an energy efficiency commercialisation strategy together with DTIC for enablers required for localising the energy efficiency value chain and the required skills and understand why this is not being done at present and export strategies e.g. cars
Bridging into work	Focus SETA bridging-into-work grant categories (WIL, internships, learnerships, artisanships) on priority occupations. More carefully quality assure these through e.g. reflective learning structured activity logbooks rather than work attendance records, to ensure learners gain relevant work		

Category	Interventions EVs	Interventions for RE and battery storage	Interventions for energy efficiency
Labour market	Increase efforts to upskill, qualify and formalise informal sector mechanics to address spatial dimensions of inequality. Take a stronger gender and disability focus in existing formal sector interventions.	Conduct a detailed mapping of the demand for RE skills across geographic localities and the institutional capacity and requirements to deliver on these at a localised level, including resourcing, accreditation etc. This can support more targeted interventions to gear up skills institutions (particularly TVET Colleges) to deliver on these skills (whether for reskilling, upskilling and skilling of new labour market entrants).	
Provisioning and qualifications	Build capacity at TVET and HEI level to address professional bodies not accepting some qualifications (or de-register these institutions) Fund a coordinated approach to the review of engineering technician programmes to ensure better alignment with emerging skills priorities Increase multidisciplinary collaborations for emerging occupations Sustain enrolments and graduation of relevant trades as there is currently a sufficient pipeline Accredit workplaces to deliver candidate support across technician categories	Develop a strategy for recognising and upskilling people working in relevant trades to create a pool of formally skilled individuals that can adapt and engage in opportunities emerging through the RE value chain. This can be achieved through RPL and ARPL across key sectors where large number of individuals are working but are not formally skilled This also includes strengthening the PV Green Card to give it more substance and formal recognition for electricians who wish to enter and compete in the Solar PV industry Together with EWSETA, develop a qualification for renewables waste recycling – particularly solar PV waste	Together with the EWSETA, help fast track the Energy Systems skills programme and review and possibly expand it to include energy systems integration, battery installation as well as energy management and optimisation

Category	Interventions EVs	Interventions for RE and battery storage	Interventions for energy efficiency
Pathway enablers	Provide more formal pathway mapping within families of occupations; and between skills programmes and full qualifications within each family	Do a research project on the skills and jobs required for the localisation of battery manufacturing in South Africa in alignment with the TIPS study on "Opportunities to develop the lithium ion battery value chain in South Africa" report in the following identified areas: 1. Mineral refining; 2. Cell manufacturing; 3. Battery manufacturing and assembly; 4. Battery recycling.	Develop partnerships for awareness programmes so organisations can do energy audits and run a parallel development programme. This could be initially supported through a government procurement programme for government facilities Develop a programme for SMME ESCO development, building on existing work but adding in other skills such as finance, HR, procurement and soft skills like problem solving and linking energy efficiency, renewable energy and battery storage skills
Pathway constraints	Incentivise workplaces through funding and mentors through CPD system to promote increased work-based learning		

Cross-cutting interventions are also recommended:

- Support the development of effective skills planning systems by developing a common language for occupations in the emerging value chains that allow for more coherent measuring and monitoring of demand and ensuring sufficient buy-in and capacity within key SETAs to embed this in their planning and resourcing life cycles.
- Develop an energy skills provision atlas for South Africa that builds on the mapping suggested above, consolidates all the available energy-related qualifications in the country in one place, and provides a planning and tracking mechanism for monitoring interventions.
- Engage the various "frontier technology" councils (e.g. the AI Council, the IOT Council) around building skills pipelines into the energy sector and develop digital skills intervention strategies for the next 5 years to be included in current curricula and upskilling programmes to equip new and current workers and entrepreneurs.
- Incentivise mentoring of technicians and trades workers through recruiting retired mentors; increasing the number of CPD points that can be earned through mentoring; and embedding a requirement for mentoring into service provider contracts (where appropriate). This must include training of mentors in new technologies and approaches.
- Bridging programmes for maths, soft skills, basic science, IT basics
- TVET lecturers upskilling - a different approach, giving them practical experience and incentivising them to include new material and getting SME training as part of the course ie over and above the theory
- Review qualifications to minimise and consolidate to give broad-based learners more flexibility in career paths. For example, in energy efficiency qualifications should cover a broad range of equipment and not be narrowly focussed on one element such as pumps

- Assessing opportunities for the circular economy

6.2 Assessing the intervention through various lenses

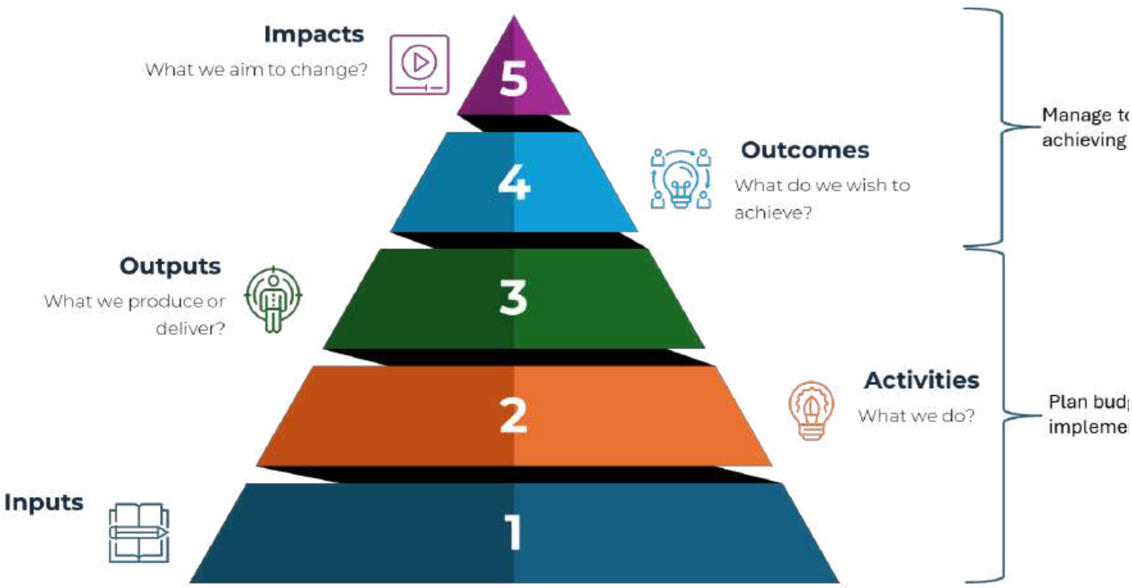
The interventions were assessed through various "lenses" to determine which would have the biggest impact over the next five years.

6.2.1 Lens of policy objectives

National policy in the three sectors is defined precisely (in the case of Electric Vehicles), emergently (in the case of Renewable Energy), and incipiently (in the case of Energy Efficiency). However, the Energy Efficiency and Renewable Energy industries preceded Electric Vehicles and are further advanced (this accounts for the limited qualitative data on Electric Vehicle pathways). The weaker quantitative data in Renewable Energy and Energy Efficiency is because these sectors are more diffuse and less regulated and organised, whereas the stronger quantitative data in Electric Vehicles is because the automotive sector is highly organised, regulated and contained.

This has impacted the level of delicacy achieved in the study. The study "backcasted" from (as yet, not always fully defined) policy objectives. A diagram from the Treasury Framework for Managing Programme Performance Information summarises how the interventions should be used to plan, budget and manage the skills development toward achieving these policy objectives.

Figure 24: Managing Interventions toward Impact



Source: Framework for Managing Programme Performance Information (2015).

Tables 30-32 below illustrate how interventions proposed for each sub-sector should be planned, budgeted and managed to achieve the policy objectives.

Table 30: Interventions in terms of policy objectives for EVs

Engineering Technician Cluster (EVs)		
Inputs		a. Automotive specialisations in Discipline-Specific Guides for engineers employed in the automotive industry are elaborated (mechanical engineers, electrical engineers, industrial engineers, software engineers…). b. Funding for candidate support is increased c. Automotive companies are accredited to provide candidate support d. Retired (or other) engineers are recruited to mentor candidates
Processes		a. Automotive engineering technician candidates are provided with supervised workplace experience
Outputs		a. Reduced % of candidate engineering technicians registered for longer than 3 years b. % increase in professionally registered previously disadvantaged engineering technicians
Outcomes		a. % increase in engineering professionals employed in automotive companies
Impacts		a. Masterplan targets are achieved in relation to localisation, transformation, production and export.

Table 31: Interventions in terms of policy objectives for Renewables

Trades Cluster, Electricians (RE)	
Inputs	a. Detailed map of demand in different parts of the country b. More detailed map of pathways within/across families of occupations c. Improved regulation of compliance in RE installations d. TVET lecturers are upskilled
Processes	a. ELCONOP support programme is delivered
Outputs	a. % increase in qualified, skilled RE staff in trade categories
Outcomes	a. 49 700 new staff employed in RE (Present Energy Scenario) are skilled and qualified b. BBBEE industry scorecard reflects transformation charter commitments
Impacts	a. SAREM targets in relation to inclusive industrial development are achieved

Table 32: Interventions in terms of policy objectives for energy efficiency

EE Cluster	
Inputs	a. Partnerships to increase awareness of EE are established b. EE industrial policy is updated, and the skills required have been identified c. A strategy for commercialising EE is in place d. Pathways within and between families of occupations are detailed
Processes	a. Bridging into work programmes are established and improved
Outputs	a. % increase in number of learners graduating each EE occupation b. % increase in PDI learners graduating
Outcomes	a. % increase in the number of EE graduates employed per sub-sector
Impacts	a. % improvements in EE implementation per sub-sector

The lens is intended to show that "demand-led" skills policy relies on clearly defined areas of demand. Given policy uncertainty and the extensive "latent demand" in each sector, this study has suggested interventions that are likely to serve the policy objectives that seem to be emerging. As policy is clarified and projects initiated, it will be important for interventions to be shaped, planned, budgeted, managed, and monitored/evaluated to achieve these.

In the case of EVs, as component manufacturing areas are agreed upon, candidate support and work-based learning should focus on the trades and engineering technicians required to manufacture these. Similarly, RPL targets and interventions should be embedded within initiatives such as the Chamdor Hubs.

In the case of Renewable Energy, the map of demand in specific locations should be the focus of upskilling TVET lecturers and delivering the ELCONOP programme.

Regarding energy efficiency, training, work-based learning, and enterprise development should focus on the specific subsectors and locations where energy efficiency awareness programmes and commercialisation strategies are implemented.

This point is worth emphasising because once targets are cascaded to SETA strategies (for example), they have sometimes been achieved through more generic approaches rather than strategically focused capacity-building partnership arrangements.

6.2.2 Lens of time

The interventions were firstly consolidated where appropriate and then mapped in terms of their implementation (starting) timeframes as outlined in the table below. The analysis showed that the three technical areas overlapped a great deal regarding solutions for enabling learning pathways, albeit with a different focus in some cases.

Allocations 33: Allocation of proposed interventions into short, medium and Long term for completion

Short term (1 year)	Medium term (2-3 year)	Long Term (3-5 years)
Engage ECSA and other bodies in elaborating relevant technician categories • Elaborate automotive specialisations in the Discipline-Specific Training Guidelines for engineering occupations employed in the automotive industry Increase capacity for candidate support and other forms of work-integrated learning. • Increase funding for candidate support • Solicit participation from automotive employers in candidate support programmes	Review and engage government on policy to • Better regulate quality and compliance in RE installations • Identify where regulations can scale energy efficiency implementa-tion and map which skills would be required as a result • Update of current energy ef-ficiency strategy Work with government to develop new strategies in the following areas: • An energy efficiency commercialisation strategy together with DTIC • Strategy for supporting JET entrepreneurship and SMME development including ESCOs adding in skills such as finance, HR, procurement and soft skills like problem-solving and linking energy efficiency, renewable energy and battery storage skills • Strategy for recognising and upskilling people working in relevant trades to create a pool of formally skilled individuals • Do a research project on the skills and jobs required for the localisation of battery manufacturing in South Africa	Engage the various “frontier technol-ogy” councils (e.g. the AI Council, the IOT Council) around building skills pipelines into the energy sector and developing digital skills intervention strategies for the next 5 years Review of qualifications to minimise and consolidate to give more broad-based learners that have more flexibility in career paths, for example in energy efficiency qualifications should cover a broad range of equipment and not be narrowly focussed on one element such as pumps

Short term (1 year)	Medium term (2-3 year)	Long Term (3-5 years)
.Increase capacity for candidate support and other forms of work-integrated learning • Increase funding for candidate support • Solicit participation from automotive employers in candidate support programmes . Promote increased collaboration between industry associations and the insurance industry to: • Promote and support improved quality through enterprise and skills development . Conduct a detailed mapping of the demand for RE skills across geographic localities and the institutional capacity and requirements to deliver on these at a localised level . Accredit workplaces to deliver candidate support across technician categories . Provide more formal pathway mapping within families of occupations (including skills programmes and full qualifications . Develop partnerships for awareness programmes so organisations can do energy audits and run a parallel development programme supported by a government procurement programme . Develop bridging programmes for maths, soft skills, basic science, IT basics . Support DHET in the development of more agile skills planning systems through developing a common language and piloting skills anticipation mechanisms for occupations in the emerging value chains to support SETAs and industry associations	**. TVET lecturers upskilling - a different approach:** • Giving them practical experience • Incentivising them to include new material in particular in relation to emerging skills • Including SME training as part of the course ie over and above the theory • Integrating energy-related skills into the National Digital Skills Strategy	

Short term (1 year)	Medium term (2-3 year)	Long Term (3-5 years)
• Use the outcomes of the above bullet point as input into a JET Skills Atlas. This Atlas would not just be a list of occupations but rather begin to detail the plethora of different pathways and high-light areas where . Review the value chains to increase focus on circularisation and promote initiatives to increase circularisation in the waste economy, e.g. recycling of tyres and other waste material		

The lens of time indicates that some of the more systemic issues, such as building foundational skills, changing policy, and evolving qualifications to allow better career progression, will take longer to complete, but some critical enablers must be addressed in the short term. These shorter-term interventions include partnering with others to avoid duplication, increasing funding to existing initiatives, and working on mentoring. These will increase impact and replicate success stories.

A skills atlas that starts to reflect some of the issues transforming the skills ecosystem, such as the broadening and clustering of occupations and the need to upskill these clusters, will set the foundation for future work on alignment with the OFO system and the review of qualifications needed to ensure better opportunities for career progression.

Emerging skills will also evolve over time, so continual reassessment and new qualifications are necessary. In the medium to longer term, if some of the foundational issues are addressed, new policy will help drive demand for skills, and upgrading educational provision and the institutional capacity to manage this will upgrade the quality of education.

6.2.3 The lens of addressing pathway barriers

When all the research was assessed, a set of pathway barriers and enablers were identified. If the system is to operate more effectively these will need to be addressed. If the interventions are mapped against the learning pathway barriers and/or enablers, the following picture emerges for the short, medium and long term.

Table 34: Mapping of interventions against pathway barriers and/or enablers for the short term

	Proposed Short term interventions									
Barriers or Enablers	Engage ECSA and other bodies	Increase funding for candidate support	Promote increased collaboration	Conduct a mapping of the demand for RE (Renewable Energy) skills	Accredit workplaces to deliver candidate support	Provide pathway mapping within families of occupations	Develop partnerships for EE awareness programs	Develop bridging programs	Support DHET for more agile skills planning systems	JET Skills Atlas
Level of foundation education in Stem (primarily) subjects for technical Jobs										
Uncertainty in demand due to either a lack of policy (or strategy eg localisation										
Pace of implementation, impacting market entry or career progression										
Legislating qualifications for compliance reasons that need government support										
Accessibility and quality of required educational provisioning										
Quality and knowledge of academic staff										
Provision of infrastructure in education institutions										
Availability of RPL programmes										
Availability and quality of mentorship										
Availability and quality of hands-on experience										
Knowledge on issues e.g. basic safety and specific brand/product training										
Lack of soft skills impacting pace of progression										
Financial constraints impacting time taken for career progression										
Opportunities for vertical career moves										
Availability of time for training										
Need for multi-skilled individuals or clusters of interrelated occupations										
Outcome	4	6	6	2	6	2	3	4	7	4

Table 35: Mapping of interventions against pathway barriers and/or enablers for the Medium term

Barriers or Enablers	Proposed medium term interventions									
	Better regulate quality and compliance in RE installations	Identify where regulations can scale EE implementation	Update of current EE strategy	EE commercialisation strategy	Strategy for supporting JET SMME development	Strategy for recognising and upskilling in relevant trades	Research project on localisation of battery manufacturing	Fast track the Energy Systems skills programme	Qualification for renewables waste recycling	Incentivise mentoring to increase work-based learning
Level of foundation education in Stem (primarily) subjects for technical Jobs										
Uncertainty in demand due to either a lack of policy (or strategy eg localisation)										
Pace of implementation, impacting market entry or career progression										
Pace of implementation, impacting market entry or career progression										
Accessibility and quality of required educational provisioning										
Quality and knowledge of academic staff										
Provision of infrastructure in education institutions										
Availability of RPL programmes										
Availability and quality of mentorship										
Availability and quality of hands-on experience										
Knowledge on issues e.g. basic safety and specific brand/product training										
Lack of soft skills impacting pace of progression										
Financial constraints impacting time taken for career progression										
Opportunities for vertical career moves										
Availability of time for training										
Need for multi-skilled individuals or clusters of interrelated occupations										
Outcome	6	4	3	1	13	13	1	6	4	11

Table 36: Mapping of interventions against pathway barriers and/or enablers for the Long term

Barriers or Enablers:	Engage the various "frontier technology" councils	Review of qualifications to minimise and consolidate to give more flexibility
Level of foundational education in STEM (primarily subjects for technical jobs)	Proposed Long te	
Uncertainty in demand due to either a lack of policy (or strategy e.g. localisation)		
Pace of implementation, impacting market entry or career progression		
Legislating qualifications for compliance reasons that need government support		
Accessibility and quality of required educational provisioning		
Quality and knowledge of academic staff		
Provision of infrastructure in education institutions		
Availability of RPL (Recognition of Prior Learning) programmes		
Availability and quality of mentorship		
Availability and quality of hands-on experience		
Knowledge on issues e.g. basic safety and specific brand/product training		
Lack of soft skills impacting pace of progression		
Financial constraints impacting time taken for career progression		
Opportunities for vertical career moves		
Availability of time for training		
Need for multi-skilled individuals or clusters of interrelated occupations		
Outcome	9	13

The following interventions contributed to addressing the highest number of barrier/enablers (6 or more).

Table 37: Interventions that address the highest number of pathway barriers and/or enablers

	Short	Medium	Long
Intervention	Increase funding for candidate suport	Better regulate quality and compliance in RE installations	Engage the various "frontier technology" counsils
	Proomote increased collaboration	Strategy for supporting JET SMME development including ESCOs	Review of Qualifications to minimise and consolidate to give more flexibility
	Accredit workplaces to deliver candidate support	Strategy for recognising and upskilling in revevant trades	
	Support DHET for more agile skills planning systems	Fast track the Energy Systems skill programme	
		Incentivise mentoring to increase work based learning.	

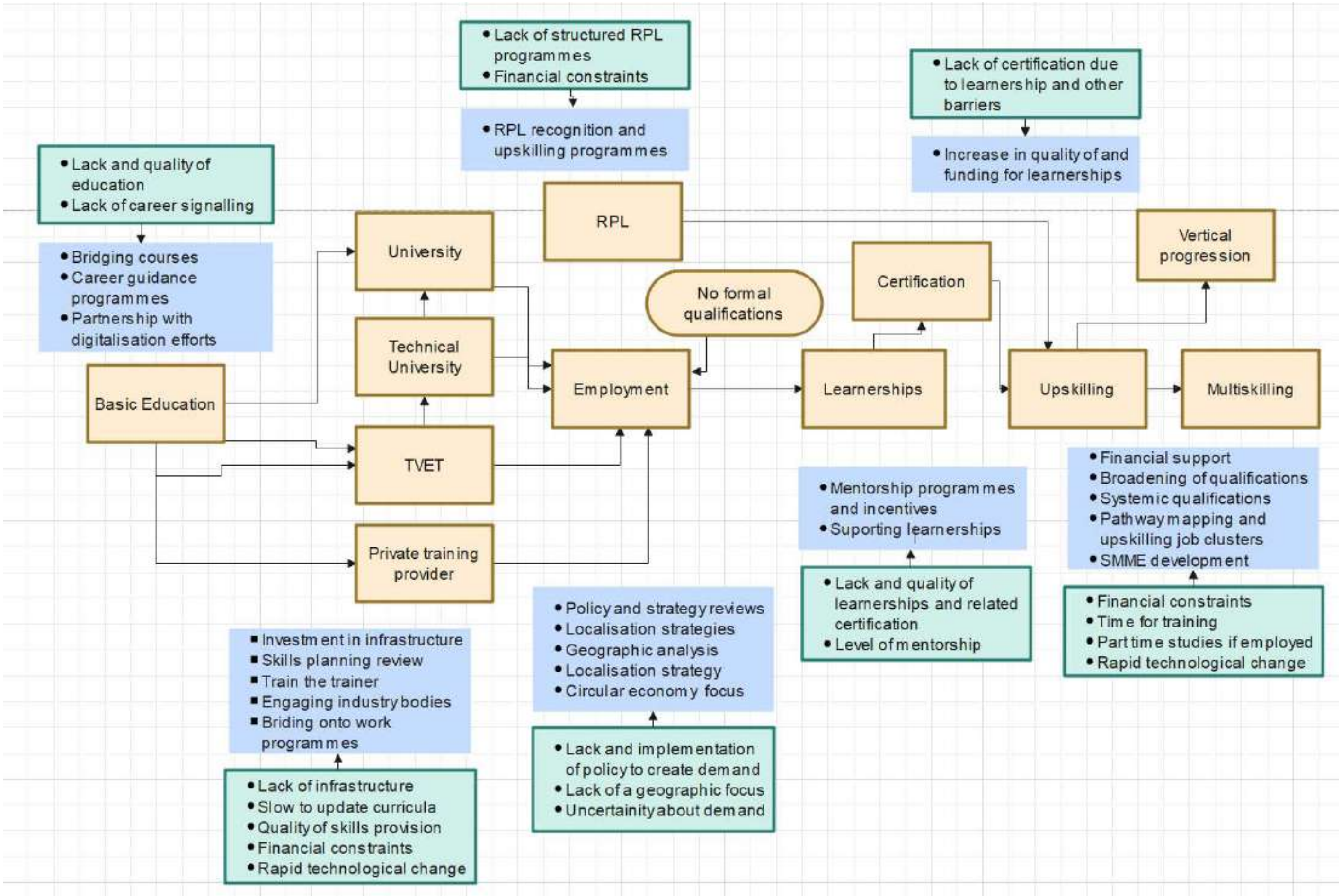
The interventions assessed to have the highest potential to address barriers include supporting a more agile skills planning system, increased collaboration, supporting SMMEs and supporting work-based learning in various forms. The need to address the qualifications system and optimise qualifications to not only be future-proofed but multidisciplinary will also contribute significantly to learning pathways agility and appropriateness for South Africa's economic context.

Again the need for a variety of interventions that address the system is evident.

6.2.4 The lens of where in a career progression the interventions would be applied

For this analysis, the barriers identified above were overlaid onto the career progression process, and the interventions were mapped to match the point in the pathway where they would be applied.

Figure 25: Mapping of career progression pathway with barriers and interventions (green indicates barriers and blue interventions)



This lens firstly showed some gaps where there were no interventions, for example, the need for career signalling and RPL support. Given the socio-economic challenges in South Africa, these are critical issues that will allow many unemployed people or employees with much more potential to study in areas where there is demand for their skills, find decent work if they are unemployed, and then progress in their careers.

Secondly, it showed that some of the barriers are common across a number of points in the career progression pathway, such as financial constraints and the quality of the steps in the process. Some of these barriers are critical to progression in the JET sector, given the rapid pace of technology change and the need to upskill and reskill as these technologies are adopted at scale.

Lastly, it reflects the interconnectedness of the system and reinforces the importance of addressing the system as a whole and not individual elements, which may have successful outcomes when looked at in isolation but not contribute to the transformation of the system. For example, if the education providers are assisted in improving infrastructure and the quality of their education and financial support is given to students, but the students cannot meet entry-level requirements due to an inadequate basic education system, then the effort is wasted. The complexity also significantly impacts skills planning and the need to develop more robust, agile and resilient planning processes that can timeously adjust to change.

6.3 Consolidated analysis and recommendations

It was noted that the interventions coalesced around the following issues:

- Policy and national strategy
- Qualification reviews to develop more broad-based qualifications that allow flexibility in career pathways
- Upskilling and supporting TVET lecturers/infrastructure
- Supporting mentorship and work-based learning
- Bridging interventions to aid in entry into the pathways but also progression
- Collaboration across various industry players to increase impact
- Future proofing qualifications in recognition of the fast-changing technology landscape

To develop the recommendations, these clusters of interventions were assessed against a set of principles. The principles around which the prioritisation of effort and focus was done were that interventions should:

- Not duplicate existing effort, but rather build on and amplify it and support collaboration and partnerships
- Align and support JET IP efforts as a major strategic driver for the country
- Focus on the system rather than the individid-ual components, as it is the pathways that are important
- Be able to provide impact

Noting that the JET IP skills chapter makes a series of recommendations as follows:

- Establishment of a three-tier JET skills ecosys-tem to coordinate and align JET skills activities across multiple institutions and stakeholders, in alignment with the Department of Higher Ed-ucation and Training's (DHET's) national Skills Master Plan 2030
- Establishment of Skills Development Zones (SDZs) (local learning networks) focused on three core value chains: in Mpumalanga (renewable energy and transmission); in the Eastern Cape (EVs); and the Northern Cape (GH2), anchored in local education institutions in part-nership with business to support community and local economic development initiatives
- JET skills needs assessments for each of these three core JET value chains and the implica-tions for tertiary education institutions JET capacity development for government and key government institutions
- Support for foundational skills development involving upskilling teachers and integrating sustainable energy concepts into school curric-ula
- Using these principles, the various clusters of interventions and the insight gained through the various lens analyses, the following recommendations are made:

No	Recommendation	Intervention cluster addressed	Justification
1	Give impetus and guidance to the JET IP activities around skills, such as the JET IP Desk which is currently being set up using the high-level framework of interventions	. Policy and national strategy . Collaboration across various industry players to increase impact . Future proofing qualifications in recognition of the fast-changing technology landscape	The framework can be used to ensure that a transformative approach is taken, where the ecosystem is unblocked in key areas to allow better career progression. The National JET Skills Advisory Forum can be utilised to give input and guidance to the proposed strategy interventions
2	Support the increase in quality of educational provisioning by doing a systems-led series of pilot programmes to work with TVET colleges, businesses and SETAs to upgrade and support as well as bridge into work and ensure learnerships and certification	. Upskilling and supporting TVET lecturers/infrastructure . Supporting mentorship and work-based learning . Collaboration across various industry players to increase impact . Future proofing qualifications in recognition of the fast-changing technology landscape	This will allow GIZ to be the convenor of several efforts and pull together funding and leanings that can be replicated. It can link to the SDZ envisaged in the JET IP skills chapter and help establish and support them where appropriate. It encourages a demand-led skills approach
3	Support an expanded and coherent RPL	. Bridging interventions to aid in entry into the pathways but also progression . Collaboration across various industry players to increase impact	This is a significant barrier to entry for many South Africans and requires a focused approach that makes RPL more accessible, affordable, and developmental in nature. This will have a significant transformative effect on the ability of young people and adults, particularly those in township communities, to gain recognition for their skills, become more mobile in the labour market, open opportunities for income generation, and progress towards a trade qualification. There are intrinsic challenges with RPL, but at least some of these lie in the models of RPL that have been attempted (largely influenced by poor assessor training). Other models piloted in SA and elsewhere are better suited to address the challenge.

No	Recommendation	Intervention cluster addressed	Justification
4	Partner with the Digital Skills Strategy	. Bridging interventions to aid in entry into the pathways but also progression . Collaboration across various industry players to increase impact . Future proofing qualifications in recognition of the fast-changing technology landscape	The first Digital Skills Implementation Plan ends in 2025. Engaging now with implementation planning for 2026-2030 provides an efficient mechanism for systemic inclusion of the JET skills priorities from basic education through TVET to universities.
5	Through the JET IP Skills Desk and Advisory Forum begin to review the qualifications framework and approach required for JET skills and skills clusters which starts with the development of a JET Skills Atlas	. Qualification reviews to develop more broad-based qualifications that allow flexibility in career pathways . Upskilling and supporting TVET lecturers/infrastructure . Collaboration across various industry players to increase impact . Future proofing qualifications in recognition of the fast-changing technology landscape	This will address the barriers of financial requirements for continual retraining and upskilling due to technology changes. It can also provide the basis for developing training for job clusters and for SMMEs where a variety of skills may be needed. It can also address the OFO alignment issue and ensure that qualifications can be quickly and efficiently developed or reviewed.

7 CONCLUSIONS

It is evident from the research that skills learning pathways in the JET areas studied are changing rapidly and fragmented. There are many barriers to educational progression. Some of the areas identified as transforming these learning pathways were identified as:

- Policy across all three areas is in place but with different impacts and focused on technology enablement and localisation opportunities, with few interconnections between PSET and planning. Policy is, however, not driving demand sufficiently.
- Technology is transforming the learning pathways and requires new skills and qualifications or new learning pathways, some of which do not exist.
- Across sectors, there is an emerging digitalisation of roles and skills needs due to the introduction of various frontier technologies.
- Emerging skills are in demand at high levels (e.g. AI, IOT) required to drive the need for the job clusters discussed in this report. High-level emerging skills are key to unlocking intermediate-level job growth in emerging skills.
- Value chains are complex, with a mixture of local and international components to increase localisation but localisation efforts could be further driving demand.
- Occupational change is occurring with the hybridisation of occupations (technical and soft skills) and more interlinked occupations within clusters or streams of occupations.
- Upskilling of the occupational family as a whole is required and, in some cases, upskilling laterally across sectors. There is also a shift in some areas to construction with all the temporary Occupational progression could be from a lower level qualification to multi-skilling, leading to a higher level qualification

The work identified several potential interventions to aid with addressing barriers and enabling a faster and easier progression along the interconnected skills pathways. These were prioritised into interventions for the short, medium and long term and prioritised. The interventions assessed to have the highest potential to address barriers include supporting a more agile skills planning system, increased collaboration, supporting SMMEs and supporting work-based learning in its various forms whilst building on existing initiatives and taking a systems approach. Addressing the qualifications system and optimising qualifications to be future-proofed and multidisciplinary will also contribute significantly to learning pathways agility and appropriateness for South Africa's economic context.

Therefore, the pace of occupational change is varied due to budget constraints and existing demand, which cause uncertainty and require agility in the market. These issues can only be addressed through radical collaboration to address the lack of coordination and integrated planning. This collaboration involves co-creating solutions from top-down strategic and bottom-up impact-forward perspectives. Only by taking this holistic approach can the identified gaps in the learning pathways be addressed.

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APPENDIX 1: INTERVIEW GUIDE

Skills Narrative/Pathway Questions for individuals in renewable occupations

Introductions & Brief Explanation of the project:

My name is (interviewees name).

I am a Researcher at the Centre for Researching Education & Labour (REAL), at the University of the Witwatersrand in South Africa. The Centre is currently working on a project that is trying to understand How people enter jobs in the energy sector. This can help us to understand how we can create more seamless access routes for young people. And this will help to create a better flow within education and training, improved connections between education and work, and improved development and use of skills at work.

We are focusing on the following emerging energy sub sectors: energy efficiency, electric vehicles, solar PV, wind energy and storage.

Inform participant about consent/anonymity:

- This interview will take approximately 30-40 minutes. All information provided will be kept confidential.
- Do you consent to being recorded for research purposes?

Bibliographic information

1. What is your name?

A) General Pathway Questions:

2. Where do you currently work within the energy sector ?

a. Can you please provide an overview of your current role and responsibilities in the energy sector?
b. In your role what other jobs do you commonly work with?

3. How long have you been working in the solar/wind/EV/EE/storage sector?

4. What motivated you to pursue a career in solar/wind/EV/EE/storage?

B) Pathway Dynamics

5. What was your first job in the energy sector?

a. Where did you work?
b. Did you study any qualifications that helped you to access this job?

C) Trace the job moves

6. From this job where did you move to?

a. What helped you to make that job move.

7. Can you give us an idea of some of the other energy jobs you have worked in?

8. What type of courses have you done?

a. Can you list them for us?
   i. Certificate/qualification/short course / skills programme ?
b. Where have you done most of your training – (private providers/ public – universities etc.; workplace-based training?)

9. Has it been difficult to find the training you need?

a. Has there been training that you think you need but you cannot find/access?

10. Did you have any mentors or influential figures who guided you in your career path?

a. If yes, how did they influence your journey?

11. What are some of the challenges you have faced along your career route (both academic and in the workplace)?

a. If so, how did you overcome them?

12. Did you participate in any internships, apprenticeships, or work-study programs related to renewable energy?

a. If yes, how did these experiences contribute to your career development?

13. Have you encountered any gaps or discrepancies between the skills you learned in your educational/training programs and the skills demanded by employers in the solar/wind/EV/EE/storage sector?

14. Looking forward, where would you like to go/move in your career?

a. Are there any specific roles or areas of specialization you are aiming for in the near future?

b. Do you think there are any skills/or other barriers that may be hampering your career progression in the energy sector ? If so, can you provide examples?

15. What advice would you give young people that are keen to enter the energy sector?

Closing:

16. Do you have any other questions for me? Or is there anything else you would like to add?

Thank you for your time and your valuable insights and participation in this interview. If we have any fur her questions we will be in contact.

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