An assessment of skills supply and demand for renewable energy, energy efficiency and regional energy integration

Final report

28th October 2022

International Labour Organization

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

real Centre for Researching Education and Labour

Contents

Acknowledgements

This report was commissioned by the International Labour Organisation (ILO) with funding from Swedish International Development Agency (SIDA) and undertaken by the University of the Witwatersrand's Centre for Researching Education and Labour (REAL). This report builds on and acknowledges the work originally undertaken by the Centre for Energy, Environment and Engineering Zambia (CEEZ).

We acknowledge the contribution by the ILO reference group inclusive of the ILO and the Kafue Gorge Regional Training Centre in guiding the project, all survey and interview respondents who provided valuable input and the participants of the validation workshop for sharing their insights on the findings and recommendations.

Abbreviations

AFUR	African Forum for Utility Regulators
DBSA	Development Bank of Southern Africa
CEEEZ	Centre for Energy, Environment and Engineering Zambia
CO_2	Carbon dioxide emissions
GDP	Gross Domestic Product
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
EE	Energy efficiency
E(S)IA	Environmental (and Social) Impact Assessment
EMS	Energy Management System
EU	European Union
EV	Electric Vehicle
KGRTC	Kafue Gorge Regional Training Centre
HR	Human Resources
IEA	International Energy Agency
ILO	International Labour Organisation
IPP	Independent Power Producer
IRP	Integrated Resource Plan
IT	Information Technology
LED	Light-emitting diode
OEM	Original Equipment Manufacturer
NGO	Non-governmental Organisation
NQA	National Qualification Authority
PV	Photovoltaic
R&D	Research and Development
RAERESA	Regional Association of Energy Regulators for Eastern and Southern Africa
RE	Renewable energy
REI	Regional energy integration
REIPPP	Renewable Independent Power Producer Programme
RERA	Regional Energy Regulators Association of Southern Africa
SACREEE	SADC Centre for Renewable Energy and Energy Efficiency
SADC	Southern African Development Community
SAPP	Southern African Power Pool
SESA	Skills for Energy in Southern Africa
SOLTRAIN	Southern African Solar Thermal Training and Demonstration Initiative
TVET	Technical Vocational Education and Training
UNEP	United Nations Environment Programme
Wits REAL	University of the Witwatersrand, Centre for Researching Education and Labour

Glossary

Apprenticeship: the systematic long-term training for a recognised occupation, taking place within an undertaking or under an independent craftsman and it should be governed by a written contract of apprenticeship and be subject to established standards (ILO, 1962).

Core work skills: the ability to learn and adapt; read, write and compute competently; listen and communicate effectively; think creatively; solve problems independently; manage oneself at work; interact with co-workers; work in teams or groups; handle basic technology; and lead effectively as well as follow supervision (ILO, 2020).

Curriculum: a description of what, why, and how well students should learn in a systematic and intentional way. The curriculum is not an end in itself but a means to fostering quality learning (UNESCO IBE, 2011).

Decent work: the availability of employment in conditions of freedom, equity, human security and dignity. It involves opportunities for work that are productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men (ILO, 2006).

Demand side management programmes: consists of focused, deep, and immediate training required such as the brief curtailment of energy-intensive processes used by a utility's most demanding industrial customers, and programmes that are broad, shallow, and less immediate such as the promotion of energy-efficient equipment in residential and commercial sectors (IEA, 2022a).

Energy Management System (EMS): automation systems that collect energy measurement data from the field and make it available to users through graphics, online monitoring tools, and energy quality analysers, thus enabling the management of energy resources (Segatto et al., 2018).

Energy efficiency (EE): the ratio of output or useful energy or energy services or other useful physical outputs obtained from a system, conversion process, transmission or storage activity to the input of energy (IPCC, 2019).

Equipment design: a form of human engineering that is concerned with the design of work tools, home appliances, and machines of all kinds, including their displays and controls (APA, 2022).

Gender equality: refers to the equal rights, responsibilities and opportunities of women and men and girls and boys. Equality does not mean that women and men will become the same but that women’s and men’s rights, responsibilities and opportunities will not depend on whether they are born male or female (United Nations, 2001).

Green economy: an economy that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP, 2010).

Green jobs: refers to work in agricultural, manufacturing, research and development (R&D), administrative, and service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; decarbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution (UNEP, 2008).

Green and/or clean technology: a technology that improves the resource or energy efficiency of production, to sustainable levels, reduces waste or increases the use of non-polluting, renewable resources (Strietska-Ilina et al., 2011).

Informal economy: refers to all economic activities by workers and economic units that are – in law or in practice – not covered or insufficiently covered by formal arrangements. The informal economy does not cover illicit activities (OECD/ILO, 2019).

Just transition: can be understood as the conceptual framework in which the labour movement captures the complexities of the transition towards a low-carbon and climate-resilient economy, highlighting public policy needs and aiming to maximize benefits and minimize hardships for workers and their communities in this transformation (Rosemburg, 2010).

Learning pathway: a sequence of activities with designated goals to help students build up their knowledge or skills in a subject area (Yang et al., 2010).

Low carbon energy: is energy that is generated using lower amounts of carbon emissions such as, wind, solar, hydro or nuclear power. These alternative methods of producing energy are better for the planet as they release less carbon into the atmosphere (Moses, 2020).

Occupation: refers to a set of jobs whose main tasks and duties are characterized by a high degree of similarity. A person may be associated with an occupation through the main job currently held, a second job, a future job or a job previously held (ILO ISCO, 2008).

Potential labour force: includes people not in employment available but not seeking and those seeking but not available (Gammarano, 2019).

Public-private partnership: an arrangement whereby the private sector provides infrastructure assets and services that traditionally have been provided by the government, such as hospitals, schools, prisons, roads, bridges, tunnels, railways, and water and sanitation plants. Cases where the private operator has some responsibility for asset maintenance and improvement are also described as concessions (IMF, 2007).

Renewable Energy (or Clean Energy) (RE): is energy from sources that are naturally replenishing but flow-limited; renewable resources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time (IEA, 2022b).

Regional Energy Integration (REI): refers to the support of energy security through integrated markets and cross border infrastructure development (Montmasson-Clair and Deonarain, 2019).

Skill: the ability to carry out a manual or mental activity, acquired through learning and practice. The term "skills" is used as an overarching term for the knowledge, competence and experience needed to perform a specific task or job (ILO, 2015).

Skills demand: the aggregation of employer skills needs, which indicate either skill sets required to carry out assigned jobs properly or people who have such skill sets (Mori, 2019).

Skills development: the full range of formal and non-formal vocational, technical and skills-based education and training for employment and/or self-employment, including pre-employment and livelihood skills training; vocational education and training and apprenticeships; education and training for employed workers, including workplace training; and employment-oriented and job-related short courses (ILO, 2020).

Skills gap: a situation in which the skills level of an employee or group of employees is lower than that required to perform the job, or the type of skill does not match the job requirements (ILO, 2021).

Skills supply means either people with sufficient skills to perform assigned jobs or those with qualifications corresponding to each occupation (Mori, 2019)

Skills shortage: a situation in which certain skills are in short supply, for example where the number of job seekers with certain skills is insufficient to fill all available job vacancies (ILO, 2021).

Southern African Development Community (SADC): is a regional economic community comprising 16 member states that aim to promote sustainable and equitable economic growth and socio-economic development through efficient, productive systems, deeper cooperation and integration, good governance and durable peace and security; so that the region emerges as a competitive and effective player in international relations and the world economy (SADC, 2022).

Technical and Vocational Education and Training (TVET): initial or continuing education and training provided by schools, training providers or enterprises that impart the skills, knowledge and attitudes required for employment in a particular occupation, or group of related occupations, in any field of economic activity (ILO, 2015).

Executive summary

The SADC region relies heavily on energy produced from coal and water and has over the years grappled with an energy crisis seen through insufficient and inefficient energy supply. This crisis is mostly a result of a changing climate including droughts, outdated infrastructure and the depletion of natural resources. These natural resources include coal and gas and their use for power generation further contributes to climate change, who's impacts are being faced globally. There has therefore been a desire and a call to shift towards renewable energy (RE) in the SADC region, which has the resources and conditions to make this shift. This is driven by the SADC Protocol on Energy and the various national policies. The SADC Protocol on Energy (SADC 20 identifies a number of strategic plans over the last 10 years which builds on previous policy. These include "the Regional Energy Access Strategy and Action Plan 2020 to2030 (SADC, 2020), the Renewable Energy and Energy Efficiency Strategy and Action Plan 2016 to 2030 (SADC, 2016), the SADC Industrial Energy Efficiency Programme and the development of the Regional Gas Master Plan" (SADC, 1996).

Implementation has occurred at different rates in the various member states and the 2018 SADC Renewable Energy and Energy Efficiency Status Report states that, "Since 2015 SADC Member States have greatly increased their commitment to renewable energy and energy efficiency, including important innovations to stimulate mini-grids and distributed renewable energy" (SADC, 2018). This is also the case in regional integration as per the SADC Regional Indicative Strategic Development Plan (RISDP) 2020–2030 (SADC 2020) and through the Southern African Power Pool (SAPP) and its regional electricity plans, trading platforms and policy and regulatory alignment initiatives (SAPP, 2017) together with the SADC Regional Electricity Regulatory Association (RERA, 2022).

This transition to RE however, needs to be just, thereby ensuring that the current workforce is protected, and that the skills ecosystem is prepared not only to respond to current demands but those required to transition to a more just and resilient energy system.

Research aim and purpose

The main aim of the research was to provide an analysis of renewable energy RE, energy efficiency (EE) and regional energy integration (REI) skills development needs in relation to the set of skills demanded by employers and those currently available in Zambia and the SADC region. The purpose of this report is therefore to build on and enhance the insights garnered in Phase 1, and to develop recommendations to inform KGRTC's skills development strategy, including priority courses and areas of focus, and potential partnerships.

Research approach

The framing of the approach adopted aimed to set the context within which the skills are identified and therefore proposed. This contextual understanding is critical for framing the current and future (i.e., transition direction) energy system status and trends within the SADC region. This contextual assessment provided a grounding from which to better understand the skills currently supplied and in demand along the SADC region's energy value chain. Based on this, an interpretation of the potential gaps between skills supply and demand (for RE, EE and REI, and where feasible recognising country variation) provided indicative priority skills areas of focus for consideration and refinement by the KGRTC in their skills and course development strategy.

A number of mechanisms were used to gather insights and data to inform the research and findings. These being: 1) drawing on the Phase 1 research and findings, 2) developing broad overview case studies for 6 selected countries (Botswana, Mauritius, Namibia, South Africa, Zambia and Botswana), 3) a skills supply and demand survey, and 4) interviews with key informants in the selected countries.

Main findings

Emerging energy trends across the SADC region

The SADC region has a vast array of energy-related policies in place to support the significant increase in RE in the sector. These policies include at the SADC level, national energy policies, EE strategies and legislation, RE policies and legislation. These policies set a platform for REI to be achieved in the region supported by the Southern African Power Pool (SAPP) (SAPP, 2017). The policies further serve as a guideline with regards to what skills will be required for an RE transition to take place.

The need for a more efficient energy sector in the SADC region is evident due to the increasing levels of energy insecurity. Load shedding is a phenomenon faced across the region as a result of depleting resources e.g. coal, vandalism, poor/lack of infrastructure maintenance and drought. Energy insecurity has resulted in a number of countries relying on the importation of electricity which may impact the economy if importation costs are more expensive that local supply. A further concern that has been highlighted in the region is the lack of and/or slow implementation of rural electrification initiatives which results in a larger proportion of the population (who are based in rural areas) lacking access to electricity.

These challenges have led to a significant emphasis for the adoption of RE, with solar PV dominating the market, and to a lesser extent wind technology. There has been additional recent focus on green hydrogen (produced by RE) in Namibia and South Africa. In 2018, the SADC Renewable Energy and Energy Efficiency Status Report (SADC 2018) reported that "*the SADC region had 21,760 MW of installed renewable energy capacity as of mid-2018, of which 15,996 MW was hydropower*".

The SADC policies as well as national policies make the linkages back to industrial development and regional or national development plans, emphasising the key role played by energy in development and investment.

Issues of gender equality are becoming more prominent in the sector, with a desire to have more women actively involved in the sector. The survey revealed that women are increasingly enrolling in energy courses in the region although men tend to dominate the more technical and task intensive courses and roles. The various SADC documents do refer to required skills or skills development to some extent, particularly when there are new policy directions, but direct links are not made in all policies or strategies.

Energy value chain hotspots across the SADC region

The SADC region has a variety of hotspots (areas or activities of significance) and change drivers that can both impact the implementation of RE systems and create opportunities for the adoption of RE, these include:

1. A dependence on coal in countries such as Botswana, South Africa and Zimbabwe. This means that as these resources deplete, or are not aligned with the drive to net zero by 2050, these countries will be forced to realign their energy supply to more renewable and/or other lower carbon electricity sources. A shift to RE however, puts the current workforce at risk as their

skills may no longer be relevant. This risk highlights the need for a focus on reskilling and upskilling if a just energy transition to take place.

2. A narrow dependence and focus on solar PV as an RE source, resulting in the neglect of other forms of RE such as wind, geothermal, tidal, and bio energy. The neglect of the other forms of RE therefore means that the skills being supplied in the region mostly focus on solar and hydro energy, significantly reducing the potential of the sector to increase the percentage of RE in the energy mix through other technologies. This may also impact the longer-term production of green hydrogen (Namibia and South Africa).
3. A prevalence of energy insecurity, faced across the region. Load shedding, power shortages due to old or badly maintained infrastructure, severe droughts and depleting resources all result in not being able to supply sufficient electricity to meet the demand. As the sector transitions into more RE there is a need to ensure that RE technology available when needed. The region currently has a shortage of local manufacturing industries supplying RE technology, resulting in a dependence on imports.
4. There is a high desire by countries in the SADC region to achieve energy security and therefore reduce their reliance on the importation of energy. Interestingly however, is that all countries aspire to increase their energy exportation capabilities, which raises the question of who will import the energy that the countries plan to export especially if the entire region achieves energy security. This finding, therefore, calls for a realignment of energy security goals to ensure that there is not an oversupply of electricity - with all the financial impacts this would bring. This can be achieved through the SAPP planning process which will highlight these risks and help inform decision making at a national level. An updated regional plan will also give better guidance for skills provisioning due to course content being realigned to suit demand.
5. Increasing green hydrogen aspirations can raise the economic status of the region and enhance energy security. Namibia and South Africa have set in motion plans to integrate green hydrogen into their economic activities. These plans therefore raise the demand for additional renewable energy provision and green hydrogen skills at all levels of the energy skills ecosystem, from e.g. technicians, installers to maintenance personnel and project managers. This may impact on the availability of these skills in the electricity sector,
6. Universal access to electricity is a core area of concern in most SADC countries, with particular reference to rural electrification, which can be very low. This means that local rural enterprise and household economies are inhibited in their ability to grow and/or contribute to national economies.
7. In some SADC countries, such as South Africa and Zambia, the energy intensity of some sectors e.g., mining and large-scale industry, is a notable area of high energy use. These sectors in particular are affected by energy insecurity, access and cost. As such, EE initiatives in these sectors are critical.

Skills supply and demand

Energy skills demand

The analysis of the energy skills demand in the SADC region revealed that there is an overwhelming focus on RE. Solar PV is by far the most dominant, with the exception of South Africa and Namibia (both exploring wind at large scale, some of which in Namibia will be allocated to the production of green hydrogen) and Mauritius (energy efficiency) to some extent. While EE appears extensively in policy and energy planning there are low levels of implementation and therefore demand for those skills. REI is even more unexplored, as is evident from the stakeholder mapping that was conducted with few of the respondents representing REI.

In spite of the lack of focus on areas such as EE, there is an underlying demand for it in the region for energy security, affordability and climate change reasons. Participants in the study revealed that macro institutions such as the government drive the labour markets to a large extent. As an example, the current focus of government planning is on construction as opposed to operations and maintenance, driving the demand throughout the sector. Although poor and failing infrastructure denote the need for EE-related and maintenance skills as well as the anticipated new plant.

Emerging evidence suggests that the nature of changes to jobs due to the transition to RE and/or alternative energy futures is likely to require an increase in specialisations, and not necessarily new jobs.

Energy skills supply

A short course culture is emerging in the SADC region. This is being driven by urgent sector demand, response to a dynamic and changing economy and shifts in policy focus e.g., to solar energy, and the rapidly changing nature of technology and knowledge in the sector. These short courses, however, tend to focus on single skills sets (e.g. solar PV installation) as opposed to streams of work. As a result, a learner of e.g. short solar PV installation course may face challenges if they need to switch to wind or the green hydrogen sector.

The findings suggest that very few women are undertaking energy related courses with only up to 20% completing the courses. There was no clear evidence of programmes focused on women, especially rural women. This suggests the need for skills planning to be more explicit in its focus on attracting women to the sector.

Across the board, RE dominates supply and demand, again with an emphasis on solar. Within RE there is a gap that needs to be filled with regards to research and development (R&D), construction and installation, operations and management, and maintenance. Maintenance is a critical skill requirement, yet few courses focus on maintenance.

Regarding the provisioning of skills focus for KGRTC consideration, Table 1 provides an overview of indicative priority areas for skills development by energy theme.

Table 1: Proposed priority course areas of focus

Priority course area	Energy theme		
Energy theme	**RE**	**EE**	**REI**
RE technology installation, construction, management and maintenance (solar PV, wind, storage)			
RE financial modelling, analysis and investment			
RE technology sales, marketing and customer services			
Social science associated with RE technology development (notably community liaison, especially in rural areas)			
Energy auditing, monitoring and reporting (industry, business and public service)			

Priority course area	Energy theme		
Energy theme	**RE**	**EE**	**REI**
Maintenance and repair of machinery, equipment and appliances			
Procurement of low energy / EE machinery, equipment and appliances			
Regional power system modelling, policy, financing, planning and implementation			
Regional energy regulation and governance			
Rural electrification within and across the region (policy, planning, implementation)			

Conclusion and recommendations

It is acknowledged that for a just transition of the region's energy system to effectively take place across the SADC region, a realignment of skills is imperative. This study provides a broad indicative overview of the region's energy sector to inform the KGRTC's skills development and provisioning strategy. The following recommendations are made for consideration:

Skills supply recommendations:

- Adopt a multi-dimensional approach to skills development, which requires a vision beyond being a training provider. This means understanding the training requirements within the contextual (political, economic, social, technological and environmental dimensions) of the region, and how this links to education and broader social development.
- Adopt bottom-up (place-based) models of skills development that take local communities into account.
- Visioning training beyond a single job to consider related streams of work, occupations and skills.
- Proposed priority areas for course development (see Table 1 above).
- For training delivery, take innovative modalities of working into consideration.

KGRTC as a Centre of Excellence and its role in championing a stronger more coordinated SADC energy skills system:

- Adoption of a vision beyond that of being a training provider (see the adoption of a multi-dimensional approach to skills development above).
- To champion regional standards and accreditation processes to courses offered are globally and regionally credible.
- To act as a central regional hub to coordinate and facilitate energy skills development in the region, and to act as a knowledge repository and hub on energy skills in the region.
- To leverage strategic international, regional and in-country partnerships to develop, implement and evaluate skills development to transform the energy system in the region.

Development of a broader SADC regional energy skills roadmap:

Building on this research and the recommendations proposed to the KGRTC, a proposed recommendation for the ILO would be to facilitate and coordinate the development of an energy skills roadmap to support energy transformation across the SADC region. This could include:

- Further research to better understand the full spectrum of SADC country energy-related skills ecosystems, their alignment and gaps between countries and the time frame in which they will be needed;
- Consultation with key role players in the region to inform the development of the roadmap; and
- Development of the roadmap, accompanied by a financial plan to ensure delivery and occupational atlas for priority occupations.

1. Introduction

The International Labour Organisation (ILO) is supporting the Kafue Gorge Regional Training Centre (KGRTC) to implement the Skills for Energy in Southern Africa (SESA) Project. The overall objective of SESA is to "increase uptake of Renewable Energy (RE), Energy Efficiency (EE) and Regional Energy Integration (REI) interventions in Southern Africa, leading to a more sustainable and low-carbon energy mix" through skills development and the establishment of Public-Private Development Partnerships in Zambia and the South African Development Community (SADC) region. Within this context, an assessment of skills supply of and demand for RE, Energy Efficiency EE and REI has been commissioned to assist KGRTC to develop a skills development strategy targeting the Southern African Development Community (SADC) region.

The main objective of the assessment is to provide an analysis of RE, EE and REI skills development needs in relation to the set of skills demanded by employers and those currently available in Zambia and the SADC region. Insights garnered from this assessment are used to identify gaps, opportunities and specific skills needed to inform KGRTC's future positioning in RE, EE and REI within the SADC region.

The work has been undertaken in two phases:

- Phase 1: A desk-based (including literature) review and Zambian case study undertaken by Centre for Energy, Environment and Engineering Zambia (CEEZ); and
- Phase 2: Additional six SADC country case studies, surveys and interviews to gather further data and insights from key informants and employees in the region, and an enhanced understanding of education and training provision.

The purpose of this report (the outputs of Phase 2) is to build on and enhance the insights garnered in Phase 1, and to develop recommendations to inform KGRTC's skills development strategy, including priority courses and areas of focus, and potential partnerships. The intention is therefore to position the KGRTC as a Centre of Excellence in the provisioning of skills for RE, EI and REI in the SADC region.

This report is presented in five sections. Following the introduction, the methodology and review of literature underpinning the study are presented. This is followed by a presentation of the case summaries for the six countries, survey and interview findings, and associated discussion. The final section presents the conclusion and recommendations for consideration.

2. Methodology

This section provides an overview of the research approach adopted for this project and the research methods and tools used. The framing of the approach adopted aims to set the context within which the skills are identified and therefore proposed. This contextual understanding is critical for framing the current and future (i.e., transition direction) energy system status and trends within the SADC region. This contextual assessment provides a grounding from which to better understand the skills currently supplied and in demand along the SADC region's energy value chain. Based on this, an interpretation of the potential gaps between skills supply and demand (for RE, EE and REI, and where feasible recognising country variation) provides indicative priority skills areas of focus for consideration and refinement by the KGRTC in their skills and course development strategy.

2.1 Research approach

In framing the approach to this study, researchers first reviewed the data and literature reports produced in Phase 1. From this foundation, the team then planned Phase 2, which built on the Phase 1 findings, and involved stakeholder mapping, country mini case studies, surveys and interviews in the six selected countries. The six countries were identified based on the need to build on the information collected in Phase 1, which focused on Zambia. The selection was based on selecting from English-speaking countries within SADC, the networks and contacts available and known to Wits REAL and its energy specialists, and in consultation and final agreement with the ILO. Figure 1 provides an overview of the research approach; the methods are explained in further detail below.

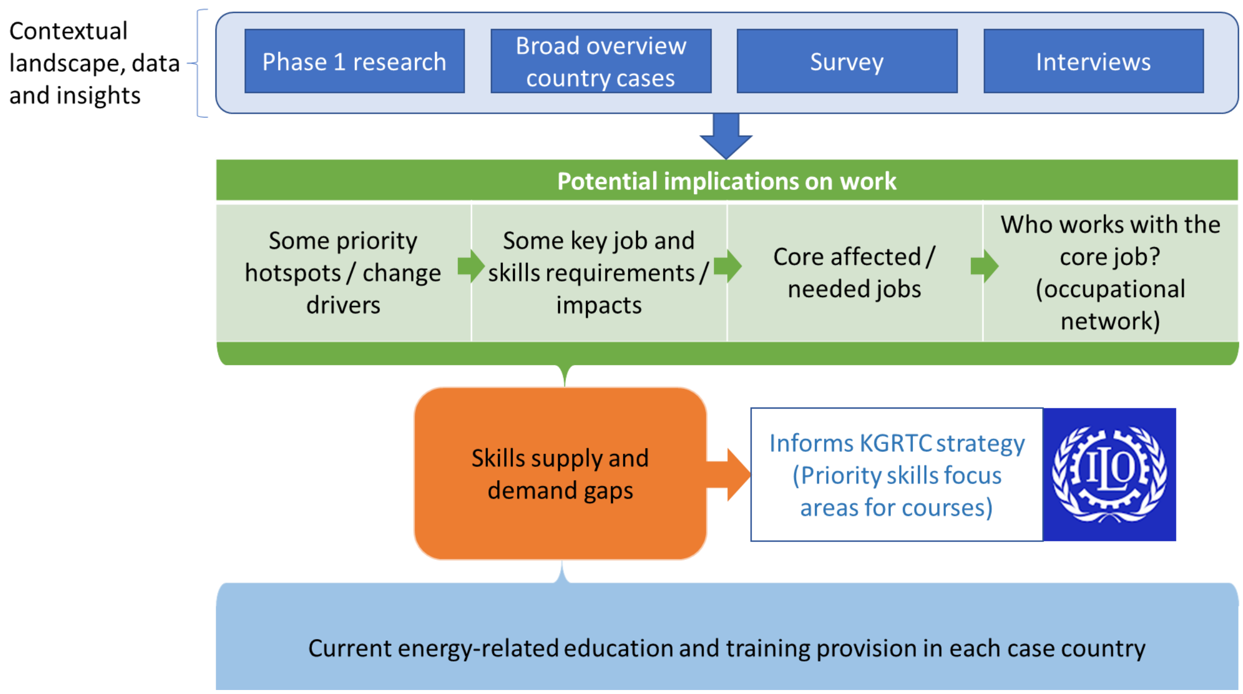

Figure 1: Overview of project methodology

2.1.1 Review of Phase 1 reports and data

The focus of Phase 1 has been included in the research approach. Phase 1 involved a comprehensive literature review of energy issues and some data reflecting demand and supply issues across some SADC countries, with an intense focus on Zambia. This review helped the study to identify research gaps and assisted in key areas to focus on. The Phase 1 outputs were first reviewed, prior to undertaking the surveys and interviews. The data produced also provided complementary data that supported data collected in Phase 2.

2.1.2 Country selection and stakeholder identification

The study targeted RE, EE and REI stakeholder organisations in six SADC Member States namely Botswana, Namibia, South Africa, Mauritius, Zambia and Zimbabwe[1]. The selection of these six countries was mainly based on their geographical positioning. Zimbabwe, Botswana, Namibia are neighbours to Zambia, where KGRTC is, making it more visible to potential trainees from these neighbouring countries. Hence these countries are most likely to be the main catchment area for KGRTC. South Africa is a major player in RE, EE and REI in the SADC region and hence was included in the sample as it is a key contributor to the understanding of the industry and regional skills needed in RE, EE and REI. The countries also house the relevant RE, EE and REI international, continental, and regional and continental organisations that include:

- SADC Secretariat (Botswana);
- SADC Centre for Renewable Energy and Energy Efficiency (SACREEE), Regional Energy Regulators Association of Southern Africa (RERA) (Namibia);
- African Forum for Utility Regulators (AFUR), African Union Development Agency-New Partnership for Africa's Development (AUDA-NEPAD), Development Bank of Southern Africa (DBSA), European Union (EU) delegation, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (South Africa);
- Regional Association of Energy Regulators for Eastern and Southern Africa (RAERESA) (Zambia); and
- Southern Africa Power Pool (SAPP) (Zimbabwe).

The above organisations were also targeted in this assessment to provide their RE, EE and REI skills needs and those of their many members.

In addition to the above, for the case of including South Africa, they are a major player in RE, EE and REI in the SADC region, and in the case of Mauritius they were selected as having informed EE policy, and a 100% universal electricity access. Given the short time frame to conduct the research, selection was also based on language, with five of the six (except Mauritius) being English-speaking. The selection of these six countries hence provided useful insights into the SADC region.

The study stakeholder sample consisted of 404 stakeholder organisations from both supply (education and training) and demand (government, industry) stakeholders within the six identified countries as well as regional bodies and funders (Annexure A). These stakeholder organisations were sent surveys and/or approached for interviews to gather data and insights. Table 2 below indicates the number of stakeholder organisations in the study sample (from both Phase 1 and Phase 2) by country and skills supply or demand.

[1] SADC comprises a total of sixteen member states: Angola, Botswana, Comoros, Democratic Republic of Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, United Republic Tanzania, Zambia and Zimbabwe.

Table 2: Study sample by number of stakeholder organisations per country categorised into skills supply, skills demand or neutral

Country	Skills supply	Skills demand	Neutral	Total
Botswana	6	46	-	**52**
Mauritius	2	6	1	**9**
Namibia	8	38	-	**46**
South Africa	25	117	4	**146**
Zambia	11	47	2	**60**
Zimbabwe	5	60	-	**65**
Multilateral/regional/donor agencies	2	19	5	**26**
Total	**59**	**333**	**12**	**404**

Stakeholders were further categorised according to themes within the energy sector, namely RE, EE and REI and skills demand or supply. Table 3 illustrates how the categorisation was done, using one of the countries (South Africa) as an example:

Table 3: Types of information gathered per stakeholder in South Africa

Information / category	No. of stakeholders representing this category		
Energy theme	**Renewable energy**	**Energy efficiency**	**Regional energy integration**
	118	35	0

Note that in the case of South Africa, 7 institutions deal with both RE and EE and hence are reflected under both those categories in the table above. Annexure A categorises stakeholder organisations by RE, EE and REI for all 6 countries.

Other information captured per stakeholder as depicted in the comprehensive database included:

1. A sub-category of activities e.g., within renewable energy whether the organisation's activity is involved in solar, wind etc.
2. Type of entity e.g., a private company, or industry association.
3. Contact details, including (where feasible), a named individual, job title, email and phone number.
4. Other / notes that may be useful when engaging with the stakeholder, or to inform the research.

2.1.3 Overview country case studies

An overview case study was developed for each of the six selected countries (Botswana, Mauritius, Namibia, South Africa, Zambia and Zimbabwe) based on a desktop analysis. The cases offered the study clear entry points at country level and helped to locate the countries more explicitly within the study. The cases aimed to develop the contextual socio-political and socio-technical context of skill formation. This desktop work reviewed the policy context, and a high-level review of value chains. The review encompassed demand, both in terms of current industrial development trajectories and in terms of expanded more responsive outlooks. This expanded value chain work helped to surface tentative key lock-ins (unsustainable hotspots) and significant change drivers in the country's energy value chain. The detailed cases of each country are presented in Annexure B and will provide useful follow-up information to the KGRTC. An assessment of the implications for skills was also included.

However, a summary of each case study, with a focus on emerging implications for the world of work, is presented within the findings of the report.

2.1.4 Survey

The survey focused on the supply and demand side skills, and the dynamics underpinning skill formation. It was administered using REDCAP. The survey was administered to all of the stakeholders within the database sample (300 with valid email addresses).

2.1.5 Key stakeholder interviews

Two interview schedules were developed to capture supply- and demand-side insights. See Annexures C and D. Questions asked aim to elicit more nuanced examples of skills issues from within the countries, including around the coordination between key actors in the energy sectors and transitions. All interviews were recorded and fully transcribed.

The choice of interviewees began with organisations that had SADC/multi-country reach, with final numbers determined by the research team's ability to reach the stakeholders in each country.

2.2 Data analysis

The data was analysed using thematic analysis. These themes cut across the RE, EE and REI activities. Using these themes, together with some additional themes, we aimed to establish sets of codes for each theme, for each activity. This informed our data analysis.

The relationship between supply and demand is iterative, and often contingent on coordination and planning.

2.3 Limitations

While every effort was made to produce a study with coherent internal validity, we acknowledge some limitations:

1. The countries represent a small sample in SADC, with a focus on English speaking countries. It is recognised that non-English speaking countries can also provide relevant data and insights.
2. Accessing the relevant people remotely is difficult, and the team were reliant on addresses and information available online.
3. Despite the scope being limited to English-speaking countries, in the case of Mauritius, the language of the survey was a barrier to some participants who were more comfortable with French.

To address these limitations, the research team brought in additional assistance to email and call stakeholders to ensure as representative a response rate as possible.

3. Review of literature underpinning this study

This section explores the literature that formed the conceptual foundation of this study. This comprises work on the expanded value chain for energy, understanding concepts linked to demand and supply of skills, and finally the type of transition needed for an equitable and just transition.

3.1 Contextual overview of energy within SADC

The demand for electricity worldwide was projected to grow at an annual rate of 2.7% for the period 2007-2015, slowing down to 2.4% a year for the period 2015-2030 as economies mature, and the generation and supply of electricity becomes more efficient. Over 80% of the growth between 2007 and 2030 is expected to be in non-OECD countries, with the demand in these countries expected to grow by 3.3% a year from 2015 to 2030. Noting changes in the composition of power, the most promising growth markets are emerging economies, where new capacities have to be established to meet the growing electricity demand (IEA, 2019).

Recent reports from the IEA in 2022, indicated that in 2021 the growth was 6% but that it is projected to revert back to 2,4% in 2022. The IEA does however caution that the energy sector is one with high levels of uncertainty. The IEA also predicts that renewable power will grow by more than 10% in 2022 (IEA, 2022).

Even though Africa produces just 2% of global energy-related carbon dioxide (CO_2) emissions, the continent is disproportionately on the front line when it comes to the effects of the world's changing climate. That said, Africa's growing urban populations will require more energy and power industrial production, air conditioning and an expanding use of transport. It is estimated that Africa's energy demand will grow twice as fast as the global average over the next two decades (IEA, 2019).

With more than 600 million people (43% of the continent's population) in Africa lacking reliable access to electricity and a heightened awareness of the vulnerability of the continent to climate change, there is growing interest in the role that RE, EE and REI can play in contributing to a green and just transition and broader sustainable development in Africa (World Bank, 2021). This is especially the case where fossil fuels have made a substantial contribution to GDP and economies now need to adjust and diversify.

SADC countries are able to tap into substantial renewable energy resources across the region. However, they need to consider climate change issues with respect to hydro generation, given the region's proclivity for droughts (Sikuka, 2016). Many SADC countries have energy, climate and industrial policies that envisage substantial growth in the use of renewable energy over the next few decades (see Section 4.1 'Country overview case studies'). However, slow implementation of policy, investor confidence and low economic growth rates have hindered the uptake of renewable energy (SADC, 2018). This is exacerbated by many SADC countries having low to very low rates of energy access in rural areas (SADC 2018). Renewable energies have the potential to bring modern energy services to these areas through the deployment of mini-grids or home systems, with associated job creation opportunities. This however means that different business models and operational practices need to be put in place to ensure the long-term sustainability of these initiatives (Kovandova, 2019).

There is a gap between existing skills, technological developments, and emerging practices in the transition to a low-carbon future. This necessitates a focus on reskilling, technology transfer and education and training for a just transition. In addition, adequate country-specific skills substitution is necessary to foster a low-carbon energy portfolio. In this regard, partnerships between African countries and international development agencies are focused on strategies for equipping Africans (especially youth) with skills in fields that promote a green economy. Such strategies need to creatively overcome any resistance to the transition due to lost employment opportunities in fossil fuel-based energy production e.g., coal, and changes in economic structure.

While SADC countries have protocols on industrial policy for the energy sector, employment and labour, education and training, there have not been many integrated projects to overcome sluggish growth and unemployment. However, respective member states have been making important shifts in their energy mixes. Despite a shift to modern and more efficient energy sources over this period, the continent's current policies aren't enough to put it on track to meet its development needs and provide reliable and modern energy services for all. For example, Africa has the richest solar resources on the planet but has installed only 5 gigawatts of solar photovoltaics (PV), accounting for less than 1% of global capacity (IEA 2019). With the right policies, solar could become one of the continent's top energy sources. Natural gas could correspond well with Africa's industrial growth drive and as a transitional fuel for renewable energy support and need for reliable electricity supply. Today, the share of gas in sub-Saharan Africa's energy mix is among the lowest in the world. Africa is home to more than 40% of global gas discoveries so far this decade. Investment in gas will however need to be balanced with most SADC countries aspirations to be net zero by 2050.

Africa's rich natural resources are not limited to sunshine and other energy sources. Its major reserves of minerals such as cobalt and platinum are crucial for clean energy technologies, which means the continent holds some of the key ingredients for global energy transitions such as battery storage (IEA 2019).

SADC countries also have the potential to tap into new global markets around green hydrogen and other clean molecules, through the utilisation of its renewable energy resources. Some countries have already started exploring this avenue such as Namibia and South Africa. If the use of renewable energy expands to include hydrogen production, then not only will additional skills be needed, but also more extensive supporting infrastructure (Shah, 2021).

All of these developments and potential require regional integration of energy systems and associated infrastructure like ports, water and other inputs and export hubs. SADC's Regional Infrastructure Implementation Plan and SAPP activities do begin to lay out the requirements for this regional integration. However, the report was completed in 2012 and so the context has changed considerably. The SADC Regional Indicative Strategic Development Plan (RISDP) 2020–2030 (SADC 2020) and SAPP's regional electricity plans (SAPP, 2017) have reinforced this as a necessity. Country level policies do the same (see case studies below). The plans and policies have not however fully recognised the additionally required for the renewable energy to produce and modify and/or directly export green hydrogen.

This discussion sets the context for the mini-country case studies, which provide more specific contextual information, and the discussion that follows on the energy value chain.

3.2 An expanded value-chain approach to RE, EE and REI

The value chain view considers aspects of value creation and appropriation, which can be understood as arising through a 'value constellation' and 'value grid'. Under this view, firms are arranged in a way that goes beyond the linear view of managing supply and demand relations (Holweg & Helo, 2014). Considerable additional value can be captured if firms think and work across value streams in non-linear ways. Rosenberg et al. (2020) reflect on the importance of extending standard linear industry value chains. In reflecting on coal mining value chains, they argue that several 'values' such as local development and recycling were added to the standard industry value chain, not because they occur, but because, according to sector policies, they should occur hence helping to highlight possibilities for latent jobs (jobs that are not yet visible on current industry value chains). Their expanded value chain analysis highlighted the importance of recognising innovation, regulation and other enabling functions as vital dimensions of industry value chains.

Using the case of South Africa and its electricity sector, it is possible to illustrate how the country's electricity value chain operates in a non-linear manner within the SADC region (see Figure 2).

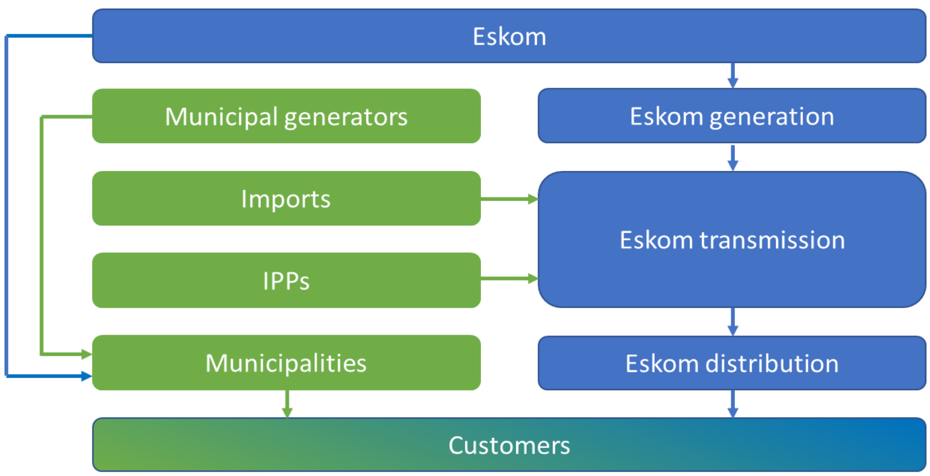

Figure 2: South Africa's electricity value chain

Eskom's value chain is vertically integrated, with it generating, transmitting and distributing electricity. It dominates the production and of electricity in the country, and also supplies the SADC region. An integrated grid connects the Southern African Power Pool (SAPP), which comprises South Africa, Botswana, eSwatini, Lesotho, Mozambique, Namibia, Zambia and Zimbabwe (DME, 2021). It also imports electricity from Lesotho, Mozambique, Zambia and Zimbabwe, and exports to Botswana, eSwatini, Lesotho, Mozambique, Namibia, Zambia and Zimbabwe (Department of Mineral Resources and Energy, 2021). The electricity generated by Eskom and IPPs, combined with imports from neighbouring countries, is supplied in bulk to distributors, i.e., large metropoles and other municipalities, and is also distributed to industrial, commercial, residential and other customers. Eskom owns and operates several coal- and gas/diesel-fired, hydro and pumped storage power stations, as well as one nuclear power station. Using this information, an expanded value chain for South Africa's energy was developed (see Figure 3). This includes value drivers that are steering the energy sector towards a low-carbon future which recognises the need for clean reliable power, insulation against fuel price volatility, reduction of the risk of regulation impact, and potentially lower long-term energy costs. This value chain also recognises that there can be bi-directional flow of electricity (indicated by bidirectional arrows from distributed or self-generation back into the grid) with consumers becoming prosumers. This value chain can apply to any of the countries considered in this study.

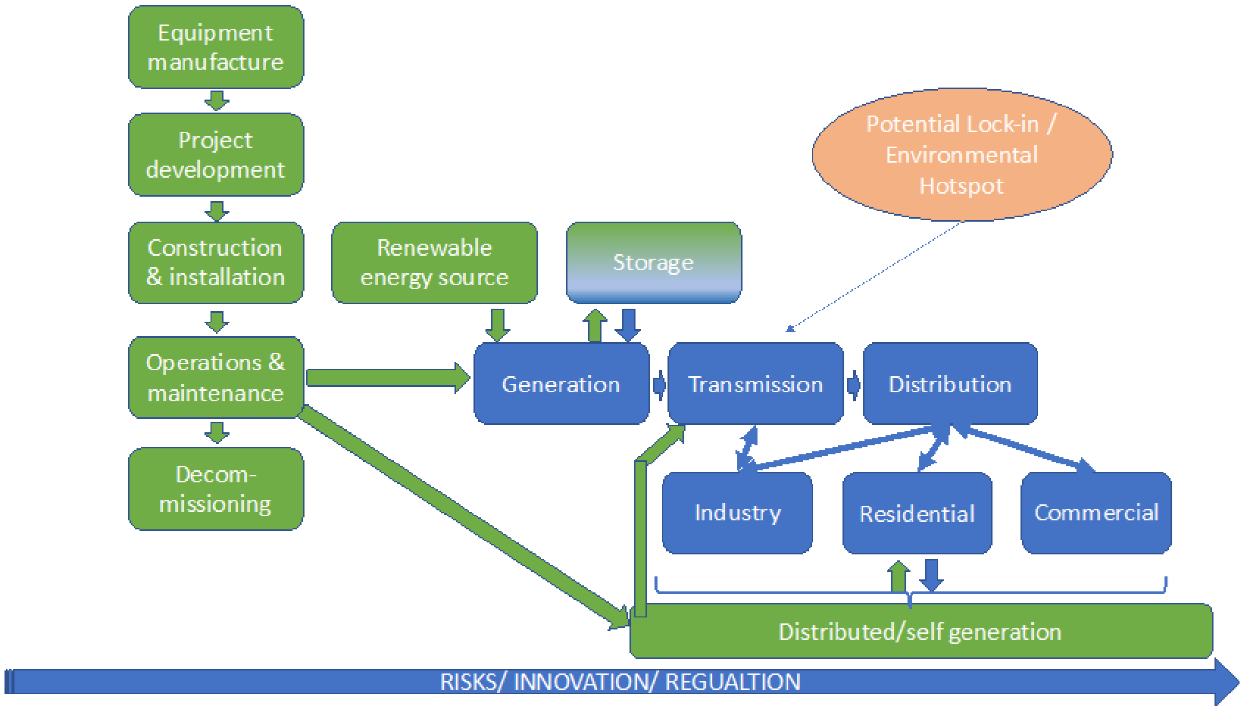

Figure 3: South Africa's expanded energy value-chain

3.3 Understanding demand, supply and skills anticipation

Distinguishing between occupations, jobs and skills, and understanding their relationship, is central to this research. Broadly an occupation is defined by the set of jobs it requires, and a job is defined by the set of skills it requires. Figure 4 presents this distinction and the conceptual orientation followed in this research.

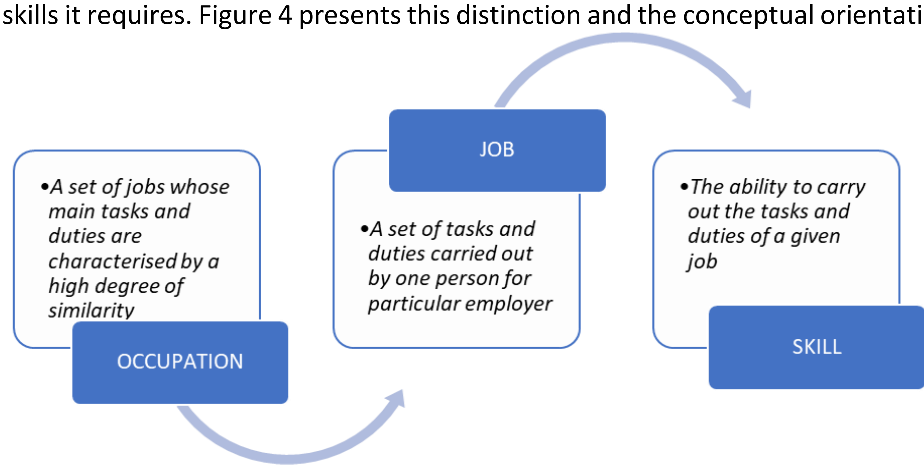

Figure 4: Relationship between skill, job and occupation underpinning the study

The distinction between jobs and skills is important because the labour market dynamics of 'greening' the economy are and will be complex in the future. The notion of 'greening' the economy will require the identification of particular occupations, jobs and skills. Below are four commonly expected impacts of 'greening' on occupations:

Table 4: Four expected impacts of 'greening' on occupations

Core green occupations	Some existing occupations are already focused directly on energy technologies, often with a high degree of specialisation, such as environmental managers or engineers but may require specialisation in certain areas e.g. renewable energy or new markets.
Changing occupations	Within some existing occupations emerging environmental challenges and opportunities are resulting in a requirement for new skill sets that differ significantly from those required for more traditional work in these occupations. For example, the installation of solar water heaters overlaps with more traditional plumbing work but differs in the specifics of its core skills requirements.
New skills need across occupations	These are existing occupations that do not have a focus on environmental issues but require supplementary skills as environmental issues emerge or are acknowledged in a particular area of work. An example may be the incorporation of sustainable investment considerations for a Fund Manager.
Newly emerging occupations	Here the requirement is for people with new skills in roles that amount to new occupations. This group is extremely difficult to deal with in existing skills planning frameworks since the occupations have yet to be defined. In many instances the skills are still emerging in response to new demands. The research for this group is qualitative as anticipatory approaches to skills planning seek to clarify what these occupations will be or look like in the near or medium term. Examples include Carbon Accountants, Market Traders, Sustainability Managers, and Chief Sustainability Officers.

Skills anticipation means 'assessing the future prospects on the labour market and the potential imbalance between the demand for and supply of skills' and 'refers to activities to assess future skills needs in the labour market in a strategic way, using consistent and systematic methods' (ILO, 2015, p. 3). Despite the existence of extensive tools and institutions for skills anticipation, as well as numerous institutions for social dialogue and stakeholder engagement, researchers and policy makers argue that the SADC region is plagued by a 'skills gap' which presents an inadequate supply of the needed skills in energy. A number of issues are associated with anticipating skills demand and supply, as follows:

- **Skills demand:** Aggregations of employer-specified data, and analysis of labour force surveys, which give snapshots and can give some (limited) insights into current and future skills demand needs, and trends over time (Allais, 2022). These do not assist in developing a picture of how requirements for work may change, particularly within the context of responses to changes in the world of work and the environmental crisis (of which energy is a significant theme).

- **Skills supply:** Processes for qualification development as well as for accreditation of part-qualifications are long and cumbersome. To date, the national qualifications framework's rules are that short programmes can only be accredited as a 'part qualification,' constituted by credits within a full qualification (Allais, 2022). The rationale for this is to address the proliferation of part qualifications that do not lead to a full qualification, as well as qualifications of extremely varied sizes. However, it creates the unintended consequence of negating the possibility that industry associations can determine the need for a short programme, get it accredited and enable the graduate to access a specific opportunity in the workplace. The effect has been that the formal qualifications requirements lead to planning based on where qualifications exist rather than on where demand is emerging.

But the biggest problem is a conflation of time horizons in our current systems, particularly in so far as to demand analysis, qualification design, and funding come together. All the data systems that we have for skills anticipation have no possibility for providing information about skills needs beyond current and emerging skills. Policy responses to identified current and emerging skills should lead to short-term, immediate interventions. And yet, our systems prevent short-term responses, because of the relationship between the qualifications system, the occupational systems, the quality assurance requirements, and the funding levers. And yet, the same data is used to inform medium to long-term planning. This means that our medium to long-term planning is extrapolated from current and emerging demand; it also means that our occupational qualifications tend to be narrow (Allais, 2022).

It is important to note that sustainability transitions like the energy transition place specific challenges on identifying future skills as they require anticipatory systems that envision a 'reformed/expanded' value chain and reformed production and consumption processes – otherwise we are predicting skills needs with traditional modes of production and consumption (thus replicating the unsustainable *status quo*). This has presented a huge challenge for skills anticipation systems globally, and authors writing about the energy transition reflect on how current anticipatory systems have failed us and hampered the green transition (Rosenberg et al., 2020). Currently skills anticipation is being conceptualised and enacted within traditional modes of production and planning.

3.5 Skills transition to a low carbon, equitable and just future

Traditional notions of the transition to a greener economy have always drawn critique as they centre on a notion of sustainability that is driven by corporate and political interests to foster the sustainable economic growth of capitalism. Mohamed and Ramsarup (2019) argues that this discourse remains too closely aligned to current systems, not considering potential limits to growth, as well as presenting an oversimplification of the systemic scope of the green transition, and misplaced optimism. Clarifying what a transition to a greener economy or what a just energy transition will involve has been surrounded by ambiguity and remains a contested terrain. Furthermore, it has been a descriptive and normative discourse used mostly by policy analysts and often as an empty signifier. In Africa, tensions and contradictions between techno-centric and more radical approaches (such as 'just transitioning') which call for structural transformation, can also be discerned in the embryonic green economy discourse within SADC. In addition, the implications of jobs that will be lost need to be carefully considered and managed.

Any study focused on the energy transition in Africa needs to consider environmental justice and how it may intersect with other dimensions of economic and social justice. Gender inequality is now widely acknowledged as a central aspect of development. Besides being a right in itself, gender equality is also an end in itself (ILO, 2015a). The pursuit of gender equality is grounded on its recognition that equality is not just an intrinsic value and a right in itself, but also instrumental in achieving economic growth and poverty reduction. Energy is a critical input in the daily lives of many women, who need energy for their household chores, such as cooking, or for productive uses that enable them to contribute to household income while confining them to certain types of occupations. They may also make use of energy for rural industry needs, such as milling grains. In developing countries, women play a vital role as energy producers and as managers of energy security for the household. Yet, relative to men, they have less access to productive assets such as land and technology, and to services such as financing and agricultural extension programmes. There is a growing body of evidence that increasing access to modern energy services can make a significant difference in women's lives for their health, time use, education and income generation.

Energy is also a key requirement for economic development. The provision of reliable modern energy for industrialisation is not only critical for lower carbon emissions, but also for new non-energy jobs that increase energy demand and economic benefit. This is recognised in the SADC Regional Infrastructure Development Plan and the SADC Regional Indicative Strategic Development Plan (SADC 2020). Without economic growth, the technological turnover of a plant is very slow and expensive. Onyango, (2021) found that across various SADC countries "... for a 1% increase in energy use, the growth of the economy rose by 19.07 percent (p=0.027) holding other factors constant. This implies that economic growth grows as consumption of energy rises significantly." Therefore, if energy security and the required skills are not addressed, there will not only be climate related implications, but economic ones as well.

In summary, this review of literature underpinning the research attempts to provide a foundation for how skills are considered to transition to a just, resilient and sustainable economy and society. Skills need to be reframed as a continuum from approaches that focus on counting present-day energy transition (green) jobs to activity focused on eradicating a dependence on fossil fuels, to more circular economies and to transform our economy from inequality towards racial, gender, and class equality (Ramsarup, 2022). The understanding of skills required to transition is a slow, long-term endeavour, that requires multilevel engagement with hidden structures and mechanisms, including history and power relations, as often socio-economic lock-ins have deep historical roots. To understand the skills and capabilities needed to support the transition to a sustainable and renewable energy sector in the SADC region, an understanding of the necessary changes at multiple analytic levels, which are related to all the other levels in the transitioning system, is required (Rosenberg et al., 2020).

The review of literature provides a basis for the analysis of data across the data sets gathered in the research, of which the findings are presented in the next section.

4. Emerging findings

This section presents the findings that emerged from Phase 1, the country mini-case studies, key stakeholder interviews, surveys and supply-side provisioning analysis. The section that follows this provides a discussion on the overarching emergent findings which in turn inform the recommendations and conclusion.

4.1 Selected overview country case studies

Overview case studies for each of the selected countries (Botswana, Mauritius, Namibia, South Africa, Zambia and Zimbabwe) were developed using data gathered in Phase 1 and new desktop research. The full case studies can be found in Annexure B. Case study summaries for each of the selected countries are presented below, with a focus on electricity. Each captures the following:

- Key demographic, economic and current and future energy market statistics and data.
- Some key energy legislation and policy and indicative potential implications on work associated with this policy.

- Some key country-specific energy value chain hotspots (areas or activities of significance) and indicative potential implications on work associated with these.
- An overview of indicative current energy-related education and training provisioning within the country. This element is discussed further in the section on 'Skills demand and supply reflections.' Detailed findings on the provisioning of education and training and demand for each of the selected countries is presented in Section 4.4 'Skills demand and supply.' Lists of identified and accredited education and training courses provided in each of the selected countries are presented in Annexure E.

Case summary: Botswana

Botswana is a landlocked country in the centre of southern Africa. Its neighbours are Namibia, South Africa, Zimbabwe and Zambia. Table 5 provides an overview of Botswana's current and future energy transition landscape, and the implications this may have on work.

Table 5: Summary of Botswana's current and future energy landscape, with a focus on electricity, and potential work implications

Introduction			
Population	2,34 million (2022)[4]	**Total electricity production**	2,730 million KWh (2018)[1]
GDP	US$ 17,61 billion (2021)[2]	**Primary energy supply**	Coal (80%), gas (10%) gas, and RE (10%)[7]
Unemployment rate	26% (2021)[4]	**Electricity market**	Commercial sector (34%), households (31%), mining (25%) and public sector (10%)[11]
Employed in the energy sector	2,427 (2021) [Electricity, gas & air conditioning supply][15]	**% of population with access to electricity**	70% (2019)[1,7] [Urban, 88%; Rural, 28%][7]
Main economic sectors	Service (65%), industrial (28%) and agricultural (2%) sectors[3]	**Future energy mix**	RE (at least 15%) by 2030, and 50% by 2036[8]
Some key energy legislation and policy	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
National Energy Policy (NEP) (2021)	Increase in RE jobs and EE, women a focus. Energy security, affordability, and access also a priority	Coal base shifting to renewable energy jobs	Mining (coal) plus transport, local businesses around coal plant

Botswana's National Energy Efficiency Strategy (NEES) (2018)	Improving overall efficiency in the country by removing barriers	Electrical machinery, equipment and appliance installers Energy auditor	Installers Operations director / manager Systems engineer / technician Electrical engineer / technician Machine operators Data analyst (carbon emissions etc) Environmental officer (industry)
Renewable Energy Strategy for Botswana (2018)	Lower carbon energy solution implementation and localisation	RE construction jobs Operations manager Maintenance	Procurement manager Finance manager Climate change manager
Republic of Botswana Off-grid Solar Action Plan (2018)	Enhance universal energy access and rural development	Solar PV installers and maintenance Project manager	Procurement manager Finance manager Community liaison manager
Some priority hotspots	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
Reliance on domestic coal for local electricity generation[7,8]	Coal and related job losses, but the RE transition is expected to take several years as the country plan shows >50% coal in 2040.	Coal mine staff (50 000) (miners and mining engineers) Coal power station and OEM staff Community liaison officer	Coal trucker Mining inspector
Unreliable utilities performance (poor financial and operational performance)[5,6,8]	More operations and maintenance jobs or upskilling required	Plant operator Power station and grid engineer Financial manager	Procurement manager HR manager
Limited and dispersed electrification and low household access to electricity, especially in rural areas[5,7,14]. Also poor payment which hinders distribution[10]	Enhanced strategy and financial capacity required to plan and roll out the energy access plan (off-grid and grid expansion)	Electrical engineer Artisan and installer Planner and modeller Policy / strategy developer	Project manager Community liaison officer Procurement manager HR manager
Limited government / institutional support and investment, policy and regulatory framework to	Improve regulatory frameworks to manage private sector participation in RE.	Policy developer Policy director) Regulatory manager / advisor	EIA specialist Financial planner Business development manager

pursue RE[5,8,9,12,13;] Exacerbated by lack of capacity to connect RE to the electricity grid[12].	Require improved understanding of RE feasibility, permitting processes and grid absorption from renewables.	Legal advisor	Risk assessor
Overview of current energy-related education and training provisioning			
The majority of the energy-related courses being offered in Botswana are certificates and short courses. The short courses and certificates are focused on electrical components such as electrical installation and electrical engineering. At undergraduate and graduate level, the energy-related courses are tailored towards engineering e.g. energy engineering and environmental engineering. These courses cover aspects of RE and EE. Green buildings courses are also provided. The RE courses are focussed on solar PV with no evidence of other forms of RE being offered. Additionally, there were no energy courses with an REI focus being offered.			

Sources: Adepeju (2022)[9]; African Energy Portal (2022)[7]; Arnoldi (2021)[5]; BPC (2018)[11]; IRENA (2021)[8]; Kgosiemang (2020)[12]; Macrotrends (2022)[2]; Nwanosike (n.d.)[10]; Rabasoma (2022)[13]; Raditholo (2019)[14]; SADC (2020[5], 2021[1]); Standard Bank (2022)[3]; Statistics Botswana (2021[15], 2022)[4]; USAID (2021)[7]; World Bank (2022)[2]

The insights gathered indicate that the country will go through a major energy transition over the next decade given that it currently has a high coal base, both locally generated and imported from South Africa. The policy of the country is to diversify mostly through the deployment of solar PV, but rural electrification is at low levels and the country will need to focus on implementation and energy efficiency to improve affordability. This means new skills across the entire value chain. Training institutions in the country will be able to provide some of the required skills but may not be able to cope with the volume required should implementation ramp up according to policy aspirations.

Case summary: Mauritius

Mauritius is an island located in the Indian Ocean, about 900km east of Madagascar. It is made up of an archipelago of several islands. Table 6 provides an overview of Mauritius' current and future energy transition landscape, and the implications this may have on work.

Table 6: Summary of Mauritius' current and future energy landscape, with a focus on electricity, and potential work implications

Introduction			
Population	1.3 million (2021)[2,6]	**Total electricity production**	2,882 million KWh (2020)[2]
GDP	US$ 11,16 billion (2021)[4]	**Primary electricity supply**	Coal (39%), fuel oil & diesel (37%), and renewables (24%)[3,8]
Unemployment rate	10% (2021)[7]	**Electricity market**	Households (39%), commercial (33%), and industrial (27%)[3]
Employed in the energy sector	2,600 (2021) [Electricity, gas, steam and air conditioning Supply][7]	**% of population with access to electricity**	100% (2019)[1,2] [Urban, 100%; Rural, 100%][2]
Main economic sectors	Financial and insurance activities (14%), manufacturing (notably textiles) (13%), wholesale and retail (12%), public service (7%), and real estate (6%)[5]	**Future energy mix**	60% renewables by 2030[3]
Some key energy legislation and policy	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
Long-term Energy Strategy and Action Plan (2009)	Some key skills required for the successful implementation of this plan include EE planning and monitoring, and RE site set up and operations, enforcement of key marketing strategies, garner finances and ensure gender inclusion at all levels.	Director Operations manager	Finance manager RE specialist Legal advisor Energy marketing professional Gender expert
Renewable Energy Roadmap 2030 for the Electricity Sector (2019)	Skills will be required to establish a green energy industry, to accelerate the share of RE in the electricity mix, to phase	RE project manager Operations manager	Electrical / RE engineer / technician Community liaison / training officer

[2] SADC (2021).

	out the use of coal in electricity generation by 2030, and to increase EE by 10% by 2030[3].		
National Biomass Energy Framework (in progress)	Energy security, climate change and link to power to produce products like green ammonia.	Material / bioenergy engineer / technician	Agriculture biomass specialist Transport and logistics manager Procurement manager Finance manager
Some priority hotspots	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
While the country does produce its own energy, it has an import dependency of almost 87%. These imports are fossil fuels, notably oil and coal[8,9,10,11]	This will require, where feasible, the increase of local RE production, and for imports to switch to lower-carbon alternatives and be as efficient as possible.	RE engineer and technician Plant operator Energy trader Procurement manager	Electrician Construction worker Electric grid controller Transmissions engineer Marketing officer Field officer Planners and modellers
Hydroelectric power generation affected by rainfall fluctuations[3]	To mitigate issues associated with hydro, skills in weather forecasting, climate change and planning are critical. In addition, other RE sources will be required e.g. solar and wind energy (see above).	Hydropower engineer (affected) Hydrologist Meteorologist Climate change scientist RE (see above)	Environmental scientist Planner and modeller Risk assessor RE (see above)
Only 5% of the energy sector workforce is women[12]	There's a need to increase and incentivise the number of women entering the sector, and to enhance RE, EE and REI training / skills development and provisioning.	Gender integration specialist	Government officer Power company manager Community liaison officer Educator (higher and basic education)
Low use of smart and RE technologies to improve EE, and increase RE use by businesses and households[13]	This needs the introduction/ incorporation of EE technology knowledge and skills in businesses and the public sector. Includes understanding of EE and RE opportunities and	Energy management supervisor Business development manager Community trainer / liaison officer RE marketer	Heads of department (business, public service) Environmental / sustainability officer Energy auditor Operations manager RE technician

	solutions.		
Need to improve EE through improved installation and maintenance e.g. of air conditioners, in businesses and public sector[13,14]	Requirements to upskill and increase the number of individuals with various machinery, tools and appliances to improve EE in businesses and the public sector.	EE educator / trainer Electrical engineer / technician Building maintenance manager Operations manager	Environmental / sustainability officer HR manager
Overview of current energy-related education and training provisioning			
Academic institutions in Mauritius mostly offer high level skills training for RE, with bachelor's degrees in energy-related courses being widely offered. Diplomas and Certificates are also offered by TVET colleges. Energy programs focus on electrical installations and engineering. The majority of the courses have an RE and EE focus with no evidence of REI courses being provided.			

Sources: Aumeeruddy (2020)[12]; Energy Efficiency Management Office (2022)[14]; ILO (2018)[13]; Imrichova and Beedassy (2020)[10]; MEPU (2020[3], 2022[9]); Richard (2021)[11]; SADC (2020[2], 2021[1]); Statistics Mauritius (2021[8], 2021a[7], 2022[6], 2022a[5]); World Bank (2022a)[4].

Mauritius is moving away from fossil fuels to RE thus shifting its skills base in generation and requiring new skills in systems operations and grid operations. The policy environment is well structured as is the supply of training and education pipelines to facilitate this. Their long-term planning does however need to be updated to reflect the current context.

Case summary: Namibia

Namibia is located in the south-west of Southern Africa, and is bordered by Angola, Zambia, Botswana and South Africa. Table 7 provides an overview of Namibia's current and future energy transition landscape, and the implications this may have on work.

Table 7: Summary of Namibia's current and future energy landscape, with a focus on electricity, and potential work implications

Introduction			
Population	2.6 million (2021)[3]	**Total electricity production**	1,296 million KWh (2018)[1]
GDP	US$12.24 billion (2021)[3]	**Primary energy supply**	c.55% imported from South Africa (coal-derived), and 45% renewables (Hydro (93%), solar (4%), wind (3%)), and fossil fuels (7%)
Unemployment rate	22% (2021)[3]	**Electricity market**	Households (35%); transport (30%); agriculture, forestry and fishing (17%), commercial and public

			services (8%), and industry (7%)[13]
Employed in the energy sector	3,278 (2018) [Electricity, gas and related industries][5]	**% of population with access to electricity**	56% (2021)[3] [Urban, 75%; Rural, 35%][2,10]
Main economic sectors	Manufacturing (11%), wholesale and retail (10%), mining and quarrying (8%), agriculture and forestry (4,5%) and electricity and water (4%)[4]	**Future energy mix**	70% renewables by 2030[20]
Some key energy legislation and policy	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
National Energy Policy (2017)	Energy security, lower carbon emissions, improved efficiency and affordability	Energy-related engineers Policy developer	Project manager / facilitator Energy economist Strategist and planner
National Renewable Energy Policy (2017)	Key skills required for the successful implementation of this policy include experts, financial experts to secure and manage funding and community engagement skills.	Director (with RE expertise)	Solar PV expert Green hydrogen expert Hydroelectric power expert Community liaison officer Legal advisor Finance manager
National Policy for IPPs in Namibia (2018)	Energy security, risk mitigation, and investment will be key to implementing this policy.	Financial manager Lawyer RE-related engineer	Business liaison manager Community liaison officer Project manager Procurement officer
National Energy Efficiency Strategy (in progress)	Energy security, affordability, lower emissions and resource use will be key components for implementation.	Electrical / mechanical engineer Project manager Building / operations manager	Standard setting association manager Communications manager Green building architect Procurement officer Energy auditor
National Electrification Policy (in final draft)	Need for policy and strategy finalisation and implementation to enhance electricity access, with a focus on rural electrification. Will	Rural electrification director Energy regulator	Project manager Design technician RE engineer Planning power distribution engineer Surveyor

	also require mobilisation of funding.		Legal counsel Environmental specialist Electrical engineer Community liaison officer
Some priority hotspots	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
Shift away from a reliance on imported power (coal-based) to locally generated RE[6,8,9,14,15.] However, this shift is compounded by a slowness in taking advantage of abundant RE sources, and limited government funds and capacity to manage / implement RE technologies[8,16]	This will require individuals who can promote, construct, install, operate and maintain RE technologies.	RE engineer / technician Energy trader	Electrician Construction worker Electric grid controller Marketing officer Community liaison officer Legal advisor
Transitioning from a fragmented centralised distribution system to a hybrid decentralised model with multiple electricity generators and suppliers[10,11,17]	If Namibia is to fully exploit RE it will need an expanded and integrated grid that can handle multiple generators and suppliers.	Electrical engineer Transmission and distribution construction manager Transmission and distribution construction technician and labourer	System operator Regulatory advisor Legal advisor Procurement officer
Drought conditions impacting on hydro generation[17]	Skills in other RE technologies will be required e.g. solar and wind energy, and capability to monitor climatic conditions to inform / mitigate hydropower provision.	Hydropower engineer Hydrologist Meteorologist Electrical engineer / technician	Customer service operator Water treatment attendant Overhead lines engineer IT engineer Transmissions engineer Legal personnel Risk assessor
Limited household electricity access in rural areas, and no energy access strategy in place[2,10,11]. This is compounded by the high cost of energy supply[18]	Need for policy and strategy development and implementation to enhance electricity access, with a focus on rural electrification. Will also require mobilisation of funding.	Rural electrification director Energy regulator	Project manager Design technician RE engineer Planning power distribution engineer Surveyor Legal counsel Environmental specialist Electrical engineer Community liaison officer

Large-scale emphasis on green hydrogen and PtX[6,7,12]	There will be a need to introduce technologies and skills to construct, operate and maintain green hydrogen projects.	Green hydrogen project coordinator	Process engineer Business development manager Electrolysis expert Hydrogen expert Solution expert Sales director Finance director Legal advisor Procurement
Overview of current energy-related education and training provisioning			
A variety of service providers from university to TVET and community colleges exist in Namibia. The education and training vary from electrical engineering degrees and Masters in RE to vocational electrical training and short courses on solar PV. There is no evidence of green hydrogen courses being offered, which is a gap that may need to be filled as the country looks to transition to green hydrogen.			

Sources: Africa Energy Commission (2021)[13]; Erastus (2020)[14]; Heita (2022)[8]; How et al. (2018)[18]; Malsang (2022)[7]; Ministry of Mines and Energy (2016[20], 2022[11]); Mnyupe (2021)[15]; Namibia Statistics Agency (2019[5], 2022[4]); Republic of Namibia (2021)[6]; Richardson (2022)[12]; SADC (2020[2], 2021[1]), Shidhika (2018)[16]; Shipunda (2022)[9]; US ITA, 2021[10]; World Bank (2022d[17],2022e[3]).

Namibia has a comprehensive policy environment and appears to be implementing their policy in earnest. Its main drivers are to decarbonise their energy mix and reduce dependence on South Africa for electricity imports. In addition, they have put in place strategies and processes to enable the country to accelerate energy generation capacity projects. Efforts are moving fast to exploit their good renewable energy resources to produce green hydrogen and other clean molecules for export. This will have a significant impact on Namibia's economy. Although they have good skills and education infrastructure and processes in place, they may need to rely on imported skills given the small population of the country and the pace at which they are moving. Good procurement skills are therefore essential.

Case summary: South Africa

South Africa is located on the southern tip of Africa and has one of the largest economies on the continent. Table 8 provides an overview of South Africa's current and future energy transition landscape, and the implications this may have on work.

Table 8: Summary of South Africa's current and future energy landscape, with a focus on electricity, and potential work implications

Introduction			
Population	60.6 million (2022)[4]	**Total electricity production**	239,459 million KWh (2020)[1]
GDP	US$ 62,94billion (2022)[5]	**Primary energy supply**	Coal (65%), crude oil (18%), renewables and waste (11%), gas (3%), nuclear (2%) and geothermal (1%)[9]

Unemployment rate	35% (2022b)[7]	**Electricity market**	Industrial sector (51%), transport (26%), commerce & public sector (11%), residential (7%), and agriculture (2%)[9]
Employed in the energy sector	59,000 (2021) [electricity][8]	**% of population with access to electricity**	85% (2019)[1,2] [Urban, 88%; Rural, 79%][2]
Main economic sectors	Mining, transport, **energy**, manufacturing, tourism and agriculture[6]	**Future energy mix**	43% coal and 34% wind and solar by 2030[10]
Some key energy legislation and policy	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
White Paper on Energy Policy (1998)	Need for good governance, leadership and coordination to implement the policy to ensure optimal energy consumption and production to meet social needs. In addition, implementation requires integrated energy planning, which in turn requires data and analysis.	Directors (national and provincial government)	See IRP hotspot / change driver below
Integrated Resource Plan (IRP) (2019)	Energy security, policy implementation, IPP procurement and management, and new markets required to implement IRP.	Planner and modeller Energy-related engineer Policy maker	Project manager Communication manager Procurement manager Financial manager Lawyer
South African National Efficient Energy Strategy (NEES) (2006)	The strategy requires individuals with the skills to develop energy efficiency plans, to monitor and report energy efficiency within operations, and to identify energy efficiency solutions.	Utilities manager Operations / buildings manager	Standards setting association manager Communication manager Green buildings architect Procurement manager Electrician / maintenance technician
Some priority hotspots	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who else will be impacted?**

While South Africa is endowed in coal deposits, emphasis is being placed on shifting away from coal extraction and use to mitigate the effects of climate change[10,14,15]. Will have significant potential job losses in the coal sector[14].	This shift will result in reduced employment in the coal sector, and the need to identify alternative sources of employment for those involved in the sector. Engineers and service functions can be easily reskilled or redeployed.	Coal mine staff (50 000) (miners and mining engineers) Coal power station and OEM staff	Coal trucker Mining inspector
The expansion of South Africa's Renewable Independent Power Producer Programme (REIPPP) and the need to significantly upscale RE. This will require a market shift to more privatisation and decentralisation[9]	With this, comes the need for individuals who can procure technologies, contractors and specialists, services (e.g., maintenance) either privately or through government tender processes. With a shift towards privatisation / decentralisation, more responsibility will fall on local governments to procure, negotiate and set tariffs, trade and manage the electricity generated within their jurisdictions.	RE procurement officer Coal procurement officer	Legal advisor Chief financial officer (CFO) IPP project manager Environmental / social impact assessors Project manager
		Electricity regulator (tariff setting, planning and monitoring)	Electricity transmission system planning engineer Electricity power cost estimator / assessor Legal expert (tariff setting and negotiations) Environmental scientist Lawyer Regulatory advisor Director: Service provision (local government)
While South Africa has an Integrated Resource Plan (IRP) it is dated. Will be reviewed and updated in 2023[19]. In addition, the future energy mix and focus is complex, much debated and unclear[20,21].	It is a requirement that the country's IRP should be updated every two years to recognise developments, trends and shifts of emphasis in the sector. This should be supported by a clear and aligned energy vision and policy, incl. industrial, climate change, and relevant sectors e.g., transport.	Director: Electricity (national and provincial government)	Energy systems modeller Energy economist Environmental scientist Policy / strategy developer / advisor Risk analyst Project manager
South Africa's energy system is vulnerable and insecure. The government-owned utility Eskom has	To transform the generation of electricity into an effective and efficient operation that the country's businesses	Maintenance technician	Electrical engineer / technician Operations manager Health & safety officer Security personnel

challenges e.g., debt, infrastructure (ageing and failing, theft, and capacity), limited maintenance, corruption and collusion[2,3,9,11,12]. Much of the above has led to forced power cuts ('load shedding') which has impacted the economy[11,12,13].	and population can rely on, will require good leadership and management, union negotiation, monitoring, risk mitigation and planning, and core maintenance skills. With the transmission grid facing constraints there is a need to expand the grid. This will require new investment and companies to coordinate the expansion.	Transmission system design engineer	Grid design engineer Specialised grid maintenance technician / artisan Energy-related engineer Grid operator
Equitable access to energy at affordable tariffs[16]. End-user inability to pay and/or electricity theft[2]	Affordability is a key issue and can result in theft or inability to pay. Energy safety nets can be considered to support poor communities of schemes like free basic electricity.	Community liaison officer Energy pricing manager Economist	Communication manager Financial manager Security manager Safety officer Regulatory advisor Lawyer
South Africa's economy is energy intensive, with the industrial sector (notably chemical and petrochemical, and iron and steel) and mining sectors being the largest consumers of energy[9]. Need to improve management or control of energy consumption in industry[17].	To minimise energy intensity and optimise energy usage (and associated carbon emissions) industry needs to adopt/improve its in-factory EE measures. This requires individuals who can e.g., develop, monitor and report on in-house energy management programmes, implement electrical demand control mechanisms, maintain and upgrade machinery, and identify EE technologies.	(Systems) engineering manager Operations / building manager	Utilities operator Electrical engineer Process technician Mechanic (e.g., electrical, diesel) Environmental sustainability officer Energy assessor Procurement manager

Overview of current energy-related education and training provisioning

Of South Africa's 26 public universities (traditional and universities of technology) 6 of the traditional offer electrical engineering degrees, with most universities of technology offer electrical engineering BTech degrees and national diplomas. However, with the shift in emphasis and need to supply the growing renewables energy sector with appropriate skills and knowledge these institutions are beginning to offer short specialist courses on the topic. For example, Stellenbosch University's Centre for Renewable and Sustainable Energy (CRSE) offers a variety of contemporary short courses on wind, storage and energy systems. The University of Pretoria's Centre for New Energy Systems, on the other hand, focuses its short courses on energy market operation, management

and optimisation. The universities of technology, as would be expected, have picked up the baton to deliver renewable energy technology skills needs with, for example, the Durban University of Technology (DUT) and notably the South African Renewable Energy Technology Centre (SARATEC) at the Cape Peninsula University of Technology (CPUT), offering a number of RE technology installation and technical courses for wind, solar and grid connection. Most of the TVET colleges focus on traditional electrical engineering, installation and infrastructure certificates, with few placing an emphasis on renewable energy or energy efficiency explicitly. The area of most activity in short course offerings is in the private college and academy space. Courses vary, and range from energy auditing, planning and management, to financing of energy projects, electrical engineering and renewable technologies design, installation and maintenance (wind and solar). Two unique provisioning offerings, are those offered by the University of Witwatersrand's Business School's African Energy Leadership Centre (AELC), which is one of the few to focus on the strategic management of energy, and Sarawak Energy which specialises in short courses which focus on energy transmission skills such as street lighting maintenance, switchboard testing and laying of underground cables (to name a few).

Sources: Africa News (2022)[13]; Caboz (2019)[11]; Creamer (2022)[19]; DMRE (2019[10], 2022[9], 2022a[18]); Evans (2021)[20]; Kan et al., (2020)[17]; Largue, (2022)[22]; Montmasson-Clair (2021)[14]; National Planning Commission (2018)[16]; News24 (2022)[3]; Njini et al., (2019)[15]; Niselow (2019)[12]; SADC (2020[2], 2021[1]); SA Government (2020)[6]; StatsSA (2022[4], 2022a[5], 2022b[7], 2022c[8]).

There is overwhelming evidence emerging from the research that there is a need to accelerate and deepen restructuring and privatisation of the energy sector and markets in South Africa to attract the required private sector investment in RE. Furthermore, information from research points to the need for the strengthening and extension of the electricity transmission line to allow connectivity of electricity capacity earmarked to be built in areas which are away from the existing transmission grid. Emerging data also points to an urgent need to improve and strengthen the planning of new electricity capacity, transmission and investment. In this regard there is increased pressure on the government to update the current Integrated Resource Plan (IRP). These trends also point to the need for the development and or deployment of specialised procurement, electricity grid design capabilities and planning skills.

Case summary: Zambia

Zambia is a landlocked country located in the northern region of southern Africa. Its neighbours include Malawi, Mozambique, Zimbabwe, Namibia, Angola, Democratic Republic of Congo and Tanzania. Table 9 provides an overview of Zambia's current and future energy transition landscape, and the implications this may have on work.

Table 9: Summary of Zambia's current and future energy landscape, with a focus on electricity, and potential work implications

Introduction			
Population	18.4 million (2021)[3]	**Total electricity production**	14,930 million KWh (2019)[1]
GDP	US$ 21.20 billion (2021)[4]	**Primary energy supply**	Hydro (83%), coal (9%), heavy fuel oil (5%), and solar (3%)[7]
Unemployment rate	13% (2022)[5]	**Electricity market**	Mining (51%) and domestic (33%)[7]

Employed in the energy sector		**% of population with access to electricity**	43% (20139)[1,2] [Urban, 80%; Rural, 14%][2]
Main economic sectors	Services (54%), industrial (mining) (40%), and agriculture (3%)[6]	**Future energy mix**	-
Some key energy legislation and policy	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
National Energy Policy (2019)	Increase in RE and EE are key policy measures. This means that new electricity generation has access to the grid. The shift to renewables There may result in some job losses at thermal plants. In addition, there needs to be an alignment with / revision of other pieces of energy legislation.	Energy-related engineer / technician Electrician	Procurement officer Lawyer Financial manager Project manager
Renewable Energy Feed-in Tariff Strategy (2017)	By putting feed in tariffs in place RE technologies will have good business cases for financing. The subsidy should be phased out over time as the energy becomes competitive.	Pricing manager System operator Energy economist	Procurement manager Financial manager Negotiator Regulatory advisor
Some priority hotspots	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
Requirement for speeder increase and uptake in RE and an increase in private participation to meet this shift[10,11]. Compounded by challenges associated with implementing a RE energy feed-in tariff due to lack of agreement[7,9].	Regulators and licensors will be required to enable the shift towards RE.	RE electrical engineer Regulatory advisor	Procurement manager HR manager Finance / investment manager Project manager

Impact of droughts on the generation of hydropower. Resulting in load shedding, which is having an impact on the economy[6,8,14].	Skills in other RE technologies will be required e.g. solar and wind energy, and capability to monitor climatic conditions to inform / mitigate hydropower provision.	Hydropower engineer Hydrologist Meteorologist Electrical engineer	Planning and modelling engineer Risk assessor Climate change / environmental scientist
Lack of a regulatory framework to guarantee security of investments. Amongst others, this impacts electrification efforts, especially in rural areas (see below)[2,11]	Capacity building and project and policy implementation support is required (including consultation). There is also the challenge associated with tariff agreements and poor governance. This requires financing on-grid connections and private investment in off-grid renewables. The latter requires the need for more effective leadership and managers. The situation would also benefit from increased access to funding.	Electrical engineer Policy developer Planning and modelling engineer	Regulatory advisor Community liaison officer Funding / investment manager Lawyer Project manager
Low rural electricity access, with low ability to pay for electricity[2,7,9,14]. Compounded by poor governance, funding and a transmission investment plan[9,13].	The combination of these two issues means that it is difficult to find sustainable business models without subsidies from government.	Energy-related engineer Energy economist Policy developer Community liaison officer	Communication manager Planner and modeller Financial / investment manager
Access to finance inhibiting universal energy access, with high upfront capital costs, with non-cost reflective tariffs hindering investments[2]. Credit risks associated with RE investment[12].	Sustainable business models need to be found that provide economic uplifting together with energy provision for long term sustainability. Subsidisation or grants for upfront capital costs.	Energy-related engineer Energy economist Policy developer Community liaison officer	Communication manager Finance / investment manager Regulatory advisor
The mining sector is a significant and growing consumer of energy[15,16].	EE measures will be critical to ensure cost regulations for the mines but also security of supply. Some	Electrical engineers EE managers Operational managers	Mining engineer Regulatory advisor Environmental / sustainability officer

	mines may decide to self-generate so additional skills will be required to do so.		Procurement officer Energy auditor
Overview of current energy-related education and training provisioning			
Zambia has a very strong educational network offering degrees and masters at university level to a variety of short courses at TVET and community colleges. RE, REI and EE are covered. Given that many private sector players are also involved in these areas; the demand should grow for these offerings. Many of the courses are demand driven for a particular market either the utility or consumers or potential IPPs or self-generators.			

Sources: African Power Platform (2021)[10]; Imasiku and Ntagwirumugara (2021)[16]; Macrotrends (2022a)[4]; Ministry of Energy (2022)[7]; Ngoma (2021)[11]; Phiri et al. (2021)[15]; Reuters (2019)[8]; SADC (2020[2], 2021[1]); Shalubala (2022)[9]; Smith (2022)[12]; Standard Bank (2022a)[6]; Stritzke et al. (2021)[13]; UNECA (2021)[14]; World Bank (2022f[5], 2022g[14]); Zambia Statistics Agency (2022)[3].

Zambia is struggling with security of supply not only because of climate impacts but also sub-optimal infrastructure. They are committed to transitioning to higher levels of renewable energy and have a strong educational capacity to train the required increase in competent energy market participants. This will however require funding or other financial mechanisms to maintain the level of support required.

Case summary: Zimbabwe

Zimbabwe is a landlocked country in the centre of southern Africa. Its main neighbours include South Africa, Botswana, Zambia, and Mozambique. Table 10 provides an overview of Zimbabwe's current and future energy transition landscape, and the implications this may have on work.

Table 10: Summary of Zimbabwe's current and future energy landscape, with a focus on electricity, and potential work implications

Introduction			
Population	15.1 million people (2022)[3]	**Total electricity production**	9,243 million KWh (2017)[1]
GDP	US$9.9 billion (2022)[4]	**Primary energy supply**	Hydropower (70%), coal (29%) and other renewables (1%) (2021)[8]
Unemployment rate	80% (2022)[5]	**Electricity market**	-
Employed in the energy sector	45,300 (2022) [electricity, gas, steam and air conditioning]*	**% of population with access to electricity**	41% (2019)[1,2,10] [Urban, 85%, Rural, 20%][2]

Main economic sectors	Services (50%), industry (36%) - notably mining - and agriculture (8%)	**Future energy mix**	RE as 16% of overall electricity supply by 2025, and 26.5% by 2030[16]
Some key energy legislation and policy	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**
National Energy Policy (2012)	In order to ensure the successful implementation of this policy there will be a need to enhance skills in EE, energy diversification through increased promotion of RE and sufficient energy governance.	Director (renewable energy)	Renewable energy coordinator RE business development manager Finance manager Energy-related engineer / technician Marketing manager
National Renewable Energy Policy (2019)	Skills in RE implementation and management will be required to meet the draft increased EE measures target of 70% by 2030.	Project manager Finance / investment manager	RE engineer / technician RE construction / installation manager Community liaison officer Regulatory advisor
Biofuels policy of Zimbabwe (2020)	Skills required to leverage sugar cane bagasse and jatropha as sources of biofuels.	Material / biomass engineer / technician	Agriculture specialist Transport and logistics manager Procurement manager Finance / investment manager
National Energy Efficiency Policy (in progress)	Skills and capacity required to develop a strategy to deliver the policy, which include the development of codes of practice, EE specification, and standards.	EE strategy specialist Regulatory advisor	EE educator / trainer Operations manager Electrical engineer
Some priority hotspots	**Potential implications on work**		
	Some key job and skills requirements / impacts	**Core affected / needed jobs**	**Who works with the core job? (occupational network)**

While Zimbabwe is endowed with large deposits of coal, its coal plants are in various states of disrepair, providing an opportunity to transition to and scale uptake of RE through adaptation of legislative framework mitigating land use issues which can lead to delays in incentivising for RE due to high production costs, and improved training of technical personnel[8,9,10,11,13].	Skills in RE planning, legislation, installation, operation, integration, and marketing to increase uptake are needed.	Project manager Finance / investment manager	RE engineer / technician Marketing manager Community liaison officer Regulatory advisor Planner and modeller
Significant and unsustainable level of government debt inhibiting investment in big electricity generation projects / infrastructure[5,12].	Skills to curb the country's debt and secure project funding will be needed.	Finance / investment manager	Finance minister / director Central bank governor Risk assessor Planning and modeller
Access to finance is limited with minimal participation by local banks in the sector. Seen as a perceived risk by investors. Also, a lack of access to funding which limits levels of borrowing[2,8]	Access to finance has implications for energy security. Risk increases cost so financial managers are a critical resource	Financial / investment manager Planner and modeller	Energy-related engineer Policy developer Risk assessor
Demand often outstrips local supply. This deficit results in loadshedding[12].	To transform the generation of electricity into an effective and efficient operation that the country's businesses and population can rely on, will require good leadership and management, monitoring, risk mitigation and planning, and core maintenance skills.	Maintenance technician Transmission system design engineer	Electrical engineer / technician Operations manager Health & safety officer Security personnel Grid design engineer Specialised grid maintenance technician / artisan Energy-related engineer Grid operator

Perennial droughts reduce power hydro power generation capacities[8].	Skills in other RE technologies will be required e.g. solar and wind energy, and capability to monitor climatic conditions to inform / mitigate hydropower provision.	Hydropower engineer Hydrologist Meteorologist Electrical engineer	Planning and modelling engineer Risk assessor Climate change / environmental scientist
Low electrification rate, and inequality in provision of electricity, particularly within rural areas. Exacerbated by soaring electricity tariffs. No mechanisms in place to subsidise electrification for rural communities[2,8,10,14].	There is a need to enhance skills that promote rural electrification with affordable tariffs for the rural communities to afford.	Rural electrification director Project manager	RE engineer / technician Planning power distribution engineer Surveyor Lawyer Regulatory advisor Environmental scientist Community liaison officer Security officer
Limited EE skills, information and awareness needed to achieve increased efficiency measures which has a draft target of 70% by 2030[6,7,15].	Skills and capacity building in EE requirements, equipment and information dissemination will be required to implement the policy.	Project manager Operations / building manager	Mechanical / electrical engineer / technician Procurement officer Energy auditor Environmental / sustainability officer EE educator / trainer
Overview of current energy-related education and training provisioning			
The two main Zimbabwean universities (University of Zimbabwe and the Midlands University) offer bachelor's and master's degrees in RE. The universities of science and technology on the other hand offer, in the main, energy efficiency bachelor's degrees, whilst the Institute of Capacity Development offers short courses on financial management of energy projects. Private providers also focus on short courses on solar power design, off-grid and solar power for municipalities and installation.			

Sources: Chipango (2020)[10]; Dzobo (2020)[7]; Farirai et al. (2020)[15]; Kumar (2021)[14]; Lloyds Bank (2022)[5]; Mawire (2021)[6]; Madya (2022)[16]; Mutasa (2021)[8]; Njenda et al. (2021)[11]; Sibanda (2022)[12]; SADC (2020[2], 2021[1]); US ITA (2022)[9]; ZimStat (2022[3], 2022a[4]); ZPC (2022)[13].

*An estimated 0.3% of the population (15 years and above) work in the electricity, gas, steam and air conditioning supply sector (ZimStat, 2021). Based on an estimated population of 15.1 million in 2022, this suggests 45,300 people work in this sector.

The research indicates that Zimbabwe lags behind in efforts aimed at promoting not only investment in renewable energy but also in ensuring that there is energy integration and adoption of energy efficient technologies and methods. In addition, there seems to be a dire need to put in place strategies aimed at enhancing the development of energy efficiency skills and awareness. Capacity and capability are required to significantly improve the population's access to electricity.

Case studies summary

All selected countries have up to date (or under review) policies in the energy space. Some are weak in terms of specific targets or not comprehensive enough (see point on grid below). There is more emphasis on RE than on EE, and policy implementation is slow. Some progress in the electricity sector has been clearly laid out in the SADC Renewable Energy and Energy Efficiency Status Report (SADC, 2018). Coordination and synergies across industrial, economic and skills policy was however difficult to trace. It is however clear that countries are not always adopting an integrated policy approach when it comes to skills development and the systemic nature of the change required, which will be essential for good policy development as well as implementation.

All selected countries have energy insecurity issues, with most experiencing load shedding. Insecurity is also linked to concerns about supply from South Africa which has non-performance plant issues and a reliance on coal. The latter being of concern for those wishing to shift away from fossil fuels as a source and impacts on their electricity availability. This highlights the need for increased investment in electricity generation and the required skills which policy dictates will in all likelihood be for solar PV and in some countries wind together with grid construction skills. Although it did not come out strongly in the case studies, energy efficiency skills are essential in managing energy security and improving affordability.

All selected countries, expressed in their long-term plans their wish to improve their energy security. Several countries have included in their plans actions to develop energy for export which reinforces the need for regional energy integration activities (see case studies). Given that the market is small, with South Africa being the exception, not all countries will be able to realise their ambitions. In addition, while a number of the countries studied have funding, there are gaps e.g., in funding plans, committed funding and implementation. This includes Zimbabwe who has funding for a renewable energy fund and two new coal units at Hwange power station (Sibanda, 2021), Namibia who have funding for their first large-scale vertically integrated green hydrogen plant using wind energy (Malsang, 2022; Richardson, 2022) and South Africa who received pledges for over US$8billion towards a just energy transition (Bloemberg, 2022). Skills in terms of accessing financing, project management, procurement and design will all therefore be needed. Imports and exports also require a trading platform, which will require energy trading skills and knowledge, as well as 'softer' skills i.e., negotiation and contracting skills.

The shift seen at the policy level in the country's energy ministries are closely aligned with their national climate change and carbon emission reduction commitments. It is also worth noting that all the case countries recognise the need for net zero carbon emissions, but do not necessarily commit to this. It is referred to in conditional terms, in other words net zero can be achieved with international financial support, technology deployment, skills programmes etc. (see case studies).

Some countries, such as South Africa, Botswana and Zimbabwe, are more dependent on coal than the others. Given that Africa is said to contribute only approximately 3% of global carbon emissions, some want to continue to run current coal plants to the end of their useful life. The transition away from coal also has significant job loss and skills implications.

Most of the selected country energy-related policies promote a radical shift away from fossil fuel energy towards an energy mix dominated by RE, making some shifts to increase the number of renewables in their relative energy mixes. In the relevant policy documents, there is some differentiation between large-scale grid connected and small-scale RE, including off- and micro-grid. There is however limited data on renewables that individual or small-scale businesses and other organisations are installing, such as rooftop

PV, but some information on rural off- or mini-grid programmes. More detailed data and analysis is required to identify the appropriate skills programmes required for the sometimes very different skills required for grid planning, design and connection.

- Except for South Africa, most of the case study countries focus on solar PV and with little on wind or solar. This has big implications for skills development given this narrow focus on Solar PV.
- Namibia and South Africa are advanced in terms of green hydrogen and other clean molecules as part of their renewable energy ambitions. This has implications for the quantum of skills needed and competition for them in the market, especially as the global market is driving demand, and skills are mobile.

The grid operation and maintenance, and grid expansion needed to accommodate increased energy generation and renewables, is mentioned in a number of country policy documents. However, it has low priority and little or no investment is made in the planning, design and expansion of such grids. This results in (or will) significant network problems currently experienced in these countries. This indicates a need for grid planning and design related interventions and skills. These countries include South Africa, Zambia and Namibia. Engineering jobs as well as modellers and system operators will primarily be impacted.

While evidence of IPPs being brought into the market is acknowledged, it is very slow in most countries, therefore, electricity markets and deregulation are not big drivers, with the exception of South Africa. This will have to, as a necessity, change over time as IPPs and other actors enter the market. Where markets are changing there is an increasing need for regulators that understand more open markets, power purchase agreements etc. This means training for regulators on these new markets, pricing methodologies and changing roles in a different market is required.

The skills implications associated with the trends and policy ambitions highlighted above often refer to skills at a very high level, although some do provide for skills development programmes. Some skills development programmes are comprehensive but focus on technologies rather than the enabling environment e.g. procurement, project financing etc. (aka the expanded value chain). There is very little focus on education and training provision for lower skill levels and community learning.

Table 11 below indicates (highlighted cell) the identified hotspots (areas of significance in terms of impact, activity, or ambition). These are drawn from the country case studies.

Table 11: Indicative hotspots (areas of significant impact or activity), by selected country

Hotspot (area of significance)	Country					
	Botswana	Mauritius	Namibia	South Africa	Zambia	Zimbabwe
Reliance on coal as an energy source	■			■		■
Current dependency on energy imports		■	■			
Unreliable electricity utility performance (energy insecurity)	■			■	■	■
High cost of / inability to pay for electricity			■	■	■	
Limited and dispersed electrification (especially in rural areas)	■		■		■	■
Transitioning to increased use of RE	■	■	■	■	■	
Limited understanding / use of RE technologies		■				
Limited / slow support, investment and capacity for RE	■		■		■	■
Limited / dated policy and regulatory framework for RE	■			■	■	
Limited / constrained grid connection capacity for RE	■			■		
Significant emphasis on green hydrogen			■	■		
Emphasis of biofuels						■
Hydro electric power affected by rainfall fluctuations	■		■		■	■
Limited understanding / use of EE technologies		■				■
Improvements required in EE (industry, business, public service)		■	■	■	■	■
Limited number of women in the energy sector workforce		■				

This suggests that the areas of most significance across the selected countries are:

- All, except for Zimbabwe, have ambitions and/or are in the process of transitioning to increased RE, with Botswana and South Africa's coal dependency (aka climate change) one of the key catalysts for them. Whilst Zimbabwe, on the other hand, is still favouring coal in its energy policy.
- While these ambitions exist, there are however inhibitors to RE transitioning and uptake, notably limited or slow support, investment and capacity for RE, with some countries (Botswana, South Africa and Zambia suggested to have limited or dated IRPs or regulatory frameworks to expedite and support the transition.
- Four of the six countries had notable energy insecurity issues due to utility performance due to e.g. corruption, lack of funding, poor maintenance, fluctuating hydropower etc.
- For those countries relying on hydropower (Botswana, Namibia and Zambia) drought and/or fluctuating rainfall significantly affected capacity to deliver electricity.
- Most of the selected countries have policies or recognise the need to improve EE. In the case of Mauritius, this is a significant area of activity (industry and public service). In the case of Zambia and South Africa, their economies are energy intensive (mining and large industry) and given levels of energy insecurity in these countries EE becomes paramount in these sectors. What did emerge is that most countries required heightened awareness and understanding of EE e.g., procurement, planning and monitoring.
- A significant area that emerged from this analysis was the poor universal access to electricity, particularly in rural areas.

Some areas of significance were country specific, such as green hydrogen for Namibia and South Africa, and hydropower for Botswana, Namibia and Zambia, biomass in Namibia, EE and gender equality within the energy sector for Mauritius.

These hotspots are aligned with some of the core change drivers for action and implementation e.g. a shift away from coal, or the lack of economic (industrial and household) activity in rural areas due to limited access to electricity. The most significant change drivers are often reflected in policy. While RE and EE are acknowledged in most policies, the issue is around the ability (financial, capacity and willingness) to implement the policy.

This assessment provides a useful reflection on what energy 'subject' areas of focus should be considered to inform skills development (and courses) offered by the KGRTC, noting that some may be country specific, such as skills associated with green hydrogen (Namibia and South Africa, and however, that skills training on maintenance (infrastructure and machinery [energy efficiency]) are critical across the board. What is also clear, is the need to consider leadership skills and knowledge development, with particular reference to an improved understanding of RE opportunities and implementation thereof, policy development and implementation (with emphasis on expanded / decentralised systems due to RE uptake, rural electrification, and IRPs/consolidated energy strategy). Running alongside these leadership areas of focus would be the necessary areas of knowledge and skills associated with implementation to support e.g. regulatory advisors (drafting legislation, tariff setting), and planners and modellers. Many of these latter areas are core for REI.

4.2 Survey findings

The purpose of the survey was to establish what respondents understood to be the current nature of demand for skills in RE, EE and REI and the supply of skills development programs available to meet that demand. The demographics of the respondents are provided, followed by their involvement across the three energy themes. The section provides a review of the skills demand and supply responses. It should be noted that while 84 responses were received, not all respondents answered all questions. As a result, the insights presented only reflect the completed responses.

4.2.1 Respondent overview

Most responses received were from South Africa (22%), followed by Namibia (20%), Zimbabwe (15%), Zambia (15%), Botswana (10%) and Mauritius (4%). The respective types of organizations that responded to the survey are presented in Figure 5 below, with Energy Service Companies and Small and Medium Enterprises (SMME's) constituting the majority of the organizations that responded. Training providers (private and public) jointly formed 20% of the responding organizations. Majority (29%) of the respondents came from small organisations (Table 12), followed closely by large organizations (26%).

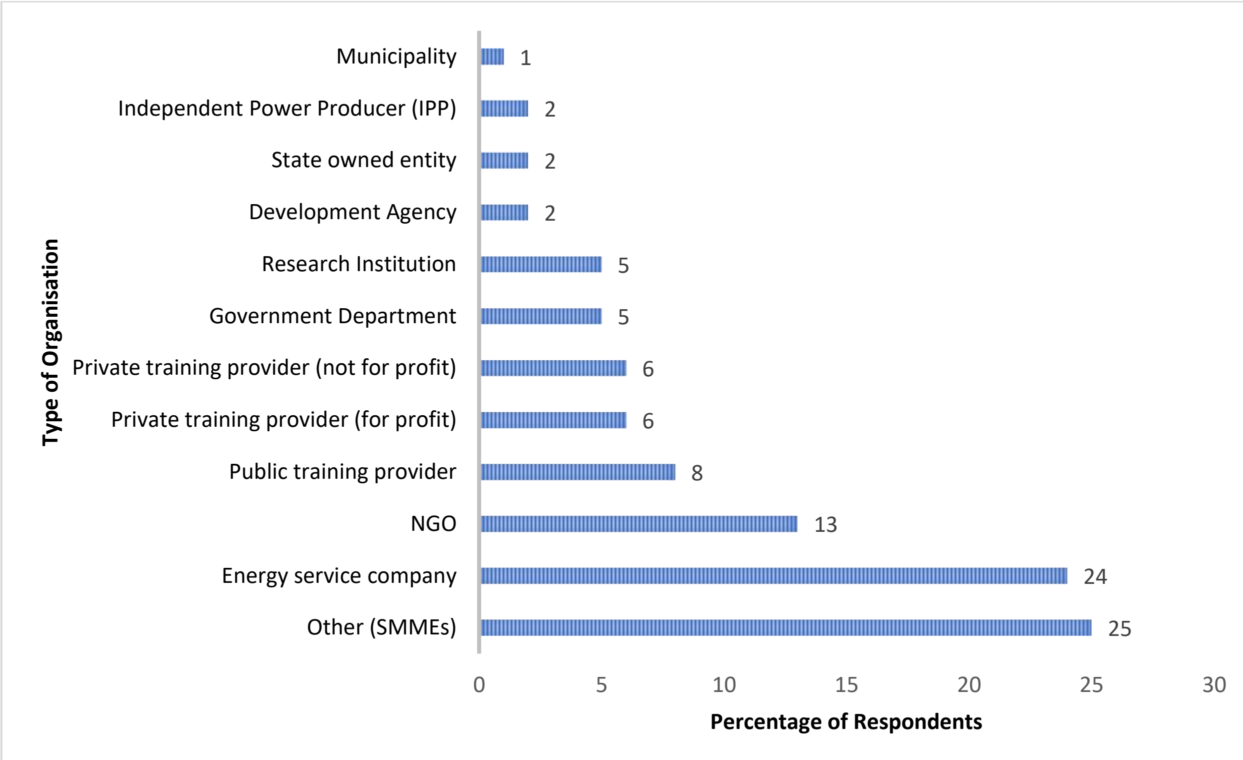

Figure 5: Organisation type associated with survey respondents

Table 12: Size of responding organisations

Organisation size	Percentage
Very small (less than 10 employees)	24%
Small (10 - 49 employees)	29%
Medium (50 - 249 employees)	21%
Large (250 or more)	26%

Figure 6 provides details on the specific RE areas that respondents are involved in. Within RE there is a high prevalence (75%) of respondents in solar energy. Some respondents (21%) acknowledged involvement in wind energy. Survey respondents did not indicate involvement in sub sectors such as hydroelectric power. This finding corresponds with other RE findings in the region which reflect that solar energy initiatives rank high in Africa, with the continent having significant potential for successful solar projects. Between 2010 and 2020 solar energy projects accounted for 60% of RE investments in Southern Africa, representing approximately USD 13.5 billion (IRENA & AFDB, 2022). Wind energy project investments ranked second at 35% (USD 7.8 billion).

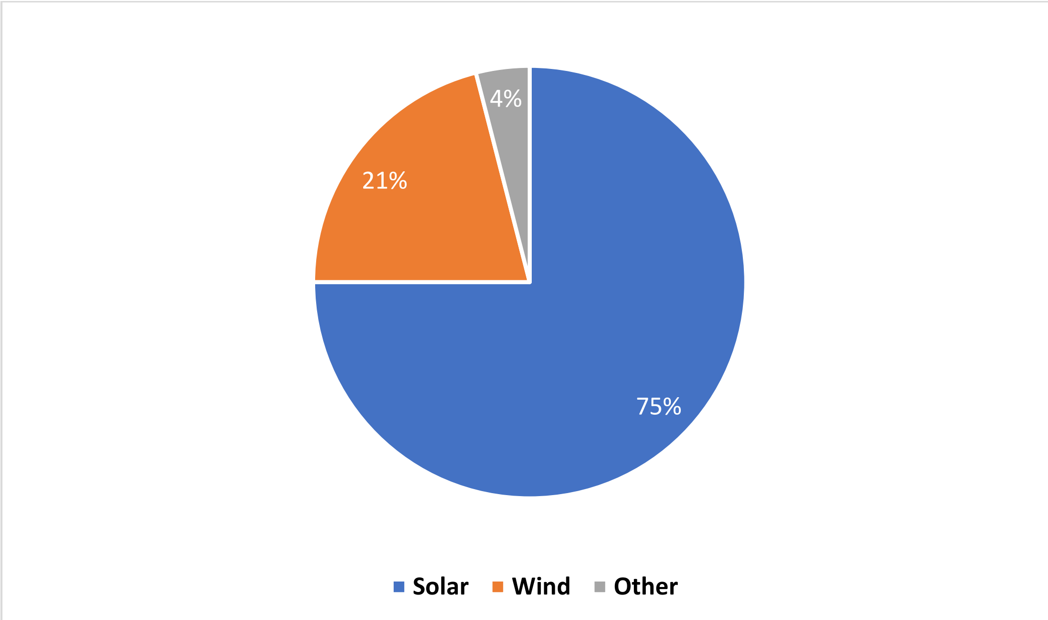

Figure 6: Respondent involvement in RE

With regard to respondent involvement in EE 24 of the respondents stated that they worked broadly across EE (Figure 7), while 14 and 9 stated that they worked in energy management systems, and demand-side and load management respectively. A few respondents (3) within EE worked in/on transmission and distribution losses. Within REI, 15 of the respondents (Figure 8) were operating in grid integration. Other respondents acknowledged involvement in areas such as quality control, standards and policy.

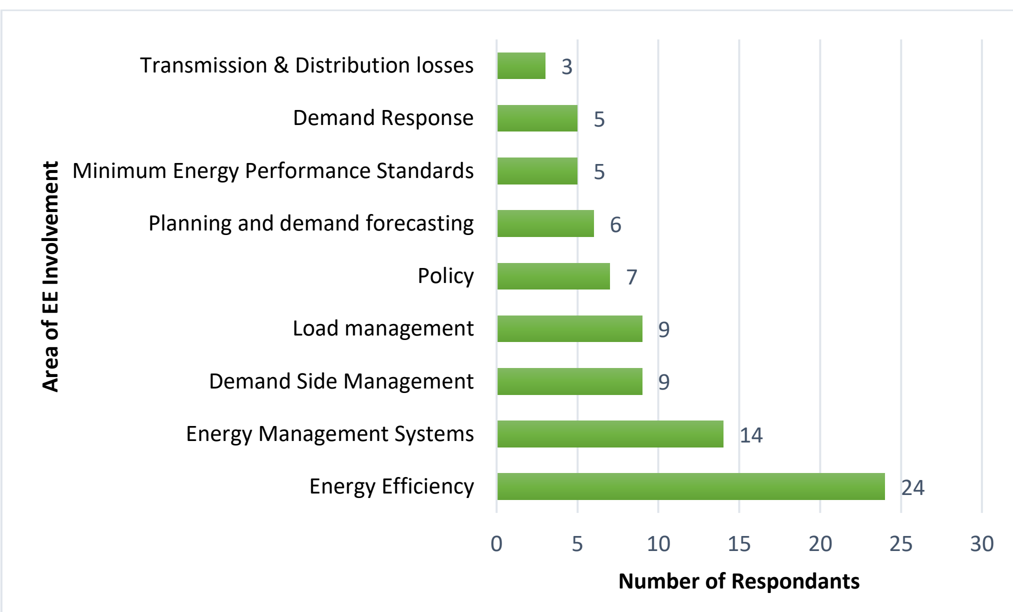

Figure 7: Respondent involvement in EE

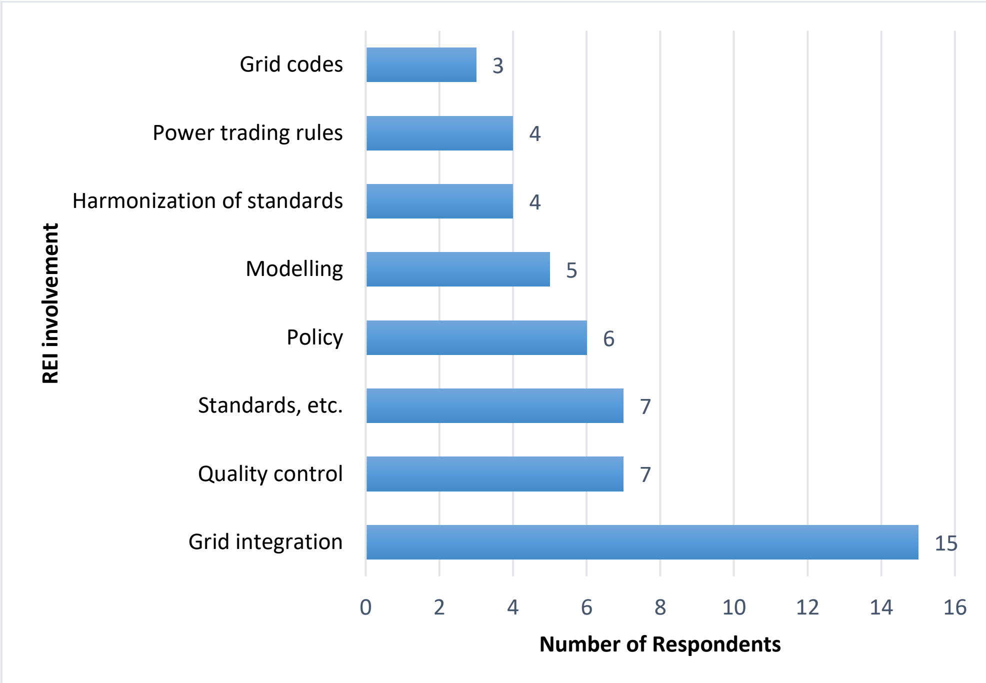

Figure 8: Respondent involvement in REI

Looking across the 3 themes RE, EE and REI the overlaps in the areas that respondents work in substantiates the point, as per the literature review, that the expanded energy value-chain is dynamic, and that it involves a mix of activities across the value-chain and are therefore integral in the transition towards a low carbon economy. Considerable additional value can be captured if organizations and individuals think and work across value chain activities in non-linear ways.

4.2.1 Respondent insights on skills supply

Respondent insights reflect the different types and mechanisms of education and training provisioning used by employees and education and training providers combined.

The data suggests that a considerable amount of energy-related formal skills programmes are provided in the region ranging from certificates to post-doctoral qualifications. Certificates are however the most commonly offered programmes in RE, EE and REI with 17, 14 and 7 respondents stating that their institutions offered energy certificates respectively (Figure 9). Additionally, organizational based training is widely offered in the SADC region. For RE, continuing professional development and on-the-job training were the most offered forms of training by organisations (26 respondents), while on-the-job training was the main programme offered in EE (27 respondents). Induction type training was the least popular type of training for both RE and EE (Figure 10). A similar trend was evident for REI with continuing professional development and on-the-job training being the main forms of training offered by organizations (Figure 11).

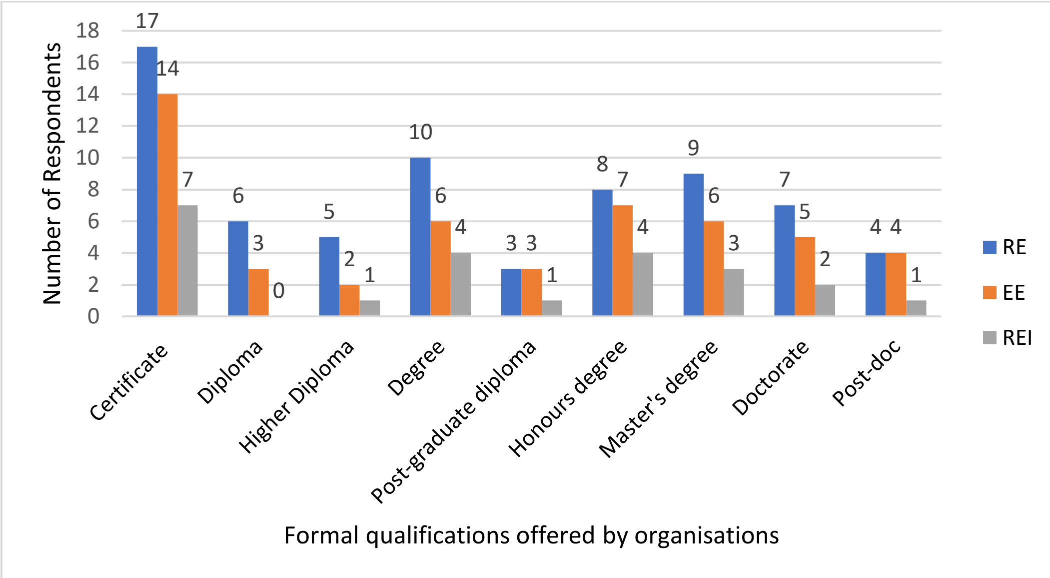

Figure 9: Number of respondents providing formal qualifications

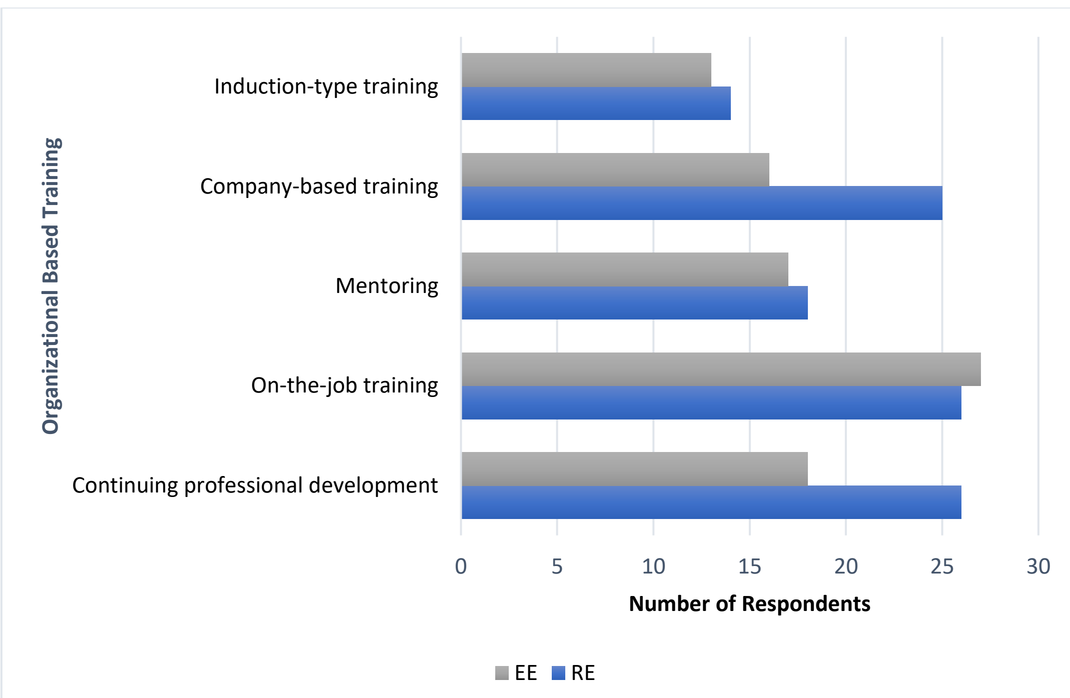

Figure 10: RE and EE training provided by respondents

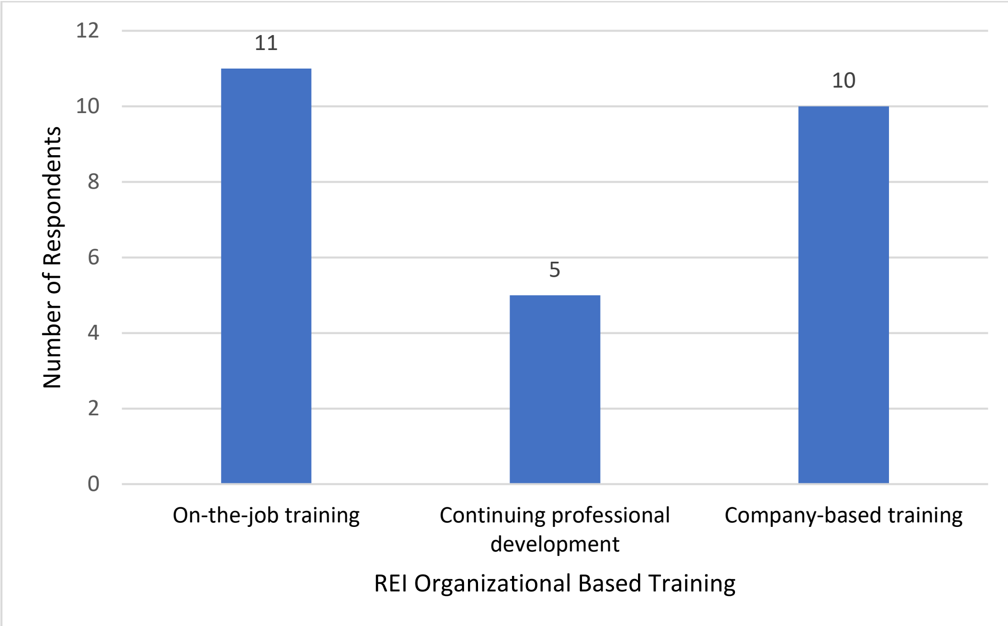

Figure 11: REI training provided by respondents

Alongside formal and informal skills provisioning 'add-on' services are also provided. Figure 12 suggests that across RE, EE and REI courses offered, the most common forms of 'add on' support are coaching and mentoring and academic support (e.g. writing and/or research skills).

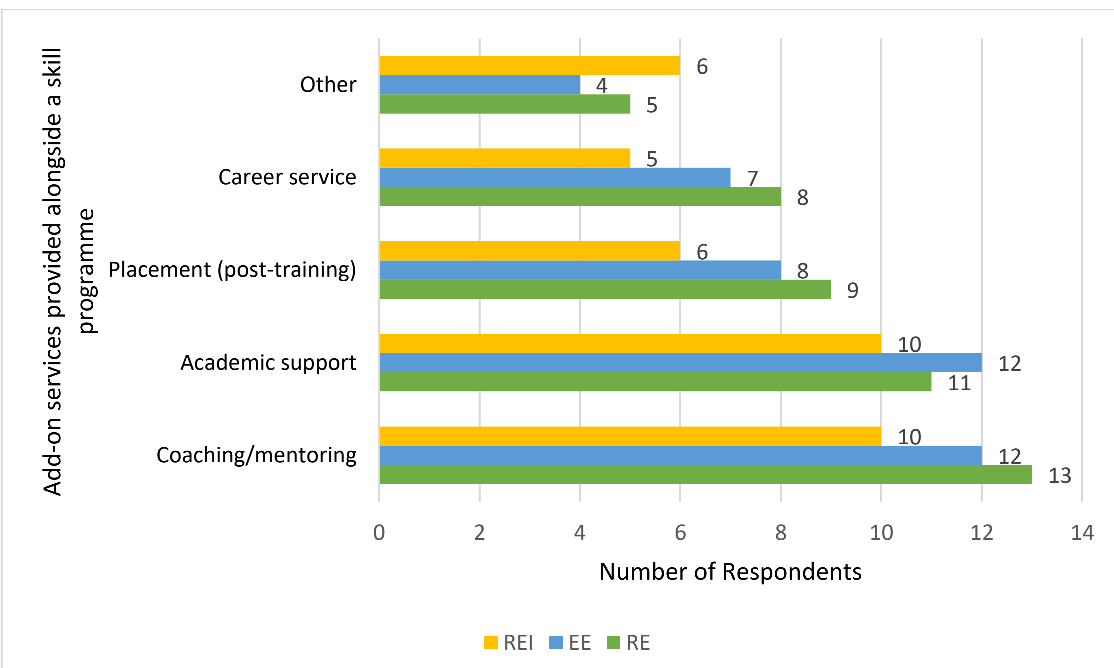

Figure 12: Add-on support provided by respondents

The survey further asked respondents to indicate if teachers/trainers had a formal teaching qualification with an energy-related background. Majority of the respondents indicated that their institutions had between 0 to 20 trainers with formal qualifications. Figure 13 indicates that the trainers mostly had an RE background, followed by EE and lastly REI (supported by 20, 17 and 14 respondents respectively).

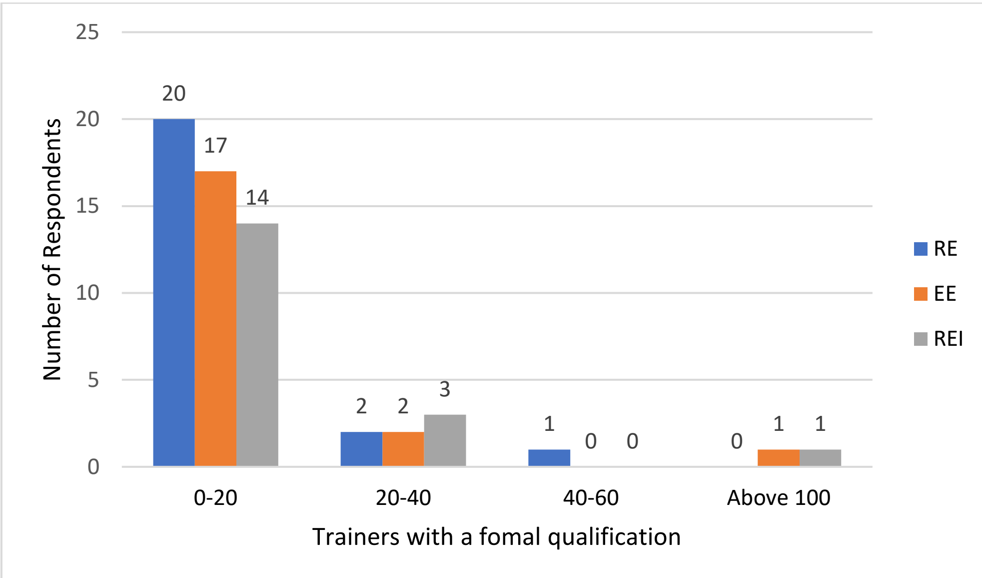

Figure 13: Number of trainers with formal qualifications

The survey further sought to determine the participation of women in energy related training. It was found that of the trainees completing energy courses women mostly accounted for up to 20%, with RE courses dominating (Figure 14).

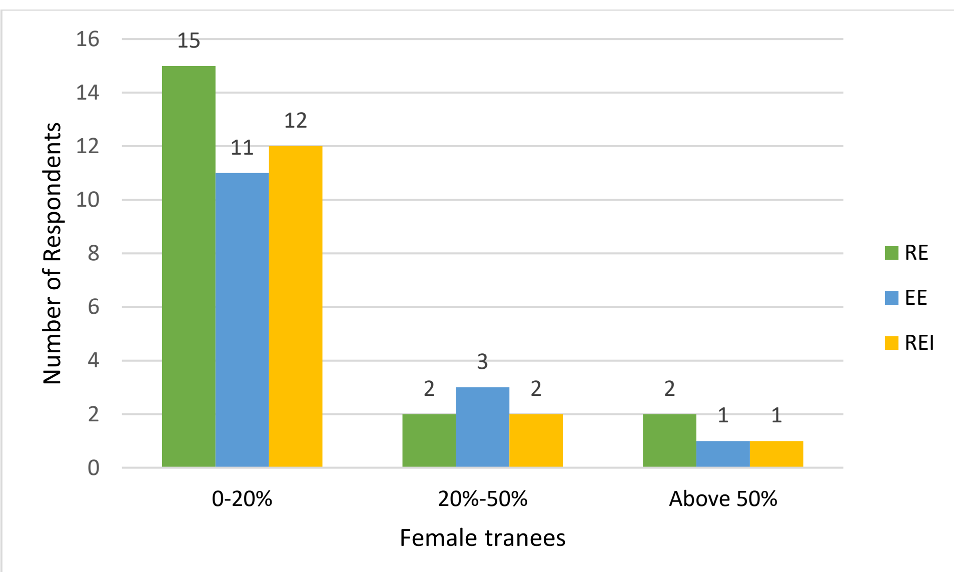

Figure 14: Percentage of female trainees completing energy related courses

Respondents were also asked to compare their training infrastructure e.g., classrooms and equipment to that used by other entities in the energy sector currently, and in the next five years. The majority of respondents (57%) were of the view that their current training infrastructure was equitable to that offered elsewhere in the sector (Figure 15). Looking five years into the future respondents (48%) still felt that training infrastructure would be equal across the board, yet there was an increase in the number of respondents who were of the view that training infrastructure would be below industry standard (Figure 16). The survey, however, did not delve into the potential reason for this decline.

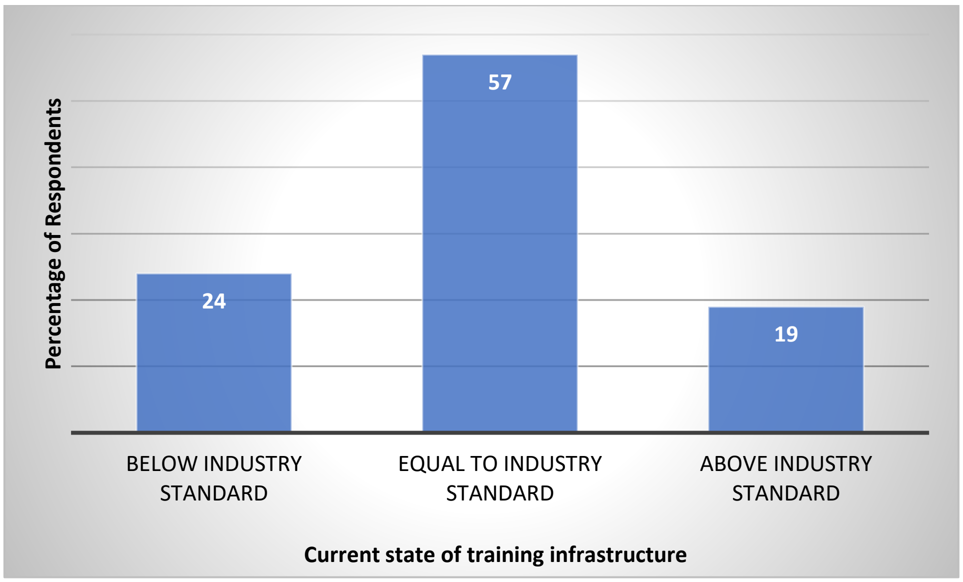

Figure 15: Current state of training infrastructure within the energy sector

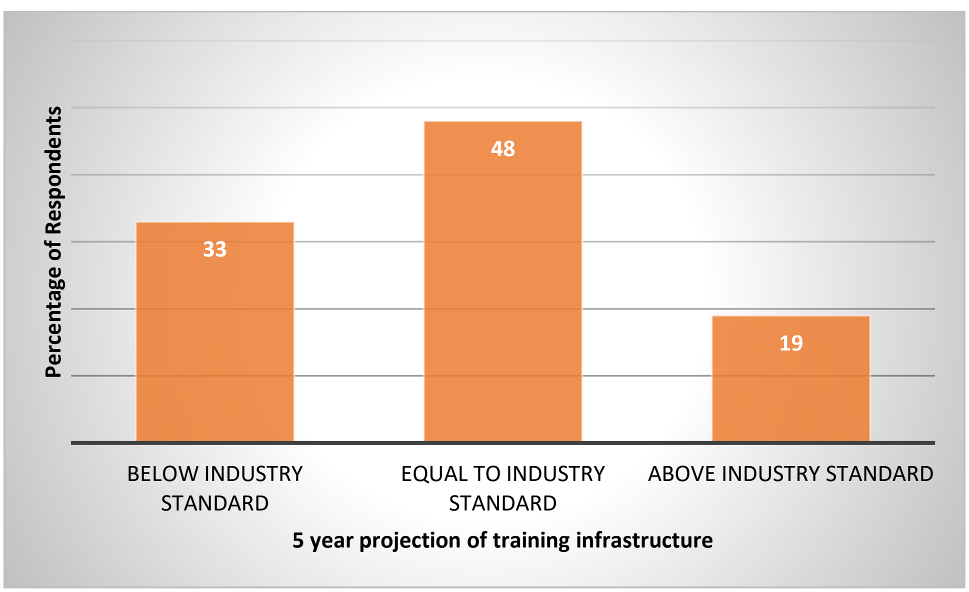

Figure 16: Five-year projection of the state of training infrastructure within the energy sector

In summary, the survey findings indicate that formal education and organizational based training is provided and acknowledged by respondents. It was evident that gender inclusion in the sector is low, with women only forming approximately 20% of graduates. Further, there is significant focus being placed on solar energy which speaks to a gap in demand and supply of courses/skills related to other forms of renewable energy such as green hydrogen, geothermal and bioenergy.

It should be noted that the survey results are indicative and broad, and therefore in areas of significance or of interest, that further research is undertaken to better understand some of the findings.

4.3 Interview findings

Interviews were undertaken across the six selected countries with key stakeholders who represented a broad range of regional and international development agencies, government, public and private education and training providers, research institutions and NGOs. The purpose of the interviews was to delve deeper into the contextual and future landscape of energy provision and consumption in the SADC region, and to unpack the current and future associated skills supply and demand requirements.

Interviewees commented that it is important for energy and related policy to be integrated and comprehensive, well planned and implemented to ensure the right signals are sent to the market, in order to allow and enable timely development of required skills. Several interviewees felt that government policy and education infrastructure was lagging reality on the ground. As a result, disparate and siloed skills interventions are taking place due to a lack of coordination at a national or regional level. This could mean that national plans cannot be implemented as the integrated skills picture is not, in many cases, in place. Key skills required in relation to this coordination and management weakness, would be executive awareness and training, including leadership development, to ensure direction setting and implementation are carried out in a considered and timely manner. This would also require policy development and non-technical skills such as problem solving, critical thinking and systems analysis across the value chain.

A key outcome of this research is that the full and expanded energy value chain, and therefore, associated skills need to be considered. Interviewees suggested that this is not always the case, with an emphasis often placed on technological and infrastructure construction training and skills. Interviewees highlighted that e.g., finance, procurement, project management, markets and trading training and skills are also required to enable the transformation of the energy system. Regarding infrastructure, it was noted that training and skills are required for operations and maintenance, as these are not always considered. This is particularly the case in current situations where infrastructure failure is the cause of load shedding. In addition, future skills requirements are broad and need artisan and vocational programmes with practical training opportunities to be in place to really have a social impact. This is due to the fact that extensive operations and maintenance skills are required and would include technician jobs as well as artisans, who benefit from vocational training and certification on specific technologies and procedures. This is especially the case for new renewable energy technologies construction and operation and energy efficiency implementation.

Interviewees indicated that the skills required to transition will not always be new skills. For example, at the engineering level it may be that only specialist skills are required (upskilling) and given that the number of people required to run a renewable plant is low, experience skills and not necessarily graduate (theoretical) skills are needed. These up- and re-skilling requirements should be in conjunction with a base set of critical skills which are spread across several projects or plants, primarily high-level jobs such as engineers. While not all skills required will be new skills, there will be an increased need relating to the shift to renewables. This would include a need for additional grid skills that will be critical for expansion and integration requirements as well as dealing with climate change adaptation. This shift will also mean the decommissioning of fossil-fuel powered plants, which will require specific knowledge and skills, e.g., environmental skills to ensure legal compliance and social skills that would need to work with local communities and businesses to develop a social plan. Transitioning will also require the critical recognition of standards and OEMs specific training and where this will take place. It is likely that those involved in standards and OEMs will be mobile, and therefore will need to be where the opportunity for employment arises. It is critical to ensure that standards are put in place so that retraining does not have to be done in order to comply with different standards of accreditation bodies. Regional course or qualification accreditation bodies could be considered to assist with the setting of these standards. In addition, many OEMs require certified training on their equipment, so understanding what baseline training is and what is OEM specific is essential.

A number of issues were raised by interviewees about either skill not being ready when needed, or that people do have the skills, but are not able to find work. For example, in South Africa, should the IRP be realised by 2030, 1,800 to 2,200 people in low level wind construction jobs will be needed per year which would take 15 years at the current training rate. This suggests that incentives for training should be considered by governments to ensure training and skills demand is met. Currently, interviews indicated that there is a lack of government support for training development in the energy sector.

Linked to the adequacy and timeliness of skills provisioning and availability, is the concern that skills pathways are not in place from the school level through to tertiary education and work-related learning. This is exacerbated by a lack of access to tertiary education. As a result, future energy skills requirements may not be filled or be made available at the appropriate time. This may result in the need to import skills which undermines efforts to maximise local employment development and the associated socio-economic benefits. In addition, individuals imported to undertake a task or activity will not necessarily impart their knowledge and skills. Therefore, it will be difficult to overcome this challenge in the short to medium term. Some interviewees suggested that to mitigate a shortage, 'train the trainer programmes' are required, especially in TVET and community colleges to achieve the desired number and quality of training required to transition the sector and meet capacity demands.

As a concluding comment, many of the interviewees noted the importance of partnership, and how partnerships had assisted in delivering their work. In addition, partnerships have been used to move quickly and cover more issues or geographical reach. From the perspective of skills provision, partnerships at all levels of training are also needed i.e. universities with TVET colleges, private providers etc.

4.4. Skills provisioning findings

This section presents the results of an assessment undertaken of skills provisioning in each of the selected countries. Energy skills supply data was gathered from the National Qualification Authority (NQA) websites of each country (Figures 17 and 18, and Annexure E). There were, however, some limitations seen through Zimbabwe not yet having an NQA website and Mauritius having very few courses listed on their NQA website. To counter these limitations, the study went a step further to collect, via desktop search, energy-related course data from university, college, TVET and NGO websites in each country (see Figure 19 and Annexure F). It is recognised that while not all provisioning can be captured, these findings provide a robust indication of energy-related skills provisioning across the selected case countries. Information gathered has enabled insights to be presented on the variability of the types, length and institutions offering the courses, and where feasible across the RE, EE and REI themes.

A review of the NQA data on accredited courses offered suggests that the current energy skills supply in the selected countries varies considerably (see Figure 17). South Africa has the majority (60) energy courses offered with certificate courses dominating the list. Botswana, Mauritius and Namibia also have an evident dominance of Certificate courses. Zambia on the other hand has more bachelor's degree energy courses (9 out of 16 of the energy courses listed). Graduate courses are uncommon with only South Africa and Zambia having master's and Doctoral courses related to energy. It is estimated that the majority (85%) of the courses on offer have a direct link to RE and REI has the least (7%) representation among the energy courses (Figure 18). This reflects a large gap that exists with regards to ensuring energy security and efficiency and well as the development and sustainability of integrated power systems.

The energy related course data derived from a variety of websites paints a different picture. Short courses are dominating the energy skills supply side in the SADC region (Figure 19), as they represent the majority of the courses being offered in Botswana, South Africa, Zambia and Zimbabwe. These short courses mostly last for a specific period of days and tend to be practical in nature. Certificates on the other hand are the most offered types of energy courses in Namibia, while bachelor's degrees seemingly dominate skills supply in Mauritius. Zambia offers the most energy related courses (151), followed by South Africa (111). The NQA and other websites all reflect very low numbers of graduate programs being offered in the region.

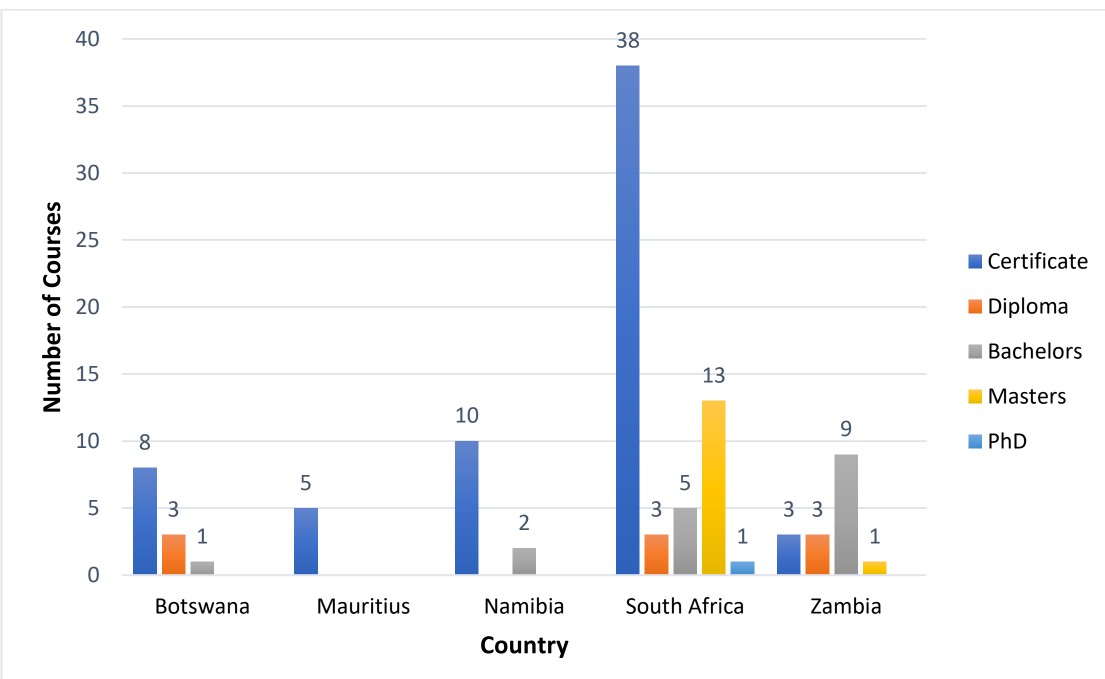

Figure 17: Number of energy courses derived from NQA websites

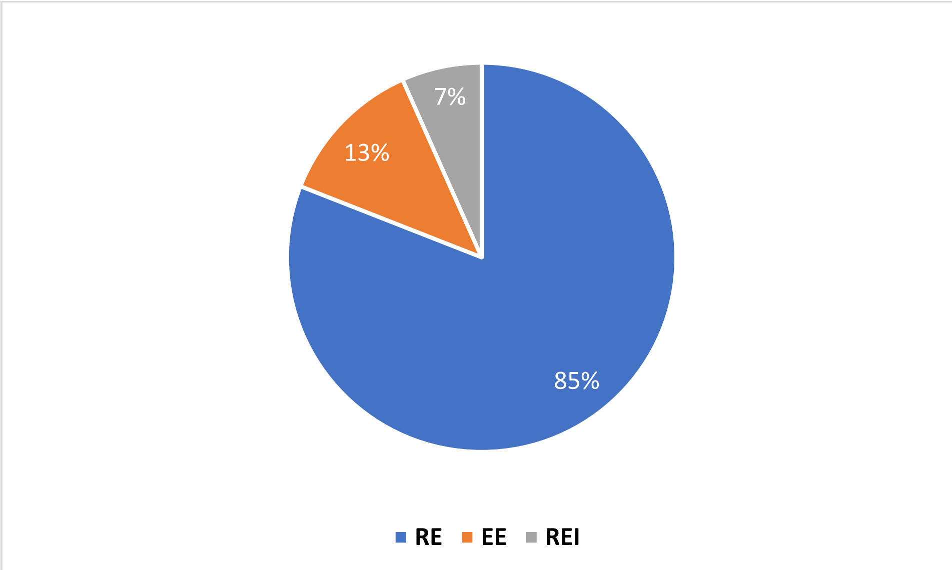

Figure 18: Thematic representation of energy courses listed on NQA websites

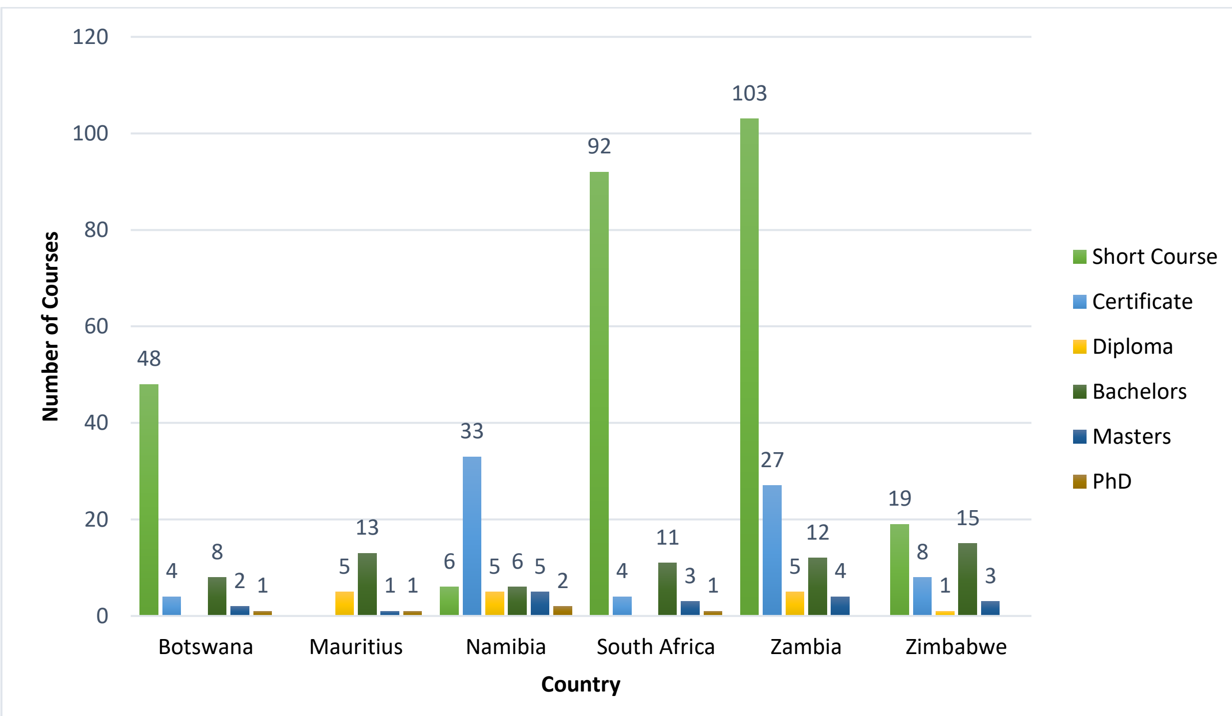

Figure 19: Number of energy-related courses derived from a variety of country websites

These findings indicate that short courses are becoming increasingly popular in the SADC region as they offer an opportunity for trainees to gain practical RE skills quickly and can be a favourable method of upskilling. Short courses can however lead to a workforce that is not easily able to transition due to the job specific nature of the courses i.e. they do not follow specific streams of work. Lastly, there is currently a strong focus on hydro and solar PV in the region with little to no skills being offered on other forms of RE such as biomass, wind, geothermal, and tidal for coastal areas. This lack of diversity in RE skills provision therefore speaks to a gap that will need to be filled by education and training providers as well as the potential RE skills that they need to focus on. Additionally, courses with an EE and REI focus are in short supply and there are very few courses related to energy policy, leadership and management.

5. Emerging insights and lessons

In the section insights emerging from across the different data sets are provided. Since skill formation is complex the relationship between supply and demand is regarded as iterative and contingent. The insights presented are framed to include supply-demand and coordination. Although presented separately, it should be recognised that the relationship between the three dimensions are relational.

5.1 Supply versus demand insights

Drawing on the findings presented above, and a review of the accredited and additional courses identified, it is possible to provide an overview of skills provisioning and demand across the selected SADC countries. While based on a set of selected SADC countries, the information presented in the tables below provide useful, indicative overviews of the synergies and potential gaps between skills provisioning and demand for RE (Table 13), EE (Table 14), REI (Table 15) and overarching RE, EE and REI (Table 16).

NOTE: Interpreting the tables

- The columns titled ‘skills demand’ reflects the type and level of skills demand identified. Where a skill is similar to or correlates with a course(s) offered, it is listed against the identified course / course theme listed in the ‘skills supply’ column. Where a skill has been identified, but a course was not identified, this indicates a potential gap between skills demand and supply.
- The columns titled ‘skills supply’ indicated accredited and other energy-related courses identified by country. The latter is indicated by a highlighted cell under the country column against the course / course theme.

Table 13: A indicative comparison of renewable energy skills supplied (by country) and in demand

Skills demand	Skills level			Skills supply	Country					
(Skills associated with the following)	High	Medium	Low	(Indicative list of courses provided, by theme)	Bot	Mau	Nam	SA	Zam	Zim
RENEWABLE ENERGY										
Installation of technologies (solar, wind, biogas, storage)				Electrical installation / technology						
				Electrotechnics						
				Energy storage systems						
				Renewable energy engineering / technologies						
				Wind farm project development						
				Wind energy technologies						
				Solar PV/equipment installation						
				Solar water heaters						
Civil engineering for RE infrastructure				Civil engineering						
Electrical engineering for RE installation, operations and maintenance				Electrical / electronic engineering / technology						
				Automotion engineering						
Environmental and social impact assessments (new / upgrades)				Energy project EIA						
				Solar PV EIA						
Community liaison (and research)										
Financial modelling, analysis and investment				Energy studies (commerce)						
				Solar PV financing						
Manufacture (inc. R&D/recydability) (Solar PV, wind, hydro, hydrogen, biogas, energy storage)				Hydropower technology						
				Solar PV design						
				Bioenergy science						
				Mechanical engineering						
				Materials engineering						
Construction site management (commissionind & decommissioning)				Electrical infrustructure / construction						
				RE technology construction/installation						
Maintenance of technologies (schedules, procedres, installations)				Solar PV/equipment maintenance						
Operations and management (Solar PV, wind, hydro, hydrogen, biogas, energy storage)				Wind energy operation & management						
				Hydropower plant operation						
				Hydropower technology and management						
				Nuclear power plant process control						
				Solar PV operation						
Sales, marketing and customer services										
Systems design (solar PV, wind, hydro, green hydrogen, biogas)				Electrical power systems						
				Micro-hydropower generation systems						
				Solar PV systems						
				Wind energy systems						
				Renewable energy systems						
Technical (high voltage overhead lines, underground cables, wire testing, substation operations, switching etc)				Electrical line mechanic						
				High voltage engineering						
				High voltage overhead line work						
				Internal wire testing						
				Electrical substation operations technician						
				Low voltage installation						
				Low voltage distribution system & switching						

Table 14: A indicative comparison of energy efficiency skills supplied (by country) and in demand (by skills level)

Skills demand	Skills level			Skills supply	Country					
(Skills associated with the following)	High	Medium	Low	(Indicative list of courses provided, by theme)	Bot	Mau	Nam	SA	Zam	Zim
ENERGY EFFICIENCY										
Electrical engineering for machinery / goods installation, operations and maintenance	■	■		Diesel efficiency management				■		
	■	■		Electrical power engineering / technician					■	
	■	■		Electrical installation and maintenance	■	■				
	■	■		Energy engineering	■			■		■
	■	■		Energy efficiency technician				■		
Energy auditing and monitoring	■	■		Energy auditing / assessment				■		■
	■	■		Energy audit technician				■		
	■	■		Energy environmental monitoring				■		
Energy (efficiency) management system development	■	■		Energy efficiency / management				■	■	
Maintenance of systems, machinery, equipment, sub-stations products e.g. lighting (schedules, procedres, installations)		■	■	Electrical principles and systems				■		
		■	■	Maintenance management of electrical and mechanical equipment					■	
		■	■	Electronic systems maintenance and repair					■	
	■	■		Street lighting maintenance				■		
Operations management (processes and practices)	■	■		Energy behaviour change				■		
	■	■		Energy optiimisation tools				■		
	■	■		Sustainable energy				■		
	■	■		Industrial / management engineering	■	■	■	■	■	■
Procurement (contracts and purchase agreements), cost control, procedures etc)	■	■								

Table 15: A indicative comparison of regional energy integration skills supplied (by country) and in demand (by skills level)

RENEWABLE ENERGY INTEGRATION										
Power systems (modelling, grid compliance, transmission planning, control etc)	■	■		Electrical power systems			■	■		■
	■	■		Electricity market operation				■		
	■	■		Power station switching				■		
Energy regulation (adminisation, legislation, reduce CO2, ensure equitable access, tariffs)	■			Electricity ordinance				■		
	■			Energy regulation				■		
Rural electrification (strategy, project management, community liaison)	■	■								
Leveraging data in the grid to respond to demand and changes (IT, digital tech)	■									
Energy system design and modelling	■			Energy systems	■			■		
Smart-grid (project management, legal, planning, storage, microgrids etc)	■			Renewable energy integration					■	

Table 16: A indicative comparison of overarching energy-related skills supplied (by country) and in demand (by skills level)

Skills demand	Skills level			Skills supply	Country					
(Skills associated with the following)	High	Medium	Low	(Indicative list of courses provided, by theme)	Bot	Mau	Nam	SA	Zam	Zim
OVERARCHING										
Climate change and energy research and analysis	■			Energy & climate change				■		■
Environmental sustainability compliance, monitoring, reporting etc	■	■		Sustainable energy				■		
Energy policy development (writing and implmentation)	■			Energy policy				■		
Energy project development and management (new builds, upgrades, decommissioning)	■	■		Energy management / utilisation	■			■	■	
	■	■		Energy project management & evaluation				■		
	■	■		Energy (project) planning & evaluation						■
	■	■		Energy project financing & investment				■		■
Corporate finance (investment analysis, procedures, risk analysis, financial models (etc)	■			Energy infrastructure project finance				■		■
Business development (solutions strategy, cost structuring, negotiations)	■									
Health and safety (new builds, upgrades, decommissioning)		■								
Procurement (contracts and purchase agreements, cost control, procedures etc)	■	■		Renewable energy technology procurement					■	
Leadership (strategy, risk management, negotiation, problem solving)	■			Energy leadership				■		
Quality assurance (turnkey, procurement, data analysis, management)	■			Renewable energy turnkey QA/QC management					■	

A comparison of supply and demand tables illustrate some striking reflections. The first being that traditional engineering disciplines are well covered across all of the selected countries, yet demand is requiring more specialised engineering and/or technician-related knowledge and skills e.g. hydropower, green hydrogen, solar PV and renewable engineering. It is likely that these are covered within the curricula of the traditional degrees, diplomas and certificates, but it is also possible that traditional education provision may not be keeping pace with the changes required within the engineering and technical fields and including either more in-depth information on emerging technologies or supplemental courses and qualifications.

As can be seen from the list of courses by theme, RE dominates. However, within RE there is an overriding focus on solar and wind technologies, and to a lesser degree hydro. The emphasis of these courses tends to be on installation, operations and systems. While the region tends not to have a large RE manufacturing base, the engineering and technical courses could provide the knowledge and skills to undertake research and development to inform the manufacture or assembly of appropriate technologies that are context specific, as well as inform feasibility and viability of technologies. While construction of RE is a critical component, especially if country RE ambitions are to be met, there are few courses specific to this element of generation. It may however be that construction is incorporated into installation. Another significant gap are courses offered in RE technology maintenance. Taking the full expanded energy value chain approach into account, the research suggests that there are no obvious courses offered on community liaison for RE projects, or RE sales, marketing and customer support. Aside from South Africa and Zambia, most of the selected countries are lacking in the range of skills provisioning that is required.

Regarding EE, most courses provided are of a technical (engineering / technician) nature with reference to installation and maintenance. Bar a few examples, most maintenance and repair courses are offered in South Africa and Zambia. Energy auditing and monitoring is a key skill within EE, however, few of the identified courses covered this topic, with nearly all of the courses related to this theme offered in South Africa. Few dedicated courses are offered on EE for operations management. It may be that these skills are offered elsewhere e.g. in environmental officer courses. The procurement of new technologies is a notable mechanism for reducing energy use e.g. the purchases of low-energy lighting, or A-star rated equipment and appliances. Yet no specific course on the procurement of EE machinery, equipment and appliances could be found for industry, the public sector or businesses. Given that a number of the countries in SADC have energy-intensive economies, basic skills on maintenance and repair, monitoring and auditing, and procurement for EE would therefore be considered a great need.

Very few courses are offered on REI in the region. Those that are could be considered more generic energy-systems related skills or knowledge required to inform and implement REI. Most of these courses are offered in South Africa. The most specific course that speaks to this topic, albeit for renewables, is a course on Renewable Energy Integration offered in Zambia. It should however be noted that quite a few of the skills required for REI, such as leadership, planning and modelling, strategy and policy development and project implementation are also skills that are required in the other themes. These are covered in overarching skills and supply demand tables. Of the generic courses, the most common is energy project development, which is predominantly offered in South Africa and Zimbabwe. Given that project management is critical for project development and implementation, this is an obvious gap in the region. There will also be a need for regulatory skills as competition is introduced into the electricity markets as well as trading and system operations in a market environment. Very few courses covering these aspects are available.

While there is a dominance in technical skills supply, a considerable element of demand focuses on non-traditional technical skills such as management, planning, investment, policy development, leadership and environmental management. These are paramount skills along generation, transmission and use. Emerging skills demand i.e. reflecting the expanded value chain, are human-related and recognise the impact and need to acknowledge the rights and considerations of employees and communities affected by decommissioning, new construction and expansion of RE technologies. These types of skills include customer services, social impact assessment and community liaison in affected areas.

5.2 Supply landscape insights

Some of the insights emerging from the supply landscape could be reiterated as follows:

- An analysis of the survey and courses offered per selected country suggest that a short course culture is emerging. This is being driven by urgent sector demand, response to a dynamic and changing economy and shifts in policy focus e.g., to solar PV, and the rapidly changing nature of technology and knowledge in the sector. While these short courses can be accredited or unaccredited, the data revealed high levels of unaccredited training, which is largely driven by industry needs and by outside/donor funding e.g. training courses offered by Southern African Solar Thermal Training and Demonstration Initiative (SOLTRAIN). This reveals a picture of an education and training landscape that is reactive and responding in an *ad-hoc* and fragmented way, an uncoordinated skills ecosystem not being developed.

- A more coordinated approach that focuses on building a forward looking, and more holistic (i.e. not just technical) skills ecosystem is emerging. This will involve large scale provider training which is necessary so programmes can be up-scaled and moved away from the *ad hoc*, fragmented donor/outside funded current approaches which are evident, especially in Zimbabwe and South Africa. It will also involve addressing the critical need for training the trainer programmes especially at TVET and community college levels, as many activities will shift to local municipal and district levels (i.e. the energy system is becoming more disaggregated and decentralised).

- There is a need to think and plan in terms of streams of work rather than single jobs. As learning pathways into these jobs remain unclear, there is a need to encourage both lateral and vertical learning and work transitioning. To support these non-linear transitions people, need to be trained for a stream of work i.e. once an individual want to move on from being a solar PV technician, what can they move onto e.g. supervisor or engineer? Streams of work are connected jobs that have common core knowledge (see the broader overview case studies), and planning in this way promotes lateral transitions. This will however require a number of complementary education and training interventions to support learning and work transitioning.

- Linked to the above is the need for supply to consider the provisioning and connecting of skills across the broader expanded energy value chain. This includes the urgent need to meet the demands OEMs with a standardisation of training programmes, accreditation and specialised training for different OEM requirements, given the fact that a number of skills are based on specific OEM technologies

- Although almost all the policy documents identified in the country mini-case studies (see Annexure B) speak to the inclusion of women and in some cases youth, this has not been translated into an increased number of women working in the energy sector (IFC, 2019). While the survey suggests women are undertaking energy related courses (see Figure 14), only 20% are completing the courses. No clear programmes focused on women, especially rural women - and as indicated previously, the energy transition will see a shift to more localised rural opportunity for job creation and need. This suggests the need for skills planning to be more explicit in its focus on attracting women (and youth) into education and training and therefore the sector.

- An important finding on education and training infrastructure emerged, which worryingly suggested that respondents felt that appropriate training infrastructure is likely to be on the decline (see Figures 15 and 16) over the next five years. With the need to expand the number of people entering the sector to facilitate the energy transition, and a shift that is likely to require more technical and digital competencies, it will be critical that current supply infrastructure and equipment is maintained, expanded and keeps up with technical and digital trends, and mirrors the technical needs of demand. In addition, infrastructural developments need to be well considered i.e. where are people going to be needed, who will be needed and when? This should aid in determining the suitable mechanisms for education and training delivery, and local physical supply infrastructure.

5.3 Demand landscape insights

Some of the insights emerging from the demand landscape could be reiterated as follows:

- Systems and institutions for analysing labour demand are weak and there is evidence of skills anticipation that is led largely from policy and macroeconomic job projections. A couple of interviewees highlighted this difficulty. Although skills anticipation and planning are increasingly seen as a priority, national or sectoral structures and organisations that analyse current and emerging labour market requirements are difficult to identify. This has presented a picture across countries that governments are moving too slowly, and the nature of demand is being driven by big industry in the sector. This is evidenced in the interviews and survey, both of which highlighted that government planning is lagging developments on the ground. For example, it was identified that the current energy focus is on construction rather than operations and maintenance, and that planning, and skills forecasting is a significant issue.

- Overwhelmingly there is a prioritisation of RE compared to EE and REI. This can also be seen in the SADC work progress is reviewed (SADC, 2018). Solar PV is by far the most dominant, with the exception of South Africa and Namibia (both exploring wind) and Mauritius (energy efficiency) to some extent. The survey data clearly highlights this. EE is considered in all the selected countries at the policy level but does not appear to receive the same amount of attention as RE. REI is even less so, as it requires policy reformulation, market development, trade, policy development and knowledgeable leadership. The issue of grid integration was raised in the interviews and the survey (see Figure 6) where it was highlighted that only 18% of respondents work on grid issues. These are complex macro-economic areas of work and require high levels of coordination and planning.

- With reference to the nature of demand being projected, there are two major areas of focus with differing skills requirements, these being:
    - Skills required for development and implementation of large-scale energy generation of RE connected to the main grid; and
    - Off-grid generation capacity, including the planning and design of mini-grid energy generation.
    - Market regulation and management

  This has implications for the nature and spread of skills required to successfully execute these projects or programmes, especially given many of the applications are and will be mostly localised in rural areas and will often require the training of local communities to do basic operation and maintenance. Given the nature of the technologies required, the need for high level engineering jobs will shift in the value chain. They will be required in the upstream stages of the value chain, such as design and construction, rather than just operations, where mid-level and lower-level skills e.g. artisans and operators (mid-level) and artisan assistants and 'handymen' (lower level) will be needed. In the case of artisans, their role and need will be critical, given the increase in construction, implementation and maintenance of new RE plants and technologies. Such occupations would include welders, electricians, fitters and turners and other similar-related jobs. This trend was echoed in the interviews and the survey, which shows that there will be a deficit of skilled suppliers in RE given the quantum of anticipated increase.

- Demand across the value chain was not clearly evident across the country mini-case studies, survey, interviews and course provisioning. The types of jobs articulated the most were largely technical jobs e.g. engineers and technicians. However, through the interviews and country case studies a more nuanced understanding of a broader set of supporting and enabling skills were identified, such as financial, procurement, regulation, and legal. However, while identified they did not emerge as a priority, and were poorly articulated or very broadly defined. This illustrates that much of the policy and research is siloed (e.g., focusing on one component of the energy value chain), too high level (e.g. referencing RE or EE and not being more specific as to type e.g. solar or wind), and most importantly did not acknowledge the skills and occupations required to support key technological jobs to implement their work. Something highlighted in this research and intimated in the country mini-case studies through the identification of occupational networks associated with needed and or affected jobs associated with country-specific value chain hotspots and change drivers.

- Emerging evidence suggests that the nature of changes to jobs due to the transition to renewables and/or alternative energy futures is likely to require an increase in specialisations, and not necessarily new jobs, for example specialist hydrogen engineers, or future forecasting data analysts to interpret the impact of potential increased droughts on the supply of hydropower (as witnessed in Zambia, for example). This is reflected in the survey data through the number of short courses being offered in RE to meet industry demand. These short courses suggest a 'topping up' of skills e.g. for an electrician to work with solar PV, other than new jobs that may require a more theoretical long term period of academic study. This is supported in the interviews which also identified that experience is a preference (that can be upskilled) rather than the creation of new jobs.

- The focus remains on current models of production and consumption, which are also overwhelmingly in the formal sector; methodologies for surfacing future jobs beyond this type of demand modelling were few and unclear. This also suggests that current and short-term emerging demand was the main focus with little robust and detailed medium- to long-term skills anticipation. In addition, this situation is perpetuated with a focus on singular RE solutions e.g. solar PV or technical skills for e.g. engineers. Therefore, it is not possible with the currently available information to ascertain whether the current levels of training identified in Section 4.4 will meet the needs going forward, and when these skills will be needed. In some cases, the 'horse has bolted' prior to adequate skills planning, as is the case with green hydrogen, which has rapidly entered the frame within industry in South Africa and Namibia (see broad overview country case studies), yet very few if any adequate skills planning or courses have been put in place to understand the broader set of skills and jobs required to meet these ambitions and the additional RE required (see courses offered by country in Annexure E).

It should also be noted that many skills demands require some form of specialism – either to reflect the stage in the value chain, or the energy technology; or there are a general set of skills and knowledge required within different energy fields. Some of the skills and knowledge are detailed below:

- Procurement: Legal, processes, methods, assessments, financials, for human resources, services and technologies.
- Community liaison (social impact): Gender, youth, cultural sensitivities, human rights
- REI: legal and financial advisory, design, planning and modelling.
- Leadership: Complex and strategic thinking, systems thinking, problem solving, decision making, consultation / negotiation and risk assessment.
- RE (solar, wind, hydro and geothermal): design (including R&D and circularity), planning, manufacture, installation, operation and management, maintenance, decommissioning (including recycling).
- EE: Solution research and assessment, procurement, monitoring and reporting, maintenance.
- Integrated policy development

6. Looking forward: Recommendations to inform a skills strategy

The following section provides an overview of the recommendations proposed to inform the KGRTC's skills development strategy and provisioning. However, it is important to reiterate that much more work is required to present a more comprehensive study of a just energy transition to get clearer perspectives. In light of this, the recommendations below provide a guide and considerations to inform how a skills strategy could position the centre as a leader within the SADC region.

6.1 Recommendations per energy theme

6.1.1 Renewable energy

A number of SADC countries are dependent on fossil-fuels to generate electricity. This has resulted in most identifying the need to shift to RE, which is recognised in policy. However, in a number of instances while recognised in policy implementation is slow due to e.g. lack of funds, a country being seen as an investment risk, political agendas and will. Most policy emphasises an increased uptake in solar PV and wind technologies, with some expanding this to include other technologies.

Skills supply vs demand

- Majority of the courses provided in the region fall under RE with courses such as electrical installation and engineering being popular.
- Very few undergraduate courses in RE, dominated by short courses with a focus on solar PV and installation, to a lesser extent wind power.
- There is an emphasis of these courses tends to be on installation, operations and systems.
- Very few courses on other RE e.g., biogas, geothermal, and hydropower.
- Countries such as South Africa and Zambia offer the broadest variety of RE courses across education types.
- Zambia has a strong focus on hydropower with both supply and demand being high.

6.1.1 Energy efficiency

Only South Africa and Mauritius have explicit EE policy, with Zambia and Zimbabwe's EE policy in development. Countries with a large mining and manufacturing base are energy intensive e.g. Zambia and South Africa, and therefore a reduction in energy consumption, and therefore the adoption of EE practices, is critical. EE is also key for reducing cost and increasing energy security and resilience, especially in SADC countries suffering from insecure and vulnerable energy supply e.g., brought on by extensive load shedding.

Skills supply vs demand

- In comparison to RE, few courses explicitly target EE in the region.
- Most EE courses offered are technical and focus on installation and maintenance.
- There is a gap in EE courses for operations management e.g. planning, auditing and monitoring; and procurement of energy-saving machinery, equipment and appliances for industry and the public sector.
- EE may be a component of some technical courses offered (requires further investigation) e.g. electrician.
- EE is not explicitly in demand, but is likely to be embedded in other subjects e.g. energy management.
- Most maintenance and repair courses are offered in South Africa and Zambia.

6.1.1 Regional energy integration

A critical component of REI is the adoption of a systems approach to incorporating RE into distribution and transmission systems. While this may be acknowledged by some countries, it is very poorly articulated within the SADC region, with efforts focused on siloed activities. Another key component of REI is rural electrification across the region and the critical need for increased access.

Another significant component of REI is coordination and planning. Some of the insights emerging from the coordination and planning landscape could be reiterated as follows:

- The general response to the energy transition reflects a reactive, limited, adaptive response. While there are pockets in innovation they are fragmented and reactive to an emergent national need. This reactive approach has already created scenarios where skills needed were unavailable and had to be imported. This is indicative of a system that lacks forward planning.
- While all selected countries reflected energy 'policies were in place,' coordination between industrial, economic, environmental and skills policy at a country level showed clear gaps. None of the countries reported clear skills plans, skills policies or strategies that complimented their energy policy and targets (see detailed country case studies in Annexure B). This clearly suggests that skills development is seen as separate or an 'add-on' to technological processes, resulting in the gaps between supply and demand (as highlighted above). While coordination nationally was difficult to discern, coordination across the region reflected even larger gaps and requires more attention and understanding to nuance the specific skills requirements. Some of this does emerge in the case studies, which through the identification of the value chain hotspots and change drivers and implications on work, the ministerial and government leadership to transition the energy system will be paramount.
- Coordination and cooperation by education and training stakeholders across the system within countries and across the selected countries was difficult to ascertain or identify. Planning and proper sequencing of energy capacity building activities at country level and across the region

emerged as an area for urgent action. Educational stakeholders across educational sub-sectors will need to work together.

- An important coordination role that was clearly absent in the findings is the role of leading regional standards and accreditation processes. This is an important process to ensure the standards are globally and regionally credible, so that skills development is properly accredited and are transferable (this relates to the comment regarding OEMs above).
- The energy transition is driven by a jobs narrative, as such this remains dislocated from a strong sustainability foundation and imperative which is evident of an uncoordinated energy transition.

REI skills supply vs demand

- Very few regional policy, systems planning and integration courses are offered. Evidence of REI courses are mostly in South Africa, Zambia and Zimbabwe.
- No specific courses identified for rural electrification across the region.
- Overarching skills such as policy development, leadership, planning etc. are likely to be offered via other avenues e.g. MBAs, business and public sector degrees. Little explicit for REI.

6.2 Skills supply recommendations

6.2.1. Multi-dimensional approach to skills development

The formation of a strategic institution or hub to inform, anticipate, coordinate and integrate skills needs and plans for a just energy transition in Southern Africa is complex. It needs a vision beyond being a training provider. While this means understanding different types of training needs, features of training, how much and for whom, inter-relationships between different types of training and training providers, it also requires an understanding of the structure of the economy and labour markets, governance and funding, links to general and higher education and broader social development. This is the role of education, training and development a centre like KGRTC should seek to lead and coordinate as a hub within SADC. Such a 'Skills Hub for Just Transitioning and the Future of Work' would focus on foresight and integrating the skills intelligence work being done in pockets in the region. It would support cross-sectoral and proactive national level strategic planning for skills relevant to the economic diversification and sustainable economies required to ensure just transitions.

A multi-dimensional approach to skills development is required. This is crucial to distributive justice within the Just Energy Transition and to position the KGRTC as a regional leader. This will require a multi-dimensional skills strategy, which could include:

1. Reskilling and upskilling existing adult workers so they are better equipped to navigate the energy transition. This will involve skills analyses to identify detailed and country-nuanced demand, putting in place substantive short- and longer-term training programmes, recognition of prior learning, promotion of labour market policies, and the creation of new job opportunities especially with lower levels of foundational skills, digital innovation and more.

2. Aligning the energy skills development system with the anticipated labour force needs of the future, with a particular focus on jobs to support a just energy transition. This involves sophisticated anticipatory skills development and labour market intelligence, as well as the strengthening of skills system innovations across the energy value chain and its associated ecosystem i.e. not to be relegated to a narrow band of technical skills only. It also involves investing in skills development capacity and building of new types of skills and specialisms.

3. Ensuring foundational skills through the education system to improve the adaptive capacity of the broader workforce. This involves curriculum transformation, teacher capacity development in the schooling and post-schooling system (especially also TVET and community educator competences), restructuring employer-provider (demand-supply) relations, and expansion and diversification of learning pathways (currently the green skills arena is over-dominated by high skills learning pathways).

4. The skills strategy will need to offer national level strategic support and local level alignment with emerging priorities and opportunities. The centre should investigate how it can work with governments but also consider bottom-up skills processes that could be driven and/or informed by local affected communities.

Importantly, skills development for the just energy transition, is a key enabling factor, and should be given added impetus through mechanisms that can successfully and proactively bridge the skills system, its planning and implementation mechanisms. Therefore, the KGTRC needs to envision its skills strategy with this forward-looking broad perspective to make it a leading skills entity.

6.2.2 Proposed priority areas for course development

Regarding the provisioning of skills focus for KGRTC consideration, Table 17 provides an overview of indicative priority areas for skills development by energy theme.

Table 17: Proposed course areas of focus and priority

Priority course area	Energy theme		
Energy theme	**RE**	**EE**	**REI**
RE technology installation, construction, management and maintenance (solar PV, wind, storage)			
RE financial modelling, analysis and investment			
RE technology sales, marketing and customer services			
Social science associated with RE technology development (notably community liaison, especially in rural areas)			
Energy auditing, monitoring and reporting (industry, business and public service)			
Maintenance and repair of machinery, equipment and appliances			
Procurement of low energy / EE machinery, equipment and appliances			
Regional power system modelling, policy, financing, planning and implementation			
Regional energy regulation and governance			
Rural electrification within and across the region (policy, planning, implementation)			

6.2.3. Visioning training beyond a single job: Streams of work

Training beyond a single job, will mean the centre needs to consider key streams of work, which connect lateral and vertical jobs and where people can transition to. So, design training forms a mind-set of a stream of work that has core knowledge but that enables people to transition between related jobs.

It will also be important to consider the multiple levels of a skills ecosystem, and this includes the work streams that key occupations are associated with e.g. who do they work with. In workplaces people work in teams, or clusters. Engaging any change within a workplace involves considering people in a core job but also the people this job works with (see the country case studies), as tasks are often distributed in workplaces. To ensure that sustainable change is affected in workplaces, it is suggested that jobs within a cluster and shared work environment are considered, and therefore how training impacts the different jobs roles within this cluster.

6.2.4. Bottom-up models of skills development that take communities into account

It is recommended that the KGTRC should acknowledge any energy transition in the SADC region, and cannot leave behind communities affected by changes to the energy system e.g. a shift from coal mining to renewables, and people outside the formal labour market. It therefore needs to focus extensively on bottom-up models of skills, drawing from local and place-based models as each location has its own characteristics, issues, capabilities and capacity. Drawing inspiration from focused economic development zones, focused skills development zones could be piloted with the intention that they can be scaled and replicated across different contexts as appropriate. By integrating work opportunities related to locally relevant value chains and skills development, greater support for work integrated learning and transitioning from learning to work and/or livelihood creation could be enhanced. These skills development zones could support the capacity development of lecturers and trainers in local TVET, and community colleges, new course and curriculum development based on local demand and opportunities, better quality learning and ultimately enhanced employability of graduates, and importantly maximise linkages across types of skills development providers, including work integrated learning and formal learning programmes. This will in turn strengthen employer-provider relations and the relevance of courses offered. This work would also focus on the development of integrated learning pathways that support the progression of young learners, community members, and workers requiring up- and re-skilling in the context of energy transitions.

6.2.5 Innovative modalities of working

Another consideration is for the KGRTC to investigate new ways of working given the modalities of working and the demand for more specialised training as follows:

- Training that avoids travel and associated costs can be considered. Examples include more on-line training especially on theoretical subjects that do not require e.g. practical demonstrations.
- Training on demand processes rather than very structured programmes for example for OEM requirements. This may require that trainers are trained across a variety of subjects so they are more flexible and will not have low demand periods.
- Send lecturers to central areas where training is needed (models of mobile training, blended or hybrid).

6.3. KGRTC as a Centre of Excellence and its role in championing a stronger more coordinated SADC energy skills system

Currently skills development supporting the transition can clearly be characterised as reactive, limited and adaptive. Although 'policies in place' there is no clear coordination - no clear skills plan, skills policies or strategies to compliment energy policy and targets. Furthermore, it is difficult to ascertain coordination by education and training stakeholders across the system.

There is hence a role for KGRTC in championing a more coordinated, proactive approach to skills development that can support the transition (strengthening the system through anticipating, coordinating and integrating skills needs and plans).

This will need:

1. **A centre vision beyond being a training provider:** This means understanding different types of training needs, features of training, how much and for whom, inter-relationships between different types of training and training providers, it also requires an understanding of the structure of the economy and labour markets, governance and funding, links to general and higher education and broader social development.
2. **Championing regional standards and accreditation processes:** This is an important process to ensure the standards are globally and regionally credible, so that skills development is properly accredited and transferable.
3. **KGRTC to play a centralised coordination, facilitation and knowledge hub role:** This means the KGRTC could play a critical facilitating role as an intermediary for skills development. In this role the KGRTC could also serve as a repository for what is happening in the SADC region or as a research hub. The KGRTC could also connect local initiatives in line with international processes and best practices through partnerships in key areas.

6.3.1 KGRTC partnerships

Implementation of key partnerships will be critical for the KGRTC's implementation strategy. The database created through this research offers a good spread of key stakeholders across the selected countries. Figure 20 presents a partnership framework which could guide the KGRTC's mapping of stakeholders:

Figure 20: Proposed partnership framework

An illustrative list of potential partners (Table 18) identified during the country mini-case studies and interviews are categorised below into the various elements of the partnership model.

Table 18: Potential initial KGRTC partnership entities for consideration

Organisation	Interest / training	Partnership framework category	Country
Association of Municipal Electricity Utilities (AMEU)	Electrical artisan and engineering technician training	Flexibility New skills Research	South Africa
Clean Energy Research Centre, University of Botswana	Renewable energy research	Research	Botswana
Renewable Energy & Energy Efficiency Institute (REEEI)	Training	Flexibility	Namibia
Renewable Energy & Energy Efficiency Institute (REEEI)	Policy setting, research and training	Research Flexibility	Mauritius
South African Renewable Energy Technology Education Centre (SARETEC)	Renewable energy installation training	Flexibility Research	South Africa
RES4Africa	Micro grid and off grid renewable energy installation training as well as middle manager and executive training	Flexibility New skills	Italy
PIESA	Standards development	Standards Research	(Virtual)

Organisation	Interest / training	Partnership framework category	Country
Power Africa	Renewable energy training	New skills Research	USA
Original Equipment Manufacturers (OEMs)	Training on their equipment	Standards and accreditation	Various countries
African Union Development Agency (AUDA)	Energy planning and modelling as well as trading	New skills Research	South Africa
International Atomic Energy Association (IAEA)	Regional Centre of excellence on Energy planning and modelling as well as trading	New skills	Switzerland
International Renewable Energy Association (IRENA and International Energy Agency (IEA)	Modelling tools (open source)	New skills Research	Abu Dhabi. United Arab Emirates France
AIR Academic Initiative for Renewables	Research	Research	Germany
Florence School of Regulation and potential Africa School of Regulation	Tertiary education institution, which offers training on energy, electricity regulation	New skills	Italy

6.4 Broader SADC regional energy skills roadmap

Building on this research and the recommendations proposed to the KGRTC, a proposed recommendation for the ILO would be to facilitate and coordinate the **development of an energy skills roadmap to support energy transformation across the SADC region**. It is suggested that this activity includes the following:

- Builds on the research undertaken to inform the KGRTC skills development strategy;
- Undertakes further research to better understand the full spectrum of SADC country energy-related skills ecosystems (including political, economic, social, technological and environmental dimensions). Including areas of alignment and gaps between countries.
- To hold a workshop or series of SADC regional workshops with key role players, e.g. the SADC Secretariat (Botswana); SADC Centre for Renewable Energy and Energy Efficiency (SACREEE), Regional Energy Regulators Association of Southern Africa (RERA) (Namibia); African Energy Leadership Centre (AELC); African Forum for Utility Regulators (AFUR) (South Africa); KGRTC, Regional Association of Energy Regulators for Eastern and Southern Africa (RAERESA) (Zambia); and Southern Africa Power Pool (SAPP) (Zimbabwe) to:
    - Present an overview of energy transformation in the region and the associated skills ecosystems; and
    - Consult on the alignment of regional energy transformation activities to inform the development of the roadmap.
- Development of a SADC regional energy skills roadmap, including e.g., priority activities, occupation and skills priorities, core partnerships to implement the strategy and timelines. The roadmap should be supported by:

- A **financial plan to ensure delivery** (including finance access); and
- An **occupational atlas for priority occupations**, which includes a detailed listing of priority occupations required to transform the SADC region's energy system to one that is just, resilient and sustainable. For each occupation, the associated definition, skills, knowledge and qualifications required are presented.

References

Adepeju, A. (2022, January 7). African Development Bank's SEFA to provide $1m in support of Botswana's energy transition. *BizWatch Nigeria*. Available at: https://bizwatchnigeria.ng/african-development-banks-sefa-to-provide-1m-in-support-of-botswanas-energy-transition/#:~:text=The%20Sustainable%20Energy%20Fund%20for%20Africa%20%28SEFA%29%20%28bit.ly%2F3JQ7ilg%29%2C,grant%20to%20facilitate%20Botswana%E2%80%99s%20transition%20to%20clean%20energy

Africa Energy Commission. (2021). *Namibia*. African Union and AFREC Energy. Available at: https://au-afrec.org/en/southern-africa/namibia

Africa Energy Portal. (2022). *Botswana*. Available at: https://africa-energy-portal.org/country/botswana

Africa News. (2022, May 17). South Africa: Battling shortfall of generating capacity, Eskom announces load shedding. *Africa News*. Available at: www.africanews.com/2022/05/16/south-africa-battling-shortfall-of-generating-capacity-eskom-announces-load-shedding//

Allais, S. (2022). *Beyond 'Supply and Demand': Moving from Skills 'Planning' to Seeing Skills as Endogenous to the Economy*.

Aumeeruddy, A. (2020, July 14). *New skills for new jobs*. United Nations Development Programme. Available at: https://www.undp.org/mauritius-seychelles/blog/new-skills-new-jobs

APA. (2022). *APA Dictionary of Psychology: Equipment Design*. Available at: https://dictionary.apa.org/equipment-design .

Arnoldi, M. (2021, August 27). Irena guides Botswana govt on its immense renewable energy potential. Engineering News. Available at: https://www.engineeringnews.co.za/article/irena-guides-botswana-govt-on-its-immense-renewable-energy-potential-2021-08-27/rep_id:4136

Bloemberg. (2022). South Africa's government wants access to $8.5 billion climate financing money. *BusinessTech.* Available at: https://businesstech.co.za/news/business/609624/south-africas-government-wants-access-to-8-5-billion-climate-financing-money/

BPC. (2018, August 31). Presentation on electricity supply in Botswana. *China Business Forum*, Botswana. Available at: https://www.gobotswana.com/sites/default/files/china_mission_bpc_presentation_27_august_2018.pdf

Caboz, J. (2019, March 18). Poor maintenance and management decisions are still at the heart of load shedding crisis: Here's why. *Business Insider South Africa*. Available at: www.businessinsider.co.za/maintenance-behind-eskom-blackouts-2019-3

Chipango, E. (2020, January 14). How politics and poverty affect electricity provision in Zimbabwe. *The Conversation*. Available at: https://theconversation.com/how-politics-and-poverty-affect-electricity-provision-in-zimbabwe-127755

Creamer, T. (2022, July 14). IRP 2019 implementation to continue while plan is reviewed, consulted and updated. *Engineering News*. Available at: https://www.engineeringnews.co.za/article/irp-2019-implementation-to-continue-while-plan-is-reviewed-consulted-and-updated-2022-07-14

DME. (2021). *The South African Energy Sector Report*. South African Department of Mineral Resources and Energy. Available at: http://www.energy.gov.za/files/media/explained/2021-South-African-Energy-Sector-Report.pdf

DMRE. (2018). *Integrated Resource Plan 2019.* Department of Mineral Resources and Energy (DMRE). Available at: http://www.energy.gov.za/IRP/2019/IRP-2019.pdf

DMRE. (2022). *The South African Energy Sector Report 2021.* Department of Mineral Resources and Energy (DMRE). Available at: www.energy.gov.za/files/media/explained/2021-South-African-Energy-Sector-Report.pdf

DMRE. (2022). *Industrial energy efficiency.* Department of Mineral Resources and Energy (DMRE). Available at: https://www.savingenergy.org.za/programmes/index.html

Dzobo, O., Tazvinga, H., Chihobo, C. and Chikuni, E. (2020). The adoption of energy efficiency and a policy framework for Zimbabwe. *Journal of Energy in Southern Africa* 31(3). Available at: http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S1021-447X2020000300001

Energy Efficiency Management Office. (2022). Guidelines: Installation and maintenance of air conditioners. Available at: https://eemo.govmu.org/Documents/awareness/Guidelines%20-%20Installation%20and%20Maintenance%20of%20Air%20Conditioners.pdf

Erastus, N. (2020, February 25). Namibia scraps energy monopoly. *The Namibian*. Available at: https://www.namibian.com.na/198402/archive-read/Namibia-scraps-energy-monopoly

Evans, J. (2021, November 8). The real deal with renewable energy in South Africa: Unpacking the suite of options. *Daily Maverick*. Available at: https://www.dailymaverick.co.za/article/2021-11-08-the-real-deal-with-renewable-energy-in-south-africa-unpacking-the-suite-of-options/

Farirai, F., Nyoni, S. and Chiwaye, N. (2020, October). *Status of energy efficiency in Zimbabwe and the region*. [Presentation]. Zimbabwe National Energy Efficiency Policy Stakeholder Workshop. Available at: https://www.researchgate.net/publication/352653041_STATUS_OF_ENERGY_EFFICIENCY_IN_ZIMBABWE_AND_THE_REGION

Gamble, J. (2022). 'Occupation', labour markets and qualification futures. *Journal of Vocational Education & Training*, *74*(2), pp.311-332.

Gammarano, R. (2019). *Persons Outside the Labour Force: How Inactive are they Really?* ILOSTAT. Available at: https://ilostat.ilo.org/persons-outside-the-labour-force-how-inactive-are-they-really/#:~:text=The%20potential%20labour%20force%20includes,in%20accessing%20employment%20is%20explicit.

Heita, J. (2022, March 15). Namibia's N$3,4b electricity import bill in 2021. *EagleFM*. Available at: https://www.eaglefm.com.na/news/namibias-n34b-electricity-import-bill-in-2021/

Holweg, M., & Helo, P. (2014). Defining Value Chain Architectures: Linking Strategic Value Creation to Operational Supply Chain Design. *International Journal of Production Economics*, 147, 230–238.

How, A., Lopes, J. and Kroes, G. (2018). *Technical market review: Country Profile: Namibia*. DNV-GL and Climate Technology Centre & Network: Available at: https://www.ctc-n.org/system/files/dossier/3b/country_profile_-_namibia.pdf

IEA. (2019). *Africa Energy Outlook 2019*. International Energy Association. Available at: https://www.iea.org/reports/africa-energy-outlook-2019

IEA. (2022a). *Glossary*. International Energy Association. Available at: https://www.eia.gov/tools/glossary/index.php?id=D

IEA. (2022b). *Renewable Energy Explained*. International Energy Association. Available at: https://www.eia.gov/energyexplained/renewable-sources/

IEA. (2022c). *Africa Energy Outlook 2022*. International Energy Association. Available at: https://www.iea.org/reports/africa-energy-outlook-2022

IEA. (2022d). *Electricity market report.* International Energy Association. Available at: Electricity Market Report - July 2022 – Analysis - IEA

IEA. (2022e). *Zambia*. International Energy Association. Available at: https://www.iea.org/countries/zambia

IFC. (2019). *Energy2Equal: Empowering Women in Africa's Renewable Energy Sector*. International Finance Corporation, World Bank Group. Available at: https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/energy2equal-africa

ILO. (1962). *Vocational Training Recommendation*. Available at: https://www.ilo.org/dyn/normlex/fr/f?p=NORMLEXPUB:55:0::NO::P55_TYPE,P55_LANG,P55_DOCUMENT,P55_NODE:REC,en,R117,/Document

ILO. (2006). *Decent work*. United Nations Economic and Social Council. Available at: http://www.ilo.org/global/topics/decent-work/lang--en/index.htm.

ILO. (2015). *Anticipating skill needs for green jobs: A practical guide*. Available at: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_564692.pdf

ILO. (2015a). *Gender Equality and Green Jobs: Policy Brief*. International Labour Organisation. Available at: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_360572.pdf

ILO. (2018). Skills for green jobs in Mauritius. International Labour Organisation (ILO). Available at: http://ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_706879.pdf

ILO. (2018). *Skills for green jobs in Mauritius*. International Labour Organisation (ILO). Available at: http://ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_706879.pdf

ILO. (2020). *Skills Development and Lifelong Learning. Resource Guide for Workers' Organizations*. International Labour Organisation. Available at: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_761035.pdf

ILO. (2021). *Changing demand for skills in digital economies and societies: Literature review and case studies from low- and middle-income countries*. Available at: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---ifp_skills/documents/publication/wcms_831372.pdf

ILO ISCO. (2008). *Concepts & Definitions*. Available at: https://ilostat.ilo.org/resources/concepts-and-definitions/classification-occupation/

Imasiku, K. and Ntagwirumugara, E. (2021). Sustainable energy supply and business collaborations for sustainability, resilience and competitiveness in the Zambian copper industry after Covid-19. *Journal of Energy in Southern Africa*, 32(1). Available at: http://dx.doi.org/10.17159/2413-3051/2021/v32i1a8362

IMF. (2007). *Manual on Fiscal Transparency: Glossary.* International Monetary Fund. Available at: https://www.imf.org/external/np/pp/2007/eng/101907m.pdf

Imrichova, J. and Beedassy, S. (2020, June 10). *Three reasons why energy transition is important for Mauritius COVID-19 economic recovery*. United Nations Development Programme (UNDP). Available at: https://www.undp.org/mauritius-seychelles/blog/three-reasons-why-energy-transition-important-mauritius-covid-19-economic-recovery

IPCC. (2019). Annex I: Glossary [van Diemen, R. (ed.)]. In: *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)].

IRENA. (2021). *Energy profile: Botswana*. International Renewable Energy Agency (IRENA). Available at: https://www.irena.org/IRENADocuments/Statistical_Profiles/Africa/Botswana_Africa_RE_SP.pdf

IRENA and AfDB. (2022). Renewable energy market analysis: Africa and its regions. International Re

Kan, K., Mativenga, P. and Marnewick, A. Understanding energy use in the South African manufacturing industry. *Procedia CIRP*, 91, 445-451. https://doi.org/10.1016/j.procir.2020.02.197

Kgosiemang, T. (2020, March 16). Botswana's water and energy sectors extremely poor: Report. *Weekend Post*. Available at: https://www.weekendpost.co.bw/24971/news/botswanaaes-water-and-energy-sectors-extremely-poor-ae-report/newable

Kovandova, E. (2019). A New Business Model for Sustainable Rural Electrification. Center for Development Alternatives. Available at: A New Business Model for Sustainable Rural Electrification - Centre for Development Alternatives (cda.co.ug)

Kumar, R. (2021). *Zimbabwe Data Portal: Goal 7: Affordable and Clean Energy*. ZimStat. Available at: https://zimbabwe.opendataforafrica.org/tzqised/goal-7-affordable-and-clean-energy

Largue, P. (2022, June 9). No clear plan for South Africa's life after coal. *Power Engineering International*. Available at: https://www.powerengineeringint.com/renewables/strategic-development/no-clear-plan-for-south-africas-life-after-coal/

Lloyds Bank. *The economic context of Zimbabwe*. Available at: https://www.lloydsbanktrade.com//en/market-potential/zimbabwe/economical-context

LSE. (2022). Biofuels policy of Zimbabwe (BPZ). Grantham Research Institute on Climate Change and the Environment, London School of Economics (LSE). Available at: https://climate-laws.org/geographies/zimbabwe/policies/biofuels-policy-of-zimbabwe-bpz#:~:text=The%20Biofuels%20Policy%20of%20Zimbabwe,biodiesel%20from%20jatropha%2C%20until%202030.

Macrotrends. (2022). *Botswana GDP 1960-2022*. Available at: https://www.macrotrends.net/countries/BWA/botswana/gdp-gross-domestic-product

Macrotrends. (2022a). *Zambia GDP 1960-2022*. Available at: https://www.macrotrends.net/countries/ZMB/zambia/gdp-gross-domestic-product

Madya, N. (2022). Renewable energy laws and regulations Zimbabwe 2023. ICLG.com. Available at: https://iclg.com/practice-areas/renewable-energy-laws-and-regulations/zimbabwe

Malsang, I. (2022, May 22). Namibia heads to Europe to market its sunshine. *Taipei Times*. Available at: https://www.taipeitimes.com/News/biz/archives/2022/05/22/2003778582

Mawire, W. (2021). Zimbabwe's national energy efficiency policy zero draft to undergo validation. *Green Business Gazette*. Available at: https://www.gbg.co.zw/2021/05/18/zimbabwes-national-energy-efficiency-policy-zero-draft-to-undergo-validation/#:~:text=According%20to%20the%20ministry%2C%20the,Income%20economic%20status%20by%202030.

MEPU. (2020). *Energy observatory report 2020*. Ministry of Energy and Public Utilities (MEPU) and Energy Efficiency Management Office. Available at: https://eemo.govmu.org/Communique/Final%20Energy%20Observatory%20Report%202020.pdf

MEPU. (2022). *Renewable energy roadmap 2030 for the electricity sector: Review 2022*. Ministry of Energy and Public Utilities, Mauritius Renewable Energy Agency, Central Electricity Board, and Energy Efficiency Management Office.

Ministry of Energy. (2022). *Energy sector.* Ministry of Energy Zambia. Available at: https://www.moe.gov.zm/?page_id=2198

Ministry of Energy and Power Development. (2020). Biofuels policy of Zimbabwe. Available at: https://www.zera.co.zw/Biofuels_%20Policy_of_Zimbabwe.pdf

Ministry of Mines and Energy. (2016). *National Integrated Resource Plan 2-16 for the electricity supply industry in Namibia*. Government of the Republic of Namibia. Available at: https://www.ecb.org.na/images/docs/Noticeboard/ELECTRICITY%20SECTOR%20NATIONAL%20INTEGRATED%20RESOURCE%20PLAN%20(NIRP)%202016%20Version%201.pdf

Ministry of Mines and Energy. (2021). *National electrification policy: Final draft.* Available at: https://www.ecb.org.na/images/docs/Policies/National%20Electrification%20Policy%20-%20Final%20-%202021215.pdf

Ministry of Mines and Energy. (2022). *Electricity division*. Available at: https://mme.gov.na/directorates/energy/electricity/

Mnyupe, J. (2021, November 4). Namibia's energy transition: Moving from policy to climate action. *The Namibian*. Available at: https://www.namibian.com.na/6215025/archive-read/Namibias-energy-transition--Moving-from-policy-to-climate-action

Mohamed, N. and Ramsarup, P. (2019). *Green economy transitions and skills: Global and South African perspectives*. Routledge.

Montmasson-Clair, G. (2021). *Making sense of jobs in South Africa's just energy transition: Managing the impact of a coal transition on employment*. Trade & Industrial Policy Strategies (TIPS). Available at: www.tips.org.za/images/Policy_Brief_Making_sense_of_jobs_in_South_Africas_just_energy_transition_Managing_the_impact_of_a_coal_transition_on_employment_April_2021.pdf

Montmasson-Clair, G. and Deonarain, B. (2019). *Regional integration in southern Africa: A platform for electricity sustainability*. Trade & Industrial Policy Strategies (TIPS). Available at: https://unctad.org/system/files/non-official-document/unda1617ld02_electricity_SA_en.pdf

Mori, J. (2019). *Dynamic skill formation in Vietnam: Beyond a 'skill mismatch' paradigm*. [Doctoral dissertation], Cardiff University, United Kingdom.

Moses, M. (2020). *What is Low Carbon Energy?* EDF Energy. Available at: https://www.edfenergy.com/for-home/energywise/low-carbon-energy#:~:text=Low%2Dcarbon%20energy%20is%3A,less%20carbon%20into%20the%20atmosphere.

Mutasa, R. (2021, November 19). *Africa Energy Futures: Zimbabwe*. DLA Piper. Available at: https://www.dlapiper.com/en/africa/insights/publications/2021/11/africa-energy-futures/africa-energy-futures-zimbabwe/#:~:text=In%202021%2C%20energy%20supply%20in,%2C%20geothermal%2C%20biofuels%20and%20biomass.

Namibia Statistics Agency (2019). *Namibia labour force survey 2018 report*. Available at: https://d3rp5jatom3eyn.cloudfront.net/cms/assets/documents/Labour_Force_Survey_final_-_2018.pdf

Namibia Statistics Agency. (2022). *Gross domestic product: First quarter 2022*. Available at: https://nsa.org.na/page/publications/

National Planning Commission. (2018). *Energy*. [NPC Economy Series]. Department of Planning, Monitoring and Evaluation (DPME). Available at: www.gov.za/sites/default/files/gcis_document/201802/npc-energy-paper.pdf

News24. (2022, October 10). Weekend wrap-up. *News24*. [Email].

Nicelow, T. (2019, March 24). Load shedding through the years and how Eskom has struggled to keep the lights on. *Fin24*. Available at: www.news24.com/fin24/Economy/Eskom/sunday-read-load-shedding-through-the-years-and-how-eskom-has-struggled-to-keep-the-lights-on-20190324

Njenda, T., Munochiveyi, M., Marufu, T. and Chirodza, J. (2021). Potential, Prospects and Challenges Associated with the Implementation of Photovoltaic Solar Energy in Zimbabwe. *South Florida Journal of Development*, 2 (3). https://doi.org/10.46932/sfjdv2n3-034

Njini, F., Cohen, M., & Vecchiatto, P. (2019). Renewables in, coal out: South Africa's energy forecast. *Renewable Energy World*. https://www.renewableenergyworld.com/wind-power/renewables-in-coal-out-south-africas-energy-forecast/

Nwanosike, S. (n.d.). EEDC decries poor payment culture for electricity supply in the South-East. *The Herald*. Available at: https://www.herald.ng/eedc-decries-poor/

OECD/ILO. (2019). *Tackling Vulnerability in the Informal Economy*. OECD Publishing, Paris. Available at: https://www.oecd.org/fr/publications/tackling-vulnerability-in-the-informal-economy-939b7bcd-en.htm

Onyango, R. (2021). *Energy use and economic growth in the Southern African Development Community (SADC)*. [Master's degree]. University of KwaZulu-Natal, Durban. Available at: https://researchspace.ukzn.ac.za/xmlui/bitstream/handle/10413/20143/Onyango_Rebecca_Beth_Akinyi_2021.pdf?sequence=1&isAllowed=y

Phiri, J., Malec, K., Kapuka, A., Maitah, M., Appiah-Kubi, S., Gebeltová, Z., Bowa, M. and Maitah, K. (2021). Impact of agriculture and energy on CO_2 emissions in Zambia. *Energies,* 14 (8339). https://www.mdpi.com/1996-1073/14/24/8339

Rabasoma, K. *Solar thermal technology in the Botswana energy mix: Issues and prospects*. [Poster]. Clean Energy Research Centre, University of Botswana. Available at: https://www.researchgate.net/publication/359942433_Solar_Thermal_Technology_in_the_Botswana_Energy_Mix_-Issues_and_Prospects

Raditholo, G. (2019). *The energy sector of Botswana: Vision, action plan and investment opportunities*. Africa Energy Market Place Round 3. [Presentation], 25-26 June 2019. Available at: https://africa-energy-portal.org/sites/default/files/2019-07/Botswana%20AEMP%20Presentation.pdf

Republic of Namibia (2021). *Namibia's updated nationally determined contribution*. Available at: https://www4.unfccc.int/sites/SubmissionsStaging/NationalReports/Documents/5823401_Namibia-NC4-1-Namibia%20-%20NC4%20-%20Final%20signed.pdf

RERA. (2022). *Regional Energy Regulators Association.* Available at: RERA – Regional Energy Regulators Association (rerasadc.com)

Reuters. (2019, December 12). Zambia's power supply deficit worsens as water levels sink. *Reuters*. Available at: https://www.reuters.com/article/us-zambia-electricity-idUKKBN1YG1DZ

Richard, N. (2021, November 19). Over the last five years, how has the energy mix changed, and what have been the key drivers? *DLA Piper*. Available at: https://www.dlapiper.com/fr/africa/insights/publications/2021/11/africa-energy-futures/africa-energy-futures-mauritius/

Richardson, E. (2022, May 20). Green energy to drive economic growth. *Energize*. Available at: https://www.energize.co.za/article/green-energy-drive-economic-growth

Rosemberg, A., (2010). Building a just transition: The linkages between climate change and employment. *International Journal of Labour Research*, 2(2), p.125.

Rosenberg, E., Ramsarup, P. and Lotz-Sisitka, H. (2020). *Green skills research in South Africa: Models, cases and methods*. Routledge.

SADC. (1996) *SADC protocol on energy.* Southern African Development Community (SADC). Available at: https://www.sadc.int/document/protocol-energy

SADC. (2018). *SADC 2018 Renewable energy and energy efficiency status report*. Southern African Development Community (SADC).Available at: 2018 SADC Renewable Energy and Energy Efficiency Status Report - REN21

SADC. (2020). *Regional indicative strategic development plan (RISDP) 2020–2030*. Southern African Development Community (SADC).Available at: SADC Regional Indicative Strategic Development Plan (RISDP) 2020-2030 | SADC

SADC. (2021). *SADC sectoral statistics database 2020.* Southern African Development Community (SADC). Available at: https://www.sadc.int/sadc-statistics/sadc-sectors-2020-web-long-version-4-december-2021infra

SADC. (2022). *Southern African Development Community: Towards a common future.* Southern African Development Community (SADC). Available at: https://www.sadc.int/member-states

SAPP. (2017). *SAPP Pool Plan.* Southern Africa Power Pool (SAPP). Available at: SAPP Pool Plan 2017 Main Volume_0.pdf

Segatto, M., de Oliveira Rocha, H., Silva, J., Paiva, M. and Cruz, M. (2018). Telecommunication technologies for smart grids: Total cost optimization. *Advances in Renewable Energies and Power Technologies* (pp. 451-478). Elsevier.

Sibanda, P. (2022, April 30). 60% of Zim has never known electricity. *News Day*. Available at: https://www.newsday.co.zw/2022/04/60-of-zim-has-never-known-electricity/

Sikuka, J. (2016). *Challenge of balancing competing water, energy needs in SADC*. Available at: Challenge of balancing competing water, energy needs in SADC | Knowledge for Development (sardc.net)

Shah, O. (2021). *Africa Hydrogen Economy: Untapped potential for green hydrogen supply.* Available at: Africa hydrogen economy: untapped potential for green hydrogen supply (h2bulletin.com)

Shalem, Y. and Allais, S. (2018). *Linking knowledge, education and work: Exploring occupations. Working paper*. Available at: https://hsrc.ac.za/uploads/pageContent/1044864/Linking%20Knowledge%2011Nov20%20LowRes.pdf[13].pdf .

Shalubala, C. (2022, March 9). Pace at which Zambia is transitioning to renewable energy worrisome – Johnstone. *News Diggers!* Available at: https://diggers.news/business/2022/03/09/pace-at-which-zambia-is-transitioning-to-renewable-energy-worrisome-johnstone/

Shidhika, F. (2018). *Solar energy for rural development*. Proceedings of the conference on solar power systems for Namibia, 16-18 May.

Shipunda, S. (2022, April 14). Namibia and energy transition. *Energy Central News*. Available at: https://energycentral.com/news/namibia-and-energy-transition

Smith, T. (2022, May 4). $15.5m Investment into Zambia's first renewable energy buyer. *ESI Africa*. Available at: https://www.esi-africa.com/renewable-energy/15-5m-investment-into-zambias-first-renewable-energy-buyer/

Standard Bank. (2022). *Botswana: Economic and political overview*. Available at: https://www.tradeclub.standardbank.com/portal/en/market-potential/botswana/economical-context

Standard Bank. (2022a). *Zambia: Economic and political overview*. Available at: https://www.tradeclub.standardbank.com/portal/en/market-potential/zambia/economical-context#

Statistics Botswana. (2021). *Quarterly multi-topic survey (QMTS): Quarter 4, 2021*. Available at: https://www.statsbots.org.bw/sites/default/files/Quarterly%20Multi-Topic%20Survey%20Report%20Q4%2C%202021.pdf

Statistics Botswana. (2022). *2022 Population and housing census: Preliminary results v2*. Available at: https://www.statsbots.org.bw/sites/default/files/publications/2022%20Population%20and%20Housing%20Census%20Preliminary%20Results.pdf

Statistics Mauritius. (2021). *Digest energy 2020*. Available at: https://statsmauritius.govmu.org/Pages/Statistics/By_Subject/Energy_Water/Energy_Water.aspx

Statistics Mauritius. (2021a). *Labour force, employment and Labour force, employment and unemployment: Year 2021 highlights*. Available at: https://statsmauritius.govmu.org/Pages/Statistics/ESI/Labour/Labour/LF_Emp_Unemp_1Qtr21.aspx

Statistics Mauritius. (2022). *Population and vital statistics: Republic of Mauritius, Year 2021 highlights*. Available at: https://statsmauritius.govmu.org/Pages/Statistics/ESI/Population/Pop_Vital_Yr21.aspx

Statistics Mauritius. (2022a). *National accounts estimates (2018-2022): June 2022*. Available at: https://statsmauritius.govmu.org/Pages/Statistics/ESI/National_Accounts/NA/NAE_Jun22.aspx

StatsSA. (2022, July 28). *60,6 million people in South Africa.* Department of Statistics South Africa. Available at: https://www.statssa.gov.za/?p=15601

StatsSA. (2022a, September 6). *South African GDP declines by 0,7%*. Department of Statistics South Africa. Available at: https://www.statssa.gov.za/?p=15728

StatsSA. (2022b, June 1). *South Africa's youth continues to bear the burden of unemployment*. Department of Statistics South Africa. Available at: https://www.statssa.gov.za/?p=15407

StatsSA. (2022c). *Quarterly employment statistics.* Department of Statistics South Africa. Available at: https://www.statssa.gov.za/publications/P0277/P0277March2022.pdf

Strietska-Ilina, O., Hofmann, C., Haro, M. and Jeon, S. (2012). *Skills for green jobs: A global view*. International Labour Organisation. Available at: https://www.ilo.org/global/publications/ilo-bookstore/order-online/books/WCMS_159585/lang--en/index.htm

Stritzke, S., Trotter, P. and Twesigye, P. (2021). Towards responsive energy governance: Lessons from a holistic analysis of energy access in Uganda and Zambia. *Energy Policy*, 148. https://doi.org/10.1016/j.enpol.2020.111934

United Nations. (2001). *Gender mainstreaming: Strategy for promoting gender equality, 1.* Office of the Special Advisor on Gender Issues and Advancement of Women, United Nations.

UNECA. (2021). *Regulatory review of the electricity market in Zambia: Towards crowding-in private sector investment.* United Nations Economic Commission for Africa. Available at: file:///C:/Users/nicol/Downloads/Regulatory%20Review%20of%20the%20Electricity%20Market%20in%20Zambia%20(1).pdf

UNEP/ILO/IOE/ITUC. (2008). *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World*. Available at: https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_158727.pdf

UNEP. (2010). *Driving a Green Economy through public finance and fiscal policy reform*. United Nations Environment Programme. Available at: https://www.greengrowthknowledge.org/sites/default/files/downloads/resource//Driving_a_GE_through_public_finance_and_fiscal_policy_reform_UNEP.pdf

UNESCO IBE. (2011). *Curriculum*. Available at: http://www.ibe.unesco.org/en/glossary-curriculum-terminology/c/curriculum-plural-curricula

USAID. (2021). *Botswana: Power Africa fact sheet*. Available at: https://www.usaid.gov/powerafrica/botswana#:~:text=POWER%20AFRICA%20FACT%20SHEET%20Power%20Africa%20has%20supported,and%20explains%20Power%20Africa%27s%20involvement%20in%20the%20country.

US ITA. (2021). *Namibia: Energy*. United States of America Department of Commerce and International Trade Administration. Available at: https://www.trade.gov/country-commercial-guides/namibia-energy

US ITA (2022). *Zimbabwe: Country commercial guide: Energy*. Unite United States of America Department of Commerce and International Trade Administration. Available at: https://www.trade.gov/country-commercial-guides/zimbabwe-energy

The World Bank. (2021). *Energy Progress Report*. Available at: Tracking SDG 7 | Progress Towards Sustainable Energy (esmap.org)

The World Bank. (2022). *GDP (current US$): Botswana*. Available at: https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=BW

The World Bank. (2022a). *Data: Mauritius*. Available at: https://data.worldbank.org/country/mauritius

The World Bank. (2022b). *Access to electricity (% of population): Mauritius*. Available at: https://data.worldbank.org/indicator/EG.ELC.ACCS.ZS?locations=MU

The World Bank. (2022c). *Namibia*. Available at: https://data.worldbank.org/country/namibia

The World Bank. (2022d). *Namibia*. Available at: https://data.worldbank.org/country/namibia

The World Bank. (2022e). *The World Bank in Namibia: Overview*. Available at: https://www.worldbank.org/en/country/namibia/overview

The World Bank. (2022f). *Unemployment, total (% of total labour force) (modelled ILO estimate): Zambia*. Available at: https://data.worldbank.org/indicator/SL.UEM.TOTL.ZS?locations=ZM

World Bank. (2022g). *Electricity service access project*. Availability at: https://projects.worldbank.org/en/projects-operations/project-detail/P162760

Yang, F., Li, F. and Lau, R. (2010). An open model for learning path construction. *International Conference on Web-Based Learning* (pp. 318-328). Springer, Berlin, Heidelberg.

Zambia Statistics Agency. (2022). *Population*. Available at: https://www.zamstats.gov.zm/?playlist=2f357cd&video=9d4f479

ZimStat. 2021. Third quarter quarterly labour force survey 2021. Zimbabwe National Statistics Agency (ZimStat). Available at: http://www.zimstat.co.zw/wp-content/uploads/publications/Economic/Employment/Labour_Force_Report_2021.pdf

Zimstat. (2022). *2022 Population and housing census: Preliminary report on population figures*. Zimstat, Harare.

ZPC. (2022, May 6). *Power column Q1 2022*. Zimbabwe Power Company. Available at: https://www.zpc.co.zw/articles/2022/05/06/power-column-q1-2022

Annexures

Annexures referred to accompany this report separately.