CHECK REGIONAL INNOVATION PROJECT

Overview of the Green Energy and Solid Waste Management System in the Western Cape

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Abiola Kehinde (University of Cape Town)

Jürgen Becker (University of the Western Cape)

Table of Contents

List of tables

List of figures

List of abbreviations

CoCT	-	City of Cape Town
CGCSA	-	Consumer Goods Council of South Africa
CHEC	-	Cape Higher Education Consortium
DEA&DP	-	Department of Environmental Affairs & Development Planning
EPR	-	Extended producer responsibility
GES	-	Green Economy Sector
DFFE	-	Department of Forestry, Fisheries, and the Environment
IndWMPs	-	industry waste management plans
IWMP	-	Integrated Waste Management Plan
NEMA	-	National Environmental Management Act
NEMWA	-	National Environmental Management Waste Act
NWMS	-	National Waste Management Strategy
RIS	-	Regional Innovation Systems
RE	-	Renewable Energy
REIPPPP	-	Renewable Energy Independent Power Producer Programme
SAFLWVA	-	South African Food Loss and Waste Voluntary Agreement
US	-	Stellenbosch University
WC	-	Western Cape
WCG	-	Western Cape Government
WCGES	-	Western Cape's Green Economy Sector
WC IWMF	-	Western Cape Industry Waste Management Forum
WC IWMOF	-	Western Cape Integrated Waste Management Officers' Forum

WCP	-	Western Cape Province
WCR	-	Western Cape Region
WCRAG	-	Western Cape Recycling Action Group

1. Introduction

The Cape Higher Education Consortium (CHEC) aims to establish the Western Cape as a strong higher education region through systemic inter-institutional cooperation and academic programme collaboration.

The University of the Western Cape (UWC), in collaboration with the University of Stellenbosch (US) has successfully responded to a Joint Research Programme call for proposal from the CHEC/WCG.

The Cape Higher Education Consortium (CHEC) is currently coordinating a project with the Western Cape Government (WCG) on Regional Innovation Systems (RIS). The joint task team consists of partners from the University of the Western Cape (UWC), Stellenbosch University (US), WCG and CHEC. Further information on CHEC can be found at www.chec.ac.za

In response to the COVID-19 pandemic, the economic and governance sections of the WCG's Provincial Recovery Plan identify the importance of innovative systems in addressing developmental priorities within the region. At the core of the RIS approach is an emphasis on economic and social interactions between agents, spanning the public and private sectors, to engender and diffuse innovation within regions embedded in wider national and global systems.

The Project includes a specific focus on the following economic sectors:

- Green Economy (focussing on Renewable Energy and Solid Waste Management)
- Biotech
- BPO Sector
- ICT / Digital technology (including Fintech, Internet Security, Payment systems)
- Agriculture and Agri Processing

This document focuses on the Green Economy Sector. The research undertaken includes the identification of existing networks and role-players, factors that influence regional innovation in these sectors, and any further support required.

The key impact metrics will be focused on:

- Inclusive employment and jobs
- Community safety and prosperity
- Spatial transformation and innovation

As a preliminary to this, the research team undertook to prepare a desktop study of the Western Cape RIS by looking at key sectors. In the regard, the reports take a sectoral approach to RIS by focussing on the following sectors:

- Green Energy and Solid Waste Management
- Biotech
- Business Process Outsourcing (BPO)
- 4IR and Digital technology
- Agriculture and Agric processing) for the project, which is the subject of this report.

The current report will focus specifically on green energy and solid waste management. The report is intended for internal use only because it may contain proprietary information which may not be open source. The report is not meant to be an exhaustive account of all the innovation initiatives in the province regarding green energy and waste management. The idea is to provide a summary of key initiatives and to define the measurement framework and key metrics used to examine RIS in the province from a sectoral perspective.

2. Aim and objectives

The goal of this report is to present a relevant set of information on the state of innovation in Western Cape's Green Energy Sector (WCGES) and Waste Management Sector (WMS), through:

1. Desktop research to identify existing networks and role-players and factors that influence regional innovation in WCGES and WMS by:
    - Desktop review on the Green Energy Sector (GES) and Waste Management Sector (WMS) with specific emphasis on the Western Cape Province (WCP).
    - Environmental scan using both qualitative and quantitative data points
    - Working within the established measurement framework (See Appendix A) to collect data, and
    - Calculate key metrics contained in the measurement framework.
2. Formalization of the knowledge acquired in the step 1 to operationalise the metrics developed through the measurement framework.
3. Visualization of key metrics through the Environmental System Research Institute (ESRI) Geographic Information System (GIS).

To achieve the set goals above, this report seeks to address the following questions, which are:

- Who are the main role players and stakeholders involved in innovation in the GES and WMS in the WCP?
- What does the policy and regulatory framework look like for GES and WMS?
- What promotes innovation in GES and WMS in the WCP?
- What hinders innovation in GES and WMS in the WCP?
- What is the competitiveness of the sector regionally, nationally, and internationally?
- What are the main private and public sector initiatives driving GES and WMS?
- What is the level of maturity of the sector in terms of the 7 functions of the measurement framework.
- What support is needed, particularly from WCG, to foster regional development?

Scope

The scope of this report is to assist CHEC in updating the baseline information on the Green Economy sector in the Western Cape. In the current investigation, the green economy is limited to renewable energy generation and solid waste management.

The scope of work entails:

- Literature review on the sector with specific emphasis on the Western Cape Province
    - Utilising publicly available literature on the GES sector
    - Meeting with the GES sector agency
    - Collecting information on GES initiatives
    - Develop a baseline understanding of the sector landscape, including key players, high level value chain and business models
- Environmental scan using both qualitative and, where possible quantitative, data points
    - Review of domestic and global positioning of the Western Cape GES sector
    - Inputs from key players

3. Methodology

The following methodology was used to prepare this baseline overview:

- Secondary desk research of relevant research papers, articles, and documents on innovation systems
- Secondary desk research of the relevant policies and strategies affecting the WC BPO system
- Secondary desk research of the relevant models guiding the discourse on the WC BPO system
- Interviews and other engagements with selected practitioners to add value by corroborating, or contesting, the findings.

The generally accepted protocols of conducting secondary research and the appropriate conventions for referencing secondary research data have been followed consistently.

The intention of the project was to utilize quantitative methods to build an interactive and visual presentation of the main actors, intermediaries, and their interactions, however access to data proved to be exceedingly difficult and cumbersome. As a result, the current version of the report will capitalize predominantly on qualitative data sources. However, the intention is to supplement the current version of the report with quantitative data. The project also aimed to establish a common measurement framework that can be used by future researchers to enhance and enrich our current understanding of Regional Innovation Systems in the Western Cape Province.

4. Framework

The research team spent considerable time conceptualising and operationalising the innovation measurement framework.

4.1 Innovation system

Innovation System (IS) is a collection of entities that interact and perform various activities that generate knowledge, disseminate knowledge, and drive the economy.

They are typically filled by individuals, groups, or companies with specific skills (Freeman C, 1987; Lundvall, 1993; Nelson, 1993; Oyelaran-Oyeyinka & McCormick, 2007). Edquist (2001) defined an innovation system as "all the major economic, social, political, organisational and other factors that influence the development, diffusion and use of innovation" (Edquist, 2001). An innovation system consists of common elements that work together to create an innovation system. The approach or interpretation of these elements is what distinguishes them from each other.

Several approaches have been developed to analyse an innovation system (IS). Carlson et al. (2002) elaborate on these in their publication on Innovation Systems. They mentioned six major approaches to analysing IS. The input-output analysis was introduced by Leontief in 1941 and focused on the flow of goods and services between sectors. The development blocs were introduced in 1950 by Dahmén. This approach introduced the notion that the innovation system is a complex and dynamic system. The development blocs focus on the role of entrepreneurs (Carlson et al., 2002). In the late 80's and early 90's, the concept of the National Innovation System (NIS) emerged and was introduced by Freeman, Lundvall, Nelson, and several others. In the 1990s, the Regional Innovation System (RIS), Sectoral Innovation System (SIS) and Technological Innovation System (TIS) grew out of the NIS ideas (Hekkert et al., 2007). In 1990, Michael Porter introduced the Diamond Approach. The Diamond Approach consists of factor conditions, related industries, business strategies, demand conditions, Structure, and competition (Carlson et al., 2002). The innovation system converts innovation into vectors. When innovation is scalar and has only magnitude, it supports innovation by giving it a direction in which it grows and inevitably supports economic growth.

A more systematic approach is to study how structural elements interact, exist in an innovation system, and influence how innovation works in that system. These elements are often labelled or categorized according to the role they play in the system. Three examples of this classification are components and relationships (Edquist, 2001), structural elements (Hekkert et al., 2007; Wieczorek & Hekkert, 2011), and structural components (Bergek et al., 2008). Since Edquist introduced these elements in 1997, further classifications have been used in the work of Hekkert et al.

(2007) and Bergek et al. (2008). In 2008, Bergek et al. (2008) categorized the elements as Actors, Networks, and Institutions. In a paper published in 2011, Wieczorek and Hekkert further categorized these factors into four subcategories: actors, institutions, interactions, and infrastructure (Wieczorek & Hekkert, 2011).

Essentially, these authors' taxonomies are the same and offer similar insights. Actors are represented as individuals, organizations, or networks of entities. These are entities that regularly interact with the economy or other entities. Institutions are defined as a set of actions and can be either soft or hard. Soft institutions are behaviours that are habitually performed as part of everyday life, such as habits and routines. Hard institutions are more formal, usually learned or developed forms of behaviour, some examples are rules, norms, and strategies. Interactions are like Bergek's Networks and Edquist's Relationships categories. Interaction factors consider relationships between entities in the system. They can be either informal or official. The final element of infrastructure specifies the resources provided and consumed by the entities in the system. These often appear as financial (venture capital, funds, investors), physical (buildings, roads, bridges, etc.) and knowledge (university institutions, training systems, libraries, etc.) (Wieczorek & Hekkert, 2011).

There are several ways these elements interact. The combination of these element interactions is usually categorized as a function of the innovation system (Edquist, 2001; Hekkert et al., 2007; Bergek et al., 2008; Wieczorek & Hekkert, 2011). Hekkert et al. (2007) presented seven functions that exist in the regional innovation system. These seven functions are entrepreneurship, knowledge development, knowledge dissemination, search direction, market building, resource mobilization, and legitimacy creation (Hekkert et al., 2007). All functions are effectively interconnected and accomplishing one function can affect another (Hekkert et al., 2007). A functional approach was used to develop the evaluation framework and maturity indicators as shown in **the appendix A**. All sectors use the same measurement framework, but not necessarily the same metrics. This can be explained by the uniqueness of each sector. Some metrics may be relevant and important in one sector, but less important in another. Additionally, not all metrics are geospatial in nature and the data may not be represented as such. Because of this, not all metrics are displayed at the GIS level.

4.2 Types of innovation systems

The main feature that distinguishes the various types of (IS) is the type of boundary that is drawn around the elements when analysing the system. These boundary types are typically geographical, industry, industry, or technology oriented (Edquist, 2001; López-Rubio, Roig-Tierno & Mas-Verdú, 2022). All types of innovation systems are fundamentally the same and can be treated as different versions of the basic IS concept (Edquist, 2001). Different types of innovation systems can coexist, and their structural elements may overlap. His four most common types of innovation systems are country, region, sector, and technology (Hekkert et al., 2007; Kastelle, Potts & Dogson, 2009).

The concept of a NIS was the first example of a classified innovation system. NIS is commonly used to classify a country's innovation system and its capabilities. Identify stakeholder connections and activities that are critical to improving the country's innovation performance. Actors should act as members of a knowledge-based economy where the emphasis is on the creation, dissemination and use of knowledge and information (OECD, 1997). The introduction of the NIS approach also marked the growth of systematic approaches to replace the traditional method of studying technological development, the linear innovation model (OECD, 1997). The impact of innovation on economic development was assumed in the form of NIS. Initial analysis of NIS initially took two approaches. Some scholars focused on the institutions that influence innovation, and he approached the NIS, while another approach focused on the interactions between firms within his NIS' boundaries (Kastelle, Potts & Dodgson, 2009). In recent years, these two approaches have been merged to create more complex and comprehensive analytical frameworks.

In 2002, Chung stated that the NIS can be represented as a matrix of regional and sectoral innovation systems (Chung, 2002). Using this idea, NIS can be seen as a combination of RIS and SIS. Hekkert et al. (2007) proposed a similar concept of borders and how they can overlap and share structural elements, and expressed it using NIS, SIS, and TIS. NIS consists of RIS-A, RIS-B, SIS-1, and SIS-2. The combination of these innovation systems results in sector- and region-specific

transversal innovation systems. RIS-A and SIS-2 are classified by sectors specific to RIS-A, whereas SIS-1 is present in both RIS-A and RIS-B.

4.3 Innovation system boundaries intersection (adapted from Hekkert et al., 2007)

RIS applies the same concept as NIS but zooms in on a particular region. RIS boundaries can be either physical (such as rivers, mountains, etc.) or political geographies (states/states, municipalities, constituencies, etc.) (Asheim, Smith & Oughton, 2011). The concept of clusters has appeared in the literature alongside RIS. It is important to note their existence and relevance. Clusters focus on links between firms to better understand the activities between different firms within a domain. Non-business stakeholders, such as knowledge development and dissemination institutions, may be involved in cluster analysis, and clusters can be viewed as units within her RIS. The main difference between clusters and RIS is that the cluster approach applies networks between entities for analysis while RIS theory applies a systematic lens involving political and theoretical concepts (Asheim, Smith & Oughton, 2011). RIS's analysis includes more factors than clusters, such as: Use of Policy, Market Impact, Institutions, and Adoption Culture.

The depiction of SIS focuses on territories rather than defining its boundaries at the level of economic sectors (Gutiérrez, Verónica & Smith, n.d.). These boundaries can be defined by a specific industry (wind energy, solar energy, etc.) or a set of industries with common operating structural elements (green energy, etc.). The limits that define TIS are like SIS in that they use theoretical limits rather than more simply defined limits. A TIS focuses on technical changes in a particular technology or type of technology used. This distinction distinguishes TIS from large-scale technical systems (LTS) or, alternatively, technology-specific innovation systems (TSIS) (Hekkert et al., 2007). TIS boundaries can bridge SIS, RIS and even NIS.

5. Definitions - frame of reference

5.1 Green energy and waste management

This section provides an environmental scan of the GES and solid waste management sector of the Western Cape economy. The review will look at the global view of the sectors including the evaluation of Wesgro. The review will also focus on the main characteristics and inherent dynamics of the sectors.

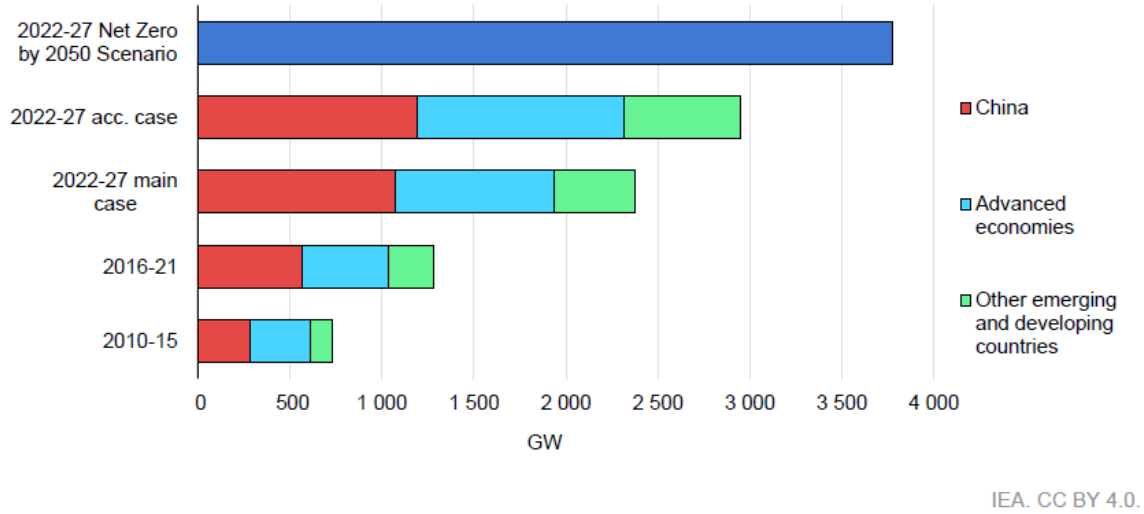
5.1.1 Global context

COVID-19 has had a tremendous impact on the world at large, but it has had little effect on the renewable energy sector (IEA, 2022). However, the effect of the invasion of Ukraine by Russia has given the renewable energy sector a chance to prosper globally (IEA, 2022). Also, because of the global energy crisis and high prices for fossil fuels and electricity, renewable energy technologies are now much more appealing from an economic standpoint.

According to the IEA's main-case prediction, global renewable capacity is anticipated to rise by almost 2 400 GW (almost 75%) between 2022 and 2027, which is equivalent to the People's Republic of China's current installed power capacity. The projection for most advanced economies is based on the lofty goals and policy incentives of these nations, but there are still difficulties with implementation, particularly when it comes to obtaining permits and expanding grid infrastructure. The main obstacles to a more rapid spread of renewable energy in emerging economies continue to be policy and regulatory uncertainty, as well as difficulties with implementation. Lastly, in the IEA’s main-case scenario, insufficient grid infrastructure and a lack of affordable finance in developing nations slow down the commissioning of numerous projects more quickly.

Renewable capacity expansion is shown in figure 5.1 to be about 25% larger in the expedited case scenario than in the main case, producing nearly 2 950 GW in total additions globally. IEA (2022) explained that this amount of energy can only be achieved when the countries address those difficulties earlier mentioned within 12 to 24 months. For the IEA Net Zero by 2050 scenario, the rate of renewable capacity expansion in the main case is expected to increase by 60 % throughout the forecast

period. However, in the accelerated scenario, growth over the following five years will close the gap for renewable electricity growth required to reach net zero emissions by 2050 (only if there is adequate policies and speedy implementation of countries' existing goals).



Note: acc. case = accelerated case.

Figure 5.1: The main and accelerated cases for renewable capacity growth between 2010-2027

In Figure 5.1, China is expected to add about half of the world's new renewable energy capacity between 2022 and 2027, as growth quickens during the following five years despite the elimination of subsidies for solar and wind power. Long-term revenue certainty for renewables is provided by the 14th Five-Year Plan's ambitious renewable energy targets, market reforms, and strong provincial government backing. Thus, according to the main case estimate, China will achieve its 2030 wind and solar PV capacity targets in 2025.

The European Union, the second-largest growing market after China as shown in Figure 5.2, has experienced stable growth in renewable capacity between 2016-2021 when compared to 2010–2015, but its rate of increase is anticipated to more than double in the next five years (2022-2027). Prior to Russia's invasion of Ukraine, several EU member states had already introduced aggressive targets and measures to speed up the deployment of renewable energy. Since then, the European Union has proposed even more aggressive goals under the REPowerEU package to end imports of Russian fossil fuels by 2027. As a result, IEA predicted that the EU

measures put into place since the start of the conflict will hasten the implementation and deployment of renewable energy sources. Such as expanding wind and solar PV power generation to minimize natural gas use in the EU electricity sector. Apart from China, the renewable capacity growth for other countries in the world is shown in Figure 5.2.

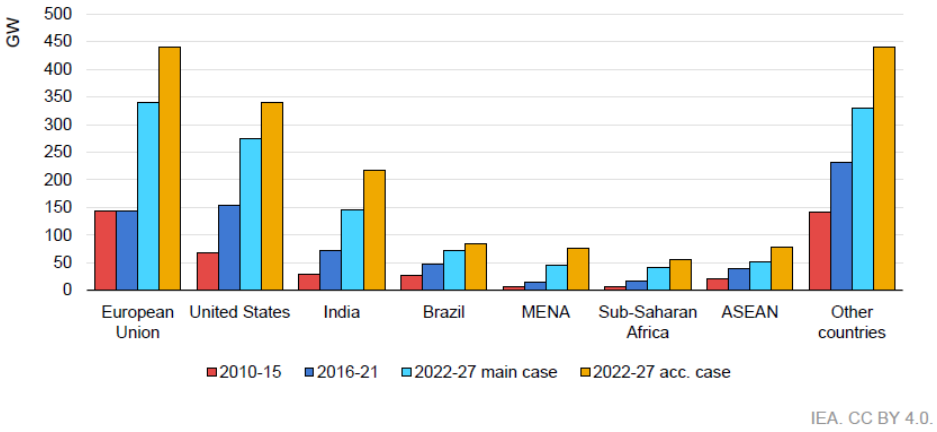


Figure 5.2: The main and accelerated cases for renewable capacity growth outside of China, 2010-2027

The expansion of renewable energy in the United States was nearly doubled during the previous five years (IEA, 2022). The UA Inflation Reduction Act (IRA), which was passed in August 2022, extended tax incentives for renewable energy sources until 2032, giving wind and solar PV projects long-term visibility. In India, the number of new installations is expected to double over the course of the forecast period, with solar PV expected to lead the way to help the country reach its ambitious goal of 500 GW of renewable energy by 2030 (IEA, 2022). Figure 5.3 shows the yearly net renewable capacity addition by technology. Solar PV (distributed and utility scale PV) technology is expected to dominate renewable energy capacity from 2022-2027.

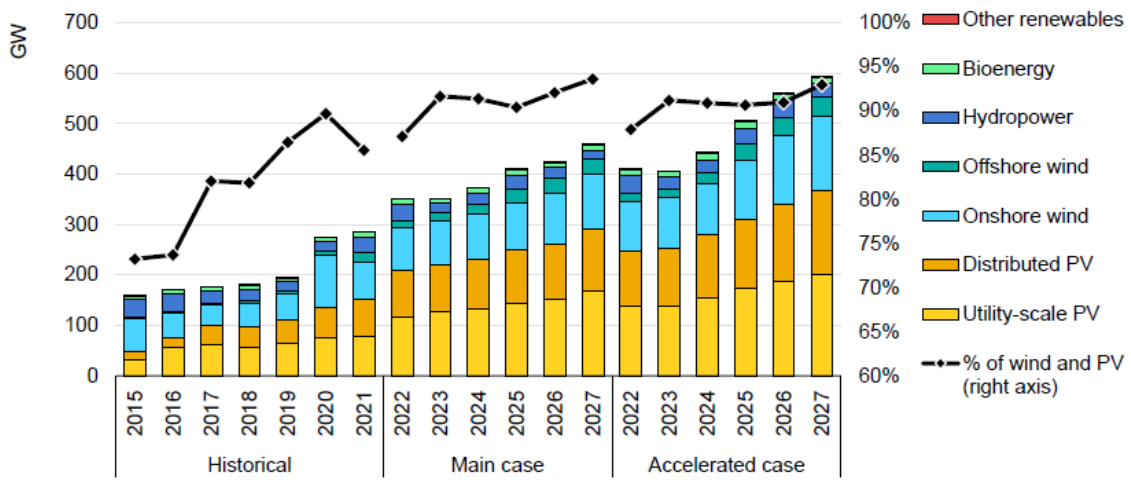


Figure 5.3: The main and accelerated cases for renewable annual net capacity additions by technology, 2015-2027

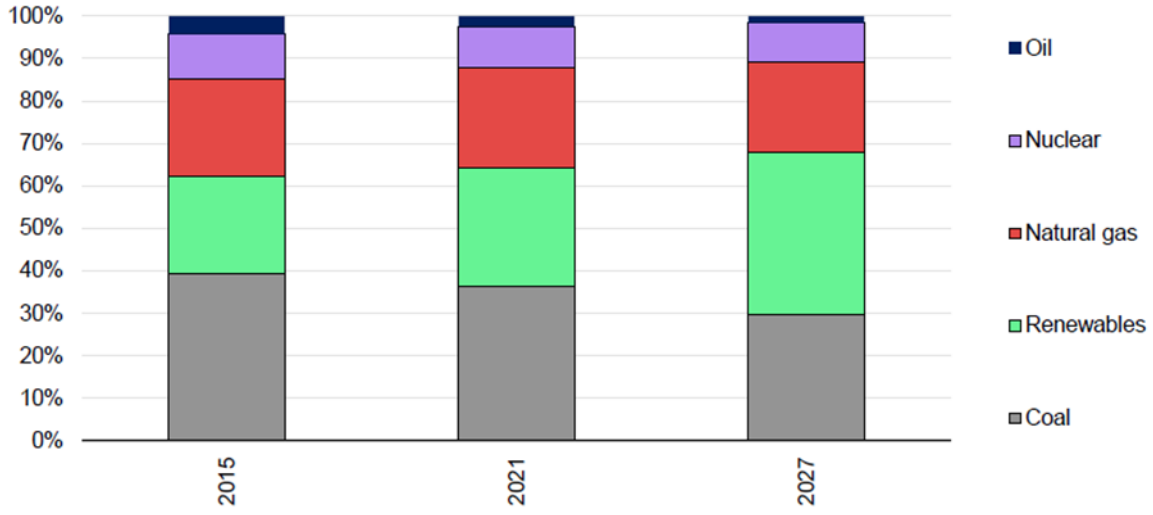


Figure 5.4: Electricity generated by technology globally in 2015, 2021 and 2027

In the next three years, renewables are expected to surpass coal as the dominant energy source used to generate electricity globally, according to the main-case forecast shown in Figure 5.5. Nearly 40% of the world's electricity will come from renewable sources in 2027 as shown in Figure 5.5, making up for coal, natural gas, and nuclear' s diminishing market shares.

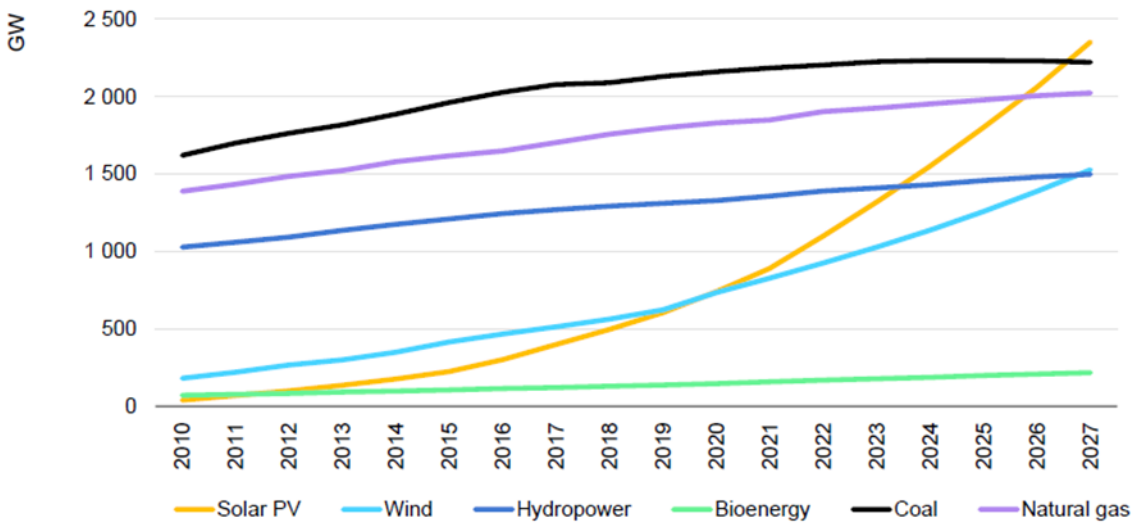


Figure 5.5: Cumulative energy capacity by technology from 2010-2027

For waste management, the annual global production of municipal solid waste (MSW) is about 2 billion tonnes per annum. A broad category of "urban" wastes, such as MSW, commercial and industrial (C&I) trash, and construction and demolition waste (C&D), is estimated to be between 7 and 10 billion tonnes annually.

Even though generation rates vary greatly within and between nations, there is a significant correlation between MSW generation per capita and national GDP as shown in Figure 5.6.

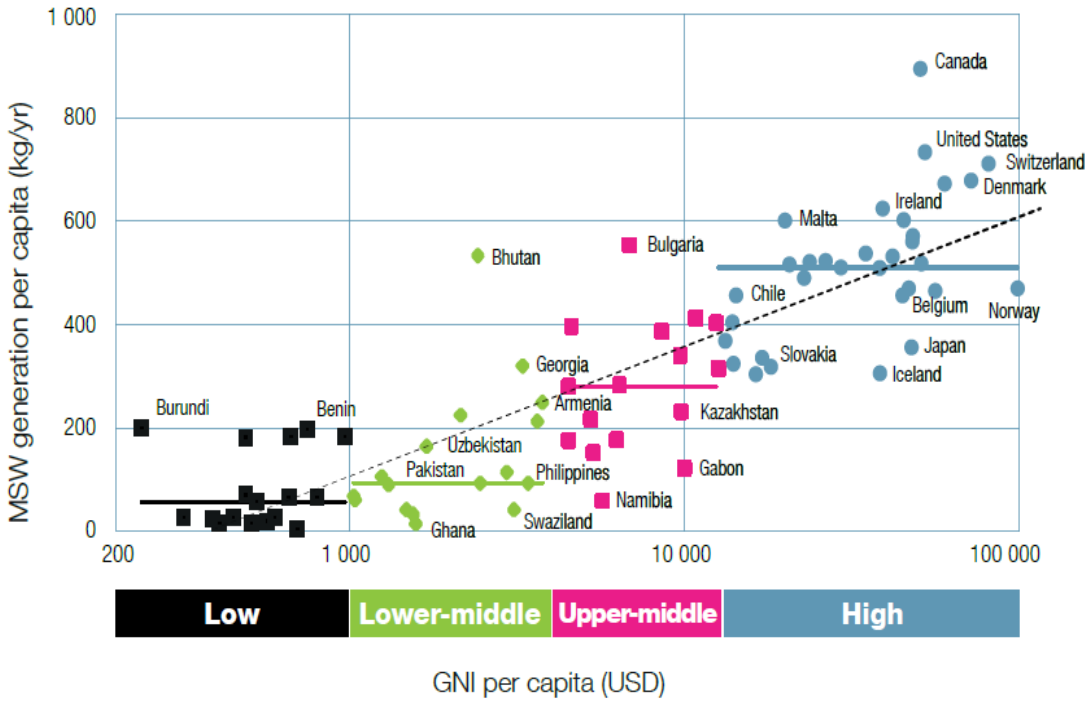


Figure 5.6: Generation of waste against the country's income level

The rates of MSW creation in high-income nations are already starting to stabilize or even slightly decline, which may signal the start of the 'decoupling' of trash growth from economic growth. However, one can anticipate a steady rise in the amount of garbage produced per person if economies in low- and middle-income nations continue to grow quickly as shown in Figure 5.7.

In all regions of the world besides those with high incomes, waste production is increasing quickly due to population growth, city migration, and economic growth. The conventional high-income nations generated around half of all garbage in 2020. This is expected to soon change, with Asia expected to surpass these nations in terms of total MSW generation by 2030 and Africa perhaps surpassing both later in the century as shown in Figure 5.8.

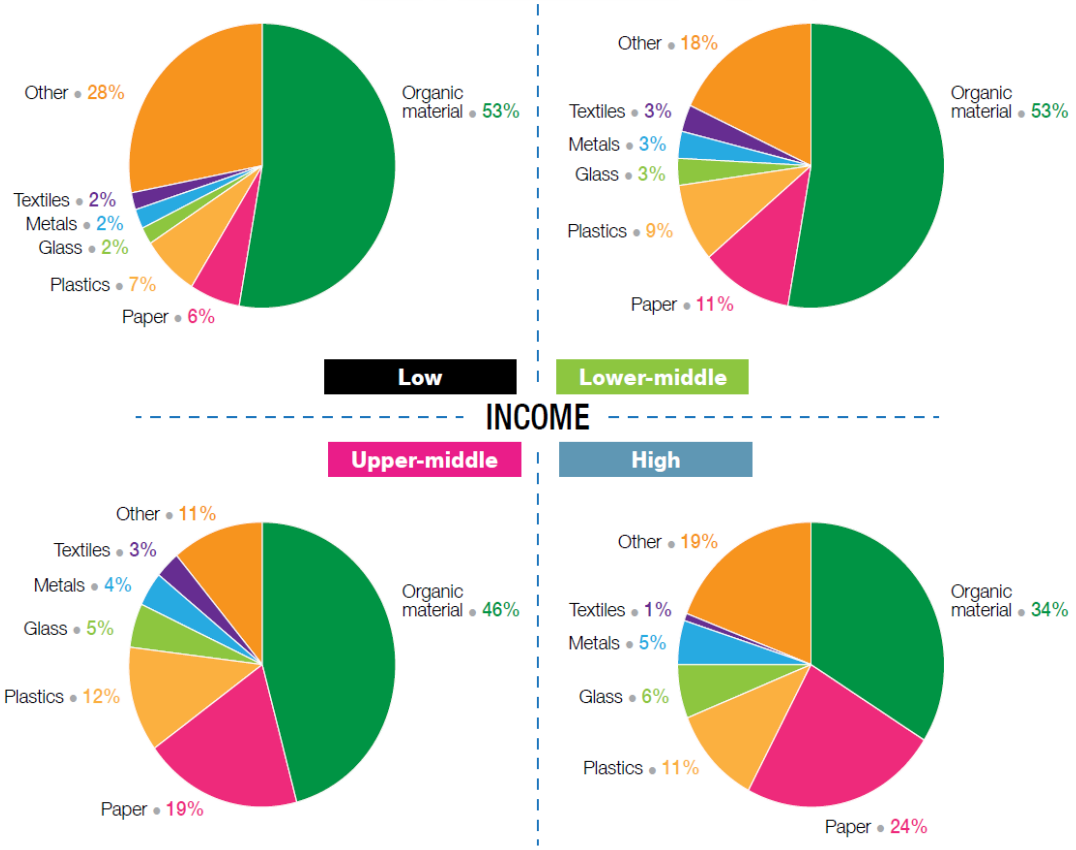


Figure 5.7: The variation in MSW composition grouped by country's income levels

In low-income nations, organic waste typically makes up between 50 and 70 percent of all MSW, but in high-income countries, organics often make up between 20 and 40 percent.

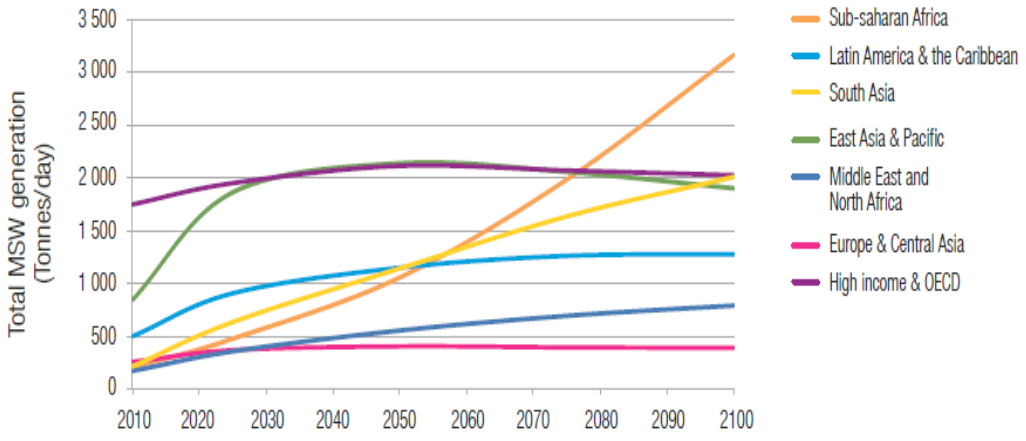


Figure 5.8: Total MSW generation by region

A correlation between the amount of paper and income levels has been observed (23% of MSW in high-income nations, 19% to 11% in middle-income countries, and 7% in low-income countries). Plastic trash levels appear to be high overall (8% to 12%), with less of an income-level reliance than other waste kinds. Materials that are "dry recyclable" (metals, glass, and textiles) make up 12% of MSW in high-income countries, 12% and 9% in middle-income countries, and 6% in low-income nations. Despite being expected to account for less than 1% of all MSW across all income levels, household hazardous waste (HHW) makes some management alternatives significantly more challenging.

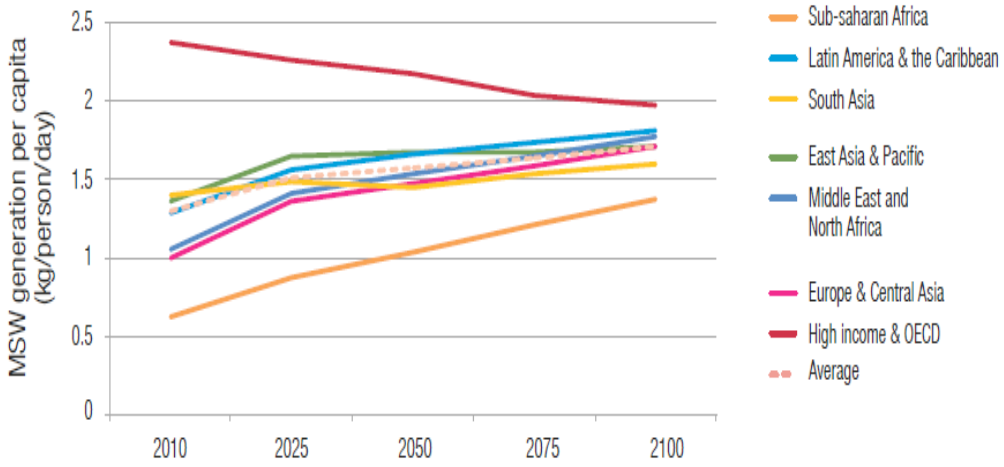


Figure 5.9: MSW generation per capita by region

The collection of MSW from the entire metropolitan population should be a top public health priority. According to available data, several middle-income countries—particularly those with GNI per capita above USD 2500—have achieved tremendous improvement in recent years. While estimates are substantially lower in other nations, the median collection coverage is still over 50% in low-income nations. In many countries' more rural parts, it also falls off dramatically. At least 2 billion people are thought to live in countries where solid trash collection is still unavailable.

Eliminating unregulated dumping is a top goal for environmental protection. Evidence implies that there has been significant progress. However, the regulated disposal rates in high- and upper-middle-income countries are 100% and 95%, respectively, whereas in low-income countries, the rates are frequently well below 50%, and 0% controlled disposal is still very prevalent in rural areas of many nations. Waste disposal frequently takes the form of unregulated dumpsites with open burning in lower-income countries. At least 3 billion people are thought to live in countries where there are no controlled garbage disposal facilities.

Recycling could be a source of income, aid in the conservation of finite resources, and lessen the amount of waste that needs to be disposed of. However, the cleanliness, separation, and presence of components in adequate quantities are crucial for recycling to be successful. Over the past 30 years, recycling rates in high-income countries have steadily increased, mostly due to legislative and economic measures. The informal sector frequently achieves recycling rates for MSW of 20 to 30 percent in lower-income nations.

With strong international "commodity" markets for ferrous and non-ferrous metals, paper, plastics, and textiles, the secondary materials sector operates internationally. Most secondary materials come from industry and are used primarily within national borders, but since the 1990s, there has been a sharp increase in the supply of materials from MSW recycling, along with a significant shift of the world's manufacturing sector to Asia in general and the People's Republic of China (PRC) in particular, which has created an increasingly transnational and even global market. 60% of the weight of the world's imports of scrap aluminium, 70% of recovered paper, and 56% of waste plastics come from the PRC.

However, waste categories have a wide range of definitions, waste quantities are frequently not monitored, and national reporting methods are frequently unreliable. It is therefore not surprising that there is a lack of acceptable breadth and depth as well as poor and unreliable international statistics on MSW creation, composition, and management. For other waste kinds, the global data situation is still worse. The performance of a city's MSW management system is benchmarked here using recent work that identified indicators to do so.

5.1.2 Wesgro

Wesgro is the Western Cape's official tourism, trade, and investment promotion agency. The main promoter of RE and waste management in WCR is Wesgro. Wesgro is the Western Cape's official tourism, trade, and investment promotion agency. Wesgro is assisting investors to land their green economy projects (e.g., Renewable energy projects) in the Western Cape (DEA&DP, 2022; GreenCape, 2022b, 2022a).

Through the support of GreenCape and Wesgro, green economy investments of approximately R11.6 billion were committed to the Western Cape during 2020/21. These investments will lead to the creation of approximately 970 jobs in the Western Cape and were in a commercial rooftop PV solar system, a crypto-driven global peer-to peer solar panel leasing platform and cloud computing data centres. During 2020/21, a total of 1670 support engagements were undertaken with businesses and municipalities, with an additional 30 businesses being provided with technical advisory support towards encouraging the take up of rooftop PV systems. Due to load shedding, the renewable energy and energy services sector desk recorded higher instances of support to green economy businesses.

5.2 Green energy

Renewable energy (RE) has been the main centred focus in the energy space towards transitioning away from coal to more sustainable energy (Yuan et al., 2022). Coal is the major resource used to generate energy in SA. The energy policy in SA was built mainly around this cheap coal energy generation. However, the coal power plants are becoming outdated, which has resulted in energy crises in SA. Effort to rebuild another one has been disallowed due to the pollution it caused to the environment. Out of these problems, many initiatives have been promoted to help with the escalating energy crises and for the government to adhere to the Paris Agreements of global warming. These initiatives pressured the government to convert the current fossil fuel energy generation to a greener and cleaner source of energy. In response to this pressure, RE through Renewable Energy Independent Power Producers Procurement

Programme (REIPPPP) was established in 2011 with the goal to promote green energy into the national energy mix in SA. The programme aims at a share of 36 % for renewable energy in the South African electricity supply mix by 2030 (DMRE, 2021).

Presently, renewable energy is about 11 % share in the South African electricity supply mix, which means 25 % share of renewable energy is needed to be achieved within 2022 to 2030. By 2030, the electricity generation mix is set to comprise of 33364 MW (42.6%) coal, 17742 MW (22.7%) wind, 8288 MW (10.6%) solar photovoltaic (PV), 6830 MW (8.7%) gas or diesel, 5000 MW (6.4%) energy storage, 4600MW (5.9%) hydro 5,1860 MW (2.4%) nuclear and 600MW (0.8%) concentrating solar power (CSP) (DMRE, 2019, 2021; IPPO, 2019). Approximately 6 422 MW of electricity has been procured from 112 REIPPP in seven bid rounds as shown in Figure 5.10. Approximately 5 250 MW of electricity generation capacity from 81 IPP projects has been connected to the national grid (DMRE, 2021; GreenCape, 2022b; IPPO, 2021).

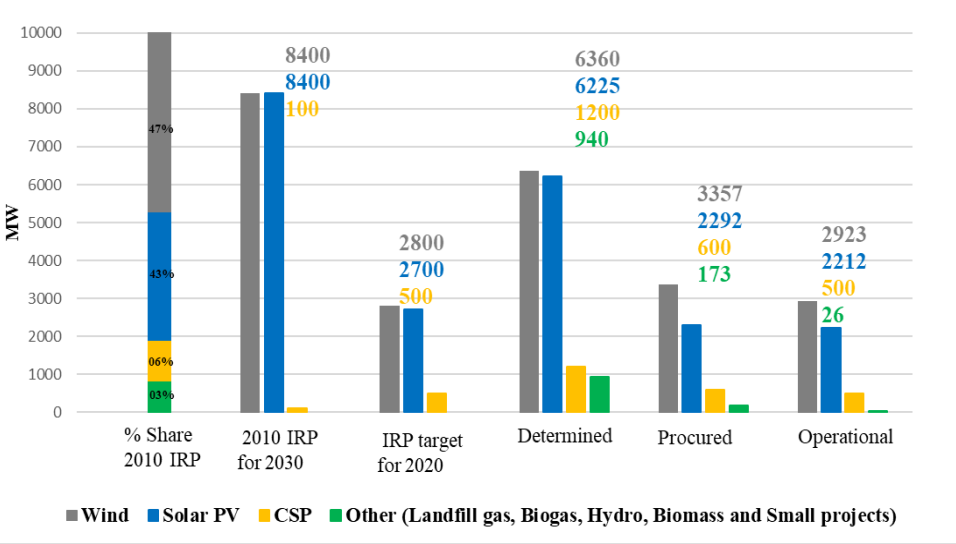


Figure 5.10: Renewable energy technologies' mix in SA's 2010 IRP

In the WCR, 13 % of the total number of the IPP projects have been procured between November 2013 and June 2021. Also, seven of the 25 preferred bidders in bid window (BW) 5 are in the WCR. The total REIPPP capacity allocated to WCR is 15 % including the BW 5 procurement (GreenCape, 2022b). The government of Western Cape

government through municipal energy resilience (MER) initiative has adopted small-scale embedded generation (SSEG) in WCR using rooftop solar PV. This is done in conjunction with the various municipalities that adopted SSEG tariffs and regulation approved by the National Energy Regulator (NERSA) to further improve the economy of the WC (DEA&DP, 2019; GreenCape, 2022b, 2022a).

Currently, the development of RE is fast growing in WC. Due to the ongoing rolling blackouts in South Africa and international pressure to move away from fossil fuel energy creation - a strong RE industry developed in WC. The next section will look at the most prominent role players and stakeholders in the RE industry.

5.2.1 Main role-players / stakeholders

When looking at the main role-players, one needs to differentiate between large RE projects and small-scale embedded generation (SSEG). For large RE, the main role-players are listed in Table 5.1. This includes the project development stages, which are the development, construction, and operation and maintenance. The SSEG role-players are listed in Table 5.2.

Table 5.1: List of companies in Western Cape involved in large-scale RE

Main role-players / stakeholders	Description	Project stages involved	Companies involved in Western Cape Region
Independent power producers (IPP)	It is responsible for project initiation and development, finance, land acquisition, and bidding. It may sometimes be a project sponsor or may submit a bid with the support of such a company.	Project development, construction, and operation and maintenance	Earth & wire (pty) ltd; G7 Renewable Energies (Pty) Ltd; Veroniva (PTY) Ltd
Original equipment manufacturer (OEM)	It is a major technology supplier, including the solar panel manufacturer of choice for solar power plants. This actor plays a key role in determining the technical partners that make up the project and can also play the role of O&M.	Project construction, and operation and maintenance	Kestrel renewable energy (Pty) ltd; SetSolar (Pty) ltd; Photovoltaic Technology Intellectual Property (Pty) Ltd; JA Solar (Pty) Ltd
Operation and maintenance company (O&M)	It is usually a major equipment supplier or technical department well-versed in the specific technology.	Project construction, and operation and maintenance	IMF projects (pty) ltd; Sunglow solar (pty) ltd; Glamaglo (pty) ltd
Engineering, procurement, and construction (EPC)	This player is typically responsible for managing the various subcontracts during the construction stage of a project. It may also be involved during the design and development stage of the project.	Project development, construction, and operation and maintenance	Ramano Solar (PTY) Ltd; Scatec (pty) Ltd; Group five (Pty) Ltd

Table 5.2: List of companies in the small-scale embedded generation

Main role-players / stakeholders	Description	Companies involved in Western Cape Region
Energy services contracting (ESC)	ESC works across the value chain including measurement and verification. Although, an independent consultant is required to perform this function. There are two common ESC type energy contracting: **Energy supply contracting** (ESCo) to supply energy units. **Energy performance contracting**, which provides measured energy savings against a specified and agreed baseline.	GreenCape, Umoya Energy (pty) Ltd
Consultants	Consultants include energy auditors, certified measurement, planning engineers, and verification professionals (CMVP), accountants, and lawyers.	Cape Solar PV consultant ltd; BVI (pty) Ltd; KAM Computing & Consulting Engineers; ExSolar Solutions (Pty) Ltd.
Financiers	Financiers provide funding and financing mechanisms to bring projects to life. **Project finance** – commercial banks (business and asset finance, self-funded individuals (with cash reserves) and PPA financiers (such as private equity funds, debt facilities). **Funding for ESC** – commercial banks, private equity funds, corporate foundations, private and family foundations, and venture capitalists.	FNB; Absa; Investec, Nedbank; Wesgro; Trivest, Standard bank; Department of trade and industry; Department of National Treasury, Provincial Government of the Western Cape etc.

Manufacturers and suppliers	Manufacturers and suppliers include technology suppliers or original equipment manufacturers (OEMs). They manufacture and supply equipment and form part of typical energy efficiency or supply interventions.	GreenSun Cape Town Ltd; M Solar Power (Pty) Ltd; JA Solar (Pty) Ltd
Installers	Most energy service companies, EPCs, and project developers use installers that specialise in both energy efficiency and SSEG (technology-specific).	Solar4eden (pty) Ltd, Overberg Renewable Energy Ltd.
Engineering, procurement, and construction (EPC)	EPCs design interventions, procure, and install tailored turnkey energy efficiency and/or RE solutions.	Juwi renewable energy (pty) Ltd; Adenco Construction Ltd.
Engineering, procurements, construction, and managements (EPCM)	Under an EPCM contract, the owner maintains more control of the project. The contractor manages the construction project, but only under the direction of the owner. With an EPCM contract, the owner is responsible for hiring suppliers, construction workers and other contractors, and the EPCM contractor will manage these contractors.	Karoo Solar (Pty) Ltd; Group five (Pty) Ltd.
Project developers	Project developers handle tasks that focus on moving the project along toward successful completion. In the ES value chain, they play more of a business development role as they focus on, for example, project design and procurement but make use of specialised installers.	SOLA Group (pty) ltd; Wineland Solar (pty) Ltd; Klipheuwel Wind Farm Ltd.

It is also important to consider the national role-players that drive the legislative and policy framework for RE. Although many of these regulations are not regionally determined, they have an impact on the RE sector in the WCR. Table 5.3 provides a summary of the most prominent national and regional governmental role-players.

Table 5.3: List of governmental stakeholders in the RE from national to regional

National	**South African Government**
Main role-players / stakeholders	**Description**
Department of Mineral Resources and Energy (DMRE)	The mission of the DMRE is to regulate and transform the sector for the provision of secure, sustainable, and affordable energy and the promotion and regulation of minerals and mining. This includes the electricity sector, governed mainly through the Electricity Regulation Act 4 of 2006. This department was previously referred to as the Department of Energy (DoE).
Department of Public Enterprises (DPE)	The Minister of Public Enterprises is the shareholder representative of the South African government and has oversight responsibility for Eskom.
Eskom	Eskom is a state-owned energy utility. It owns most of the electricity generation and transmission infrastructure. It is an important key role-player in the electricity sector, especially as a delivery vehicle for numerous government programmes.
National Treasury (NT)	NT is responsible for financial and reporting oversight for Eskom (as a state-owned entity) and has played a pivotal role in providing government loans and guarantees in favour of Eskom

Department of Water and Sanitation (DWS)	DWS oversees water allocations and ensures adequate water supply infrastructure, among others, for the South African electricity sector
Department of Environment, Forestry and Fisheries (DFFFE)	DFFE ensures adherence to environmental compliance and rights protection relating to preventing pollution, ecological degradation, promoting conservation, and securing ecologically sustainable development.
National Energy Regulator of South Africa (NERSA)	NERSA issues licences for the operation of generation, distribution, and transmission infrastructure; regulates imports, exports, and trading of electricity; determines and approves electricity prices, tariffs, and the conditions under which electricity may be sold.
Department of Trade, Industry and Competition (dtic)	Responsible for ensuring industrialisation through the REIPPPP's economic development component, especially local content and black economic empowerment and development of small businesses
Regional	**Western Cape Region**
Main role-players / stakeholders	**Description**
Department of Economic Development and Tourism (DEDAT)	DEDAT is the custodian of the 110% Green platform and responsible for the coordination of the Western Cape green economy strategy (including implementation thereof). DEDAT also has a specific focus on energy and on economic water resilience.
Department of Environment Affairs and Development Planning (DEADP)	Their mandate is to enable a resilient, sustainable, quality, and inclusive living environment for all. They are committed to improving urban and rural areas through enhanced management of land, an enhanced climate change plan, and better living conditions for all.
Department of Local Government (DLG)	DLG is the arm of government closest to the end-users. They support and strengthens the capacity of municipalities to manage their own affairs for electricity distribution

Provincial Treasury (PT)	Give efficient supporting and sustainable public financial management to promote the development of RE in WCR.
City of Cape Town (CoCT) and six other municipalities	Municipalities are responsible for a large portion of electricity distribution in the country.
Wesgro	The official investment and trade promotion agency for the Western Cape.

Institutions that provide second level support to role-players in the RE sector are Higher Education Institute (HEI), Non-Profit Organisations (NPOs), Non-Government Organisations (NGOs), Financial Institutions, Parastatals Organisations, and Civil Society. These role-players provide support in terms of research and development, advice, and funding. The main role-players are listed in Table 5.4 below.

Table 5.4: List of supporters of innovations stakeholders in WCR

Main role-players / stakeholders	**Role-players involved in Western Cape**	**Description**
Higher Education Institute (HEI)	University of Cape Town, Stellenbosch University, University of the Western Cape, the Cape Peninsula University of Technology, and the George campus of the Nelson Mandela Metropolitan University	HEI are empowered with comprehensive research and development (R&D) capabilities and dedicated green economy skills programmes.
Non-Profit Organisations (NPOs)	Green Cape	The aim of the GreenCape is to support the growth of green economy in the WCR, which include RE.

Non-Government Organisations (NGOs)	SARETEC	Offers specialised industry-related and accredited training for the wind and solar industries.
	SAREBI	A business incubator providing non-financial support to green entrepreneurs
Financial Institutions	FNB; Absa; Investec, Nedbank; Trivest, Standard bank etc.	Provide funding and financing mechanisms to realise RE projects.
Parastatals Organisations	InvestSA One Stop Shop	Offers convenient investor support on permits, licensing, and registrations - all under one roof
Civil Society	The Fairest Cape Association; Worldwide Fund for Nature (WWF) South Africa; The Greyton Conservation Society; Lourens River Conservation Society etc	They are whistle-blower, observer, and supporter of RE in the WCR.

5.2.2 Key initiatives locally and internationally

DEDAT started the Western Cape Municipal Energy Resilience (MER) initiative in the 2020/21 financial year. This is a three-year programme running up to March 2023 as shown in the Appendix B, spearheaded by DEDAT, and supported by the combined efforts of the Department of Local Government (DLG), Provincial Treasury (PT) and the Department of Environmental Affairs and Development Planning (DEA&DP) (DEA&DP, 2022).

The main objective of the initiative is to improve energy resilience in municipalities across the Western Cape through facilitating, supporting, and positioning for the implementation of renewable energy infrastructure development (public and private) for economic growth, energy affordability, and/or municipal financial sustainability to contribute towards the target of 500MW of new energy generation capacity by 2025 (DEA&DP, 2022; GreenCape, 2022a).

DEDAT has also continued to drive the uptake of rooftop solar PV in the province through the Green Economy Ecosystem Support contract. Twenty Western Cape municipalities have been provided with support and advice around small scale embedded generation (SSEG), wheeling and / or utility scale energy matters. This has resulted in 24 municipalities allowing private rooftop PV connections to the municipal networks, with 19 of these municipalities allowing households and businesses to be compensated for feeding this electricity back into their networks (DEA&DP, 2022; GreenCape, 2022a).

Multiple direct engagements with large companies and support provided to numerous businesses through the assistance of energy sector desk resulted in the installation of approximately 49MW of registered rooftop PV in the Western Cape in the first two quarters of 2021/22 financial year. This represents R490 million worth of investment and around 120 jobs that were provided (DEA&DP, 2022; GreenCape, 2022b).

Despite all the successes in the province when it comes to independent energy generation, there are still some challenges and roadblocks to the generation of RE. The next section will investigate some of the major inhibitors in the province as it pertains to renewable energy generation.

5.2.3 Overall competitiveness locally, nationally, and internationally

RE innovation in WCR is the best among other RE innovation in other provinces. The WC RE developers dominated the REIPPPP BW5 preferred bidders. Over 75 % of the selected projects were developed by WC based project developers contributing an estimated R 40 billion of investment towards BW5. In SSEG, WC developers are leading when compared to other provinces developers in the country. Approximately, 20 % of the R75 billion SA market value for RE is located in WCR, which shows the competitiveness of the WC RE in SA. Therefore, RE developers in WCR can compete locally, nationally, and internationally.

5.3 Waste management

Waste management has been seen as one of the ways to grow SA's economy (Niyobuhungiro & Schenck, 2022). In 2016, the waste economy contributed about R24.3 billion to the South African GDP (GreenCape, 2021). It provided 36 000 formal jobs and supported about 80 000 informal jobs / livelihoods (DFFE, 2020). In WCR, over 7.7 million tonnes of waste are generated in 2015, of which ±2.4 million tonnes (31%) consisted of municipal solid waste, ±2.4 million tonnes (31%) of agricultural and forestry waste/ residues, ±1.7 million tonnes (22%) of construction and demolition waste, and ±0.9 million tonnes (11%) of commercial and industrial waste. The remaining ±0.4 million tonnes (5%) consist of other waste streams (DEA&DP, 2020a).

Waste is generated because of an increase in population growth. The WCR population makes up approximately 12 % (49 % males and 51 % females) of the national population of 59.62 million in SA (DEA&DP, 2020a). The population increased from 6.84 million to 6.97 million in 2020 at a growth rate of 1.79 per cent (DEA&DP, 2020b). The WCP is also a popular destination for semi-gyration in SA, with more high skilled South Africans choosing to relocate to the province. The WCR is the third most populated province and the second most urbanised province in SA. This population contributed greatly to the amount of waste generated in WCR (DEA&DP, 2020b). Waste is categorised as general waste and hazardous waste (DEA&DP, 2020a). The total amount of waste generated in WCR from 2018 to 2020 is shown in Figure 5.11.

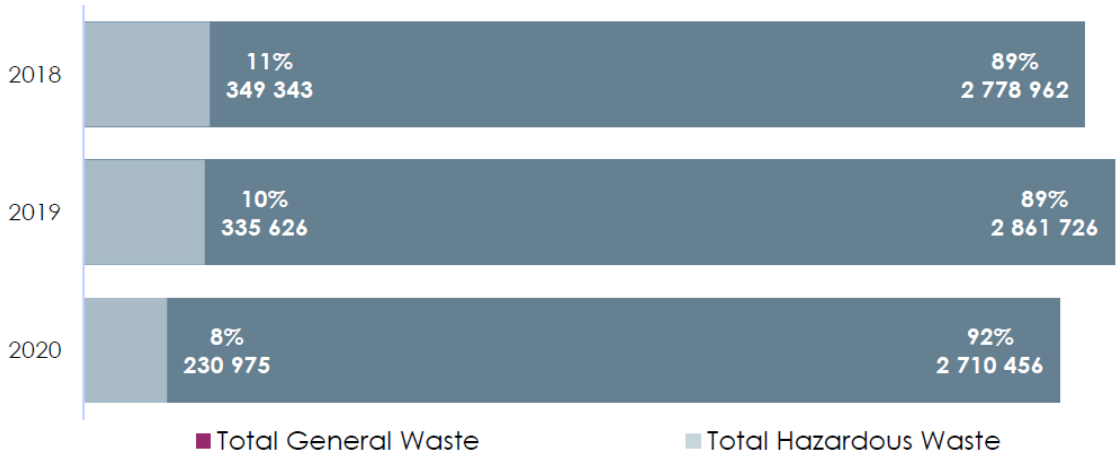


Figure 5.11: The total amount of general and hazardous waste generation 2018-2020

The WCR generated about 90 % of general waste but the amount of hazardous waste decreased between 2018 and 2020. The overall waste generation in the WCR decreased due to the impact of COVID-19 restrictions (DEA&DP, 2020a).

This impact of COVID-19 restriction can also be viewed in the amount of waste generated for 5 districts and the CoCT in the WCR as shown in Figure 5.12 and Figure 5.13. After May 2020, the amount of waste generated increased due to the relaxation of lockdown regulations (DEA&DP, 2020a).

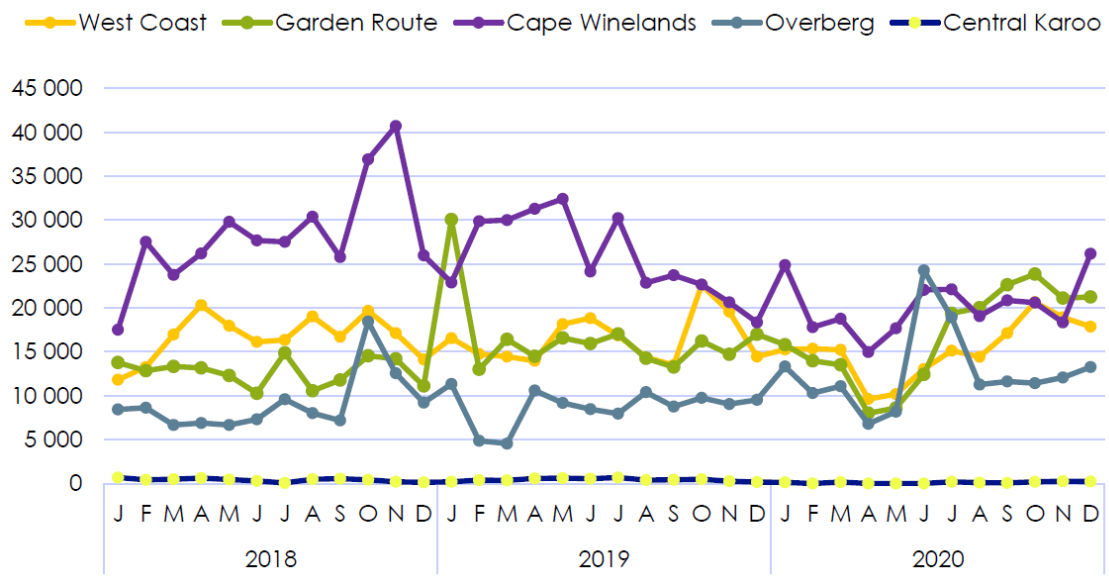


Figure 5.12: The waste generated in the district municipalities 2018-2020

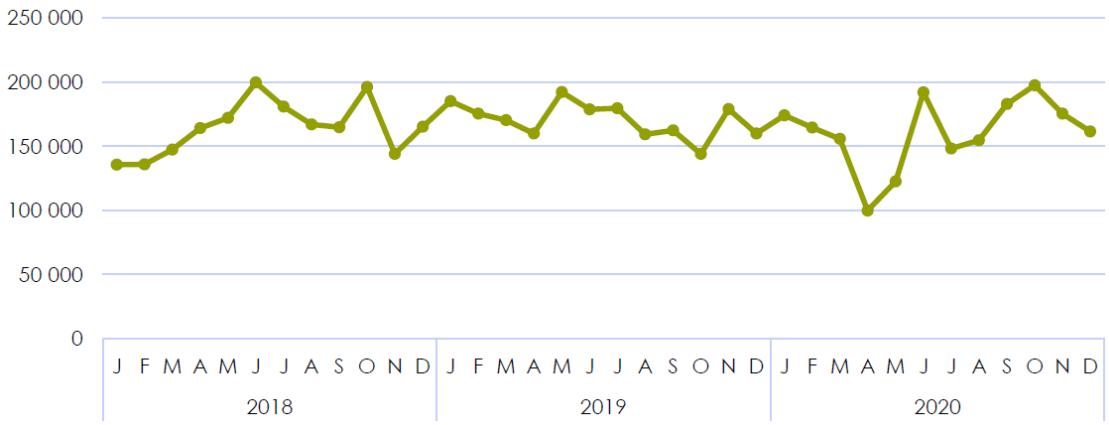


Figure 5.13: The waste generated in the City of Cape Town 2018-2020

Waste is normally disposed of to the landfill (Niyobuhungiro & Schenck, 2022). The landfill airspace available for waste is currently limited in the WCR (DFFE, 2020; GreenCape, 2021). Most of the WCR is experiencing pressure on the existing landfill infrastructure due to strong population growth in the province. Of the 25 municipalities, 22 have less than five years of airspace left. This is expected to continue in the medium term. Pressures like these provide opportunities for municipalities to diversify their waste management streams and processes. The WCG is currently investing in a waste management process to accommodate waste disposal (DEA&DP, 2020a). In Figure 5.14, there are currently 9 (nine) regional waste management facilities in various stages of operation within the Western Cape to divert waste from the landfill.

Figure 5.14: Regional Waste Management Facilities

The West Coast District Waste Diversion Facility (WDF) and Kalbaskraal within the CoCT, is in various stages of planning, The Cape Winelands District, Garden Route District are in the planning phases. Karwyderskraal in the Overberg, Vredenburg in the Saldanha Bay Municipality and Highlands WDF in Swartland Municipality are operational. The Central Karoo are in the initial stages of planning for their regional facility. In addition, there are privately owned WDF in the WCR such as Mossel Bay (PetroSA), De Hoek and Riebeek West (PPC), Vredenburg (Exxaro) and Saldanha Bay (ArcelorMittal) (DEA&DP, 2020a). The amount of waste disposed and diverted in 2020 by each district in the WCR is shown in Table 5.5.

Table 5.5: The waste disposal and diversion per district in Western Cape (T)-2020

Note: The diversion rate (%) is based on the diversion of a specific waste type.

DISTRICT	ACTIVITY	MUNICIPAL	COMM & INDUSTRIAL	ORGANICS	CONSTR & DEMOLITION	OTHER	TOTAL
West Coast	Total Disposed	76 168	3 045	12 720	24 969	0	116 902
	Total Diverted	4 065	0	44 796	23 828	6	72 696
	Diversion Rate per Waste Stream	5%	0%	78%	49%	100%	**38%**
City of Cape Town	Total Disposed	1 055 939	419 230	8 271	19 759	11 843	1 515 041
	Total Diverted	112 031	2 095	139 083	140 448	25 507	419 165
	Diversion Rate per Waste Stream	10%	0%	94%	88%	68%	**22%**
Overberg	Total Disposed	106 301	57	3 260	870	2 997	113 485
	Total Diverted	1 880	3	13 247	22 720	0	37 850
	Diversion Rate per Waste Stream	2%	5%	80%	96%	0%	**25%**
Garden Route	Total Disposed	85 597	1 539	11 062	34 953	0	133 152
	Total Diverted	10 177	0	4 538	428	4 886	20 029
	Diversion Rate per Waste Stream	11%	0%	29%	1%	100%	**13%**
Central Karoo	Total Disposed	735	35	208	480	0	1 457
	Total Diverted	0	0	0	0	0	0
	Diversion Rate per Waste Stream	0%	0%	0%	0%	0%	**0%**
Cape Winelands	Total Disposed	157 899	11 641	5 035	13 866	8 775	197 216
	Total Diverted	8 365	42	29 488	28 485	1 447	67 827
	Diversion Rate per Waste Stream	5%	0%	85%	67%	14%	**26%**

The municipalities in the WCR provide a weekly door-to-door service to communities to collect and remove waste to the WDFs. The service levels vary between municipalities as shown in the Appendix B where there has been some improvement in the waste service levels compared to the previous years.

In Table 5.5, through the help of the municipalities, it is shown that there are a lot of opportunities waste management can offer in the WCR such as job opportunities, carbon emission reduction, and economic growth. The WCR identified some waste such as organics, plastic, and e-waste as potential waste that can be recycled to drive down greenhouse gases and provide economic growth at the same time. GreenCape (2021) highlighted that the organic, plastic and e-waste sector in the CoCT can add about R1.1 billion value to the Cape Town economy, which shows the importance of investing in waste management. In 2020, the WCR generated between 470 767 and 538 416 tonnes of municipal solid waste (MSW) organics, and between 288 232 and 329 844 tonnes of industrial and commercial organics. Also, the WCR generated between 43 290 and 68 501 tonnes of e-waste and generated between 214 307 and 245 103 tonnes of MSW plastics (GreenCape, 2021).

The development of waste management is growing fast in WCR, and it is essential to know the role-players or stakeholders involved, the legislation, regulation and policies in place, the promoter, the inhibitor, and the key initiative present to foster the growth of this sector to foster sustainable development

5.3.1 Main role-players / stakeholders

The main role-players / stakeholders for waste management in WCR is listed in Table 5.6.

Table 5.6: Main role-players / stakeholders for waste management in Western Cape.

Sector	Sub-Sector	Main role-players / stakeholders	Description
Public sector	National	The Department of Forestry, Fisheries, and the Environment (DFFE)	DFFE is the overarching authority for waste management in South Africa and is the licensing authority for hazardous waste treatment activities. Wate can be reported to the DFFE through South African Waste Information System (SAWIS)
	Provincial	The Department of Environmental Affairs and Development Planning (DEA&DP)	DEA&DP are generally responsible for regulating waste management within their respective boundaries. Their functions include promulgating provincial legislation; providing municipal support; and monitoring municipal and private sector activities. Waste can also be reported at the provincial level through Integrated pollutant and waste information system (IPWIS) in WC DEA&DP and Gauteng waste information system (GWIS) managed by Gauteng department of agriculture and rural development.
	Local municipalities	Thirty (30) municipalities	Municipalities are constitutionally mandated to provide waste collection,

			removal, storage, and disposal of waste generated by households within their boundaries. Although local municipalities can also provide waste related services to the private sector, they are not obligated to do so. Waste services can be undertaken either by local municipalities themselves, or they can be outsourced to the private sector
Private sector	Waste generator		Waste generators are responsible for managing their own waste. This can be done themselves, or this can be outsourced to either a private service provider or local government on request, both of which incur several service fees.
	Formal waste handler	Waste management service providers	Waste management service providers are responsible for the provision of responsible waste management services to their clients, or are contracted to do so by local municipalities.
	Informal waste handler	Waste management service providers	They play a major role in the recovery and diversion of post-consumer recyclables from kerbsides and landfills.
Household		Households	Households are generally serviced by their local municipalities, or by the private companies contracted by municipalities to collect waste

Industry associations		All listed companies in Table C.0.1	They are involved in the recycling sector with a focus on specific materials, particular industry or industry subsect.
Producer responsibility organisations			PROs are non-profit companies that have been established either by producers or any person to support the implementation of a relevant extended producer responsibility (EPR) scheme

5.3.2 Key initiatives locally and internationally

There are several initiatives that was established for waste management in WCR, which are listed below:

- **Western Cape Industry Waste Management Forum (WC IWMF**): The aim of the forum is to discuss the impact of EPR on industry linked to waste management and operation.
- **Western Cape Integrated Waste Management Officers' Forum (WC IWMOF)** takes place thrice a year in various municipal areas, with local and district municipal officials. They enlighten themselves about new innovations and technologies in waste management.
- **Western Cape Recycling Action Group (WCRAG):** The purpose of the WCRAG is to create a platform that supports the growth of the waste economy, job creation and to develop models for cooperation amongst various role-players to implement effective recycling in municipalities.

5.3.3 Overall competitiveness locally, nationally, and internationally

The WCR Waste sector is the best in waste management when compared to other provinces in SA. The momentum in the waste sector has been building towards a waste economy increasingly characterised by circularity, with much focus on beyond just recycling and taking a more progressive approach of reuse, refurbishment, and repair. This focus on landfill diversion, and specifically beneficiation, has accelerated over the last couple of years, and has been evident at all ends, from government through to business, industry, and the public.

6. Policy | government support – current policies

This section provides the currency policies and government support initiatives regarding green energy and waste management innovation in WCR. The policies and government support were identified from national level to regional level to have a bigger perspective about Innovation in WCR.

6.2 Grow for job (G4J)

From the regional perspective, there is a strategic framework that has been developed by the western cape government to promote innovation, technology development, job creation and business opportunities in the region. This strategic framework is called growth for jobs (G4J) strategic framework. The framework aims to achieve a break-out economic growth to pilot opportunity and enough employment for the people of Western Cape (WCG, 2022). The Strategic Framework has also defined important principles that serve as guiding lights for choices, decisions, and actions, assisting the WCG in its approach. They define what it should be inside and outside of its scope (WCG, 2022).

For the framework to accomplish its aim, it requires all government parastatals to work independently or in conjunction with one another. Additionally, it will require cooperation, participation and collaboration with the corporate sector or private sector, utilising Economic IQ and ensuring sustainability, among other things. The Strategic Framework also aims to establish distinct future routes using a theory of change. This will involve identifying actions in collaboration with the private sector as well as streamlining and synthesizing horizontal enablers and levers into key focus areas for action (WCG, 2022).

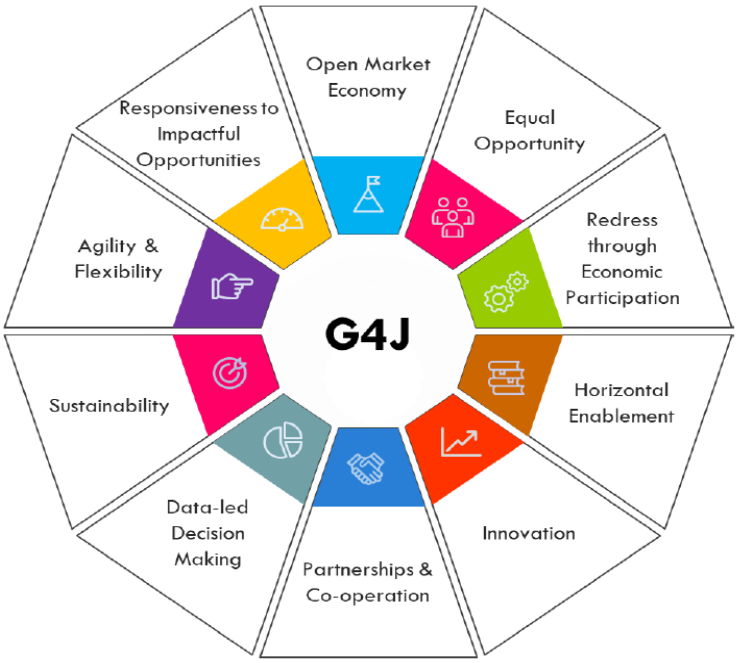


Figure 6.1: Principle underpin the grow for job strategic framework

As the region advances, it will also be necessary to conduct a more thorough analysis of potential future events, including significant uncertainties, as the region gains more insight into the path to 2035.

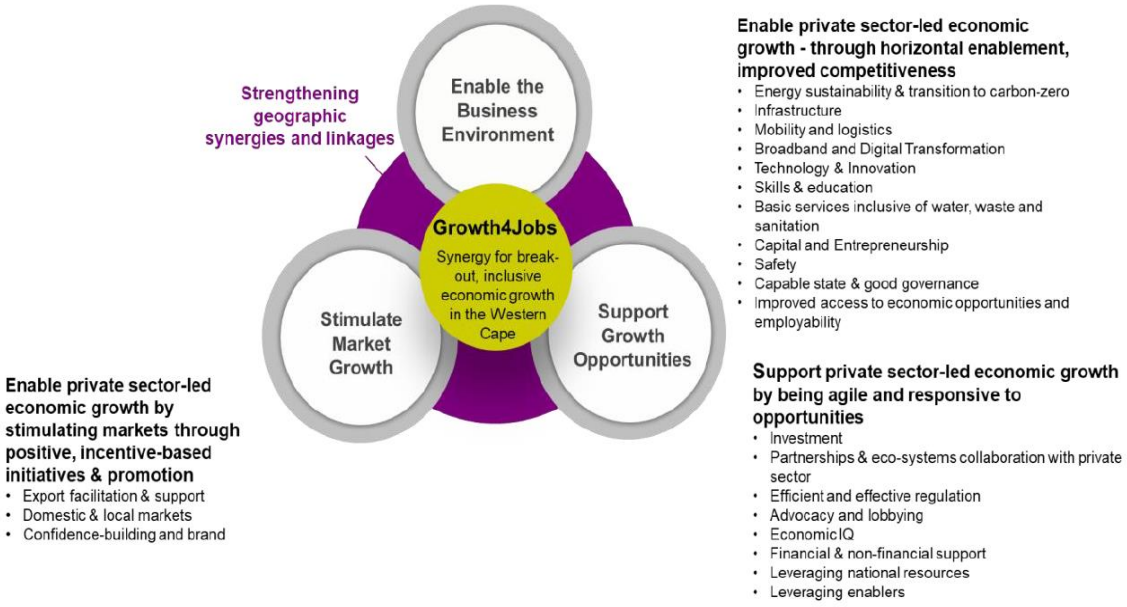


Figure 6.2: Three pillars of grow for job strategic framework

Finally, the framework highlighted three pillars for achieving break-out economic growth, which are: enabling the business environment, supporting growth opportunities, and stimulating market growth (WCG, 2022). The diagram above illustrates the pillars and the focus areas the region will be working on.

6.3 Green energy strategic alignment

Given the ongoing power crises in South Africa, the national government has taken dramatic legislative steps to deregulate the energy sector. Some of the key initiatives on the national level are worth mentioning. These include the following:

- The Risk Mitigation Independent Power Producer Procurement Programme (RMIPPPP) preferred bidders announced a total generation capacity of 1 995 MW, with a total of R45 billion investment attracted.
- Amendments to the Energy Regulation Act exempting a generation facility of up to 100MW to produce power without requiring a generation licence from NERSA.
- Twenty-five (25) Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) BW5 preferred bidders announced with a total generation capacity of 2 583 MW (with 1 608 MW of onshore wind and 975 MW of solar PV) with a total of R50 billion

Although these are largely national initiatives, they will have a significant impact on the energy policy and market in the Western Cape. According to Greencape the relaxation of regulation is likely to lead to an estimated attraction of R99 billion for solar PV, R271 billion for wind, and R48 billion for distributed generation of up to 100MW.

The key policies and legislative framework guiding REIPPP, and Municipal energy resilience (MER) initiative for Western Cape Green Energy (WCGE) are listed in Table 6.1.

Table 6.1: List of policies for RE in WCR

Policies	Description
National Development Plan (NDP) (August 2012)	Aims to eliminate poverty and reduce inequality by 2030
New Growth Path (November 2010)	Sets targets for creating jobs and identifies priority areas, with infrastructure development as key to this vision's success.
Integrated Energy Plan (IEP) (December 2016)	Outlines the general energy plan for the country. The IEP investigates energy security, access to energy, reducing the cost of energy supply, energy efficiency, localisation, and sustainability in all energy matters
Integrated Resource Plan (IRP) (November 2019)	Specifically outline the planning, sourcing, and quantities of electricity generation sources contributing to the county's generation mix
2003 White Paper on Renewable Energy (November 2003)	Determines that a significant and equitable level of national resources should be invested in Renewable Energy while setting renewable energy generation capacity targets
Policies to be developed for WCR	**Description**
Electricity Master Plans (EMPs)	The aim of this plans is to support economic growth and development, electricity efficiency, electricity supply security and provide a sustainable priced electricity supply in WCR
Cost of Supply Studies (CoSS)	Provide a sustainable RE priced electricity supply in WCR.
Energy master plans	To support RE growth and development, energy efficiency, and energy security in WCR.

Table 6.2: List of legislations for RE in WCR

Legislations	Description

ERA 4 of 2006 as amended by the Electricity Regulation Amendment Act 28 of 2007 (ERA).	These regulations guide the issuance of licences for generators and transmitters, wheelers, and distributors of electricity.
The Amended Schedule 2 of the ERA 4 of 2006 on 5 October 2021	The Amendment serves to increase the threshold for embedded generation from the current 1 MWp to 100MWp without needing a licence.
Wheeling & Energy Trading Licences:	The development of wheeling frameworks and the issuing of energy trading licenses is opening space for an increasingly distributed electricity market.
National Energy Act 34 of 2008:	The National Energy Act was promulgated to ensure that diverse energy resources are available to the South African economy in sustainable quantities and at affordable prices to support economic growth and poverty alleviation.
SANS 10142-1-2 DC wiring code	This will allow electricians to issue a Certificate of Compliance (COC) for the DC side of an SSEG installation.
Nationally Determined Contributions under the Paris Agreement	SA submitted its first NDC on 1 November 2016, outlining its pledge to transition to a lower-carbon economy. The NDC covers adaptation, mitigation as well as finance and investment requirements and is based on equity

6.4 Waste management strategic alignment

The policies, regulations and legislative framework guiding waste management in WCR are listed in Table 6.3.

Table 6.3: Regulations, policies, and legislations for waste management in Western Cape

Regulations/Policies	**Description**
The National Environmental Management Act (NEMA) (Act 107 of 1998)	These aim to ensure that negative environmental impacts are prevented, mitigated, and/or regulated. They provide an array of instruments to monitor and manage activities that have an impact on the environment. One of these instruments is the environmental impact assessment (EIA) regulations.
National Environmental Management Waste Act (Act 59 of 2008)	National Environmental Management Waste Act (NEMWA) is a waste-specific act that is guided by integrated waste management principles aimed at preventing negative waste-related environmental impacts.
National Waste Management Strategy (NWMS)— 2020	This strategy outlines the government's policy and strategic approach to waste management for South Africa for the coming years. The strategy includes a set of actions to reach strategic outcomes.
Municipal Waste Management Bylaws	These bylaws often provide obligations for both waste generators and waste handlers, including accreditation and reporting obligations.
Integrated Waste Management Plan (IWMP)	The aim of an IWMP is to give effect to the NWMS and the objectives of the NEMWA; and to include waste specific operational and support strategies, as well as a schedule of projects and activities.
Western Cape Integrated Waste Management Plan (WC IWMP)	The aim of the WC IWMP is to provide strategic direction to improve integrated waste management practices within municipalities, industry, and civil society.
New regulatory updates	**Description**
Scheduled landfill restrictions (2020/21) (R.636 of 2013)	The national norms and standards for the disposal of waste to landfill (R.636 of 2013) provide directives for the disposal of waste to landfill. Included in these norms and standards is a list of waste streams that

	are prohibited20 from disposal to landfill. The following waste streams will be banned from landfilling as of 23 August 2021: Brine / waste with high salt content; all hazardous e-waste; all batteries; persistent organic pollutant (POP) pesticides listed under the Stockholm Convention; and macro-encapsulation of waste.
Industry Waste Management notice withdrawal (GN1659 of 2019)	On 13 December 2019, the Minister of Forestry, Fisheries, and the Environment (MFFE) withdrew her predecessor's 2017 "Section 28" (NEMWA) notice (GN1659 of 2019) calling on the paper and packaging industry, the electrical and electronics industry, and the lighting industry to submit industry waste management plans (IndWMPs). Instead of IndWMPs, the Minister has made the decision to rather follow a Section 18 (NEWMA) route to implement EPR policy to ensure product stewardship within the respective industries.
Extended producer responsibility (EPR) regulations (GN400 of 2021)	On 05 November 2020, the Minister published EPR regulations (GN 718 of 2020) as a framework for the development, implementation, monitoring, and evaluation of EPR schemes for identified specific products, and to which "Producers" of those products must adhere. These regulations were subsequently amended. In January 2021 (GN20 of 2021), with additional amendments drafted and published in March 2021 (GN239 of 2021) for public comment. These regulations were finalised and gazetted (GN400 pf 2021) on and take effect as of 05 May 2021.
Plastic carrier bag and flat bag regulations amendments (GN317 of 2021)	The amendments to the Plastic Carriers Bags and Plastic Flat Bags Regulation (R.625 of 2003) were published on 07 April 2021. These amendments provide a pipeline of specifically post-consumer recyclate content requirements for plastic carrier bags or plastic flat bags manufactured, traded, or distributed in South Africa. These amendments require a minimum of 50% post-consumer recyclate from 01 January 2023, 75% post-consumer recyclate from 01 January 2025, and 100% post-consumer

	recyclate from 01 January 2027. These regulations should result in an increased demand for plastic recyclate
Exclusion of waste streams from the definition of waste (GN85 of 2020)	The waste exclusion regulations (GN715 of 2019) were published in July 2019. They regulate the application process for the exclusion of certain waste streams / portion of waste streams from the definition of waste. The exclusion will only apply to streams from specific facilities that are being applied for. The DFFE also published a notice in February 2020 (GN85 of 2020) indicating the exclusion of waste streams from a certain facility that had applied for exclusion. These streams broadly cover ash, biomass, dolerite, gypsum, silica aggregates, and slag streams as applied for
Anticipated guidelines/regulations	**Description**
Scheduled national landfill restrictions (R.636 of 23 August 2013)	The national norms and standards for the assessment of waste for landfill disposal (R.636 of 2013) provide directives for the disposal of waste to landfill, including a list of waste streams that cannot be disposed of at landfill. There are no restrictions expected for 2022; however, 2023 will require 50% garden waste to be diverted from landfill.
Western Cape organic waste landfill restriction	The Western Cape's DEA&DP has implemented an organic waste diversion plan that aims to divert 50% of organic waste from landfill by 2022, and 100% by 2027.
Draft norms and standards for organic waste composting (GN 1135 of 2019)	In September 2019, DFFE released the draft national norms and standards for organic waste composting. These norms and standards are expected to exempt composting facilities processing more than 10 tonnes of organic waste a day from requiring a waste management licence. The purpose of these norms and standards is to provide a "best practice" approach to the composting of organics that will prevent / minimise negative impacts on the biophysical, social, and economic environment.

Draft norms and standards for the treatment of organic waste (GN 275 of 2021)	Where the composting norms and standards mentioned above are focused specifically on composting treatment, the newly published norms, and standards for the treatment of organic waste focus on a wider range of treatment technologies, including mechanical, chemical, anaerobic, aerobic, and thermal technologies. The purpose of these norms and standards is to provide a "best practice" approach to the treatment of organics that will prevent / minimise negative impacts on the bio-physical, social, and economic environment.
Tyre Industry Waste Management Plan	On 01 October 2017, the then Minister of Environmental Affairs (now DFFE) withdrew South Africa's first IndWMP for tyres. However, on 29 November 2019, the Minister issued a Notice in terms of Section 29(1) of the NEMWA for the Council of Scientific and Industrial Research (CSIR), an organ of state, to develop an IndWMP for tyres. A draft plan was published for public comments in March 2020 buy not yet finalised.
Electricity Regulations on New Generation Capacity (GN500 of 2020)	Municipalities are required to purchase electricity from South Africa's central electricity utility, Eskom. In October 2021, the national DMRE gazettes the amendments to the Electricity Regulations on New Generation Capacity, enabling municipalities in good financial standing to develop their own power generation projects. These regulations may unlock municipal offtakes for waste-to-energy projects that traditionally had a limited offtake to justify a business case.
Voluntary agreements	**Description**
SA Plastics Pact	The South African Plastics Pact23 (SAPP), was launched on 30 January 2020. This pact serves to unite South Africa's plastics value chain — businesses, government, NGOs, and other organisations — behind a common vision as a new plastic economy founded on circular economy principles. At its heart,

	the SAPP is a multi-stakeholder platform to stimulate innovation, dialogue, and collaboration to unlock barriers to circularity, to create new business models, and generate job opportunities.
Food Loss and Waste Voluntary Agreement	On 29 September 2020, the Consumer Goods Council of South Africa (CGCSA), in partnership with the national department of Trade, Industry and Competition, and co-funded by the European Union launched the South African Food Loss and Waste Voluntary Agreement (SAFLWVA). The voluntary agreement commits core signatories to align operations with the United Nation's Sustainable Development Goal 12.3 to reduce food loss and waste by 50% by 2030. Among the current signatories are some of South Africa's largest food brands, including its largest retailers.

7. Innovation maturity functions

This section explained the maturity tool used to know the lifecycle stage of the green energy and waste management sector. The maturity tool is part of the inclusive regional innovation system as proposed by Grobbelaar et al (2016):

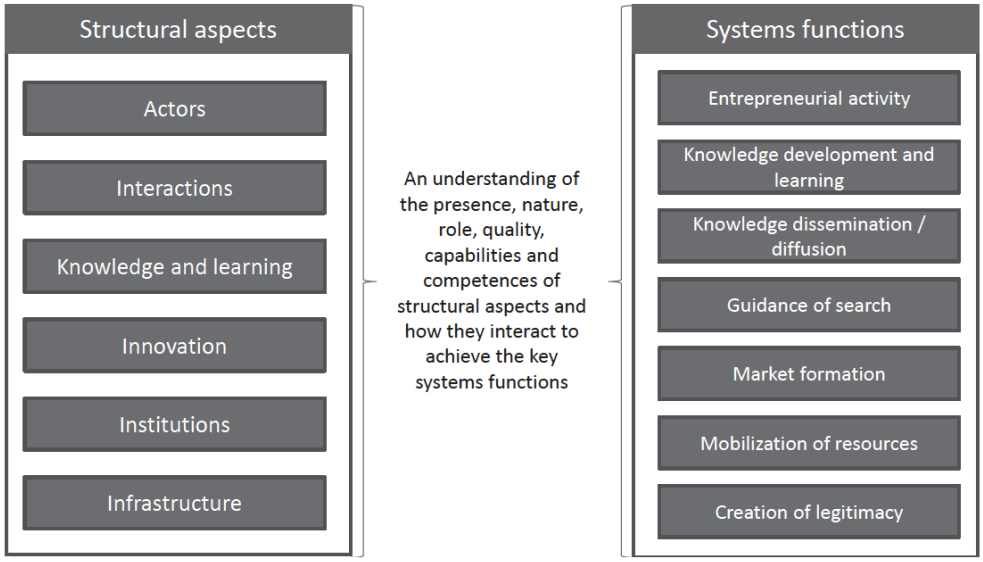


Figure 7.1: The interaction between structural element and system functions

The structural elements at play within the GES sector and therefore contributing towards creating legitimacy in the sector are reflected in Table 7.1, below

Table 7.1 Western Cape BPO industry assessed with the "Exposure of innovation to area" indicator of the RIS Framework

Structure type	Provincial structures in place

Actors	• Government Programmes
	  ○ National
	  ○ Provincial
	  ○ Municipal
	• Industry bodies
	  ○ GreenCape
	  ○ Business Process Enabling South Africa (BPESA)
	• Skills and Training institutions
	  ○ Green Energy and Waste Management Skills Academy
	  ○ EduPower Academy

	• Higher Education Institutions:
	  ○ University of Cape Town
	  ○ University of Stellenbosch
	  ○ University of Western Cape
	  ○ Cape Peninsula University of Technology
	• Offshore/onshore companies such as:
	  ○ Renewable Energies
	  ○ Teleperformance
	  ○ Cape Solar Pv Consultant
	  ○ BVI
	  ○ KAM
	  ○ GreenSun
	  ○ TBS waste
	  ○ Postwink
	• Captive green energy and waste management companies such as:
	  ○ Amazon
	  ○ Lufthansa
	  ○ Collinsons Group

Institutions	• InvestSA One Stop Shop
	• Atlantis Special Economic Zone
	• City of Cape Town incentives
	• Western Cape Government incentives
	• Drakenstein Municipality incentives
	• Other government incentives relevant for green energy and waste management:
	  ○ Foreign investment grant
	  ○ Skills support programme
	  ○ Strategic investment project programme
	  ○ Critical infrastructure facility fund
	  ○ Sector specific assistance scheme
	  ○ Export marketing and investment assistance
	  ○ Technology and human resources for industry programme
	  ○ Technology development fund
	  ○ Technology venture capital

Interactions	• Green energy and waste management Industry forums ○ Skills development

	○ Destination marketing ○ Human Capital development ○ IT and Digital Readiness ● Business Process Enabling South Africa (BPESA) events
Infrastructure	● Transport – Three national highways, MyCiti bus rapid transit service, best international airport in Africa, multiple infrastructure development projects including: ○ Integrated Rapid Transit (IRT) project ○ Terminal expansion in the Port of Cape Town ○ Extension of Cape Town International Airport's runway ○ Atlantis Green Technology Special Economic Zone (SEZ) ○ Cape Health Technology Park project ○ Cape Town Air Access project ● ICT – Multiple undersea cables, WCG broadband programme, City of Cape Town's broadband programme, 400 free Wi-Fi zones and 19 fibre providers in Cape Town ● Well develop property, financial and legal environment

The next section provides detailed description, development, implementation, and the results of the maturity model in relation to the developed framework.

7.1 Maturity model

The maturity model is developed by combining the system function approach and a life cycle stages together to create an innovation system. There are four stages of life cycle, which are birth, growth, maturity, and decline. Numeric values are assigned to the four stages of the life cycle of an innovation system as shown in Table 7.2.

Table 7.2: Maturity lifecycle stages

Life cycle stage	Birth	Growth	Mature	Decline
Designated value	1	2	3	4

The whole measurement framework with descriptions is included in Appendix E. The Table in the Appendix E represents the maturity model developed related to the system functions. The maturity model can be also called a functional maturity tool, which has thirty-five indicators that serve as the main dimensions in the model with each of the indicators having four lifecycle stages. Each stage of the lifecycle is described based on each indicator used in the model. The developed model is designed to analyse a sector within the regional innovation system.

7.2 Methodology

To apply the developed maturity model to a chosen sector in a particular region, an implementation framework is used as shown in Figure 7.2. The implementation framework depends on the institutional documents (ID) and subject matter expert's (SMEs) knowledge, opinions, and experience to know the maturity of a specific sector. As the model is designed to analyse sectors within a RIS, a sector needs to be chosen within the RIS. Within the regional innovation system, this sector sets the parameters for the sectoral innovation system. Sectoral institution documents (ID) and subject matter experts (SMEs) need to be consulted after the RIS and SIS borders have been established to obtain information from them. An SME must choose the life-cycle description for each indication that best fits their industry's needs in the region as part of the interview process. An ID must show which lifecycle description for each indication represents their institution's view on a sector in a particular region.

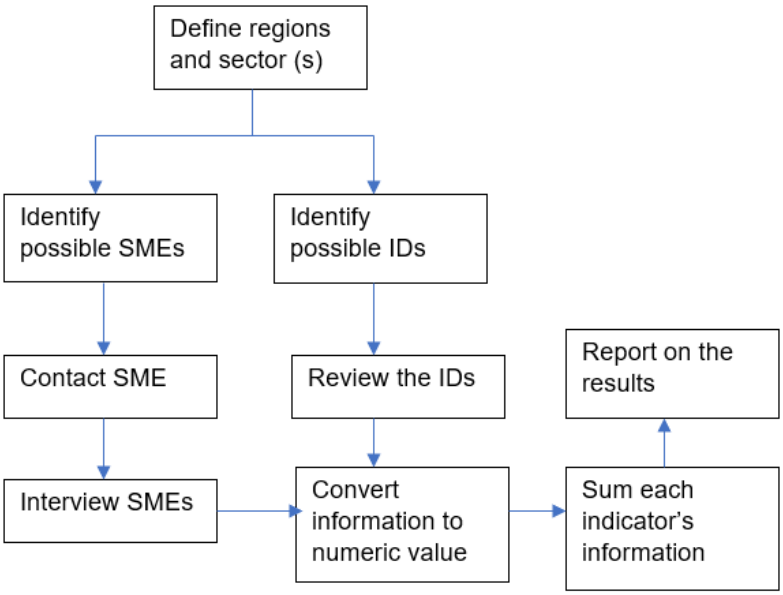


Figure 7.2: Implementation framework

Once the ID has been reviewed and SMEs have been also interviewed, the information gathered is converted to the assigned values. The average of information collected is calculated and the summation of these values provides sector maturity per function.

This data can be utilized to identify the areas of the RIS industry that require development and improvement support. The Western Cape (WC), in South Africa, has been chosen as the area to exhibit the framework research. Thus, the boundaries of the RIS are acknowledged as the Western Cape's provincial border. The green energy sector and waste management sector are the sectors that will be examined. The participants who are designated as Subject Matter Experts (SMEs) in Table 7.3 and Table 7.4 have the experience and credentials necessary to be considered for inclusion in the evaluation of the indicators.

Table 7.3: IDs and SMEs for green energy sector

Green energy sector	
IDs Code	Description
Source 1	The ID is GreenCape large scale renewable energy report 2022. The report is the product of 1000s of engagements with the stakeholders in the large-scale renewable energy
Source 2	The ID is GreenCape energy services renewable energy report 2022. The report is the product of 1000s of engagements with the stakeholders in the energy services
Source 3	The ID is Western Cape green economy report 2022. The report is the product of 1000s of engagements with the stakeholders in the green economy.
SMEs Code	Description
Source 4	This SME has experience in management, marketing, and business principles. They have actively participated in planning, expansion, and development of the Western Cape green building over the past few years. They are currently in charge of a significant endeavour to make sure that the Western Cape emerges as a significant centre for green building technology.
Source 5	This SME, who has a PhD in chemical engineering, has worked largely as a professor and researcher in the fields of renewable energy innovation and technology. Concentrate on solar and wind energy analysis. Also co-founded an institute that concentrates on resolving energy challenges through renewable energy development.

While IDs code in Table 7.3 and Table 7.4 provide a short description of the credible, impartial institutional documents used for the evaluation of the indicators.

Table 7.4: IDs and SMEs for waste management sector

Waste management sector	
IDs Code	Description
Source 1	The ID is GreenCape Waste report 2022. The report is the product of 1000s of engagements with the stakeholders in the waste management
Source 2	The ID is Western Cape state of waste management report 2022. The report is the product of 1000s of engagements with the stakeholders in the waste management
Source 3	The ID is Western Cape green economy report 2022.
SMEs Code	Description
Source 4	This SME has experience in waste management, and administration. Actively participated in planning, expansion, and development of the Western Cape Waste Management over the past few years. Currently in charge of controlling waste disposal in the Western Cape Region.
Source 5	This SME has experience in waste management and is currently director of an institution that concentrates on “waste to energy”. This SME holds a PhD in chemical engineering and has worked on the aspects surrounding waste recycling.

The following section provides the results of the maturity model for the green energy sector and waste management sector in the Western Cape Regional Innovation System. This result includes average indicator maturity per function, and sector’s functions maturity for both sectors. The average indicator maturity per function is derived from the information collected from IDs and SMEs along the four lifecycle stages. The four lifecycle stages are ranked from 1 to 4 as shown in Figure 7.2. The sector’s functions maturity is derived from the summation of the average indicators per function. The results for average indicator maturity per function and the sector’s functions maturity can be seen in the appendix F.

7.3 Green energy maturity results

7.3.1 Entrepreneurial activity

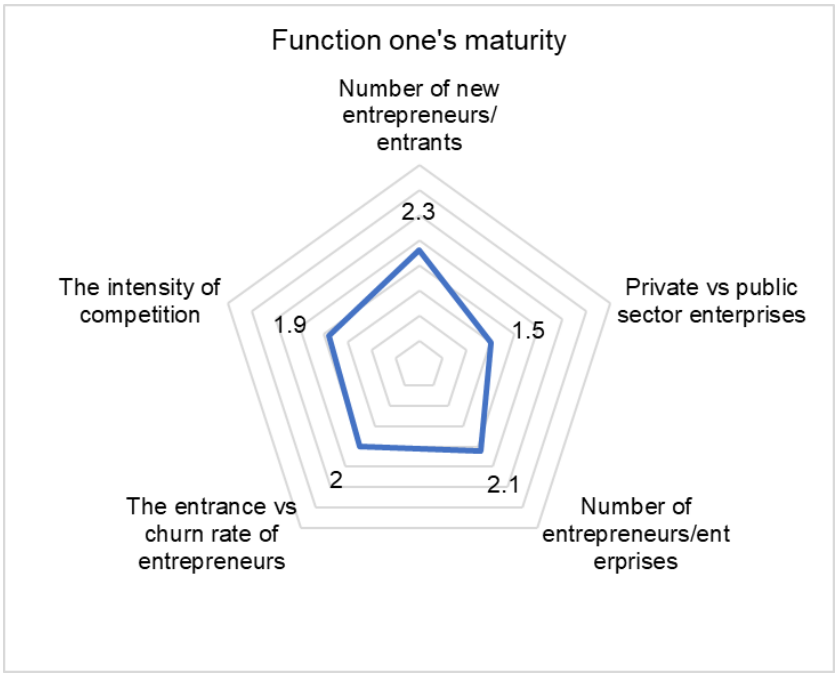


Figure 7.3: Entrepreneurial activity maturity

Figure 7.3 shows the maturity stage of the green energy sector's entrepreneurial activity in the western cape region. The "number of new entrants", "number of enterprises" and the "entrance vs churn rate of entrepreneurs" have maturity ratings of 2.3, 2.1 and 2. These indicators are still in the growth phase while "the intensity of the competition" has a maturity rating of 1.9, putting it close to reaching the growth phase. The "private vs public sector enterprise" indicator has a maturity rating of 1.5, showing it is moving away from the birth phase to the growth phase. By 2030, it is estimated that 14 million solar panels and 3600 wind turbines would be needed to adhere to IRP 2019. This will require increased production and localisation of key components. It is estimated that R38-R44 billion per year would be needed to finance the investment in renewable energy. One would think that this massive inflow in production capacity would increase entrepreneurial activity in the sector. However, the SME were not too buoyed by the prospects of increased renewable energy investment

in the sector. It may be that many of the initiatives have not flowed through into the formal economy.

7.3.2 Knowledge development

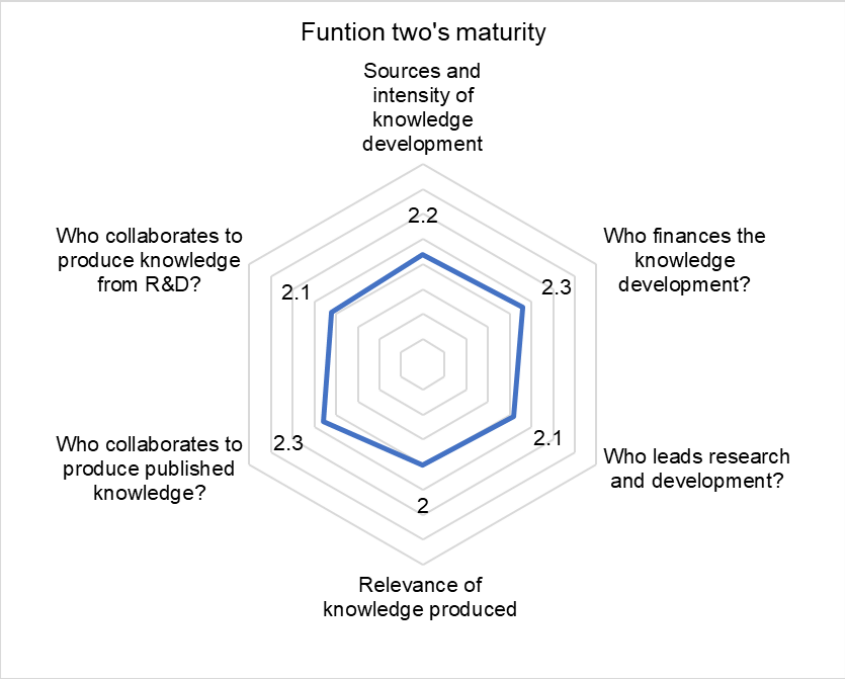


Figure 7.4: Knowledge development maturity

The maturity of the knowledge development for green energy in WCR is in the growth phase as shown in Figure 7.4. The maturing ratings for “Who finances the knowledge development?”, and “Who collaborates to produce published knowledge?” are both 2.3. The indicator ratings show that both indicators have the highest rating, and they are gradually moving away from the growth phase. While the indicators for “who finances the knowledge development?” and “who collaborates to produce knowledge from R&D?” have the same maturity rating of 2.1, “Sources and intensity of knowledge development”, and “relevance of knowledge produced” have maturity ratings of 2.2 and 2 respectively. Although the Western Cape has some of the best institutions of higher education and research centres, it is important to acknowledge that public funding on Research and Development falls short of the benchmark - 2% of GDP. Most High-income countries continuously spend more than 2% of GDP on R&D.

Although South Africa's spending on R&D has increased in recent years, it is still far below this 2% benchmark. R&D funding is also limited by the steady decrease in private sectors' share of gross expenditure on R&D (GERD) since 2010, which as of 2019/2020 stands at 31%. This is far too low to make a significant impact on innovation, especially in a research-intensive field such as GES.

7.3.3 Knowledge diffusion

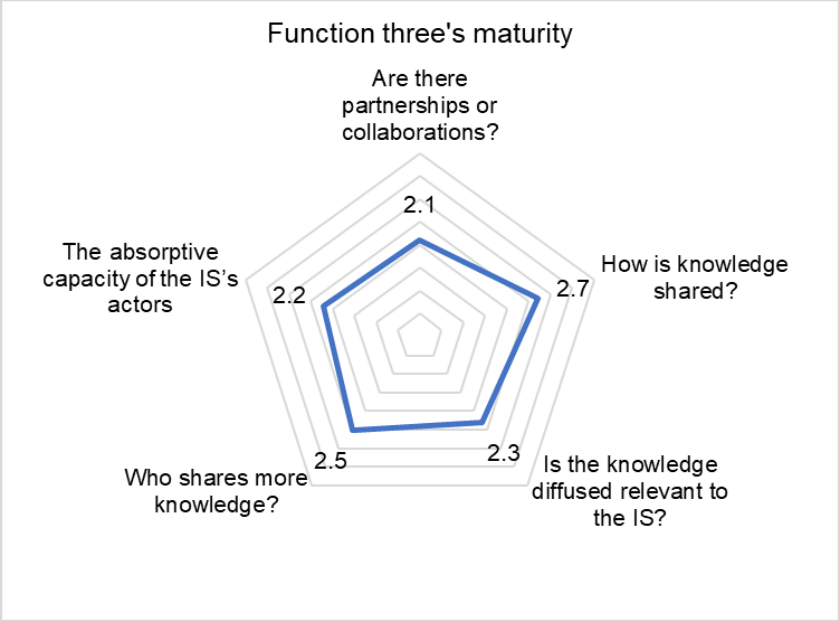


Figure 7.5: Knowledge diffusion maturity

Two out of the five indicators for the green energy sector's knowledge diffusion in WCR are close to the mature phase as shown in Figure 7.5. These indicators are "who shares more knowledge?" and "How is knowledge shared?" with maturity ratings of 2.5 and 2.7 respectively. The maturity ratings for "Are there partnerships or collaborations?" and "the absorptive capacity of the IS's actors" are 2.1 and 2.2, putting them in the growth phase. "Is the knowledge diffused relevant to the IS?" has a maturity rating of 2.3, and is gradually transitioning away from the growth phase. In the context of the Western Cape Province – research publications and patents are probably two of the best measures of knowledge diffusion and sharing. In the period 2016-2019, the University of Cape Town had the most co-publications with industry (5,2%), followed by the University of the Witwatersrand (5,1%) and the University of

Pretoria (4,9%). Several universities experienced a decline in their share of scientific co-publications with the industry. Domestic patents granted to South African residents declined by over 50% in 2020 (from 694 in 2019 to 313 in 2020), while patents granted to non-residents declined by 42% (from 5 468 in 2019 to 3 153 in 2020).

South African patent registrations at the United States Patent and Trademark Office (USPTO) declined by 13%. Overall, the number of inventions coming from South Africa are very low. In 2020 the country had 25 patent applications per million population, whereas the average for upper middle-income countries in the same year was 641. Although Western Cape region statistics are not available, one can assume that it would be in-line with national averages.

7.3.4 Guidance of search

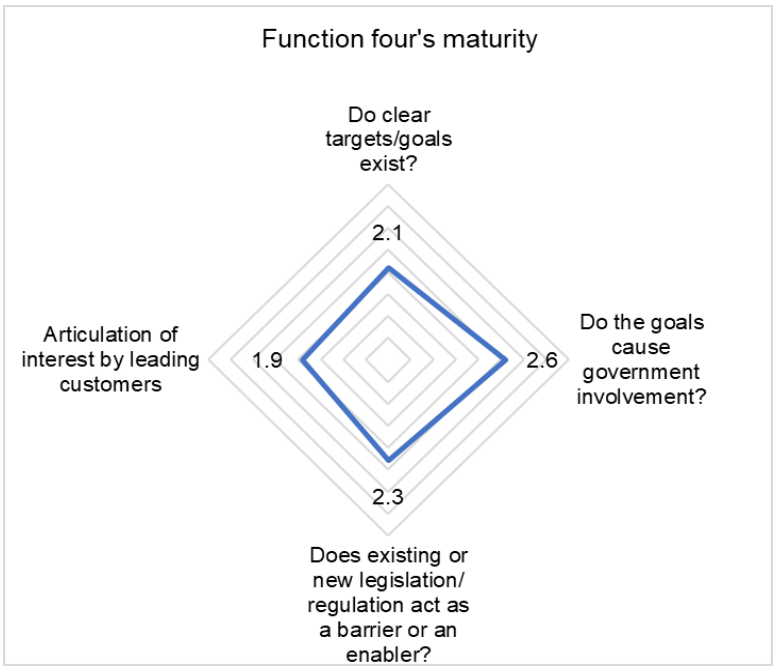


Figure 7.6: Guidance of search maturity

One out of the four indicators for the green energy sector's guidance of search in WCR are close to the mature phase as shown in figure above. This indicator is "do the goals cause government involvement?" with a maturity rating of 2.6. The maturity ratings of "Do clear targets/goals exist?" and "Does existing or new legislation/regulation act as

a barrier or an enabler?" are 2.1 and 2.3, which are in the growth phase. "Articulation of interest by leading customers" ,with a maturity rating of 1.9, is moving toward the growth phase. The Western Cape Government is committed to a net zero economy by 2050, which would suggest that green energy remains a critical part of the strategy. The policy direction from local government is clear as far as Western Cape Minister of Finance and Economic Development David Maynier launched the Western Cape Municipal Energy Resilience Fund (R13 million) targeted at qualifying municipalities for research and planning to support renewable energy projects in the province. In the Western Cape, there have been 14 utility scale renewable energy projects procured between November 2013 and June 2021 (13% of the total number of projects). In addition, seven of the 25 preferred bidders in BW 5 are located in the WC (28% of the total number of projects). The WC has been allocated 9% of total REIPPPP procured capacity to date. Including the BW5 preferred bidders, the WC has been allocated 15% of total REIPPPP capacity. Given all the activity, it is somewhat surprising that the subject matter experts were not more optimistic about the policy direction and goals.

7.3.5 Market formation

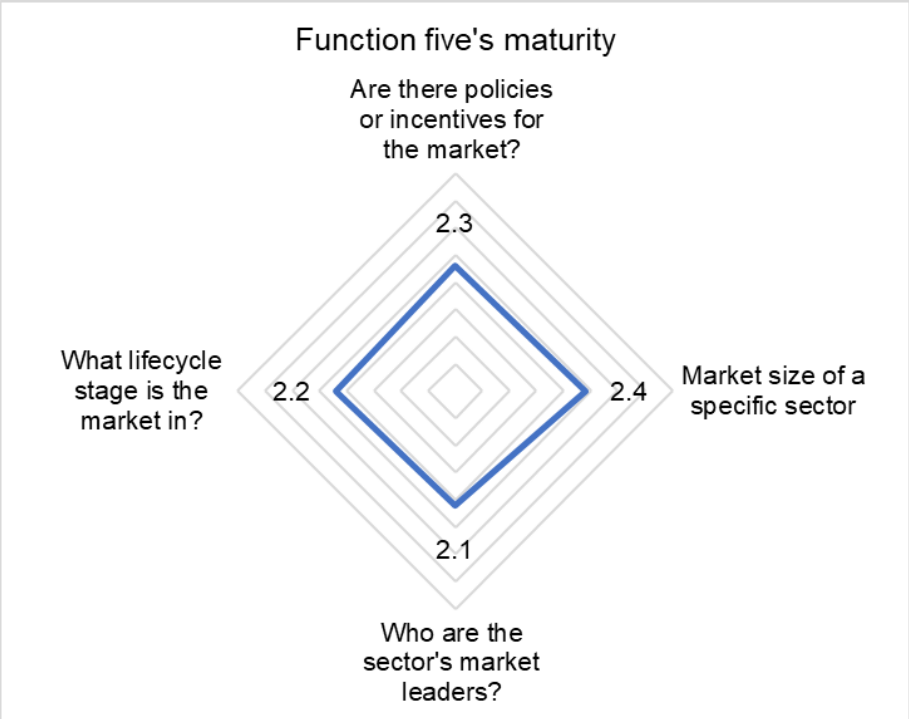


Figure 7.7: Market formation maturity

The maturity stage of the green energy sector's market formation in the western cape region is shown in the figure above. The "market size of a specific sector" and "are there policies or incentives for the market?" indicators have maturity ratings of 2.4 and 2.3 respectively. These indicators are gradually moving away from the growth phase, while "What life cycle stage is the market in? and "who are the sector's market leaders?" have reached the growth phase with maturity ratings of 2.2 and 2.1. The market for renewable energy is estimated to be between R38-R44 billion per year in South Africa. It is hard to estimate the market sizes in terms of the Western Cape province but given the ambitious goals of IRP 2019 one can expect a sizable local market, especially for the manufacturing and installation of renewable energy. Some of the most significant policy drivers include:

- In January 2021, the CCT requested a determination to allow for procurement. The CCT has committed to purchasing ~520 MW of renewable energy over the next 15 years, and most of the other metro municipalities also have committed to purchasing a similar scale.
- In June 2021, WCG DEDAT published RFI for renewable energy projects as part of Municipal Energy Resilience (MER)
- In July 2021, CCT released an RFI for innovative financing of renewable energy projects owned and operated by the city

The potential market size for the opportunity is estimated to be around 500 MW per year of which PV renewable energy will the remain the dominant technology.

7.3.6 Resource mobilisation

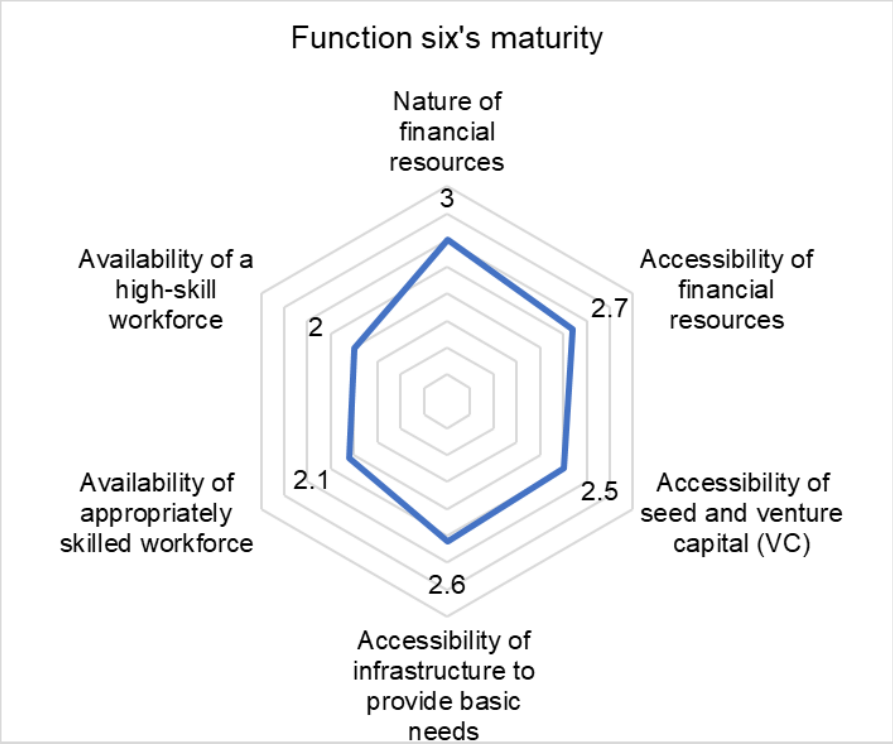


Figure 7.8: Resource mobilisation maturity

Three out of the six indicators for the green energy sector's resource mobilisation in the WCR are close to the mature phase as shown in figure above. These indicators are "accessibility of financial resources", "Accessibility of seed and venture capital", and "Accessibility of infrastructure to provide basic needs" with maturity ratings of 2.7, 2.5, and 2.6. "Availability of a high-skill workforce" and "Availability of appropriately skilled workforce" are in the growth phase, with maturity ratings of 2 and 2.1. "Nature of financial resources" has a maturity rating of 3 and is in the mature phase.

Based on the feedback from SME's – the average maturity of function 6 can be regarded as mature. One of the strongest ratings were achieved for the nature of financial resources and accessibility of financial resources. Various incentives and tax concessions have been initiated to promote investment in renewable energy. It is not surprising that the SMEs are generally optimist regarding the availability of finance.

The private sector financial institutions have a strong appetite to fund private renewable energy solutions.

7.3.7 Creation of legitimacy

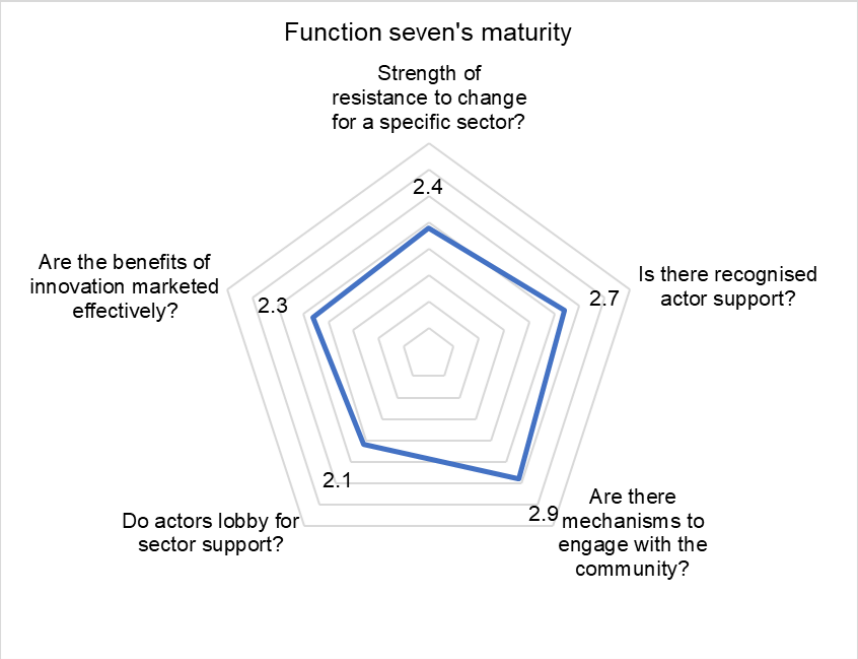


Figure 7.9: Creation of legitimacy maturity

The maturity of the creation of legitimacy for green energy in WCR is in the growth phase as shown in figure above. The maturing ratings for “Are there mechanisms to engage with the community?”, and “Is there recognised actor support?” are 2.9 and 2.7. Both of these indicators have the highest rating, and they are close to the mature phase. “Do actors lobby for sector support?”, “Are the benefits of innovation marketed effectively”, and “Strength of resistance to change for a specific sector?” have maturity ratings of 2.1, 2.3 and 2.4. These indicators show that they are still in the growth phase.

“Ensuring the provision of adequate and reliable energy services at an affordable cost, in a secure and environmentally benign manner and in conformity with social and economic development needs, is an essential element of sustainable development. Sustainable energy is an important indicator to measure as it contributes to eradicating poverty, improving human welfare and raising living standards” (TIPS, 2022). Renewable energy holds numerous societal benefits and can address inequality,

higher quality of life, and access to basic services. The sustainable and scalable nature of renewable energy has the potential to lift many people from poverty – but it would need to be implemented with the correct mix of incentives and funding from the government. Harnessing the benefits of renewable energy to meet medium term social impact goals needs to remain at the core of the WCG policy framework.

7.3.8 Green energy sector's maturity

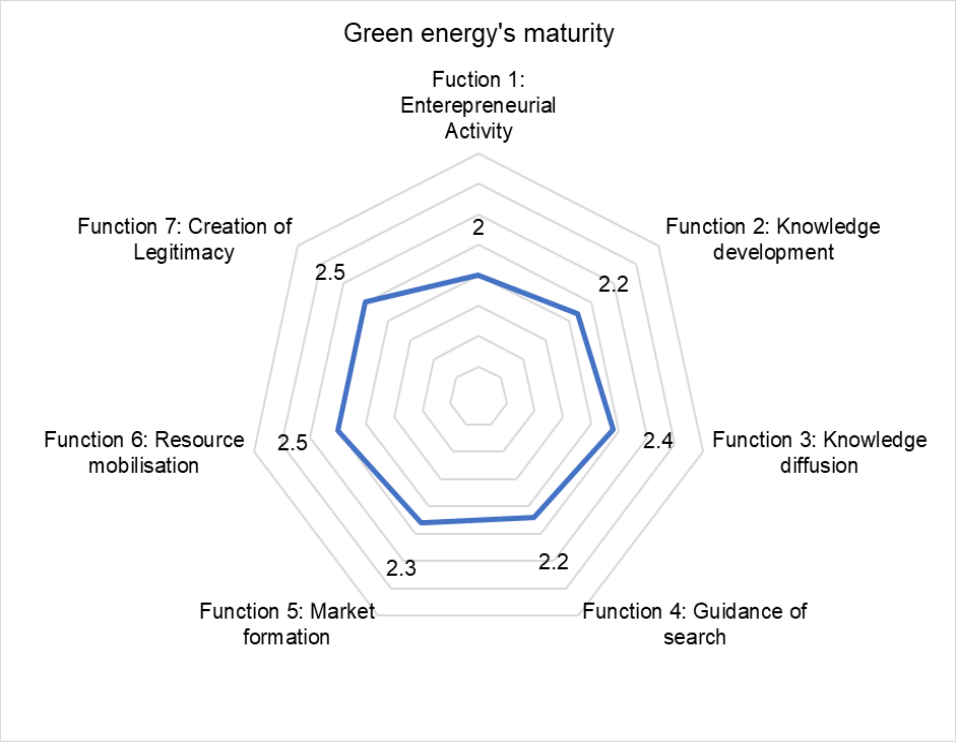


Figure 7.10: Green energy sector maturity

The maturity for the green energy sector in WCR is in the growth phase as shown in figure above. The maturing ratings for market formation, knowledge diffusion, resource mobilisation, and creation of legitimacy are 2.3, 2.4, 2.5 and 2.5 respectively. These indicators ratings show that they are gradually moving away from the growth phase to the mature phase. The indicators for entrepreneurial activity, knowledge development and guidance of search have maturity ratings of 2, 2.2 and 2.2, showing they are still in the growth phase.

On the whole – it seems like good progress is being made with the broad base adoption and implementation of renewable energy in the province. However, the level of entrepreneurial activity remains low as well as knowledge development. The WCG needs to pay specific attention to these two factors to further promote renewable energy in the province.

7.4 Waste management maturity results

7.4.1 Entrepreneurial activity

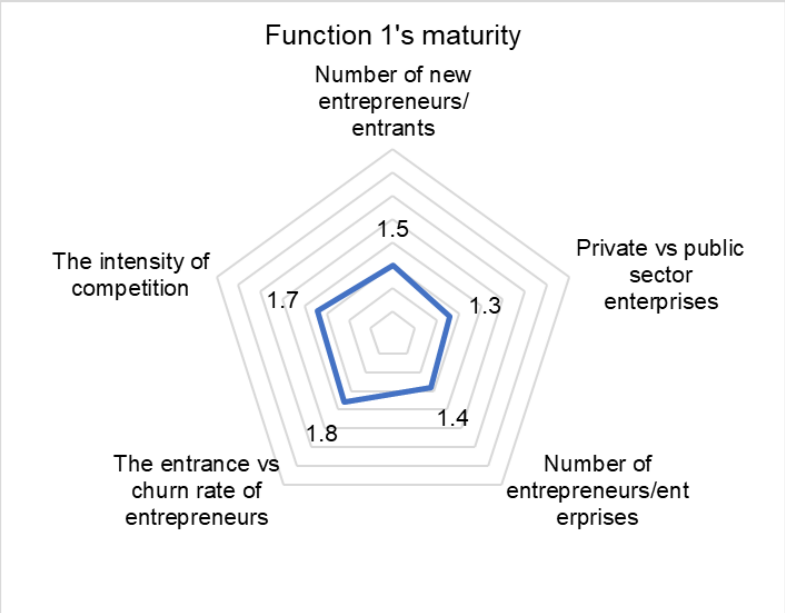


Figure 7.11: Entrepreneurial activity maturity

Figure 7.11 above shows the maturity stage of the waste management sector's entrepreneurial activity in the western cape region. The intensity of competition and the entrance vs churn rate of entrepreneurs have maturity ratings of 1.7 and 1.8. These indicators show that they are about to reach the growth phase while the number of new entrants, number of enterprises, and the private vs public sector enterprise have maturity ratings of 1.5, 1.4 and 1.3, showing that the indicators are moving away from the birth phase towards the growth phase. It is noteworthy that the average rating of the waste management sector is much lower than renewable energy. Although there

are numerous opportunities in the waste management sector – due to the high capital cost the barriers to entry are large. Each province has a designated authority responsible for regulating waste management within its boundaries. This can be undertaken by the / a municipality or outsourced to the private sector. Since 2017, 20 initiatives have been identified, but private funding is essential to attract new entrants to the sector.

7.4.2 Knowledge development

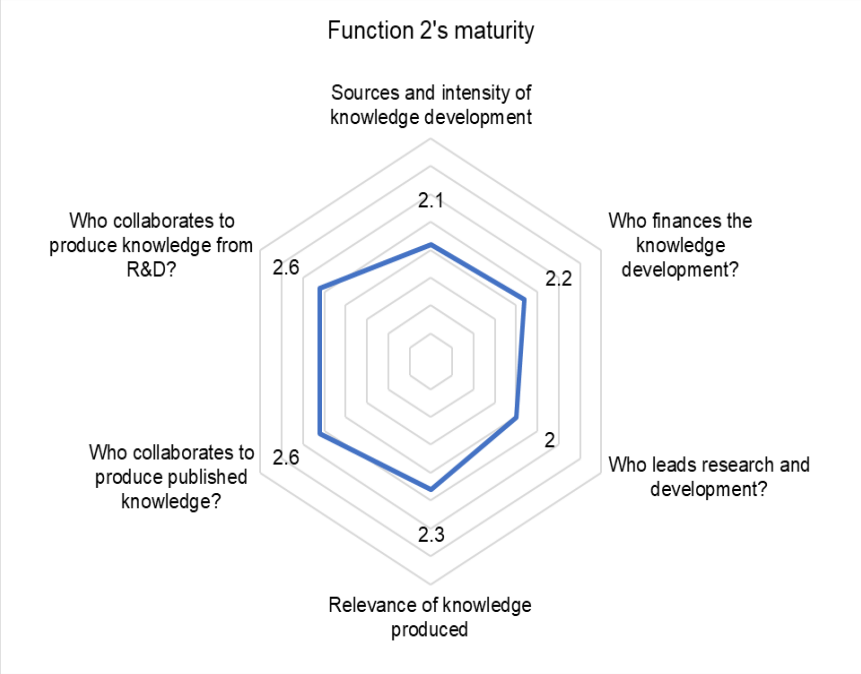


Figure 7.12: Knowledge development maturity

The maturity of the knowledge development for the waste management sector in WCR is in the growth phase as shown in the figure above. The maturing ratings for "who collaborates to produce knowledge from R&D?", and "Who collaborates to produce published knowledge?" are 2.6. This indicator rating shows that both indicators have the highest rating, and they are moving closer to the mature phase. While the indicator of "who leads research and development?" and "Who finances knowledge development?" and "Sources and intensity of knowledge development" has the maturity rating of 2, 2.2 and 2.1. These indicators show that they are still at

the growth phase. The remaining indicator “relevance of knowledge produced” has the maturity rating of 2.3, which is gradually moving away from the growth phase.

7.3.3 Knowledge diffusion

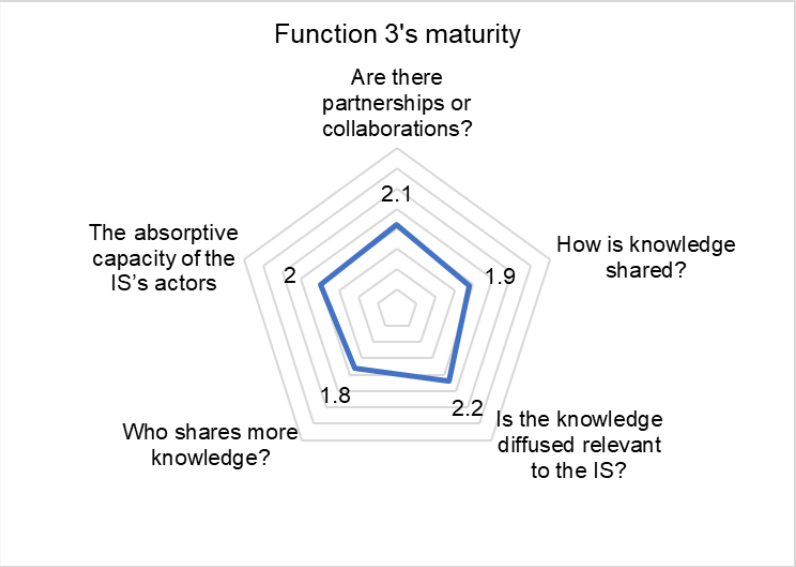


Figure 7.13: Knowledge diffusion maturity

Two out of the five indicators for the waste management sector’s knowledge diffusion in WCR are close to the growth phase as shown in the figure above. These indicators are “who shares more knowledge?” and “How is knowledge shared?”, with maturity ratings of 1.8 and 1.9. The maturity ratings of “Are there partnerships or collaborations?”, “the absorptive capacity of the IS’s actors", and “Is the knowledge diffused relevant to the IS?” are 2, 2.1 and 2.2, putting them in the growth phase. Knowledge creation and diffusion go hand in hand. South Africa has a strong research base in the technical aspects of waste management and recovery – but needs more collaboration and expertise in developing the ecosystem of waste management and beneficiation. The market for waste is much more developed in developed markets (e.g., EU, UK and US). More work is also needed on sharing knowledge to promote the circular economy and increasing recycling. Biogass remains an important area of research because it can add to the grid that is already under pressure. DFFE has confirmed that biogas installations of less than 50 MW do not require an emission

licence. More needs to be done to promote private investment in private landfills and the generation of biogas.

7.3.4 Guidance of search

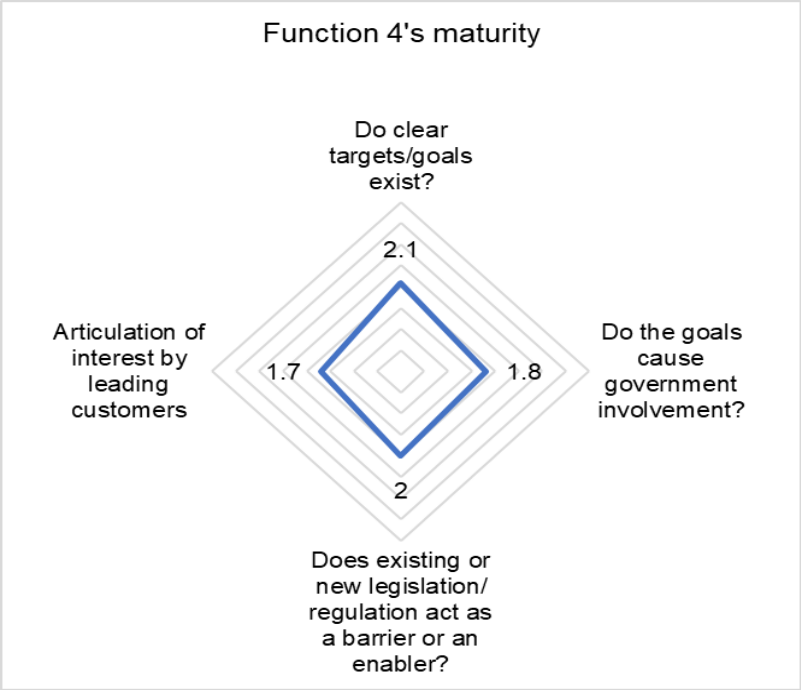


Figure 7.14: Guidance of search maturity

Two out of the four indicators for the waste management sector's guidance of search in WCR are close to the growth phase as shown in figure above. These indicators are "Articulation of interest by leading customers" and "do the goals cause government involvement?" with maturity ratings of 1.7 and 1.8. The maturity rating of "Do clear targets/goals exist?" and "Does existing or new legislation/regulation act as a barrier or an enabler?" are 2.1 and 2, which are in the growth phase.

The national Department of Forestry, Fisheries and the Environment (DFFE) is the overarching authority for waste management in SA. The WC's Department of Environmental Affairs and Development Planning (DEA&DP) is the provincial authority for the WC, with its waste department ensuring waste management policies and legislation are implemented and enforced. SA's overarching waste management framework, the NEMWA is given effect through the National Waste Management Strategy (2000). The Framework has three distinct targets:

- 40% of waste diverted from landfill within 5 years; 55% within 10 years; and at least 70% within 15 years, Zero-Waste to landfill beyond 2035
- All South Africans live in clean and safe communities with effective waste management strategies
- Drive adoption of waste management and reduce pollution and litter

Given these policy frameworks – it is surprising that the scores in function 4 received such low scores.

7.3.5 Market formation

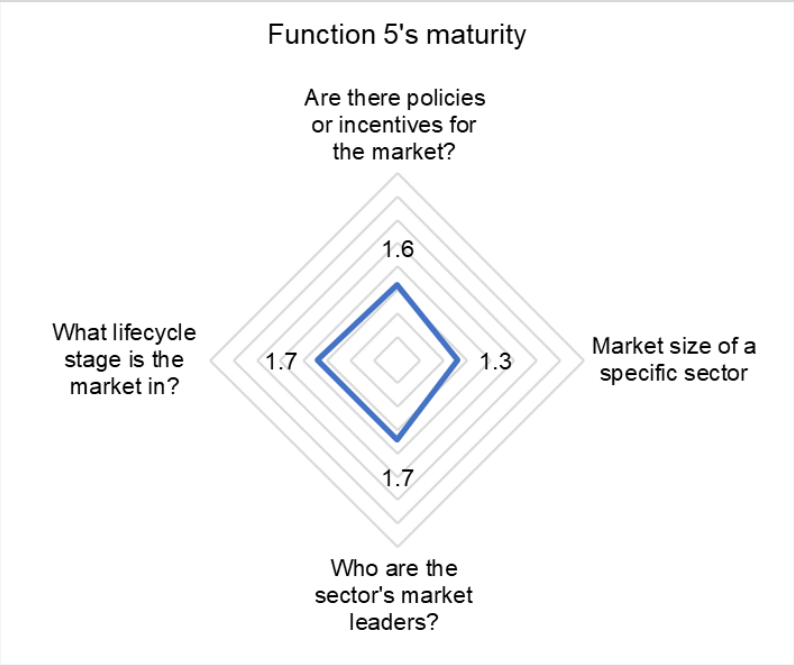


Figure 7.15: Market formation maturity

The maturity stage of the waste management sector's market formation in the western cape region is shown in the figure above. "What life cycle stage is the market in? and "who are the sector's market leaders?" have the same maturity ratings of 1.7, and "are there policies or incentives for the market? " has a maturity rating of 1.6, showing that the indicators are close to the growth phase.

The market size of a specific sector with the maturity rating of 1.3, still at the birth phase but gradually moving away from the birth phase.

7.3.6 Resource mobilisation

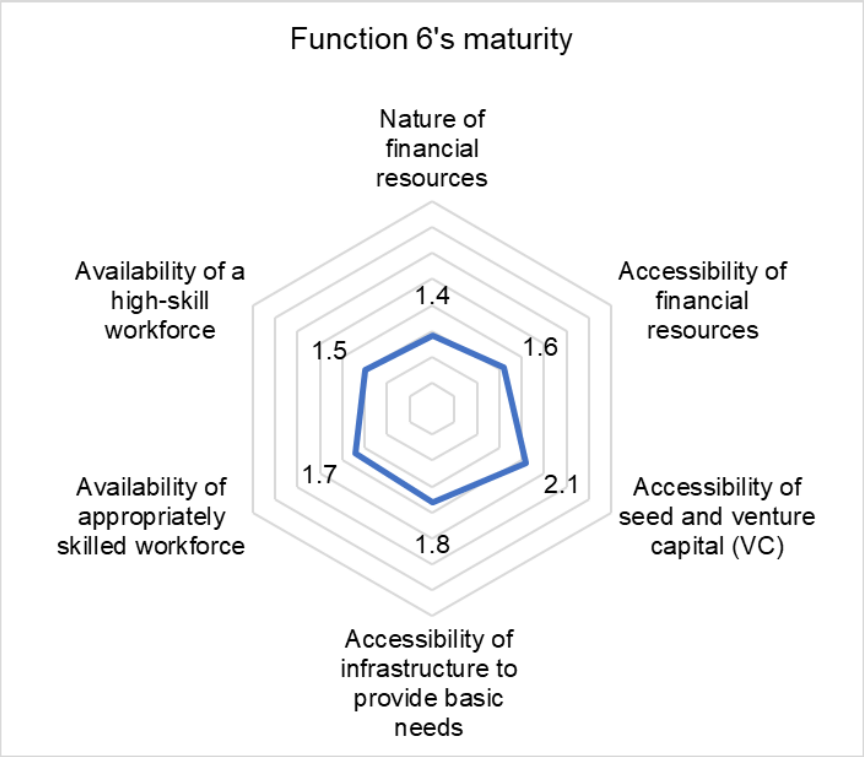


Figure 7.16: Resource mobilisation maturity

Three out of the six indicators for the waste management sector's resource mobilisation in the WCR are close to the growth phase as shown in figure above. These indicators are "accessibility of financial resources'', "Availability of appropriately skilled workforce" and ''Accessibility of infrastructure to provide basic needs" with maturity ratings of 1.6, 1.7 and 1.8. The maturity ratings of "Nature of financial resources'' and "Availability of a high-skill workforce" are 1.4 and 1.5, which are moving away from the birth phase to the growth phase. "Accessibility of seed and venture capital" has a maturity rating of 2.1 and is still in the growth phase.

South Africa ranks in one of the top 15 nations globally when it comes to driving the green economy. The GreenCape Finance Desk updates a webpage with Green finance resources including funding and incentives available for organisations. FinFind and AlliedCrowds also offer finance providers globally and locally. Thus, it seems that there are ample finance options available, but what is lacking is a skilled labour force.

7.3.7 Creation of legitimacy

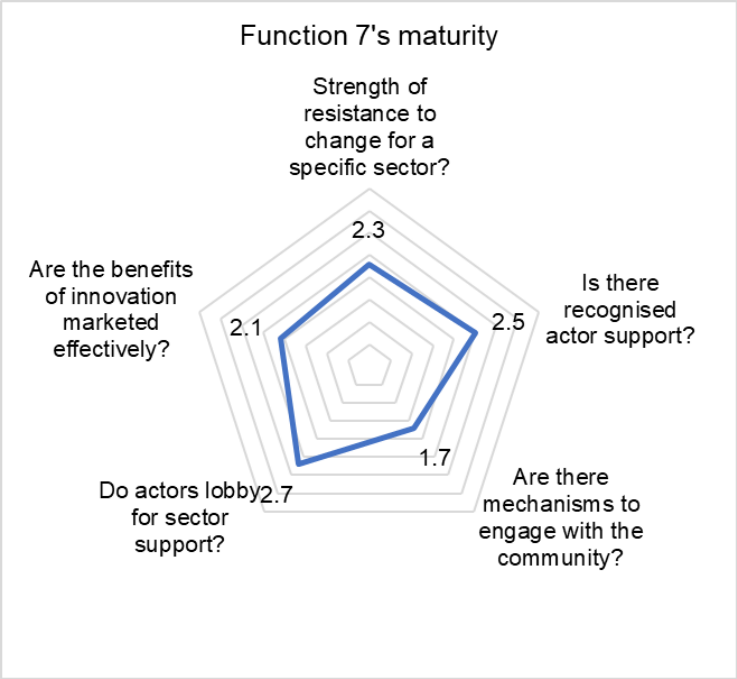


Figure 7.17: Creation of legitimacy maturity

The maturity of the creation of legitimacy for waste management in WCR is in the growth phase as shown in figure above. The maturing rating for “Do actors lobby for sector support?” is 2.7. This indicator rating shows that the indicator has the highest rating, and it is close to the mature phase. In contrast, the indicators for “Is there recognised actor support?”, “Are the benefits of innovation marketed effectively” and “Strength of resistance to change for a specific sector?” have maturity ratings of 2.5, 2.1 and 2.3 respectively, showing they are still in the growth phase. Only the indicator of “Are there mechanisms to engage with the community?” with a maturity rating of 1.7 is still at the birth phase but is close to reaching the growth phase.

7.3.8 Waste management sector's maturity

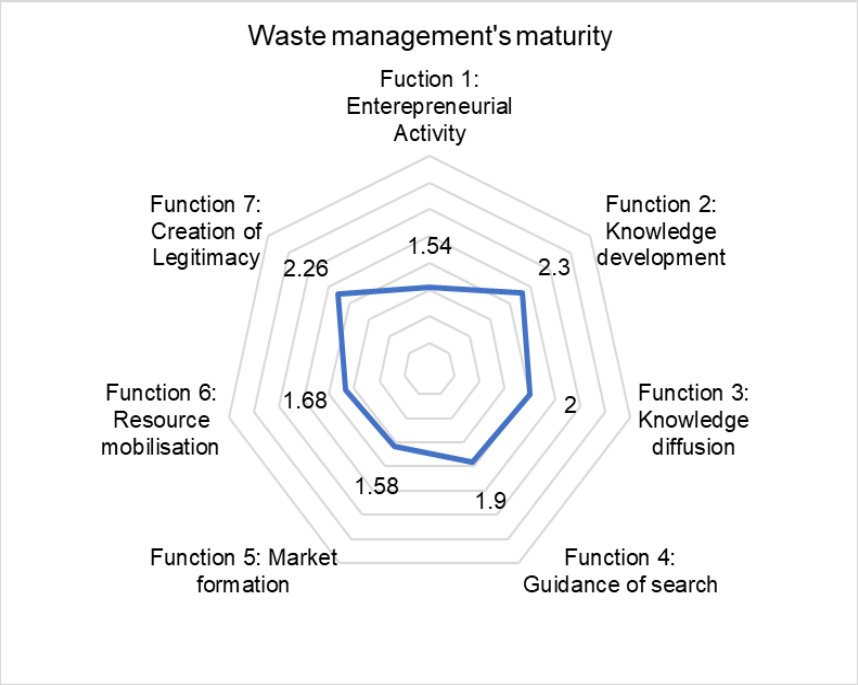


Figure 7.18: Waste management sector maturity

The maturity for the waste management sector in WCR is in the growth phase as shown in figure above. The maturing ratings for "market formation, resource mobilisation, and entrepreneurial activity are 1.58, 1.68, and 1.54 respectively. These indicators' ratings show that they are gradually moving away from the birth phase to the growth phase. The indicators of "creation of legitimacy", "knowledge development" and "knowledge diffusion" have the maturity rating of 2.26, 2.3 and 2. These indicators show that they are at the growth phase while the guidance of search with a maturity rating of 1.9 is close to reaching the growth phase.

In general, the sector seems to be in the growth phase. Clearly function 7 is the strongest measured across the SME. More work needs to be done to attract entrepreneurs to the sector, provide or facilitates that cater for capital expensive investment. One of the major opportunities is investment in R&D to support biogass extraction and the operation of private landfill sites. The circular economy is very important not only for waste beneficiations but also to reach environmental

sustainability goals. Solid waste management ticks many boxes in the context of the midterm goals of the Western Cape Government.

7.3 Maturity summary

The maturity of the green energy sector and waste management sector in the Western Cape of South Africa is summarized in Table 7.3.3 below. It lists the names, numbers, and maturity ranks of the indicators. The maturity rankings are presented visually by colouring the stages to show them in their current or changing stages.

7.3.3 Green energy overall ranking

Table 7.5: Green energy overall maturity ranking

Number	Indicator names	Maturity	Birth	Growth	Mature	Decline
F1.1	Number of new entrepreneurs/ entrants	2.3				
F1.2	Private vs public sector enterprises	1.5				
F1.3	Number of entrepreneurs/enterprises	2.1				
F1.4	The entrance vs churn rate of entrepreneurs	2				
F1.5	The intensity of the competition	1.9				
F2.1	Sources and intensity of knowledge development	2.2				
F2.2	Who finances knowledge development?	2.3				
F2.3	Who leads research and development?	2.1				
F2.4	Relevance of knowledge produced	2				
F2.5	Who collaborates to produce published knowledge?	2.3				
F2.6	Who collaborates to produce knowledge from R&D?	2.1				
F3.1	Are there partnerships or collaborations?	2.1				
F3.2	How is knowledge shared?	2.7				
F3.3	Is the knowledge diffused relevant to the IS?	2.3				

F3.4	Who shares more knowledge?	2.5				
F3.5	Absorptive capacity of the IS's actors	2.2				
F4.1	Do clear targets/goals exist?	2.1				
F4.2	Do the goals cause government involvement?	2.6				
F4.3	Does existing or new legislation/ regulation act as a barrier or an enabler?	2.3				
F4.4	Articulation of interest by leading customers	1.9				
F5.1	Are there policies or incentives for the market?	2.3				
F5.2	Market size of a specific sector	2.4				
F5.3	Who are the sector's market leaders	2.1				
F5.4	What life cycle stage is the market in?	2.2				
F6.1	Nature of financial resources	3				
F6.2	Accessibility of financial resources	2.7				
F6.3	Accessibility of seed and venture capital (VC)	2.5				
F6.4	Accessibility of infrastructure to provide basic needs (business-facing as well)	2.6				
F6.5	Availability of appropriately skilled workforce	2.1				
F6.6	Availability of a high-skill workforce	2				
F7.1	Strength of resistance to change for a specific sector?	2.4				
F7.2	Is there recognised actor support?	2.7				
F7.3	Are there mechanisms to engage with the community?	2.9				
F7.4	Do actors lobby for sector support?	2.1				
F7.5	Are the benefits of innovation marketed effectively?	2.3				

7.3.3 Waste management overall ranking

Table 7.6: Waste management overall maturity ranking

Number	Indicator names	Maturity	Birth	Growth	Mature	Decline
F1.1	Number of new entrepreneurs/ entrants	1.5				
F1.2	Private vs public sector enterprises	1.3				
F1.3	Number of entrepreneurs/enterprises	1.4				
F1.4	The entrance vs churn rate of entrepreneurs	1.8				
F1.5	The intensity of the competition	1.7				
F2.1	Sources and intensity of knowledge development	2.1				
F2.2	Who finances knowledge development?	2.2				
F2.3	Who leads research and development?	2				
F2.4	Relevance of knowledge produced	2.3				
F2.5	Who collaborates to produce published knowledge?	2.6				
F2.6	Who collaborates to produce knowledge from R&D?	2.6				
F3.1	Are there partnerships or collaborations?	2.1				
F3.2	How is knowledge shared?	1.9				
F3.3	Is the knowledge diffused relevant to the IS?	2.2				
F3.4	Who shares more knowledge?	1.8				
F3.5	Absorptive capacity of the IS's actors	2				
F4.1	Do clear targets/goals exist?	2.1				
F4.2	Do the goals cause government involvement?	1.8				
F4.3	Does existing or new legislation/ regulation act as a barrier or an enabler?	2				

F4.4	Articulation of interest by leading customers	1.7				
F5.1	Are there policies or incentives for the market?	1.6				
F5.2	Market size of a specific sector	1.3				
F5.3	Who are the sector's market leaders	1.7				
F5.4	What life cycle stage is the market in?	1.7				
F6.1	Nature of financial resources	1.4				
F6.2	Accessibility of financial resources	1.6				
F6.3	Accessibility of seed and venture capital (VC)	2.1				
F6.4	Accessibility of infrastructure to provide basic needs (business-facing as well)	1.8				
F6.5	Availability of appropriately skilled workforce	1.7				
F6.6	Availability of a high-skill workforce	1.5				
F7.1	Strength of resistance to change for a specific sector?	2.3				
F7.2	Is there recognised actor support?	2.5				
F7.3	Are there mechanisms to engage with the community?	1.7				
F7.4	Do actors lobby for sector support?	2.7				
F7.5	Are the benefits of innovation marketed effectively?	2.1				

8. Findings

8.1 Promoters

8.1.1 Green energy main promoters

The key promoters for green energy are listed below:

- Public procurement of new generation capacity
- Increase the energy mix in the Western Cape to promote energy security and independence from ESKOM
- Promote biogass and green hydrogen economy in Western Cape since these energy sources can create critical baseload for heavy manufacturing and related industries needed for job growth in the province
- Large scale batter storage should be promoted to bolster the grid during demand shocks
- Increase local manufacturing of PV components
- Increase investment in R&D that is needed to drive digitalization of renewable energy

8.1.2 Waste management main promoters

The key promoters for waste management in organic waste, plastic and E-waste are listed below

Table 8.1: Waste management promoters

Waste management	Main promoters
Organic waste	· Organic waste landfill restrictions by 2027 · Decreasing municipal landfill airspace · Increasing cost of landfilling · Carbon tax liability · Market demand for clean dry recyclables · Energy security · NWMS organic waste related targets
Plastic waste	· Decreasing municipal landfill airspace · Perceived job potential · Global / local plastic sentiment
E-waste	· Precious metal prices · National e-waste landfill bans · National battery landfill bans · Perceived job potential

8.2 Barriers

8.2.1 Green energy main barriers

The key barriers for RE are listed below.

- Inability to ensure continuity and continued transparency in the roll out of the RE procurement programme will affects the growth of RE in WCR

- Inability to support the local manufacturing base to attract new investment and build confidence.
- Unable to prioritise the reform of the country's electricity sector to reflect sustainable resources and market offerings in SA especially WCR
- Installations of poorly designed, sub-par systems. Partially mitigated by the PV Green Card, but poor quality is still a risk, particularly on smaller projects.
- Regulatory certainty as the sector is still adapting to the most recent developments in municipal processes, system registration and wheeling.
- Tariff uncertainty as municipalities can change or remove feed-in-tariffs on an annual basis which makes long term projections difficult

8.2.2 Waste management main barriers

The key barriers for waste management in organic waste, plastic and E-waste are listed below.

Table 8.1: Key barriers in organic, plastic and e- waste in Western Cape Waste Management

Waste management	Main inhibitors
Organic waste	• Inadequate source separation. • Compost certification of post-treated organic is heavily regulated. • Competition with unregulated livestock farmers. • Cost of landfilling. • Lack of heating grid. • Confidence in bioenergy projects. • Short procurement durations. • Strict procurement process. • Lack of a bio-based electricity grid. • Sensitive market for by-products

Plastic waste	• Slow growth in end-markets. • High levels of contamination. • Virgin plastic price variability. • Unregulated labelling systems. • Lack of accurate plastic data. • Contamination of alternative to plastics. Narrow focus of initiatives
E-waste	• Lack of reliable data. • Licensing of recycling/recovery facilities. • Access to feedstocks. • Cherry-picking of high-value e-waste. • DFFE view of transboundary e-waste movement

9. Government support (existing and proposed)- Recommendation

The following recommendation listed below will help to increase the development of green energy and waste management innovation in WCR.

For renewable energy sector:

Increasing a strong business case: Energy users that emphasize long-term resilience to rising electricity bills find investment decisions to be appealing because of an increasingly compelling business rationale.

Renewable energy licence threshold: The level of competition on 150-500 kWp projects has diminished since many established market players are shifting capacity to larger projects because of the increase in the embedded generation license threshold.

Increase access to finance: Commercial banks have opened access to capital by designating certain portfolios to fund SSEG and large scale RE projects.

The adoption of smart meter integrated systems on the savings sharing model is being driven by the demand for usage monitoring and bill reduction.

Private sector-led transition: Due to the increased grid dependability and revenue collection possibilities without needing to make a major investment, the present transformation is being led by the private sector. This is a good for sustainable transition to renewable energy.

For waste management sector:

Western Cape 2027 organic waste landfill restrictions: The DEA&DP has created a provincial organic waste strategy to meet the 2027 target. Five (5) overall goals have been broken down into fourteen (14) objectives: Waste reduction, resource recovery

from organic waste streams, infrastructure support for resource recovery, promotion of organic waste beneficiation, and better waste information management.

Abattoir waste landfill restrictions and Liquid waste landfill restrictions: Restriction to abattoir and liquid waste to the landfill will reduce waste and further create a better environment in the society.

Cost of Landfilling Waste generators still view landfilling as an expensive expenditure, particularly in the Western Cape, even though South Africa's landfilling costs are very modest when compared to benchmarks in more developed nations. Of all the metros in the nation, the CCT has the highest landfill entrance costs (R533 excl. VAT/tonne in 2020/21). In the upcoming years, this is anticipated to climb faster than inflation. The expense of landfilling will be a major impediment to landfill alternatives for private sector organic waste before the provincial organic waste disposal regulations are completely implemented in 2027.

Operation Phakisa: Three of the 20 initiatives used to expedite trash diversion through the Chemical and Waste Operation Phakisa have an organic waste component: The 2023 zero-sewage-sludge-to-land/landfill goal will concentrate on making WWTW biogas operations easier. The goal of diverting all meat production waste to value-added solutions by 2023 will focus on achieving this goal. The goal of the 50% home organic separation at source effort is to impose separation at source standards on municipalities, particularly metros, by the year 2023.

Community Engagement: South African and Western Cape is a water scarce region. Community engagement and inactivation to recycle and curb pollution is vitally important in the circular economy. The Western Cape has taken the lead nationally in the collection and recycling of waste, however the next important step is grassroot education and engagement with regard to recycling. The percentage of recycling is still too low in South Africa compared to other middle-income countries. Incentivising the collection of glass, cans and tyres have greatly increased the recycling of these waste streams. Plastic is a major polluter and should be targeted.

10. Conclusion and future activities/research

The Western Cape government have embarked on a new strategic direction through the implementation of the Growth for Jobs (G4J) Strategic Framework. At its core the strategy calls for break out economic growth in order to drive large scale employment opportunities for its citizens. Despite the many successes of the province including sound corporate governance, prudent fiscal spending, curbing corruption, and increasing service delivery, the province has not been able to break out of the slow economic growth that characterises the rest of the South African economy.

This is somewhat surprising given the large-scale trend of skilled emigration to the province of skilled workforce, solid foreign direct investment and a booming tech start up industry. The G4J framework calls for growth between 4%-6% to make a substantial impact on large scale job creation and curing of income inequality. The main mechanism is through horizontal enablement of the private sector-led economic growth. This is in stark contrast to the national policy which is dependent on strong government intervention and participation in the formal economy. The new policy of horizontal enablement is built on three basic principles, (a) enable the business environment, (b) stimulate market growth, and (c) support growth opportunities. Our assessment of the Green Energy and Waste Management sector indicate that the province is already doing allot to enable private sector to flourish in these areas, but access to finance and markets remain important enablers. In both these sectors the demand for services should be stable and oversubscribed, but the WCG may have to help entrepreneurs in the private sector access to the local market and long-term contracts (off take agreements) to activate funding. There is no doubt that the private-public model can work well to drive innovation and growth, but it may not be inclusive growth. It is important from a policy perspective not to pick winners and losers but to allow the market economy to drive the most innovate and effective outcome. What is important for the Western Cape government is to lay the foundations for private sector to innovate.

Furthermore, the Higher Education sector has a significant role to play in graduating student with the right skillset to be successful in the digital economy. Given the local beneficiation requirements for many of the large-scale government tenders, there is a dire need for skilled entrepreneurs to drive innovation in these two sectors.

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Appendix A: Developed framework

A.1 Defined structural elements

Structural elements are entities in the regional innovation system that drive and influence the innovation capacity and abilities of the system. The four main structural elements expected to be seen in a RIS are actors, institutions, interactions, and infrastructure. They are defined and discussed in the table below.

Table A.0.1: Table of Elements

Element	Category	Identified/Examples
Actors: The innovation system components, primarily individuals and organisations, which produce the innovation activities.	Research	Higher education institutes, research organisations
	Public	Local municipalities, National and provincial government State-owned enterprises, NGOs, Consumers, Libraries
	Private	Enterprises (start-up/company, SMEs) champion, Industry, Financial Organisations (Banks, Venture capitalists), Support organisations (incubation hubs/accelerators), informal businesses, freelancers, Special purpose entities, NPOs
Institutions: The sets of habits, routines, and concepts (soft institutions) common to	Hard = rules, laws, regulations, instructions	University and community interaction policies, governmental innovation policies, reward policies for innovation, support programs/systems, laws, tax incentives/exemptions

humans that are shaped by rules, norms, and strategies (hard institutions).	Soft = customs, common habits, routines, established practices, traditions, ways of conduct, norms, expectations	Openness (innovation, new knowledge), common/traditional trade habits, community habits, organisational culture
Interactions: The relationships and linkages that exist amongst actors, institutions, and innovations.	Formal relationship	Collaborative agreements, sponsorships, investment agreements
	Non-formal relationship	Community leadership, knowledge access/showcase events (workshops, seminars, podcasts, focus groups), stakeholder interviews, technology transfer
Infrastructure: 1. Physical infrastructure is tangible infrastructure such as buildings, machines, and equipment. 2. Knowledge infrastructure refers to any form of knowledge, expertise, and information. 3. Financial infrastructure encompasses all forms of financial support typically generated through subsidies, financial programs, and grants	Physical	University buildings, event venues, water, internet, electricity supply, offices, warehouses, stores, human capital, police presence, health care services, security measures (crime rate), housing, coworking spaces, coffee shops
	Knowledge	Literature repositories, educated workforce, courses, publications and reports, intellectual property, patent databases
	Financial	Investments, grants, loans, crowdfunding

A.2 Defined Innovation System Functions

The table below presents the different system functions according to Hekkert, MP, et al (2012). The functions and their definitions are presented along with probing questions to link these functions to regional innovation systems. These questions act as a starting point to identifying different indicators for each function, step 3.

Table A.0.2: Functions summary table (Hekkert et al., 2007; Wieczorek & Hekkert, 2012)

	Function	**Definition**	**Probing questions for RIS**
F1	Entrepreneurial activity	Entrepreneurs are needed in any innovation system. They convert knowledge, networks, and markets to create and use business opportunities.	• Who promotes entrepreneurial activity in the RIS? • Who utilises innovation more? i.e., Emerging firms and developed firms. Includes social and traditional entrepreneurs.
F2	Knowledge development	An important aspect of innovation is the knowledge creation process. This includes learning by searching and learning by doing.	• How is knowledge created in the region? • Knowledge needs to be created to enable innovation. • Decide on the types of knowledge and the sources of knowledge. • Can measure with patents, R&D projects, and R&D investments.
F3	Knowledge diffusion	Support the diffusion of ideas and innovations through supply and demand-side support mechanisms/diffusion.	• How do you share the knowledge that had been created?

		The exchange of information is important, namely in a research and development environment. Activity can be seen through 'learning by interacting' or 'learning by using'	• Look at networks that exist. Can be measured by several workshops or conferences hosted, the size of these events also plays a factor. • The market of knowledge plays a role here: measure by the number of publications and their citations
F4	Guidance of search	Guidance towards correct investment in technologies and developments This function helps create goals and targets to direct knowledge creation and diffusion. It shows that change does not happen by itself. A catalyst is needed to activate it.	• Is there a clear goal to improve innovation? • Is the innovation agenda pushed by different actors?
F5	Market formation	As new technologies are not optimised on release. An environment must be created to help increase the diffusion rate of new technologies.	• Are the appropriate policies implemented? i.e., financial incentives, forms of money injection, demand-side policies. • Is there a market developed for innovation to exist?

F6	Resource mobilisation	It refers to the activities involved in the mobilisation and alignment of resources in the innovation system. Financial and human capital is crucial as a foundation for any innovation system. They are also required for knowledge creation to begin.	• Are resources easily available for the actors involved in the innovation? • Are there programs to improve resource availability?
F7	Creation of legitimacy	When a new technology is introduced, it needs to enter the market or create its own. Various partnerships, such as putting new technology on the agenda (F4), lobbying for resources (F6) and favourable tax regimes (F5). These types of actions create a new technologies legitimacy.	• How is the innovation promoted to the public? Is it marketed well; are discussions held? • Can be measured by How much effort is done for innovation to exist within the area? • Look at the increase of various interest groups and their collective effort.

A.3 Proposed Indicators

F1: Entrepreneurial activity			
Indicators (Letinić & Štavlić, 2011)	**Diagnostic questions**	**Elements**	**Possible sources for data gathering**
Enterprise newness, integration & presence	Type of enterprise (new/existing) How far are they from the "centre" of business in the region	***Actors***: SMEs, Enterprises/Company champions	• Databases about company registrations, addresses/locations,

		Institutions: Tax exemptions, subsidies, grants ***Interactions:*** Contractual agreements, company registrations ***Infrastructure*:** Offices, warehouses, stores	central business area and the number of buildings in the area. ● Local information from actors in the area about policies in the area.
Private sector	What percentage do private sectors make up in the area Types of companies in the private sector (help label RIS's main industry)	***Actors***: SMEs, Enterprises/Company champions, state-owned enterprises, NGOs, governments ***Institutions:*** Support programs, common/traditional trade ***Interactions***: Contractual agreements, registrations ***Infrastructure*:** Offices, warehouses, stores, educated workforce	● Databases about company registrations, company industry, private or public status
SME's percentage in the area	What ratio are SMEs to large corporations	***Actors:*** SMEs, Enterprises/Company champions	

		Institutions: Governmental innovation policies, reward policies, laws, support programs/systems, tax incentives/exemptions, community habits, trade habits ***Interactions:*** Collaborative agreements, investment agreements, community leadership ***Infrastructure:*** Offices, warehouses, stores, human capital, incubators, accelerators	• Databases about company registrations, company number of registered workers
Percentage of formal to informal traders	How formalised (urbanised) is the area? Are there more formal offices than stalls/spaza shops	***Actors***: Informal businesses, SMEs, Enterprises/Company champions ***Institutions:*** Community habits for informal or formal trade ***Interactions:*** Community leadership, complementary knowledge access ***Infrastructure***:	• Databases about company registrations, addresses/locations, central business area and the number of buildings in the area. • Inspections of area for informal traders' amount and density

		Offices, warehouses, stores, human capital, informal trade space	
Factors affecting business	What is an area's business conditions?	***Actors:*** Local municipalities, national & provincial government	• Area inspections to determine the presence of business conditions • Infrastructure reports about the municipal area • Discussion/survey individuals in the area
		Institutions: Laws, tax exemptions, community/governmental policies	
		Interactions: Community leadership	
		Infrastructure: Water, internet, electricity supply, offices, warehouses, stores, human capital, police presence, health care services, security measures	
F2: Knowledge Development			
Indicators (Botha et al., 2019)	**Diagnostic questions**	**Structures**	**Data gathering**
Sources of knowledge development (Learning by doing)	What institutes/organisations exist that creates knowledge in the area	***Actors*** Higher education institutions, research organisations, enterprise champions, NGOs, state-owned enterprises	• Databases about educational institutes, research organizations' locations

		Institutions University publication policies/KPIs, municipal reward policies for innovation, tax exemptions, openness to innovation	• Interviews/surveys, questionnaires with companies to assess their level of knowledge creation
		Interactions University and community interaction, collaborative agreement, sponsorships, bursary, knowledge access events	
		Infrastructure University building, libraries, literature repositories, educated workforce	
Knowledge type	What knowledge is being created? (Explicit, implicit & tactic)	***Actors*** Higher education institutions, research organisations, enterprise champions	• Database with patents projects from educational institutes and research organisations • Databases about the area's infrastructure (libraries) • Interviews/surveys with companies to assess their level of knowledge creation
		Institutions Support programs/systems, grants	
		Interactions University and community interaction, knowledge access events	

		Infrastructure Libraries, literature repositories, workforce, forums, human capital	• Interviews/surveys with the community regarding forums and knowledge access events
Research Collaboration	Who is included in the knowledge creation process? (Source to source, source to the user)	***Actors*** Higher education institutions, research organisations, enterprise champions, government entities, NGOs, state-owned enterprises	• Interviews/surveys with the community regarding forums and knowledge creation events • Interviews/surveys with actors to assess their level of knowledge creation • Industry partnered publication repositories/patents
		Institutions University publications (reports and journal articles), policies/KPIs, municipal reward policies for innovation, tax exemptions, openness to innovation	
		Interactions University and community interaction, knowledge access events, collaborative agreements	
		Infrastructure	

		Investments, grants, libraries, literature repositories, workforce, forums, human capital	

F3: Knowledge Diffusion			
Indicators (Botha et al., 2019; Lööf & Broström, 2008)	**Diagnostic questions**	**Structures**	**Data gathering**
Partnerships	Between what actors are the main knowledge-sharing networks	***Actors*** Higher education institutions, research organisations, enterprise champions, government entities, NGOs, state-owned enterprises	Interviews/surveys with the community regarding forums and knowledge sharing events Interviews/surveys with actors to assess their level of knowledge sharing Industry partnered publication repositories/patents Databases with industry funding & partners
		Institutions University publication policies/KPIs, openness to innovation	
		Interactions University and community interaction, collaborative agreements, knowledge access events	
		Infrastructure	

		Libraries, literature repositories, workforce, forums, human capital	
The intensity of knowledge sharing	How much knowledge is shared between sources and users?	***Actors*** Higher education institutes, research organisations, enterprise champions, government entities, NGOs, state-owned enterprises ***Institutions*** Openness to new knowledge ***Interactions*** Knowledge access/sharing events, community leadership ***Infrastructure*** Libraries, literature repositories, workforce, forums, human capital, courses, university building, schools	Databases with industry funding, number of patents. Literature repositories with industry partnerships Surveys/interviews with the community to gauge openness to new knowledge Database with events hosted in the area concerning teaching/knowledge sharing
Distribution methods	How is knowledge shared? Impact of the density of people? Type of knowledge sharing (codified (explicit), tacit or implicit)	***Actors*** Higher education institutes, research organisations, enterprise champions, government entities, NGOs, state-owned enterprises ***Institutions*** Openness to new knowledge	Database with events hosted in the area concerning teaching/knowledge sharing A database about density and number of people, sector (student/working) along with the number of interactions

		Interactions Knowledge access events, community leadership ***Infrastructure*** Libraries, literature repositories, workforce, forums, human capital, university building, schools, courses	Survey/interviews to determine the types of knowledge transferred (explicit, tactic or implicit) Data source about events in the area (webinars, seminars, etc.)

F4: Guidance of Search			
Indicators (Botha et al., 2019; Wieczorek & Hekkert, 2012)	**Diagnostic questions**	**Structures**	**Data gathering**
Targets/goals	Is there a set goal in the area? Do policies/programmes align to achieve the aim/goal?	***Actors*** Local municipalities, national and provincial government (area focused), enterprise champions, NGOs, state-owned ***Institutions*** Laws, reward policies for innovation, tax exemptions ***Interactions***	• Database/mining for information regarding incentives for innovative solutions • Interviews/surveys focused on identifying targets/goals set by enterprises or government (i.e., carbon-neutral goals)

		Investment agreements, community leadership ***Infrastructure*** Water, internet, electricity supply, offices, healthcare, security, police presence	
Known constraints	Are there constraints that limit innovation?	***Actors*** Local municipalities, national and provincial government (area focused), enterprise champions ***Institutions*** Laws, university, and community interaction policies ***Interactions*** Collaborative/investment agreements ***Infrastructure*** Water, internet, electricity supply, offices, healthcare, security, police presence	• Area inspection to identify possible constraints • Interviews/surveys with enterprises & community focusing on possible constraints
Main Promoters	Does the private, public or both promote innovation? (Percentage/financial units)	***Actors*** Local municipalities, national and provincial government (area	

		focused), enterprise champions, NGOs, state-owned	• Database/mining for records of innovation promoting events or programs in the area • Interviews/surveys with businesses and municipalities about events, programs/events that promote innovation in the area
		Institutions University and community, and governmental interaction/innovation policies, support programs/systems, the openness of the community	
		Interactions Collaborative agreements, sponsorships, investment agreements, community leadership, knowledge access events	
		Infrastructure Event venues, offices, warehouses, stores, human capital, libraries, educated workforce, investments, grants, loans, crowdfunding, courses	

F5: Market Formation			
Indicators (Lee et al., 2018)	**Diagnostic questions**	**Structures**	**Data gathering**
Social structures/policies	What incentive is there to invest in innovative programs or businesses? Are the private & public sectors promoting innovation in the area?	***Actors*** Local municipalities, national and provincial government, enterprises, financial organisations, support organisations, higher education institute ***Institutions*** Governmental innovation policies, reward policies for innovation, tax incentives/exemptions ***Interactions*** Sponsorships, investment agreements, community leadership, knowledge access events ***Infrastructure*** University building, event venues, human capital, educated workforce, investments, grants, loans, crowdfunding	• Database/mining on any incentives/programs in areas that encourage innovation (i.e., Hackathon, Ideasmash, etc.) • Database/mining about financial investments into new companies in the area • Information from SARS regarding tax incentives • Interviews/surveys with actors to identify any events or incentives that exist

Market orientation	Are there already markets & for what? Are actors enriching the market? Who is enriching the market?	***Actors*** Local municipalities, national and provincial government, state-owned enterprises, NGOs, enterprises, informal businesses	• Interviews/surveys with actors about the most known types of innovations (goods & services) in the area. If innovations or companies are marketed at all?
		Institutions University & community interaction policies, support programs/systems, openness to innovation	
		Interactions Collaborative agreement, investment agreements, sponsorships, knowledge access events	
		Infrastructure Event venues, internet, stores, warehouses, investments, grants, loans, crowdfunding	

F6: Resource Mobilisation			
Indicators (Botha et al., 2019)	**Diagnostic questions**	**Structures**	**Data gathering**
Financial access	Can people access funding?	***Actors*** Enterprise champion, informal businesses, financial organisations, support organisations, NGOs, state-owned enterprises ***Institutions*** Tax incentives, laws ***Interactions*** Sponsorships, investment agreements ***Infrastructure*** Investments, grants, loans, crowdfunding	• Interviews/surveys with actors about where enterprises secure funding and its accessibility • Databases/mining focused on investments made in a certain area
Human resource access	What types of workforces are in the area? Level of education of workforce in the area?	***Actors*** Higher education institutes, local municipalities, national and provincial government, NGOs, NPOs ***Institutions***	• Database on education sources • Database on level of education per area • Database on types of work available per area

		University and community interaction policies, support programs, community habits, organisational culture	• Database on number of people/densities per area
		Interactions Collaborative agreements, investment agreements, Community leadership, workshops, seminars	
		Infrastructure University buildings, human capital, housing, internet, water, electricity supply, health care services, educated workforce, courses	
Level of collaboration	Are there shared resource pools in the area or is it more individual?	***Actors*** Higher education institutions, research organisations, local municipalities, state-owned enterprises, NGOs, national and provincial government, enterprise champions, support organisations	• Interviews/surveys focusing on actors' access to resources. Do they get resources from others, or do they try themselves, information about the resources? • Databases/mining focused on identifying shared resource pools or sources in the area
		Institutions	

		University & community interaction policies, support programs/systems, openness to resource sharing, technology transfer	
		Interactions Collaborative agreement, investment agreement, sponsorships, knowledge access events	
		Infrastructure University building, event venues, human capital, libraries, literature repositories, educated workforce, courses, intellectual property	
Basic needs (adjusted)	Are basic needs met? Water, food, security, health care, shelter, internet, *education (school ratings)* How well is each need met?	***Actors*** Local municipalities, state-owned enterprises, NGOs, national and provincial government, enterprise champions, support organisations	• Databases/mining focusing on if basic needs are met • Databases/mining on education ratings per area (school ratings/capabilities) • Interviews/surveys with actors to determine how well basic needs are met
		Institutions Laws, support programs/systems, community habits	

		Interactions Community leadership	
		Infrastructure water, internet, electricity supply, police presence, health care services, security measures (crime rate), housing	

F7: Creation of Legitimacy			
Indicators (Lee et al., 2018)	**Diagnostic questions**	**Structures**	**Data gathering**
Exposure of innovation to area	Do people in the area know about innovations? (Creation of niche markets) Are there programmes to promote development/inclusion to the innovations access?	***Actors*** Higher education institutions, research organisations, local municipalities, state-owned enterprises, NGOs, enterprise champions, support organisations	• Interviews/surveys focused on finding out if actors know about innovations, determining their exposure • Databases/mining for events in areas that showcase innovation
		Institutions University and community interaction policies, governmental innovation	

		policies, support programs/systems, community openness	
		Interactions Community leadership, knowledge access/showcase events	
		Infrastructure University building, internet, libraries, educated workforce, crowdfunding	
Demand vs Supply uncertainty of innovation	Where do an area's popular innovations exist on the demand and supply uncertainty plot	***Actors*** Consumers, enterprise champions	• Interviews/surveys with actors about innovations and their accessibility in the area
		Institutions Actors' openness to innovation, customs	
		Interactions Community leadership, knowledge access	
		Infrastructure Educated workforce, investments, grants, loans, crowdfunding	

Appendix B: Municipalities energy resilience

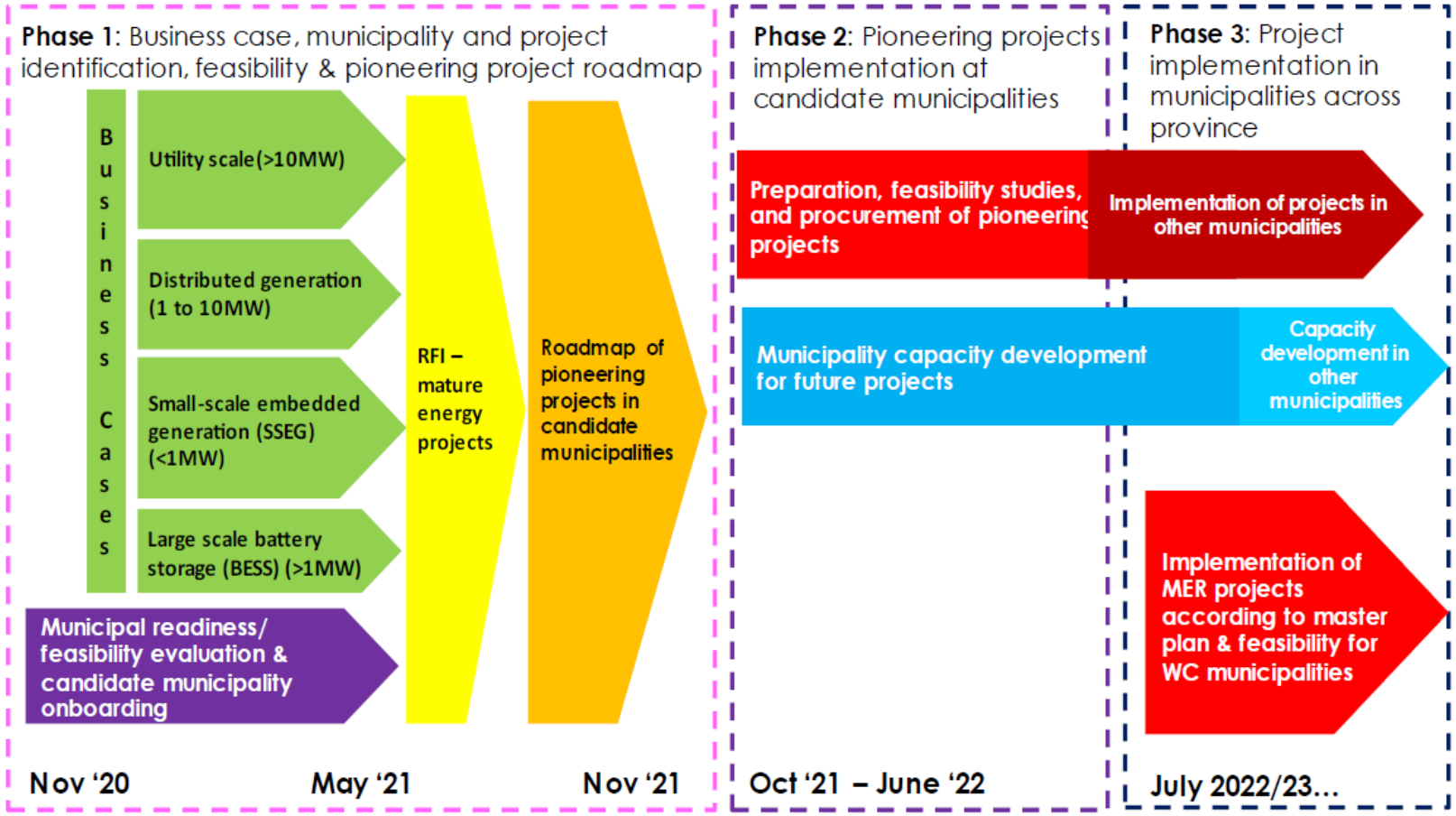

Figure B.0.1: Western Cape municipalities energy resilience initiatives

Appendix C: Municipalities waste disposal service

Table C.0.1: Waste service level per municipalities

MUNICIPALITY	BASIC REFUSE REMOVAL % (2017/2018 ANNUAL REPORTS)	BASIC REFUSE REMOVAL % (2018/2019 ANNUAL REPORTS AND LATEST IWMPS)
Beaufort West	100	100
Bergrivier	100	100
Bitou	95	88.6
Breede Valley	67	100
Cape Agulhas	100	100
Cederberg	100	100
City of Cape Town	99.9	99.2
Drakenstein	100	100
George	100	93.3
Hessequa	91	74.4
Kannaland	66	79.2
Knysna	94	93.1
Laingsburg	100	100
Langeberg	79	100
Matzikama	100	100
Mossel Bay	98.2	87.2

MUNICIPALITY	BASIC REFUSE REMOVAL % (2017/2018 ANNUAL REPORTS)	BASIC REFUSE REMOVAL % (2018/2019 ANNUAL REPORTS AND LATEST IWMPS)
Oudtshoorn	100	87.4
Overstrand	100	100
Prince Albert	100	100
Saldanha Bay	78	96.5
Stellenbosch	71	93.7
Swartland	83	100
Swellendam	88	87
Theewaterskloof	100	100
Witzenberg	100	100

Appendix D: Industries waste management service

Table D.0.1: The key waste management organisation contacts in Western Cape

Organisation	Focus of Support	Email	Website
ARO	Waste reclaimers / pickers	africanreclaimers@gmail.com	www.facebook.com/africanreclaimers
CGCSA	Retail and manufacturers	fsiservices@cgcsa.co.za	www.cgcsa.co.za
Collect-a-Can	Metal can recycling	jenette@collectacan.co.za	www.collectacan.co.za
COPCO	Compostable plastics	info@copco.co.za	–
ERA	E-waste recycling	erainfo@eranpc.co.za	www.eranpc.co.za
EWASA	E-waste recycling	info@ewasa.org	www.ewasa.org
FERTSA	Fertilizer / compost	general@fertasa.co.za	www.fertasa.co.za
IWMSA	Waste sector	info@iwmsa.org	www.iwmsa.co.za
LightCycleSA	Lighting waste recycling	info@lightcyclesa.org	www.lightcyclesa.org
MetPac	Metal packaging	info@metpacsa.org.za	www.metpacsa.org.za
ORASA	Organic waste recycling	Info@orasa.org.za	www.orasa.org.za
Packaging SA	Packaging	liza@packagingsa.co.za	www.packagingsa.co.za
PASA	Polystyrene recycling	info@polystyrenesa.co.za	www.polystyrenesa.co.za
Petco	PET beverage bottle recycling	info@petco.co.za	www.petco.co.za
PlasticsISA	Plastic sector	Karen.Wichman@plasticssa.co.za	www.plasticsinfo.co.za
Polyco	Polyolefin recycling	lisl@polyco.co.za	www.polyco.co.za
RecyclePaperZA	Paper / cardboard recycling	info@pamsa.co.za	www.recyclepaper.co.za
SABIA	Biogas	secretary@sabia.org.za	www.sabia.org.za
SAEWA	E-waste recycling	envirosense@xsinet.co.za	www.sa.ewastealliance.co.za
SAPP	Plastics	info@saplasticspact.org.za	www.saplasticspact.org.za
SAPRO	Plastic recyclers	lisa@plasticrecyclingsa.co.za	www.plasticrecyclingsa.co.za
SAWPA	Waste reclaimers / pickers	–	www.facebook.com/SAWPAZA
SAVA	PVC recycling	info@savinyls.co.za	www.savinyls.co.za
TGRC	Glass recycling	info@tgrc.co.za	www.theglassrecyclingcompany.co.za

Appendix E: Functional maturity tool

Table E.0.1: Functional maturity tool

		Indicator	Birth	Growth	Mature	Decline
F1	Entrepreneurial activity	Number of new entrepreneurs/ entrants	A low number of new enterprises. Enterprises are not innovation focused.	A rapid increase of new enterprises. Few established innovation-focused enterprises.	Continuous introduction of new enterprises. Most enterprises are innovation focused.	It is difficult for newer enterprises to compete due to too many large corporations. Enterprises do not focus on innovation.
		Private vs public sector enterprises	The sector is made up of a small number of private enterprises and is majorly made up of public enterprises.	The sector has a growing number of private enterprises that build healthy relationships with public enterprises.	The sector is majorly made up of private enterprises but works in synergy with the public enterprises present.	The relationship between private and public enterprises deteriorates. A large number of enterprises leave the system in a shake-out event.
		Number of entrepreneurs/enterprises	A low number of enterprises. Enterprises are not innovation focused.	An increased number of enterprises. Few established innovation focus enterprises.	A large number of enterprises. Most enterprises are innovation focused.	Multiple large corporations dominate the market. Enterprises do not focus on innovation.
		The entrance vs churn rate of entrepreneurs	There is a slightly higher entrance ratio	There is a continuous increase in the entrepreneur entrance	There is little to no difference between the entrepreneur entrance	There is a continuous increase in the churn rate of entrepreneurs

			than the churn rate of entrepreneurs.	ratio compared to the churn rate of entrepreneurs.	ratio and the churn rate of entrepreneurs.	compared to the entrepreneur entrance ratio.
		The intensity of competition	There is no or minimal competition in the IS. There is a small number of actors that compete.	There is increasing competition among a growing actor base. The marketplace is competitive.	There is a large amount of competition in the IS. The market is moderately concentrated.	The market is highly concentrated or is dominated by few market leaders, decreasing the intensity of competition.
F2	Knowledge development	Sources and intensity of knowledge development	Minimal or no knowledge creation occurs from sector participants. No apparent R&D efforts from enterprises.	Continuous increase of knowledge created. An academic institution in the sector's region has increasing knowledge production. A small number of enterprises are involved in producing R&D contributions.	A large amount of knowledge is constantly generated. Academic institutes produce large volumes of multi-topic knowledge. Enterprises are aiding in knowledge creation through published R&D efforts.	There is a decreasing amount of knowledge generation. The academic institute associated with the sector has a much lower output than usual. Enterprises have shifted their focus away from performing R&D.
		Who finances the knowledge development?	There is minimal or no funding for knowledge development.	There is an increasing number of well-known funding sources for knowledge development.	It is clear where to obtain private or public finances for knowledge development.	There is a decrease in the number of funding sources for knowledge development.
		Who leads research and development?	There are no leaders in research and development.	There is an increasing number of prominent leaders in research and development	There is a large number of prominent leaders in research and development	Leaders start decreasing their contributions and/ or

						start leaving the system.
		Relevance of knowledge produced	A small amount of academic knowledge produced is relevant to the sector's priorities.	A growing level of academic knowledge activity is produced relevant to the sector's priorities.	More sector-relevant knowledge is produced from academia and the private sector.	The knowledge produced has shifted focus away from the sector and is developed more for other sectors.
		Who collaborates to produce published knowledge?	There is no to minimal collaboration among actors of published knowledge.	Actors collaborating to produce published knowledge increases rapidly.	There is clear evidence of who collaborates when producing published knowledge.	Collaboration efforts among actors to produce published knowledge decrease.
		Who collaborates to produce knowledge from R&D?	There is no to minimal collaboration among actors of R&D knowledge.	Actors collaborate to produce R&D knowledge increases rapidly.	There is clear evidence of who collaborates when producing R&D knowledge.	Collaboration efforts among actors to produce R&D knowledge decrease.
F3	Knowledge diffusion	Are there partnerships or collaborations?	No clear partnerships between enterprises.	There are some collaborations among enterprises and between academic institutes.	Evident collaboration among enterprises and between academic institutes.	A decreasing number of collaborations among enterprises and academic institutes.
		How is knowledge shared?	Minimal or no knowledge diffusion attempts or events occur in the sector.	Knowledge is mainly shared unintentionally. Intentional knowledge-sharing events are increasing in the sector.	Ongoing formal events occur between various innovation-related parties related to the sector.	A decreasing number of formal events focused on previous innovations occur in the sector.
		Is the knowledge diffused relevant to the IS?	The knowledge diffused in the area has minor relevance to the	There is an increase in the efforts to diffuse	There is a high level of activity to diffuse new	Participants in the sector have shifted their focus from the

			leading sectors in the IS.	sector-relevant knowledge.	and sector-relevant knowledge.	currently diffused knowledge, decreasing its relevance.
		Who shares more knowledge?	There are no leaders in knowledge-sharing efforts.	There is an increasing number of prominent leaders in knowledge-sharing efforts.	There is a large number of prominent leaders in knowledge-sharing efforts.	Leaders start decreasing their contributions and refocusing their efforts on other innovations or sectors.
		The absorptive capacity of the IS's actors	IS actors struggle to absorb and utilise the diffused knowledge.	IS actors' ability to absorb and utilise the diffused knowledge improves.	IS actors absorb and utilise the diffused knowledge effectively.	IS actors reject the diffused knowledge as they have shifted their focus and do not absorb it anymore.
F4	Guidance of search	Do clear targets/goals exist?	No innovation-orientated sector-focused targets and goals exist.	Innovation-orientated sector-focused targets and goals are being set and achieved.	Innovation-orientated sector-focused targets and goals have been achieved in the region.	Innovation-orientated sector-focused targets or goals are not revised when met or fail to be achieved.
		Do the goals cause government involvement?	The government is not or is minimally involved with goal setting or contributing to achieving sector-focused goals.	The government is increasingly involved with goal setting or contributing to achieving sector-focused goals.	The government is steadily involved with goal setting or contributing to achieving sector-focused goals.	The government decreases its support for goal setting or contributing to achieving sector-focused goals.
		Does existing or new legislation/ regulation act as a barrier or an enabler?	Current legislation acts as a solid barrier to innovation in the IS.	Impeding legislation is relaxed, or new legislation is	Impeding legislation is minimal, or new legislation strongly	Current legislation is outdated and hinders innovation; it needs to be updated again.

				introduced to aid innovation in the IS.	aids innovation in the IS.	
		Articulation of interest by leading customers	There is minimal to no interest articulated by leading customers in the innovation system. The IS actor's demand is not apparent.	Leading customers increasingly articulate their interests showing the IS participant's demand.	It is clear what the IS's interest is and is well articulated. All actors understand each other's demands.	The interest is not articulated well, and the customer's interest has shifted to other innovations or sectors.
F5	Market formation	Are there policies or incentives for the market?	No policies or incentives exist to promote innovation or innovative related solutions.	Policies or incentives to support innovation are introduced and utilised by various entities.	The market is well-formed and self-sufficient. Policies or incentives do not significantly affect the market's growth.	The policies or incentives in place do not have any impact, and the market is beginning to decrease in size due to other markets.
		Market size of a specific sector	The sector's market is non-existent/tiny and would require work to develop.	The sector's market is snowballing and receiving increasing growth.	The sector's market has slowed but is receiving a sustaining amount of support.	The sector's market size is decreasing and needs to pivot to accept newer innovations.
		Who are the sector's market leaders?	It is not easy to identify the sector leaders. The market is still for new entrants to succeed.	Clear sector leader(s) emerge and can be easily identified. There is still space in the market for new entrants.	Sector leaders are easily identifiable; they dominate the market, making it difficult for new entrants to succeed.	The sector's market starts to lose its relevance, and the sector leaders withdraw or shift their focus from the sector.
		What lifecycle stage is the market in?	The market is a niche market and has limited structural elements.	The market is bridging and welcomes more elements. The elements find it easy to grow.	The market is mature; it is large and well-established. Structural elements are	The market is declining and is either left to phase out or

					comfortable, and there is minimal change.	renewed by aiming to grow again.
F6	Resource mobilisation	Nature of financial resources	There are few funding resources or mechanisms available.	There is an increasing number of different funding resources or mechanisms available.	There is a large variety of types of funding resources or mechanisms available.	There is a limited number of types of funding resources or mechanisms available.
		Accessibility of financial resources	Financial resources are not available or are difficult to obtain.	Financial resource access is increasingly more accessible, and investors are showing increased interest.	Established financial resources exist (i.e., established banks, venture capital firms and angel investors).	Financial resources are withdrawing their support from the sector.
		Accessibility of seed and venture capital (VC)	Seed and venture capital are not available or are difficult to obtain.	Seed and venture capital access are increasingly more accessible, and investors are showing increased interest.	Established access to seed and venture capital exists (i.e., established venture capital firms and angel investors).	Financial resources are withdrawing their support and leaving the system.
		Accessibility of infrastructure to provide basic needs (business-facing as well)	The infrastructure to meet basic needs is mediocre or non-existent.	The infrastructure to meet basic needs is improving and is accessible.	The infrastructure to meet basic needs is well-developed and stable.	No further investments into the infrastructure to meet basic needs are made, and they start to deteriorate.
		Availability of appropriately skilled workforce	There are minimal or no appropriately skilled workers available.	There is a significant increase in appropriately skilled workers to employ.	There are plenty of appropriately skilled workers in the region.	There is a decreasing number of appropriately skilled workers
		Availability of a high-skill workforce	There are minimal or no highly skilled workers available.	There is a significant increase in highly	There are plenty of high-skill workers in the region.	There is a decreasing number of high-skill workers

				skilled workers to employ.		
F7	Creation of legitimacy	Strength of resistance to change for a specific sector?	The sector's participants resist change and are not open to innovative ideologies or influences.	The sector's participants are opening up to different innovations and are starting to welcome them into their everyday lives	The sector's participants are accepting of innovative solutions and continuous change. There are plenty of examples of what innovation does for the sector. Prominent entities buy into innovation	The sector's participants are starting to lose trust in innovations and what innovation does for the sector.
		Is there recognised actor support?	There are no recognisable brands or enterprises supporting innovation within the sector.	Large enterprises are starting to support and fund innovation activities and actors within the sector.	There is consistent and committed support from recognised enterprises for innovation activities and actors within the sector.	Large enterprises are withdrawing their funds and support for innovative activities within the sector.
		Are there mechanisms to engage with the community?	There is none to a few ways for innovation-driving actors to engage with the sector's community.	There is an ever-growing number of ways to engage with the sector's community on innovation topics.	There are established mechanisms to engage with the sector's community.	Current engagement mechanisms are overused, and the sector's community shift their focus while participation decreases.
		Do actors lobby for sector support? (Are there resources or formal structures to empower	Actors do not or barely lobby for support from the appropriate support actors in the IS. There	Actors are increasingly lobbying for their required resources, legislation changes,	There is a continuous group lobbying for required resources, changes to legislation,	Lobbying groups' presence is diminished, and there is decreased lobbying activity.

		lobbying for actor support?)	are no formal processes to follow to lobby.	and goals implementation.	and implementation of goals.	Formal processes become challenging to navigate.
		Are the benefits of innovation marketed effectively?	None to a minimal effort to market innovation within the sector is performed.	The benefits of innovation are increasingly marketed and made more apparent to actors within the sector.	The benefits of innovation are marketed effectively and are understood by actors within the sector.	There is confusion regarding the benefits of innovation; some of the benefits expressed are outdated and should be revised.

Appendix F: Maturity results

Table F.0.1: Green energy maturity result

	Indicator	Source 1	Source 2	Source 3	Source 4	Source 5	Ave	Total
Function 1: Entrepreneurial Activity								
F1.1	Number of new entrepreneurs/ entrants	2	2	2	2.5	3	2.3	
F1.2	Private vs public sector enterprises	1	2	1	1.5	2	1.5	
F1.3	Number of entrepreneurs/enterprises	2	2	2	2.5	2	2.1	
F1.3	The entrance vs churn rate of entrepreneurs	2	1	2	3	2	2	
F1.5	The intensity of competition	2	2	2	2	1.5	1.9	1.96
Function 2: Knowledge development								
F2.1	Sources and intensity of knowledge development	2	2	2	2.5	2.5	2.2	
F2.2	Who finances knowledge development?	2	3	2	2.5	2	2.3	
F2.3	Who leads research and development?	2	2	2	2	2.5	2.1	
F2.4	Relevance of knowledge produced	2	3	2	2	1	2	
F2.5	Who collaborates to produce published knowledge?	3	3	2	2	1.5	2.3	
F2.6	Who collaborates to produce knowledge from R&D?	2	3	2	2	1.5	2.1	2.2
Function 3: Knowledge diffusion								
F3.1	Are there partnerships or collaborations?	2	2	2	2.5	2	2.1	

F3.2	How is knowledge shared?	3	3	3	2.5	2	2.7	
F3.3	Is the knowledge diffused relevant to the IS?	2	3	2	2	2.5	2.3	
F3.4	Who shares more knowledge?	3	3	2	2.5	2	2.5	
F3.5	The absorptive capacity of the IS's actors	2	2	2	2.5	2.5	2.2	2.36
Function 4: Guidance of search								
F4.1	Do clear targets/goals exist?	2	2	2	2	2.5	2.1	
F4.2	Do the goals cause government involvement?	3	2	3	3	2	2.6	
F4.3	Does existing or new legislation/ regulation act as a barrier or an enabler?	2	2	2	2.5	3	2.3	
F4.4	Articulation of interest by leading customers	2	2	2	2	1.5	1.9	2.23
Function 5: Market formation								
F5.1	Are there policies or incentives for the market?	2	2	3	2.5	2	2.3	
F5.2	Market size of a specific sector	2	3	2	2.5	2.5	2.4	
F5.3	Who are the sector's market leaders?	2	2	2	2.5	2	2.1	
F5.4	What life cycle stage is the market in?	2	3	2	2.5	1.5	2.2	2.25
Function 6: Resource mobilisation								
F6.1	Nature of financial resources	3	3	3	3.5	2.5	3	
F6.2	Accessibility of financial resources	3	3	3	2.5	2	2.7	
F6.3	Accessibility of seed and venture capital (VC)	2	2	3	3	2.5	2.5	
F6.4	Accessibility of infrastructure to provide basic needs	3	3	3	2	2	2.6	
F6.5	Availability of appropriately skilled workforce	2	2	2	2.5	2	2.1	

F6.6	Availability of a high-skill workforce	2	3	2	1.5	1.5	2	2.48
Function 7: Creation of Legitimacy								
F7.1	Strength of resistance to change for a specific sector?	3	2	3	2	2	2.4	
F7.2	Is there recognised actor support?	2	3	3	3	2.5	2.7	
F7.3	Are there mechanisms to engage with the community?	3	3	3	2.5	3	2.9	
F7.4	Do actors lobby for sector support?	2	2	3	2	1.5	2.1	
F7.5	Are the benefits of innovation marketed effectively?	3	2	2	2.5	2	2.3	2.48

Table F.0.2: Waste management maturity result

	Indicator	Source 1	Source 2	Source 3	Source 4	Source 5	Aveg	
Function 1: Entrepreneurial Activity								
F1.1	Number of new entrepreneurs/ entrants	2	1	2	1	1.5	1.5	
F1.2	Private vs public sector enterprises	1	1	2	1.5	1	1.3	
F1.3	Number of entrepreneurs/enterprises	1	2	1	1	2	1.4	
F1.3	The entrance vs churn rate of entrepreneurs	2	2	1	2.5	1.5	1.8	

F1.5	The intensity of competition	2	1	2	1.5	2	1.7	1.54
Function 2: Knowledge development								
F2.1	Sources and intensity of knowledge development	2	2	2	2.5	2	2.1	
F2.2	Who finances knowledge development?	3	2	2	1.5	2.5	2.2	
F2.3	Who leads research and development?	2	2	2	2.5	1.5	2	
F2.4	Relevance of knowledge produced	2	2	2	3	2.5	2.3	
F2.5	Who collaborates to produce published knowledge?	3	3	2	2	3	2.6	
F2.6	Who collaborates to produce knowledge from R&D?	3	3	3	2.5	1.5	2.6	2.3
Function 3: Knowledge diffusion								
F3.1	Are there partnerships or collaborations?	2	2	2	2	2.5	2.1	
F3.2	How is knowledge shared?	2	1	2	2.5	2	1.9	
F3.3	Is the knowledge diffused relevant to the IS?	2	2	2	2.5	2.5	2.2	
F3.4	Who shares more knowledge?	2	1	2	2	2	1.8	
F3.5	The absorptive capacity of the IS's actors	2	2	2	1.5	2.5	2	2
Function 4: Guidance of search								
F4.1	Do clear targets/goals exist?	2	2	2	2.5	2	2.1	
F4.2	Do the goals cause government involvement?	2	2	2	2	1	1.8	
F4.3	Does existing or new legislation/ regulation act as a barrier or an enabler?	2	2	2	2.5	1.5	2	
F4.4	Articulation of interest by leading customers	2	2	2	1	1.5	1.7	1.9

Function 5: Market formation								
F5.1	Are there policies or incentives for the market?	2	2	1	2	1	1.6	
F5.2	Market size of a specific sector	2	1	1	1.5	1	1.3	
F5.3	Who are the sector's market leaders?	2	1	2	1.5	2	1.7	
F5.4	What life cycle stage is the market in?	1	2	2	2	1.5	1.7	1.58
Function 6: Resource mobilisation								
F6.1	Nature of financial resources	2	1	2	1	1	1.4	
F6.2	Accessibility of financial resources	2	2	2	1	1	1.6	
F6.3	Accessibility of seed and venture capital (VC)	2	2	3	2	1.5	2.1	
F6.4	Accessibility of infrastructure to provide basic needs	2	2	2	1.5	1.5	1.8	
F6.5	Availability of appropriately skilled workforce	2	1	2	1.5	2	1.7	
F6.6	Availability of a high-skill workforce	1	2	2	1.5	1	1.5	1.68
Function 7: Creation of Legitimacy								
F7.1	Strength of resistance to change for a specific sector?	2	2	3	2.5	2	2.3	
F7.2	Is there recognised actor support?	3	3	2	2	2.5	2.5	
F7.3	Are there mechanisms to engage with the community?	2	1	2	1.5	2	1.7	
F7.4	Do actors lobby for sector support?	3	2	3	3	2.5	2.7	

F7.5	Are the benefits of innovation marketed effectively?	2	2	3	2	1.5	2.1	2.2 6