

VALUE, POWER, AND EMBEDDEDNESS IN THE SOUTH AFRICAN WIND TURBINE TOWERS MANUFACTURING SECTOR:

Implications for Industrial Policy

By
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EXECUTIVE SUMMARY

This paper explores how South Africa can leverage its renewable energy transition to promote domestic industrial development by expanding participation in wind energy production networks in ways that expand social and economic value capture, highlighting opportunities in wind turbine tower manufacturing.

Key Findings

Narrow and Asymmetrical Policy Metrics: Key South African impact reporting evaluates success through narrow and asymmetrical metrics—such as local content expenditure, B-BBEE spending, electricity generated, carbon emissions, and "job-years" — which measure progress towards an energy transition while failing to capture true technological upgrading, stable employment duration, or equitable gender distribution.

Participation vs. Value Capture: While South Africa has successfully scaled its renewable energy capacity, its domestic participation in related production networks remains limited. High-value components and functions, including technology development and product design, remain tightly controlled by foreign multinational original equipment manufacturers (OEMs). Moreover, because public procurement frameworks are historically tethered to lowest-price criteria, tenders systematically favour cheaper imported components over localized options, further reinforcing foreign network dominance.

Power Dynamics: The structural landscape of South Africa's wind global production network is shaped by an unequal distribution of power. Multinational OEMs and large project developers control networks in ways that often limit smaller South African firms' opportunities. Institutional actors govern the regulatory, policy, procurement, and financing conditions under which firms participate, invest, and upgrade, while also influencing which technologies and firms gain access to capital and shaping national priorities. These actors can support localisation and domestic capability development, but international trade rules, competing policy objectives, and financing criteria that favour established firms and short-term bankability can also reinforce existing corporate power and constrain domestic upgrading.

Collective power is exercised by business associations, coal-sector interests, trade unions, civil society organisations, and communities seeking to influence the energy transition. With objectives that can sometimes conflict, these coalitions have varying levels of influence.

Embeddedness: Value capture depends on how South African firms are embedded within production networks. Network embeddedness involves complex sets of relations that support benefits such as learning through partnerships, while also creating impediments driven by powerful actors' priorities. Territorial factors and social dynamics also shape opportunities for value capture. Stronger territorial

linkages can support skills, supplier development, and value capture, while shallow localisation may generate limited longer-term industrial benefits. Societal embeddedness entails dependence on social structures that facilitate production. These include social reproduction, much of which is carried out by women, and community relationships that can enable projects to operate. Network, territorial, and societal embeddedness can therefore create opportunities for upgrading, but they can also reproduce dependence, insecure employment, gender inequality, and unequal developmental outcomes.

Core Recommendations

The paper concludes that industrial policy must shift away from focusing on limited indicators that do not adequately capture relevant outcomes and move towards instituting broader frameworks to track long-term value retention, economic transformation, and genuine social equity:

- strengthening B-BBEE and localisation policies to support more meaningful domestic participation;
- building organisational and technological capabilities, including advanced technical skills and domestic R&D;
- targeting skills development towards host communities to support sustained local participation;
- creating more predictable and stable public-procurement pipelines to support investment by domestic firms;
- strengthening domestic and regional production linkages; and
- improving institutional coordination across the renewable energy and industrial-policy system.

Crucially, these imperatives raise fundamental questions regarding the role of the state in energy provision. How can a state maximise domestic value capture under private market structures, and how can calls for enhanced public coordination be reconciled with historical challenges in public-sector energy management?

TABLE OF CONTENTS

Executive Summary	3
List of Figures	7
List of Tables	7
List of Boxes	7
List of Abbreviations	8
1. Introduction	9
2. Methodology	13
2.1 Theoretical framework	13
2.1.1 Value	13
2.1.2 Power: corporate, institutional, and collective	15
2.1.3 Embeddedness	15
2.2 Data collection methods	16
2.3 Data analysis: mapping the GPN	16
3. The GPN for wind towers	17
4. Value	22
4.1 Value creation	22
4.1.1 Value creation: workers	22
4.1.2 Value creation: firms and financiers	23
4.2 Value enhancement	29
4.3 Value capture	33
4.3.1 Value capture: a global perspective	33
4.3.2 Value capture in South Africa	37
4.4 What does this tell us about value in South Africa's wind GPNs?	46
5. Power in wind turbine GPNs in South Africa	47
5.1 Corporate power	47
5.1.1 Technological power	47
5.1.2 Network power	48

5.1.3 Market power	48
5.2 Institutional power	49
5.2.1 The roles of public institutions	50
5.2.2 The roles of financial institutions	58
5.3 Collective power	59
5.3.1 Business associations	59
5.3.2 Coal sector interests	60
5.3.3 Trade unions	60
5.3.4 Civil society organisations	61
5.3.5 Host communities	61
5.3.6 Implications of collective power	62
5.4 What do these power relationships tell us about localisation in South Africa's wind GPNs?	63
6. Embeddedness in wind turbine GPNs in South Africa	65
6.1 Network embeddedness	65
6.1.1 Global network embeddedness	67
6.1.2 Domestic network embeddedness	69
6.2 Territorial embeddedness	70
6.3 Societal embeddedness	72
6.3.1 Labour conditions and decent work	73
6.3.2 Gender and social reproduction	74
6.3.3 Community conditions	75
6.3.4 What does societal embeddedness tell us about localisation?	75
6.4 What does embeddedness tell us about localisation in South Africa's wind GPNs?	76
7. Conclusion and recommendations	78
7.1 Localisation has expanded participation but not transformed value capture	78
7.2 Power shapes localisation outcomes	78
7.3 Embeddedness determines opportunities for upgrading	79
7.4 Localisation requires productive capabilities	79
7.5 Measuring localisation differently	79
7.6 Final reflections and implications	80
References	81

LIST OF FIGURES

Figure 1: The foundation, the blades, and nacelle	18
Figure 2: Wind turbine components and connection to the grid	18
Figure 3: Internal components of a wind turbine nacelle and rotor assembly	19
Figure 4: The GVC for key wind tower package activities	20
Figure 5: GPN of a wind turbine tower, linking activities to the actors	21
Figure 6: National Production Network for concrete and steel tower manufacturing	25
Figure 7: Wind turbine components and subcomponents	37
Figure 8: Top 15 Wind Turbine OEMs' new installations in 2024	43
Figure 9: Wind energy capacity in South Africa allocated by lead company or consortium	44
Figure 10: Main exports of onshore wind components, 2010 to 2021 (\$000s)	45

LIST OF TABLES

Table 1: Materials used in wind turbines	26
Table 2: Value capture for 2.5 MW Clipper Windpower Liberty turbine, 2008	35
Table 3: Value Capture for G8x 2.0 MW Gamesa (Spain) turbine, 2008	36
Table 4: Inputs required for REIPPPP Bid Window 5	39

LIST OF BOXES

Box 1: Challenges with measuring value capture from a South African perspective	28
Box 2: Chinese policies supporting low-cost production	34
Box 3: Strategic planning in South Africa: SAREM	40
Box 4: Chinese policies supporting low-cost production	52
Box 5: Characterising relationships in South Africa's Wind GPN	66

LIST OF ABBREVIATIONS

B-BBEE	Broad-Based Black Economic Empowerment
BEE	Black Economic Empowerment
BES	Battery Energy Storage
CIP	Critical Infrastructure Programme
COSATU	Congress of South African Trade Unions
CSO	Civil Society Organisation
CSP	Concentrated Solar Power
DWDI	Decent Work Deficit Index
EC	European Commission
EPC	Engineering Procurement and Construction
EV	Electric Vehicle
GHG	Greenhouse Gas
GPN	Global Production Network
GVC	Global Value Chain
GWEC	Global Wind Energy Council
ILO	International Labour Organisation
IPAP	Industrial Policy Action Plan
IPP	Independent Power Producer
IPR	Intellectual Property Rights
IRENA	International Renewable Energy Agency
IRP	Integrated Resource Plan
LIB	Lithium-Ion Battery
MCEP	Manufacturing Competitiveness Enhancement Programme
ODM	Original Design Manufacturer
OEM	Original Equipment Manufacturer
PPA	Power Purchase Agreement
R&D	Research and Development
REFIT	Renewable Energy Feed-in Tariff
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
RFP	Request for Proposals
RMIPPPP	Risk Mitigation Independent Power Producer Procurement Programme
SAREM	South African Renewable Energy Master Plan
SAWEA	South African Wind Energy Association
SE4ALL	Sustainable Energy for All
SETA	Sector Education and Training Authority
SEZ	Special Economic Zone
SME	Small and Medium Enterprise
UNFCCC	United Nations Framework Convention on Climate Change

1. INTRODUCTION

Since 2011, South Africa has rapidly scaled its renewable energy generation capacity in response to climate change and persistent electricity shortages. According to the South African Renewable Energy Master Plan (SAREM), “The contribution of renewable energy technologies to electricity generation (in terawatt-hours – TWh) increased from less than 1% in 2000 to almost 7% in 2022” (SAREM, 2024, 10). Much of this expansion has occurred through the Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), under which more than 6,000 MW of renewable electricity from independent power producers (IPPs) came on stream between 2011 and 2023. During this period, more than R209.7 billion poured into the sector through 92 publicly tendered projects (Siyobi, 2023).

Wind energy is playing a major role in the provision of renewable energy. In 2019, South Africa planned the addition of 14,400 MW of wind generation capacity by 2030, which would bring wind to just over 20% of the country’s total installed generation capacity (SA Government, 2019). Estimates then showed that it would require “5,000 new large wind turbines, with 15,000 blades” (Cronje, cited in Rivett-Carnac, 2022, 4). Subsequently, in 2025, South Africa’s Integrated Resource Plan (IRP) proposed a R2.23 trillion investment to add 105 GW of new capacity, including 34 GW of wind, to an existing 62.8 GW baseline by 2039.

This wind energy expansion is creating opportunities not only to increase electricity generation but also to develop domestic manufacturing capabilities and associated activities.

Yet renewable energy expansion does not necessarily translate into domestic value capture. Renewable energy projects can generate substantial local expenditure, while much of the production of renewable energy systems remains controlled by global firms. Additionally, where local firms are involved in production processes, ownership, technology, profits, and higher-value productive capabilities may still remain concentrated outside South Africa.

These potential outcomes raise an important industrial policy question: under what conditions can renewable energy expansion contribute to domestic industrial development and significant domestic value capture, rather than simply increasing South Africa's participation in production networks dominated by foreign firms? Answering this requires questioning the roles of the state, considering how it can intervene to maximize value capture and how such strategies can be reconciled with a troubled history of public electricity management. Navigating this unresolved tension remains a central debate within the political economy of the transition.

To address these issues, the paper examines global production networks (GPNs), focusing on how value is created, enhanced, and captured and how these processes are shaped by corporate, institutional, and collective power, as well as by firms' network, territorial, and societal embeddedness. A distinction between participation, value creation, value enhancement, and value capture is central to the paper. Value capture is a crucial aspect because it shows how South Africa benefits from participation. However, value capture is difficult to assess because it can be measured in different ways. South

African government reports frequently evaluate localisation through indicators such as local content expenditure, procurement spending, numbers of participating firms, employment (measured in “job years”), and installed generation capacity. While these indicators provide important information about the scale of activity, they obscure critical long-term outcomes, such as whether domestic firms are acquiring technological capabilities, moving into higher-value functions, or retaining profits and ownership. Moreover, this narrow measurement framework fails to capture the true duration and stability of employment, alongside vital distributional dimensions like job quality and gender equity.

The paper argues that assessing the developmental contribution of renewable energy manufacturing requires a more refined understanding of value and of how value is created, enhanced, and captured in GPNs. A GPN perspective is particularly useful because it expands attention from the location of production (whether it is located within national borders) to the relationships, power structures, and embedded contexts through which value is generated and distributed. It allows the analysis to examine how productive activities, technology, and knowledge are controlled and how this shapes who captures economic and social value.

This paper asks a series of questions:

- How is value in the production networks of wind turbine towers created, enhanced, and captured?
- What are the power dynamics and relationships shaping the nature of localisation?
- How do firms’ forms of embeddedness (in networks, territories, and societies) shape their localisation outcomes?
- What are the implications for industrial policy aimed at strengthening localisation, decent work, and gender equity?

While opportunities for increased localisation may exist across wind energy production networks in South Africa, this paper focuses specifically on wind tower manufacturing, because South Africa already possesses important productive capabilities in this segment and the bulky nature of these components creates economic incentives for production to occur close to installation sites. Wind towers therefore represent a particularly promising and realistic entry point for domestic industrial upgrading and value capture.

Expanding domestic production could generate substantial employment, strengthen domestic manufacturing capabilities, improve the balance of trade through import substitution, reduce dependence on foreign suppliers, and create greater opportunities for decent work and inclusive industrial development. However, existing productive capabilities and localisation opportunities do not automatically translate into domestic value capture. The way production networks are structured and the power and institutional relationships within them will determine whether these potential benefits are realised.

South Africa provides an important case through which to examine the localisation of renewable energy manufacturing and its implications for decent work and gender equity. It is the African country most dependent on coal for electricity generation and consequently the continent’s highest greenhouse gas (GHG) emitter, ranking 15th globally (Eberhard, 2011; Statista, 2024). This makes it one of the countries facing the greatest risks and opportunities associated with the energy transition, particularly

in terms of energy capacity losses if renewable energy sources fail to meet demand and job losses if fewer jobs are created than are lost in the coal industry.

South Africa also has the continent's most advanced renewable energy generation and procurement programme, making it a particularly useful case for observing how industrial policy, public procurement, and localisation strategies influence production networks over time. At the same time, the country's widespread unemployment, poverty, and inequality, deeply rooted in its apartheid history (ESI Africa, 2024), make the transition politically and socially contested (Cock, 2011, 2018; COSATU, 2011; Lawrence, 2020; NUM, 2023).

As Africa's largest economy, developments in South Africa have implications well beyond its borders, through regional trade, investment, manufacturing, and energy linkages, particularly in the Southern African Development Community (SADC) (see UNECA, 2025). Furthermore, the country's prolonged experience of electricity shortages and widespread blackouts since 2007 provides an important setting for examining whether renewable energy expansion resolves or compounds existing energy deficits (Bloomberg, 2024; Erero, 2023; Malange, 2023). Consequently, although this paper focuses on South Africa, the findings contribute more broadly to debates on how African countries can leverage renewable energy transitions to promote localisation, industrial development, decent work, and gender-equitable outcomes.

This paper forms part of the Institute for Economic Justice's [Advancing a Just Energy Transition: Localisation, Decent Work, and Sustainable Livelihoods](#), which is investigating the opportunities and challenges for localisation and structural transformation, decent work, gender equality, and sustainable livelihoods related to renewable energy in Africa. The findings of this paper contribute to debates on the socio-economic implications, particularly for workers and nearby communities, of the transition from a fossil fuel-based economy to one powered by renewable energy (Cock, 2011; COSATU, 2011; Hanto et al., 2021; Lawrence, 2020; NUM, 2023). This paper also contributes to literature on localisation and local content requirements (Ettmayr and Lloyd, 2017; Leigland and Eberhard, 2018; Morris et al., 2020). Drawing on an extensive review of existing literature, the paper also builds on studies examining the localisation of technological capabilities in renewable energy component manufacturing (Baker and Sovacool, 2017; Fu and Zhang, 2011; Lewis, 2007; Zhang et al., 2015).

The paper makes two related contributions. First, it highlights the importance of moving beyond narrow localisation indicators towards a more differentiated assessment of domestic value creation, enhancement, and capture. Second, it uses a GPN lens to identify the power relations and forms of embeddedness that shape whether opportunities for localisation translate into meaningful domestic industrial upgrading and value capture. In doing so, it speaks directly to the objectives of SAREM, which provides the blueprint for the development and growth of the renewable energy and battery storage industry in South Africa (SAREM, 2024).

This paper is structured as follows. Section 2 explains the methodology, describing the theoretical framework, the data collection methods, and the process used for mapping activities and actors in the global value chain (GVC) and then maps the GPN for the South African wind turbine industry. Section 3 first maps the activity focused GPN (incorporating activities and actors) for wind turbine tower manufacturing in South Africa. Building on this foundation, Section 4 examines processes of

value creation, enhancement, and capture, including a critical assessment of how localisation and value are currently measured in South African policy. Section 5 analyses GPN power dynamics, exploring corporate, institutional, and collective power. Section 6 goes on to look at how actors in the South African wind turbine GPN are embedded in network, territorial, and societal locations. Finally, Section 7 draws together the main conclusions from the paper, providing recommendations for the development of robust industrial policy that supports localisation, decent work, and gender equity in South Africa's wind energy production networks.

2. METHODOLOGY

This section outlines the theoretical framework underpinning this paper. It then explains the methods used for data collection and analysis.

2.1. Theoretical framework

This paper uses the GPN framework to understand how complex networks and global connections shape opportunities for manufacturing in South Africa (Henderson et al., 2002). From this perspective, a GPN is “the nexus of interconnected functions, operations and transactions through which a specific product or service is produced, distributed and consumed” (Henderson et al., 2002, 445). This nexus involves “interconnected nodes and links extend[ing] spatially across national boundaries and, in so doing, integrat[ing] parts of disparate national and subnational territories” (Coe et al., 2008, 274). The GPN centres on three main concepts — value, power, and embeddedness — around which this paper is structured.

2.1.1. Value

Value is multi-faceted concept with economic and social dimensions. Economic value refers to both the surplus created by labour and the various forms of economic rent generated, enhanced, and captured in the production process. Henderson et al. (2002) theorise value in GPNs through two complementary perspectives: the Marxian understanding of surplus value — the value produced by workers beyond that required to reproduce their labour power — in combination with the orthodox concept of economic rents — returns above the normal level earned by the owners of the means of production arising from advantages associated with participation in production networks.

This paper conceptualises the creation of economic value as the process of mobilising real resources to produce commodities and facilitate capital accumulation (Mezzadri, 2021). Within this framework, value creation is shaped by how resources are combined and deployed under particular conditions of production. The resulting rents can include those arising from technological, organisational, relational, brand, or policy advantages (Henderson et al., 2002).

Value creation can also have social dimensions. In this paper, social value refers particularly to the employment and broader benefits generated through participation in production networks, including the quantity and quality of employment, opportunities for skills development, supporting local enterprise development, reducing inequalities between social groups, reducing environmental degradation, generating electricity and other benefits that may go to workers, households, and communities. The paper consequently examines value creation in terms of both the economic activities undertaken in wind energy production networks and the social value generated through those activities.

Importantly, however, value creation in a production network does not necessarily mean that the value generated is retained in the location where production occurs. Distinguishing between value creation, value enhancement, and value capture makes it possible to assess not only whether South Africa participates in wind energy production, but also whether participation strengthens domestic productive capabilities and increases the share of value retained in the country.

Value creation occurs through multiple activities carried out by different actors across a GPN. In the South African wind energy production network, key activities include the production of raw materials and components, manufacturing, transport and logistics, project development and procurement, construction and installation, operations and maintenance, and end-of-life decommissioning and recycling. Workers create value through their labour, while firms and financiers mobilise capital, technology, knowledge, and organisational capabilities to undertake and coordinate these activities. The extent to which these activities generate domestic value depends on where they are located, the capabilities involved, and the extent of domestic participation in the production network. Within this process, organisational capabilities can be a crucial lever, understood as “the ability of an organization to perform a coordinated set of tasks, utilizing organizational resources, for the purpose of achieving a particular end result” can be crucial within this process (Helfat and Peteraf, 2003).

Value enhancement refers to the process through which firms and workers build capabilities and upgrade their activities in GPNs. It can involve the acquisition and application of technology and knowledge at both firm and worker level, shaped by relationships in GPNs (Henderson et al., 2002). Technological upgrading can lead to product or process upgrading, where a firm improves its competitiveness within its position in the current production network, or to functional upgrading that involves moving into new activities. Value enhancement is not simply a matter of adopting new technologies; it entails accumulating capabilities that can enable domestic firms and workers to undertake more sophisticated activities and potentially capture a greater share of the value generated in the GPN.

However, improvements in productive capabilities and economic upgrading do not automatically translate into improved social outcomes. Economic upgrading may occur without corresponding improvements in employment quality, wages, working conditions, or the distribution of benefits. The relationship between economic and social upgrading is therefore an important consideration when assessing whether value enhancement contributes to broader developmental outcomes (Barrientos et al., 2011).

Finally, Henderson et al. (2002) conceptualise value capture as the extent to which value created in a particular location is retained there and used for the benefit of local people. At stake here is the distribution of profits, rents, interest, wages, and taxes at multiple levels: between domestic and global firms and financiers; between firms and the state; between firms and workers; and within households (IEJ, 2026). Value capture is therefore multidimensional and cannot be adequately assessed through a single indicator. Relevant indicators include ownership, profits and rents, value added, wages and employment, job distribution, job quality, tax revenues, the geographical location of production, the domestic sourcing of inputs, and impacts on local communities. These indicators capture different dimensions of where value is retained and who benefits from participation in a GPN.

Ownership is particularly important because domestic value capture may occur through both domestically owned private firms and state-owned enterprises. Domestic ownership can increase the potential for profits, strategic control, and other forms of value to be captured and retained in South Africa, but ownership alone does not establish who ultimately benefits from that value. The distribution of profits, wages, taxes, and other benefits therefore remains important regardless of whether value is captured initially by domestic firms or global firms. Ownership should therefore be understood as one important dimension of value capture rather than as a proxy for its distributional outcomes.

While an ideal measure of economic value capture would benefit from data on individual firms and other stakeholders, data available for the South African wind energy sector does not allow for this level of analysis. The paper therefore uses a pragmatic, multidimensional approach based on available evidence, including ownership structures and trade and import data. Given the limitations of the available data, these metrics provide an indicative rather than comprehensive measure of value capture, yet they offer a more refined assessment than measures of localisation based solely on total expenditure or local content spend. Assessing the distribution of social value likewise requires systematic data on who benefits from the social opportunities, such as employment generated through participation in GPNs. This paper begins to explore this dimension by examining who gains access to jobs created in South Africa's wind energy production network.

2.1.2. Power: corporate, institutional and collective

From Henderson et al.'s (2002) perspective, there are three sources of power. The first is corporate power, which refers to the capacity of a lead firm to “influence decisions and resource allocations — vis-à-vis other firms — decisively and consistently in its favour” with (Henderson et al., 2002, 450). The second is institutional power, which is held by the state, international state agencies, UN agencies, credit rating agencies, and financial institutions. Institutional power refers to the influence of these actors on decision making in GPNs. The third is collective power, which is exercised by collective actors, such as trade unions, employer associations, and human rights organisations. Collective power involves the capacity of these actors “to influence companies at particular locations in GPNs, their respective governments and sometimes international agencies” (Henderson et al., 2002, 451).

These three sources of power have wide-ranging impacts, including influence over decisions, the allocation of resources, the distribution of value capture, and the growth and upgrading of local firms in GPNs. Power relations are therefore central to understanding whether participation in renewable energy production translates into domestic value capture, or whether value, technology, and strategic control remain concentrated among more powerful firms and institutions.

2.1.3. Embeddedness

According to Henderson et al. (2002, p. 451), embeddedness refers to a firm's “social and spatial” connections “which influence their strategies and the values, priorities, and expectations of managers, workers, and communities alike”. Specifically, this relates to “the institutional fabrics and social and cultural contexts” of the firm's country of origin (p. 451). Embeddedness significantly shapes the strategies, relationships, capabilities, values, priorities, and expectations of various actors in the GPN.

From a GPN perspective, a key form of embeddedness is network position, which describes “the degree of connectivity within a GPN, the stability of its agents’ relations and the importance of the network for the participants” (Henderson et al., 2002, 452). A second form of embeddedness is territorial; this refers to how firms “absorb, and in some cases become constrained, by the economic activities and the social dynamics [within] places” (Henderson et al., 2002, 452). State policy and the legal frameworks of host countries are key drivers of territorial embeddedness. Finally, a third form is societal embeddedness, which involves an actor’s cultural and political context (Hess, 2004). In exploring societal embeddedness, this paper is interested in firms’ historical and cultural linkages to societies and households (IEJ, 2026).

Assessing these three forms of embeddedness is useful for understanding the contexts that investors face as they come into South Africa and how South African manufacturers participate and upgrade within GPNs. It elucidates: within GPNs. It also elucidates the conditions shaping domestic value creation, enhancement, and capture. It therefore helps explain why similar forms of participation in renewable energy production may generate different outcomes for domestic firms, workers, and communities.

2.2. Data collection methods

This paper draws on an extensive review of existing academic and policy literature, along with trade data, to build an understanding of the state of play in the wind turbine tower component-manufacturing sector. However, the scarcity of empirical literature on this still-emerging sector provided a challenge. Data collection therefore required some innovation and creativity.

The review adopted a broad search strategy to address these gaps, drawing on peer-reviewed research covering other countries, related sectors such as solar PV, and related themes. It also drew on non-peer-reviewed literature such as policy documents, laws and regulations, reports, conference papers, industry experts’ publications, newspapers, working papers. To expand the scope of the search, the reference lists of relevant publications were examined to identify additional sources and further searches were conducted through Google Scholar. The theoretical framework was then used to interpret and analyse this material (Willig, 2017). Together, these data collection methods helped to build a broad evidence base for the analysis, in the light of the limited empirical literature available (see, for example, Mahood et al., 2014).

2.3. Data analysis: mapping the GPN

In applying the theoretical framework to the case study, this paper sought to map the GPN of wind tower manufacturing in South Africa. The paper first identifies the GVC, considered as the productive core of the GPN, using an approach that traces the key activities involved in the production of wind turbine towers. The paper then links these activities to the various actors involved to map the wider GPN. These included: GPN. These included firms, as well as state and other institutional actors, financiers, workers, and communities. Identifying these network structures facilitated an exploration of how value dynamics, power, and embeddedness shape the potential for domestic value creation, enhancement, and capture in South Africa’s wind turbine tower production network.

3. THE GPN FOR WIND TOWERS

Wind farms comprise multiple wind turbines installed at suitable sites on land or offshore. To date, all utility-scale wind farms in South Africa have been developed onshore. Most have been developed by IPPs under the REIPPPP, through which IPPs enter into long-term power purchase agreements (PPAs) to sell electricity to Eskom, South Africa's state-owned electricity utility.¹ IPPs typically appoint engineering, procurement and construction (EPC) contractors to manage the construction of wind farms. EPC contractors oversee site development and coordinate civil, electrical, and mechanical works, engaging subcontractors for activities such as earthworks, foundations, roads, electrical infrastructure, and turbine installation. They also procure, or coordinate the procurement of, wind turbine systems from original equipment manufacturers (OEMs), such as Vestas, Siemens Gamesa, Goldwind, and GE Vernova. These project developers act as lead firms in GPNs, coordinating the design, manufacture, sourcing, and integration of wind turbine systems.

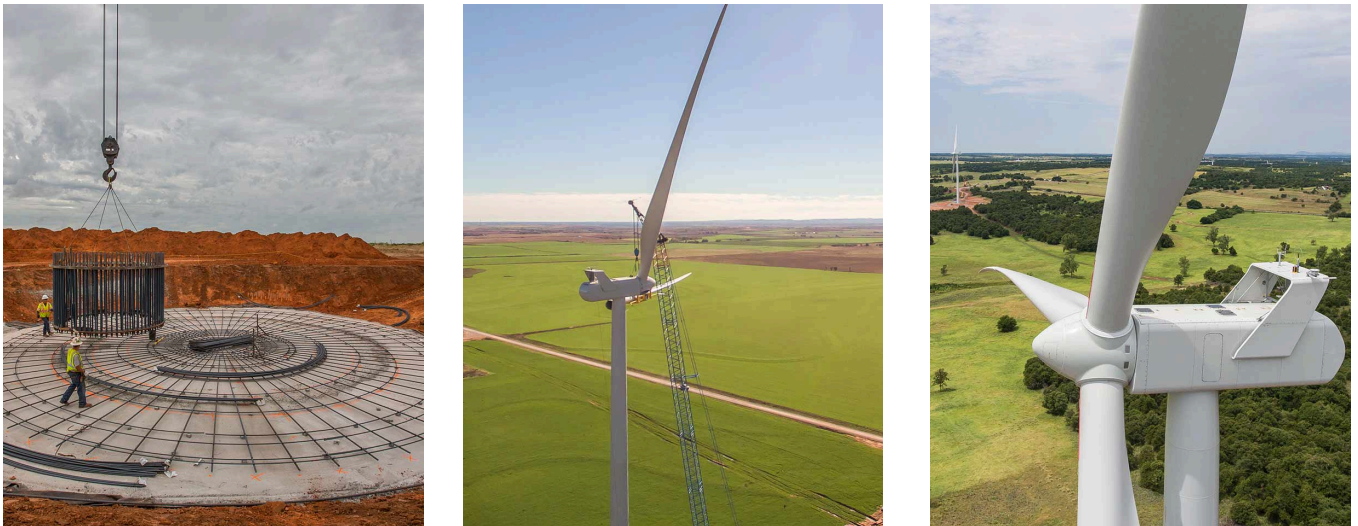
As displayed in Figures 1, 2, and 3, wind turbine systems involve multiple components:

- The foundation is made from a mixture of concrete and steel, which supports the turbine, enabling it to withstand wind loads.
- The tower, mounted on the foundation, comprises three subsections: the base section connects to the foundation; the middle section, which is the longest part, houses internal subcomponents; and the top section holds the nacelle and rotor. The tower houses cables that connect the nacelle to the transformer on the ground. Unlike the other smaller components, assembly of the tower happens onsite due to its weight and height: towers are about 120 metres high and weigh up to 2,500 tonnes.
- The nacelle houses the wind turbine's main mechanical and electrical components, including the gearbox and generator.
- The rotor looks like an airplane propeller and consists of the blades, with the hub at its centre.
- The blades capture the wind's energy, causing the rotor to turn and drive the generator, which produces electricity.

These components are produced through interconnected activities that extend across multiple firms, locations, and stages of production. The organisation of these activities provides the basis for mapping the GVC and identifying the actors involved in the wider GPN.

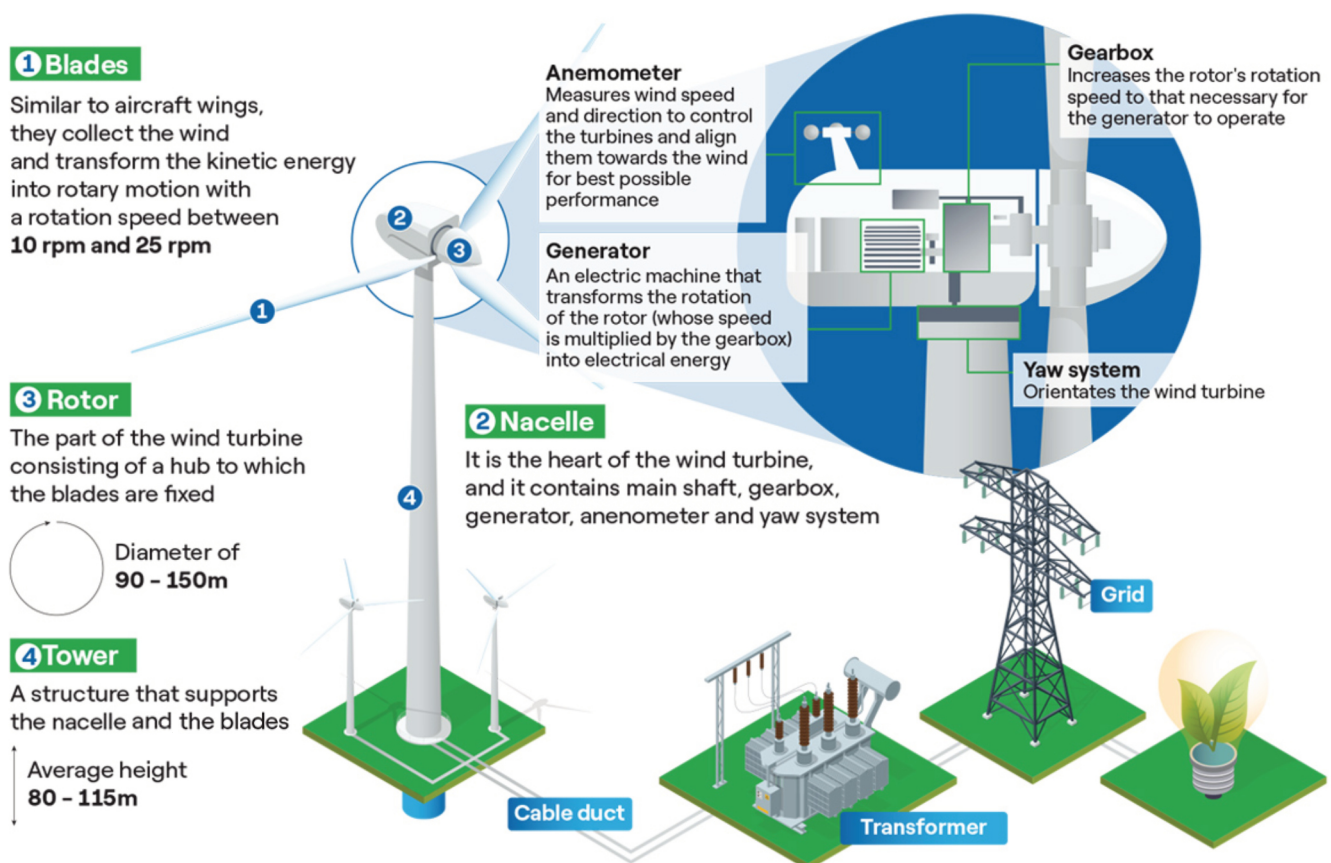
¹ In addition, Eskom has built the Sere Wind Farm, and some other actors have developed research, demonstration, and private turbines. However, the focus of this paper is on IPP-managed projects as these comprise the overwhelming majority of wind capacity installed in South Africa.

Figure 1: The foundation, the blades and nacelle



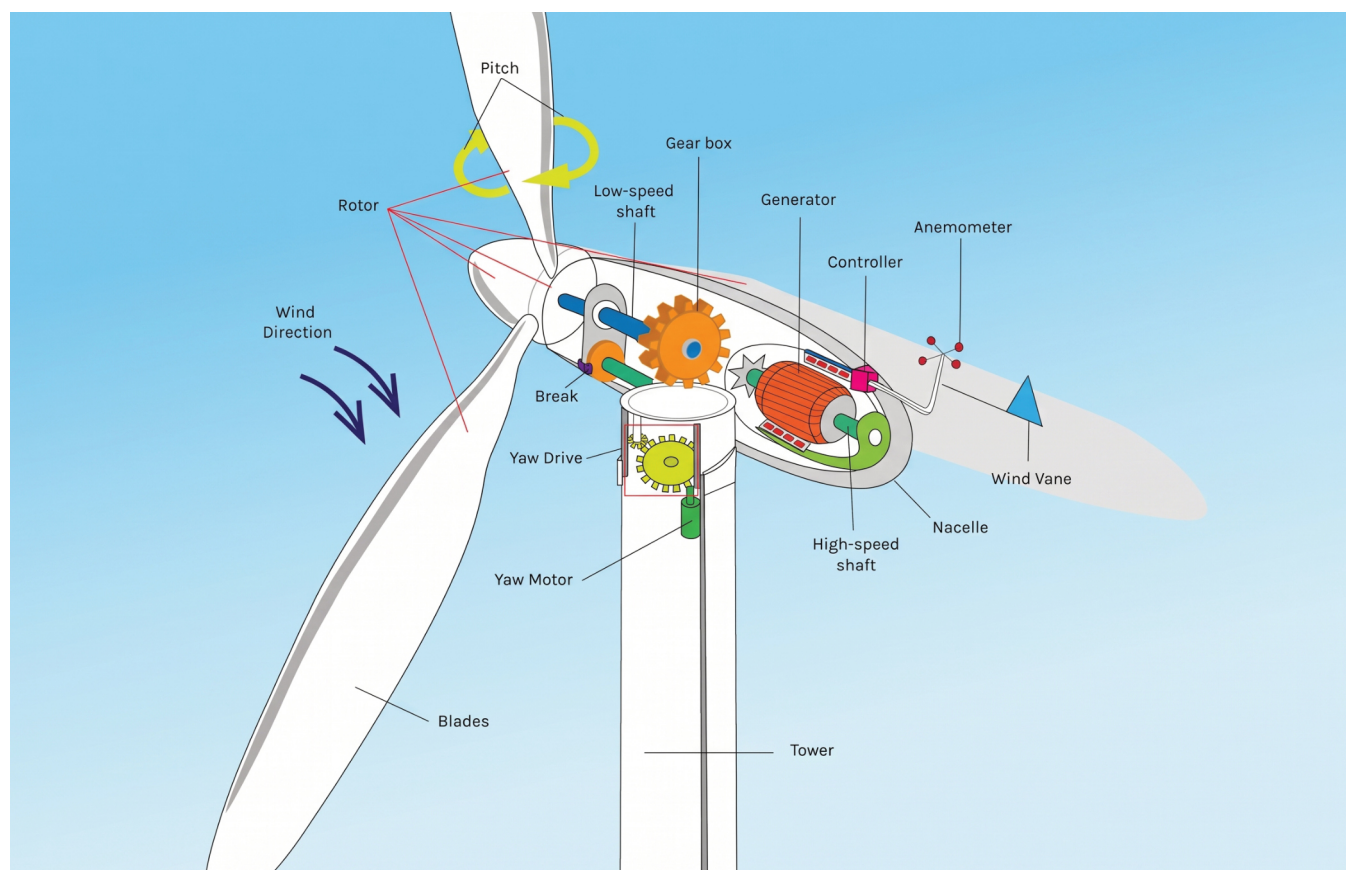
Source: Enel Green Power, undated

Figure 2: Wind turbine components and connection to the grid



Source: Enel Green Power, undated

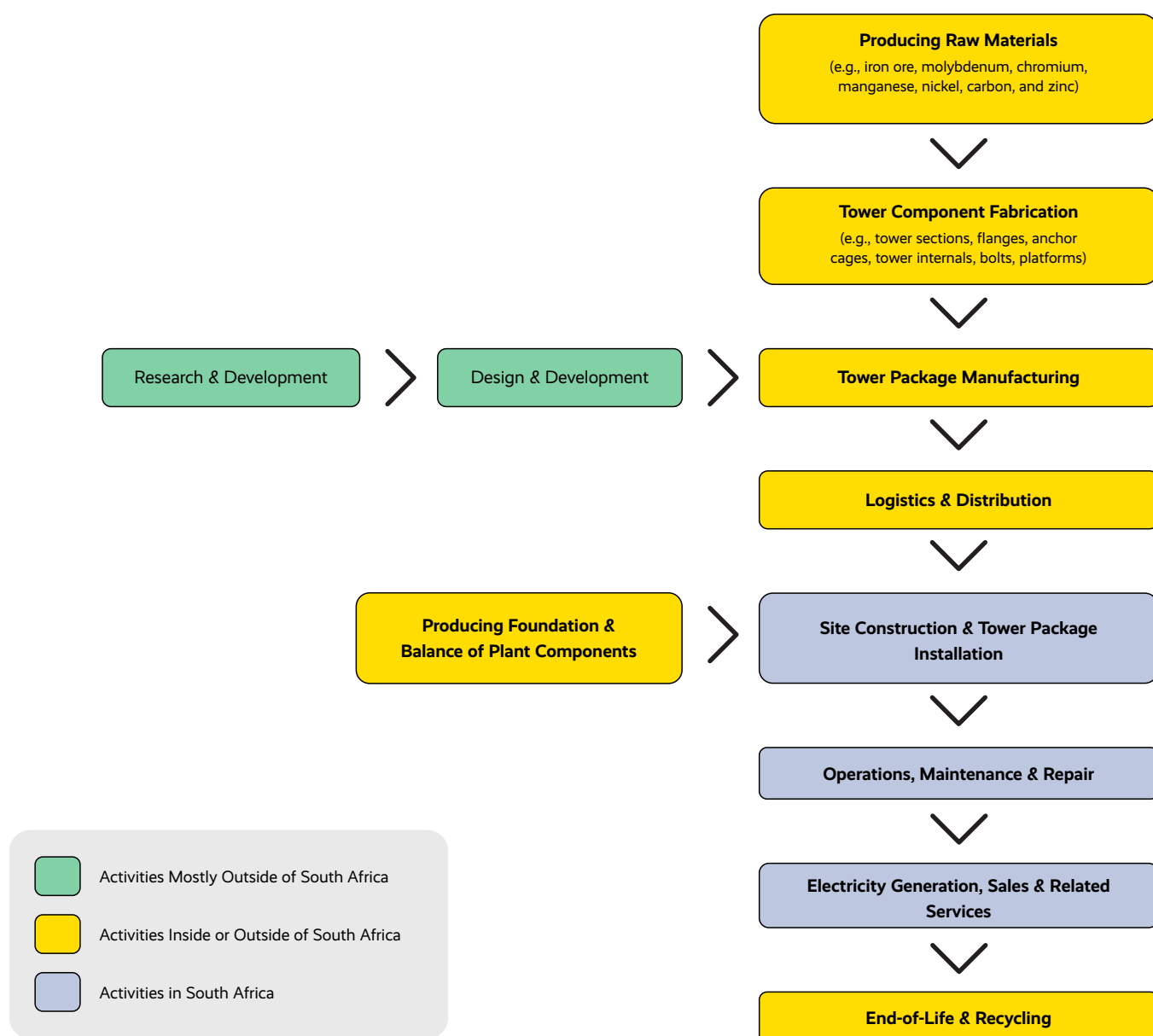
Figure 3: Internal components of a wind turbine nacelle and rotor assembly



Source: Lipták, 2025

Given their high localisation potential, this paper focuses on the production of wind towers. A set of key activities can be seen as making up the value chain of the wind tower package, which includes the tower sections together with associated components such as the anchor cage and tower internals. Many of these activities — including research and development (R&D), design and development, raw material and input production, component manufacturing, the production of building materials, and disposal and recycling — can take place outside South Africa (see Figure 4). The existing location of these activities therefore provides an important starting point for assessing the scope for localisation and domestic industrial development. Their location has important implications for value creation, enhancement, and capture; power relations; and the embeddedness of the actors discussed in subsequent sections of this paper.

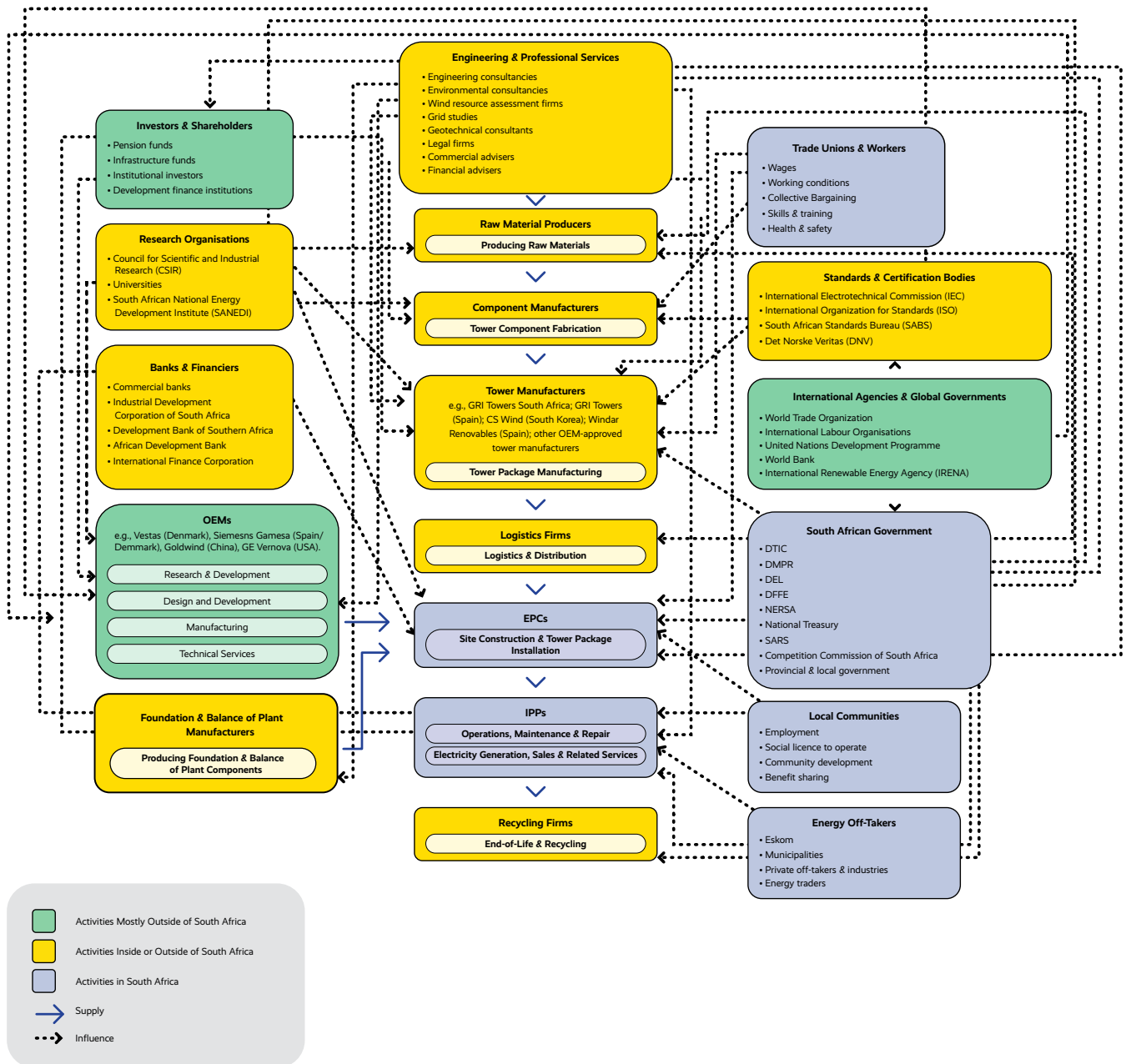
Figure 4: The GVC for key wind tower package activities



Source: author's construction, drawing from Rivett-Carnac (2022) and SAREM (2024)

Moving from the core GVC activities to the broader GPN facilitates an examination of the wide set of actors that shape how and where these activities occur (see Figure 5).

Figure 5: GPN of a wind turbine tower, linking activities to the actors



Source: author's construction

The GPN includes actors directly involved in the commercial buyer-supplier relationships that produce the wind turbine system (actors with “supply” arrows in Figure 5), such as OEMs, IPPs, and manufacturers of different components and subcomponents. Some of these actors are global, while others are based in South Africa. Production of wind tower packages combines locally produced and imported inputs. European and Chinese firms often undertake the R&D, design and development, and some manufacturing, especially of steel towers. Concrete towers, on the other hand, due to their bulky nature, create strong economic incentives for local manufacturing near the wind farms.

A variety of domestic and global actors outside the commercial core also support and shape how and where production activities occur. These include South African actors such as trade unions and

workers, the government, local communities, and energy off-takers. Other actors are predominantly global, including investors and shareholders, international agencies, and foreign governments. Finally, some actors can be based anywhere, including engineering and professional services companies, banks and financiers, research organisations, and standards and certification organisations. Mapping these actors and their relationships provides the basis for examining how power and embeddedness shape the organisation of production and the prospects for localisation. Each actor's more specific roles: localisation. Each actor's more specific roles are discussed in Sections 4, 5, and 6.

Overall, the mapping demonstrates that, although South Africa participates in multiple stages of the wind tower production network, domestic participation remains concentrated in limited elements of manufacturing and project-delivery activities. While the mapping shows a generalised GPN structure, there are important differences between tower types. Concrete tower production has established a stronger domestic foothold, while steel tower manufacturing has faced greater challenges from competition from imported towers and steel inputs. The mapping identifies existing areas of both high and low domestic participation.

However, participation alone does not establish the developmental contribution of these activities. The following section examines how value is created, enhanced, and captured across the wind tower GPN, and considers what this means for South Africa's industrial development.

4. VALUE

A key question is the extent to which current and potential wind tower production in South Africa can generate benefits for: A key question is the extent to which current and potential wind tower production in South Africa can generate benefits for the local economy and population. This section considers how value is created, enhanced, and captured in tower package manufacturing in South Africa.

4.1 Value creation

As already noted, economic value refers to the surplus created by labour and the various economic rents, and value creation involves the mobilisation and utilisation of various resources (labour and capital) to produce a commodity and ultimately profits and wealth. Alongside this economic dimension, value creation also encompasses a social dimension, which refers to employment levels and quality, skills development, and broader developmental benefits generated through participation. While economic rents typically arise from technological, organisational, or policy advantages, social value is fundamentally determined by the structural terms under which these firm activities are coordinated. For this paper, an important question is where these resources and activities are even though: located, even though production in South Africa does not necessarily mean that the associated value is domestically captured.

In the South African wind energy GPN, these diverse assets are deployed across a lifecycle ranging from the production of raw materials and components to manufacturing, construction, logistics, project development, operations and maintenance, and end-of-life activities. The opportunities for domestic economic and social value creation vary considerably across these activities. The following sections first consider value creation for workers and then for firms and financiers.

4.1.1. Value creation: workers

Wind energy production creates social value for workers through employment across manufacturing, construction, logistics, installation, and related activities. However, the quantity and quality of employment vary considerably across the production network. Employment in construction tends to be short-term and project-based, while manufacturing and operations and maintenance can provide opportunities for longer-term employment. The creation of employment therefore represents an important form of social value, but its developmental significance depends on the type of employment created and whether it provides opportunities for skills development and longer-term economic security.

More specifically, in concrete and steel tower manufacturing, employment and economic activity are generated through the involvement of various categories of workers in steel and concrete manufacturers; cement, sand, and stone suppliers; and transport and logistics service providers. Workers also contribute

to building tower sections. This includes drying, testing and certification, loading, constructing foundations, and installing and commissioning. From 2014 to 2024, the South African wind sector created more than 23,000 job-years (SAWEA, 2024; Roebeck, 2024).

Sustaining employment in tower manufacturing requires continued wind farm construction projects. Once wind farms have been commissioned, very few workers are required for maintenance, service, and repair. An additional and important factor shaping levels of employment is the way that construction projects are commissioned. In South Africa, the stop-start nature of government tenders through the REIPPPP has further contributed to precarious employment in this sector. During periods of waiting for the next procurement cycle, wind farm construction and the production of the necessary components can stall.

A typical South African example is the collapse of DCD Wind Towers. The closure of the R300 million, state-of-the-art manufacturing plant in the Eastern Cape was due to lack of demand during the suspension of the REIPPPP; it led to the loss of hundreds of jobs (MyBroadband, 2020). This illustrates that domestic production capacity can generate social value through employment, but the durability of this value depends partly on the stability of demand and procurement.

4.1.2. Value creation: firms and financiers

Firms and financiers contribute to value creation by mobilising the capital, technology, knowledge, and organisational capabilities required to undertake activities across the wind energy production network. Over the last ten years, the South African wind sector has attracted R89 billion of investment (Roebeck, 2024; SAWEA, 2024). This investment has supported activities ranging from R&D, design, and component manufacturing to project development, construction, logistics, operations and maintenance, and end-of-life activities. Through these investments, firms and financiers enable the combination of financial, technological, organisational, and productive resources necessary to transform wind resources into commercially viable energy projects.

The scale of South Africa's wind sector is significant. According to recent estimates, South Africa boasts more than 30 utility-scale wind farms, accounting for 10,450 GWh of electricity generated and available for distribution (5% of the total in 2024 and about 30% of the 9 GW of installed wind energy capacity on the continent) (Ndlovu, 2024; Stats SA, 2026). These figures demonstrate the scale of investment and productive activity in the sector, but the extent to which value is created domestically depends on where activities are undertaken, the capabilities required to perform them, the extent of local participation, and the relationships established between domestic firms and global actors.

Expenditure data is, however, useful to help to identify where significant economic activity occurs and therefore where opportunities for greater domestic value creation may exist. In the construction of wind farms, for example, wind turbine manufacturing and transportation can account for up to 75% of project expenditure, with the remaining expenditure allocated to construction, grid connection, site development, and other activities (Dedrick and Kraemer, 2011). The analysis below examines how firms and financiers create value through their participation in these activities, and which activities provide opportunities to strengthen domestic productive capabilities and expand domestic value creation.

Research and design

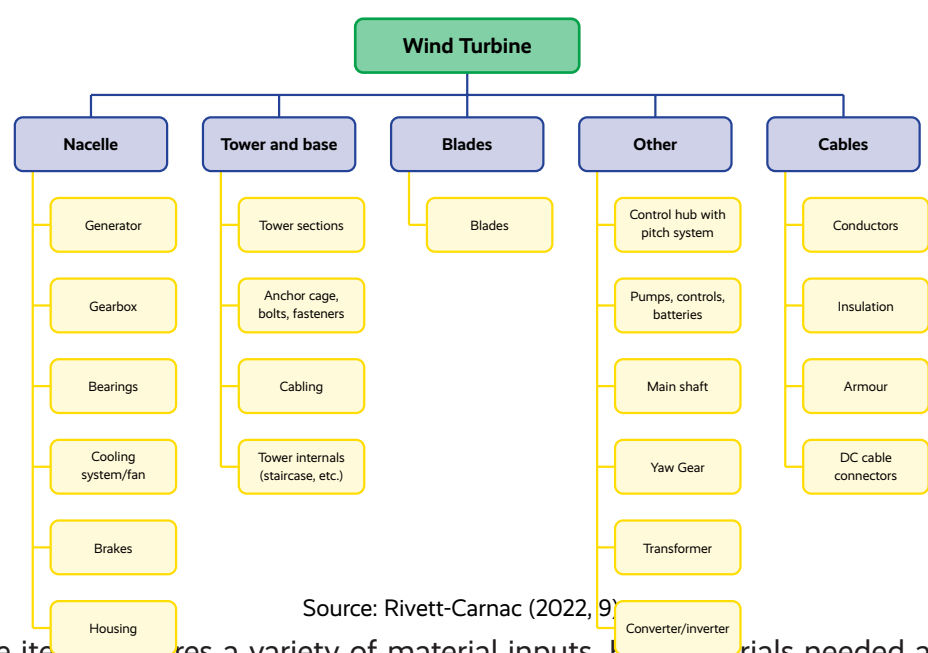
Value creation typically begins with R&D, which involves highly skilled jobs and generates technological innovations and incremental improvements in wind energy technologies. These innovations are subsequently translated into commercially viable products through design and development. Both of these stages are often carried out by OEMs. These stages involve highly skilled expertise and, as indicated in Figure 5, typically take place outside of South Africa. In some cases, OEMs license their intellectual property, engineering designs, or manufacturing specifications to other manufacturers, such as South African tower manufacturers.

In the case of towers, the design takes the form of specifications, drawings, material requirements, and instructions that guide tower package production in South African factories. Consequently, although tower package manufacturing may be localised, much of the highest-value knowledge creation and product design remain concentrated in global OEMs. This illustrates why measuring localisation through expenditure or the physical location of manufacturing alone can obscure where higher-value capabilities are created.

Inputs and component manufacturing

To understand value creation through activities in tower production networks, it is important to look at component, subcomponents, and materials. According to Dedrick and Kraemer (2011), there are more than 8,000 subcomponents in a wind turbine. Figure 6 shows major components and subcomponents.

Figure 6: Wind turbine components and subcomponents



Source: Rivett-Carnac (2022, 9)

Producing these items requires a variety of material inputs. Key materials needed are summarised in Table 1. Wind turbine manufacturing is material-intensive, capital-intensive, and requires varying

levels of labour, creating significant opportunities for industrial job creation across a wide range of raw materials and component parts.

Table 1: Materials used in wind turbines

Material	Use
Concrete	Concrete is essential for foundations and tower sections.
Steel	Steel and stainless steel are used in the manufacture of several components, including the tower, nacelle, rotor, and foundation.
Plastic	Polymers are used in the wind turbine and additionally, together with aluminium, copper, and steel, in the production of cables.
Carbon-fibre	Composite materials are primarily used in the construction of the blades, the nacelle, and the hub cover. The main materials used in the blades are carbon fibre and woven glass fibres infused with epoxy resin; the nacelle cover is made from fibreglass, which consists of woven glass fibres, polyethylene, and styrene.
Aluminium	Aluminium is used in the turbine tower and nacelle and in the production of cables.
Copper	Copper is predominantly used in the coil windings in the stator and rotor portions of the generator, in the high-voltage power cable conductors, transformer coils, and earthing.
Iron	As well as iron, minor and base metals such as nickel, molybdenum, manganese, and chromium are used in steel production. Aluminium, tin, zinc, tantalum, and precious metals, in varying amounts, are among the main constituents of electronic components for wind energy.
Chromium	
Manganese	
Molybdenum	
Nickel	
Zinc	
Neodymium	- An average permanent magnet in a wind generator contains 28.5% neodymium, 4.4% dysprosium, 1% boron, and 66% iron. - There is also limited use of rare-earth elements in magnets inside the turbine tower to attach internal fixtures (Carter, 2021). - Neodymium is the principal rare-earth element used in the generator's permanent magnet, while terbium may be added to improve its resistance to high temperatures, sometimes replacing dysprosium. - Dysprosium and terbium are viewed as highly vulnerable to supply disruption and are therefore a high supply risk (Jellicoe, 2019).
Praseodymium	
Terbium	
Dysprosium	

Many of these materials and components could be produced in South Africa. However, the feasibility of producing different parts varies. Notably, Barnes et al. (2023) identify tower internals and

complementary components — including flanges, platforms, ladders, lifting equipment, cables, fasteners, and other fabricated components — as particularly promising areas for localisation, extending the potential for value creation beyond the tower shell itself. Overall, compared with blades and nacelles, wind towers are more amenable to localisation because production is less technologically complex and relies on more codified manufacturing processes, and transport costs create incentives for regional production (Larsen and Hansen, 2022). Expanding feasible avenues for domestic component manufacturing not only creates economic value but also serves as a critical engine for long-term manufacturing employment and specialised technical skills development within the domestic industrial workforce.

Available data does not identify which components are currently manufactured domestically or the ownership structures of firms involved. Nevertheless, available evidence indicates that imported components remain common because of a range of barriers to local sourcing (Larsen and Hansen, 2022). One notable constraint is the high cost of steel in South Africa, which makes local steel tower manufacturers less competitive (Hopley and Motala, 2025). Increased access to competitively priced steel could create opportunities for expanding domestic tower and tower-internal manufacturing (Barnes et al., 2023). Other constraints include limited capabilities for mineral beneficiation, advanced materials processing, and component manufacturing in domestic firms, as well as the competitiveness of existing local manufacturers (SAREM, 2024; Larsen and Hansen, 2022; Hopley and Motala, 2025). Addressing these constraints would not simply increase the share of inputs sourced locally; it could also expand the range and sophistication of productive capabilities through which value is created domestically in the wind energy GPN.

Transportation and logistics

Given the size and weight of wind turbine towers and their components, particularly concrete towers, transport and logistics represent an important stage of the wind energy value chain. Unlike many manufactured wind turbine components, logistics activities must be undertaken locally. Additionally, because of the size and weight of wind turbine towers and other large components, specialised handling is required. As a result, transport and logistics provide significant opportunities for domestic firms to participate in wind energy production networks, even where higher-value manufacturing activities remain internationally concentrated.

Value is therefore created through the movement, storage, and coordination of materials and components between manufacturers, ports, storage facilities, and construction sites. Key logistics activities include transporting raw materials (sand, stones, and cement) to manufacturing facilities, delivering tower sections and other components to wind farm sites, and providing specialised lifting, port handling, warehousing, and abnormal-load transport services. These activities require heavy-duty equipment, technical expertise, and careful coordination, creating opportunities for high levels of local value creation through logistics and related support services, alongside related job creation. Efficient logistics are also essential for enabling the subsequent construction and installation of wind farms.

Procurement and project development

Before construction can commence, project developers must first assemble the organisational, technical, financial, and relational capabilities required to develop a viable project and secure an REIPPPP contract (see Box 1). Project development is therefore itself a key element of value creation in South Africa's wind energy production network.

Box 1: Developing a wind farm project

Following the publication of a Request for Proposals (RFP), prospective developers prepare and submit competitive bids setting out the proposed ownership, financing, technical arrangements, local content commitments, and socio-economic development contributions of the project. Successful projects are usually created through special purpose vehicles (SPVs), established specifically for the project, with ownership arrangements involving the lead developer, which may involve foreign investors, South African and Broad-Based Black Economic Empowerment (B-BBEE) partners, and community interests. If the bid is successful, this SPV becomes the IPP responsible for developing, constructing, owning, and operating the wind farm.

The lead developer also establishes a consortium comprising the technical, engineering, financial, and commercial partners needed to prepare a competitive bid. These may include a global OEM (which may also offer EPC services), engineering and environmental consultancies, financiers, legal advisers, and local partners that can help satisfy local content and B-BBEE requirements. Bids submitted to the Independent Power Producers Office (IPPO) that manages the REIPPPP are then evaluated on criteria including price, technical compliance, and economic development commitments.

Developers and their consortium partners bring together complementary expertise to undertake resource assessments, engineering and environmental studies, financial modelling, project costing, legal due diligence, and bid preparation. Drawing on this diverse range of specialised expertise, the project development phase directly drives domestic demand for highly skilled professional jobs. These activities transform a potential wind resource into a commercially and technically viable project and mobilise the relationships and financial resources required for its implementation.

A successful application results in the signing of a PPA with Eskom, providing the commercial certainty needed to secure financial close and finalise contractual arrangements with EPC contractors, landowners, communities, financiers, and suppliers of equipment, materials, and components. Through these processes, project developers and their partners create value not only through the provision of specialised services but also by mobilising capital, coordinating actors, managing project risks, and connecting global and domestic capabilities. Following financial close, the IPP initiates manufacturing, construction, installation, and grid connection activities, generating further economic and social value throughout the production network.

Construction

The construction of wind farms is another major stage in the value chain. Unlike solar energy systems and batteries, where complete systems or modules can be imported and assembled, the wind sector has elements that must involve local production and construction. Site preparation, civil works, foundations, roads, electrical infrastructure, crane operations, and tower installation must all be undertaken locally, creating value through the provision of construction, engineering, logistics, and technical services. Wind turbine towers, internal tower components, foundations, and balance-of-plant equipment represent the principal physical inputs to this stage.

Thus, each project has the potential to stimulate demand for domestic manufacturers, construction firms, engineering consultancies, logistics providers, and specialised service providers. These linkages highlight the potential for domestic value creation associated with wind energy projects. Furthermore, because civil works and site preparation are highly labour-intensive, this stage serves as the primary generator of immediate local construction jobs and entry-level employment opportunities.

Operations and maintenance

Following construction, commissioning, and grid connection, wind farms enter the operations and maintenance stage. Maintenance sustains the wind farm over the course of its life (see, for example, Monforte, 2023). Value is created through the ongoing operation, monitoring, inspection, servicing, and repair and replacement of turbines, electrical systems, and associated infrastructure. Although operation and maintenance generally requires fewer workers than the construction phase, both phases create jobs in the economy (Isely et al., 2012). This stage creates long-term, skilled employment and supports specialised technical service providers in the local economy. However, advances in digital technologies increasingly enable remote monitoring, diagnostics, and supervisory functions which can then take place outside the country (Crabtree et al., 2015; Deutsche Windtechnik, 2023). Understanding the extent to which these higher-value activities may move offshore has important ramifications for domestic value creation and job creation in the sector. On the other hand, such developments may create job opportunities in South Africa for remote monitoring of facilities in other countries.

The sale of electricity and related services represents the final revenue-generating stage of the operational value chain. Value is created through the continuous supply of electricity to the grid under long-term PPAs, as well as through activities such as asset management, performance monitoring, forecasting, compliance reporting, financial management, insurance, and customer and stakeholder engagement. Although these activities require fewer physical inputs than manufacturing or construction, they involve specialised technical, commercial, and managerial capabilities that contribute to the long-term economic viability of wind energy projects.

By anchoring these long-term technical and managerial functions locally, firms stabilise high-quality domestic employment, reinforcing the social value generated during the operational lifecycle. Furthermore, the electricity generated also creates value beyond the production network by providing an essential energy service to users, contributing to the wider functioning of the electricity system, and thereby reducing carbon emissions.

End of life decommissioning and recycling

At the end of a wind farm's operational life, value can be created through the decommissioning, refurbishment, reuse, recycling, and disposal of the towers, along with the rest of the turbines' components and associated infrastructure. Materials such as steel, copper, aluminium, and concrete can often be recovered and reintroduced into new production processes, while selected components may be refurbished for reuse. South Africa has existing businesses that can recycle some of these components. However, recycling composite materials, particularly turbine blades, remains technically and economically challenging, creating opportunities for innovation in recycling technologies and the development of domestic circular economy industries.

As increasing numbers of wind farms reach the end of their design life, end-of-life management is likely to become an increasingly important source of future value creation. Developing domestic capabilities in decommissioning, material recovery, refurbishment, and recycling could enable South Africa to generate new industrial employment opportunities and green technical skills, thereby supporting more circular and sustainable wind energy production networks.

Overview of firms' and financiers' value creation

Overall, tower package manufacturing represents one of the most significant opportunities for domestic value creation in South Africa's wind energy value chain. The bulky nature of concrete and steel towers creates high transport costs, making domestic production more economically attractive, while generating deep backward linkages into local steel, cement, and fabricated metal industries. Beyond the towers themselves, this industrial footprint stimulates demand for localised materials, components, logistics, and related services, creating a broad foundation for domestic value creation and capability development. However, this potential is currently constrained: the dominance of foreign multinational firms in the sector, together with the high cost of locally made steel, have eroded the competitiveness of local tower manufacturers and driven a reliance on imported steel and assembled tower packages, thereby undermining localisation efforts (Baker and Sovacool, 2017; Hopley and Motala, 2025).

Additional opportunities for domestic value creation arise beyond manufacturing, opening further lifecycle avenues for both economic and social value creation through project development, construction, logistics, operations and maintenance, and circular end-of-life activities. The physical existence of these activities in South Africa does not, however, establish the extent to which the value generated is retained domestically or who ultimately benefits from it. Whether these operational segments translate into meaningful economic and developmental gains for South Africa depends not only on where value is created, but also on whether firms and workers can enhance the value generated through these activities, as explored in Section 4.2, and who ultimately captures it as examined in Section 4.3.

4.2 Value enhancement

Whether the outlined opportunities for value creation translate into meaningful economic benefits

for South Africa depends on whether firms and workers are able to build capabilities and progressively upgrade their activities in GPNs. While value creation refers to the productive activities undertaken in the value chain, value enhancement depends on firms' abilities to progressively upgrade those activities by acquiring new technologies, capabilities, knowledge, and organisational competencies that enable them to undertake increasingly sophisticated and technologically complex functions over time, while systematically improving social outcomes such as employment quality.

The extent and nature of domestic value creation are therefore not static but can increase as firms strengthen their productive capabilities, progressively undertake more complex activities in GPNs, and reorganise to provide improved social outcomes. Value enhancement is important to the paper's broader argument because participation in a GPN can create opportunities for domestic value creation without necessarily strengthening the capabilities required to retain or expand that value over time. Although empirical evidence on industrial upgrading in South Africa's wind energy value chains remains limited, experiences from other countries provide valuable lessons about how firms can strengthen productive capabilities through technological and functional upgrading.

China provides an example of successful industrial upgrading in renewable energy manufacturing that perhaps can offer lessons for South Africa. Whether in wind, solar, or electric vehicles (EVs), China has emerged as the global leader, accounting for about 60% of global new renewable energy grid installations and EV sales in 2024 (IEA, 2025). Behind China's remarkable rise to the global renewable energy summit lie deliberate efforts by firms and the state to build the country's industrial capacities through technological learning, innovation, and upgrading (Graham et al., 2021; Zhang and Gallagher, 2016; Zhang et al., 2015).

The development of these industrial capacities — understood in this paper as value enhancement — involved “hardware transfer, such as tooling for factories, and intangible asset transfer, including product design and the capability of manufacturing a product and.... learning” (Grubler, 1998, cited in Zhang et al., 2015, 192-193). Such technology transfer can occur through various mechanisms, such as licensing agreements and R&D cooperation with companies that possess existing developed technology, through joint-venture partnerships, or through acquiring technological components and associated knowledge.

However, knowledge does not always flow freely across these corporate boundaries. In the latter case, where technology transfer is restricted to acquiring physical components, the underlying licences, expertise, and intellectual property remain firmly under the control of the OEM (Lewis, 2007). As discussed further below, these activities are intricately related to power dynamics.

China's solar PV industry illustrates this process particularly clearly. Zhang et al. (2015) identify three key phases in the acquisition of technology by Chinese firms: entry into the global PV manufacturing network (1998-2004); vertical integration within the network (2005-2008); and vertical integration along the network (2009-2014).

- **Entry into the global PV manufacturing network (1998–2004).** During the entry period, Zhang et al. explain that Chinese firms, such as Suntech, Yingli Solar, LDK, Trina, and JA Solar, procured almost all their manufacturing technology, equipment, and subcomponents from Global North

firms, which also provided the necessary technical training and support in the installation and use of the machinery. While receiving financial support from the government, Chinese firms recruited skilled labour, both Chinese and foreign, to run their factories.

- **Vertical integration within the network (2005–2008).** During the second period, firms expanded from assembly to upstream manufacturing, including the processing of polysilicon, ingots, and wafers, eventually gaining almost complete control of the entire production process. This process of adding new activities in the value chain can be considered as functional upgrading. The firms also built large polysilicon reserves, while continuing to acquire equipment and technology from outside China. Soon the Chinese firms began competing in the polysilicon processing market with global giants from the Global North, including Japan, the US, and Germany.
- **Vertical integration along the network (2009–2014).** In the last period, Chinese firms engaged in further functional upgrading by vertically integrating along the wider GPN beyond manufacturing of modules. Upstream integration involved moving into the production of manufacturing equipment and R&D, as well as incorporating downstream activities, including system integration and module development.

The Chinese experience demonstrates how participation in global production can provide a starting point for value enhancement when firms are able to convert externally acquired technology, knowledge, and relationships into accumulated domestic capabilities and progressively expand the range of activities they undertake in the GPN.

The Indian experience provides similar lessons. Lewis (2007) examines Suzlon, an Indian wind turbine company, which is a major manufacturer of rotor blades, tubular towers, control panels, and nacelle covers, sold globally including to South Africa. For Suzlon, licensing arrangements and international networks of subsidiary firms in the GPN helped with rapid technological knowledge acquisition. By 2007, Suzlon held a major stake in Austria-based Hansen, then the world's second-largest wind turbine gearbox manufacturer, while maintaining relationships with Germany's Winergy AG, another major supplier of gearboxes. Suzlon also acquired the German company, Repower, that previously licensed wind turbine technology to Goldwind, the Chinese wind turbine manufacturing giant.

At the same time, Suzlon focused its design and development on creating new wind turbine models, upgrading existing models, and improving rotor-blade efficiency. The company's research facilities in the Netherlands and Germany gave it access to Dutch and German technological expertise, especially concerning aerodynamic rotor blades and gearbox prototypes. These strategies, Lewis argues, also played a crucial role in technology acquisition for firms such as Vestas, Gamesa, and GE. Rather than relying solely on indigenous innovation, these firms enhanced their capabilities by actively engaging in technology acquisition and using international relationships to accumulate and deepen their own technological and organisational capabilities.

Together, these experiences demonstrate that value enhancement does not need to depend on indigenous innovation alone. Firms can strengthen productive capabilities through combinations of technology transfer, licensing, joint ventures, acquisitions, foreign investment, and sustained learning-by-doing. Evidence from the limited research on this topic in South Africa also suggests that

participation in buyer-supplier relationships has enabled selected tower manufacturers, including DCD Wind Towers and GRI Towers, to acquire production capabilities and technical know-how through collaboration with multinational OEMs (Larsen and Hansen, 2022).

These relationships illustrate the potential for participation in GPNs to support domestic capability development. However, access to foreign technology or participation in supply relationships does not in itself constitute sustained value enhancement: the critical question is whether knowledge and capabilities are transferred, retained, and developed by South African firms and workers, enabling them to undertake a progressively wider or more sophisticated range of activities.

This raises the question of which activities are most amenable to upgrading. Evidence from South Africa suggests that such upgrading opportunities are not evenly distributed across renewable energy components. Larsen and Hansen (2022) show that tower manufacturing has emerged as the most viable localisation activity because it involves well-established production technologies and more codified manufacturing processes than components such as blades and nacelles. These characteristics lower the technological barriers to entry for domestic firms and provide greater opportunities for capability development, while the size and transport costs of towers further strengthen the economic case for local production. Tower manufacturing is therefore important not only because it provides an opportunity for domestic value creation, but because it may provide a relatively accessible platform through which South African firms can accumulate manufacturing, engineering, organisational, and supplier capabilities. These capabilities could, over time, provide a basis for upgrading into more sophisticated activities and higher-quality employment structures in the wind GPN.

These experiences suggest that a localisation strategy is likely to achieve greater success by initially focusing on components for which technological capabilities can realistically be accumulated, while progressively expanding into more sophisticated activities over time. However, an important consideration is whether strategies that were used in the past would still be available to South African firms. Firms which now control these technologies may seek to prevent South African upgrading, as will be discussed further below in Section 5.

Therefore, for South Africa, the challenge is to ensure that participation in GPNs facilitates technological learning, capability development, and the progressive localisation of increasingly sophisticated activities over time.² Where this occurs, value creation in South Africa may be expanded and strengthened. Where it does not, local production may remain concentrated in lower-level activities without substantially altering existing patterns of value capture.

However, economic and technological upgrading does not necessarily translate into social upgrading or improved labour outcomes. Previous research cautions that improvements in productivity, technology, or the sophistication of production activities can occur without corresponding improvements in workers' conditions (Barrientos et al., 2011; Pearse and Bryant, 2022; Davidson, 2023). Consequently, value enhancement in South Africa's renewable energy production networks should be assessed not only in terms of firms' ability to acquire technologies and undertake more sophisticated activities, but also in terms of whether these processes contribute to better-quality and more sustainable

² This topic will be explored in a forthcoming IEJ publication.

employment. This distinction is important because enhanced productive capabilities may increase the value generated in a GPN without necessarily changing how that value is distributed or who ultimately benefits from it. These latter questions are addressed through the following analysis of value capture.

4.3. Value capture

Value capture refers to how the value generated in GPNs is retained and appropriated by different actors, including firms, workers, governments, communities, and others in the form of profits, rents, wages, taxes, and other economic, social, and environmental benefits. Assessing value capture therefore requires attention not only to where production takes place, but also to ownership, income, control, and the distribution of benefits. While the previous sections examined where value is created in wind energy production networks, this section examines where the resulting value is ultimately retained, how costs of participation are distributed, and who benefits, both globally and in South Africa.

4.3.1. Value capture: a global perspective

In the wake of the global energy transition and the economic opportunities it presents, competition among actors to capture this value is growing, with the distribution having significant implications for economic, social, and political outcomes in Africa. As renewable energy markets expand, increasing attention has therefore been paid by both scholars and policy makers to understanding how value generated in GPNs is distributed, particularly between developed and developing countries (Baker and Sovacool, 2017; UNCTAD, 2023). Research on value capture has identified a range of benefits, particularly economic and environmental benefits.

Value capture can be assessed in a variety of ways, including analysing profits (see Box 2), value added, wages, employment, tax revenues, ownership structures, and the geographical distribution of production. Because firm-level profit data is often commercially confidential, this section primarily draws on evidence regarding the geographical distribution of manufacturing and employment. Although no single indicator provides a complete measure of value capture, looking at different indicators can provide useful insights into where benefits associated with wind energy production are concentrated.

Box 2: Analysing profit to assess value capture

Dedrick and Kraemer's (2011) financial analyses of a 2.5 MW Clipper Liberty turbine, and a 2.0 MW Gamesa G8 turbine provide examples of measuring value capture through profits and costs (including taxes and wages). Tables 2 and 3 highlight the profit potential of wind tower manufacturing, which, if harnessed, has significant economic benefits for countries like South Africa. These tables show the situation for two turbine types in 2008, revealing variation in the gross margins across different components. The extent to which a

manufacturing firm can benefit from producing different components depends on a variety of factors including production costs, scale, and position in global markets, all of which vary across different locations over time.

Table 2: Value capture for 2.5 MW Clipper Windpower Liberty turbine, 2008

Component	Supplier	Supplier HQ Country	Estimated Cost as % of Total Inputs	Cost of Component	Gross Margin	Estimated Value Capture
Tower	Aerisyn (Schaff Industrie AG)	Germany	26.3	\$736,400	18%	\$132,552
Rotor blades/hub/bearings	Tecsis	Brazil	24.8	\$694,120	20%	\$138,824
Gearbox	Brad Foote/Indiana Gear	US	12.91	\$361,480	19%	\$139,916
Power converter	Xantrex	US	5.01	\$140,280	31.50%	\$44,188
Power transformer	Wesco	US	3.59	\$100,520	20.40%	\$20,506
Generator	Potencia	Mexico	3.44	\$96,320	30%	\$28,896
Main frame	ThyssenKrupp	Germany	2.8	\$78,400	17%	\$13,328
Pitch bearings	Rotek	US	1.33	\$37,240	23.10%	\$8,614
Pitch drivers	Sipco	US	1.33	\$37,240	20%	\$7,448
Cables, screws, etc.	Various	n.a.	2	\$56,000	20%	\$11,200
Nacelle housing	Tecsis	Brazil	1.35	\$37,800	20%	\$7,560
Brake system	Svendborg	Denmark	1.32	\$36,960	20%	\$7,392
Yaw bearings	Rotek (ThyssenKrupp)	US	1.25	\$35,000	23.10%	\$8,614
All other	Various	n.a.	10.67	\$298,760	20%	\$11,200
Totals			100	\$2,800,000		

Source: Dedrick and Kraemer (2011, 6)

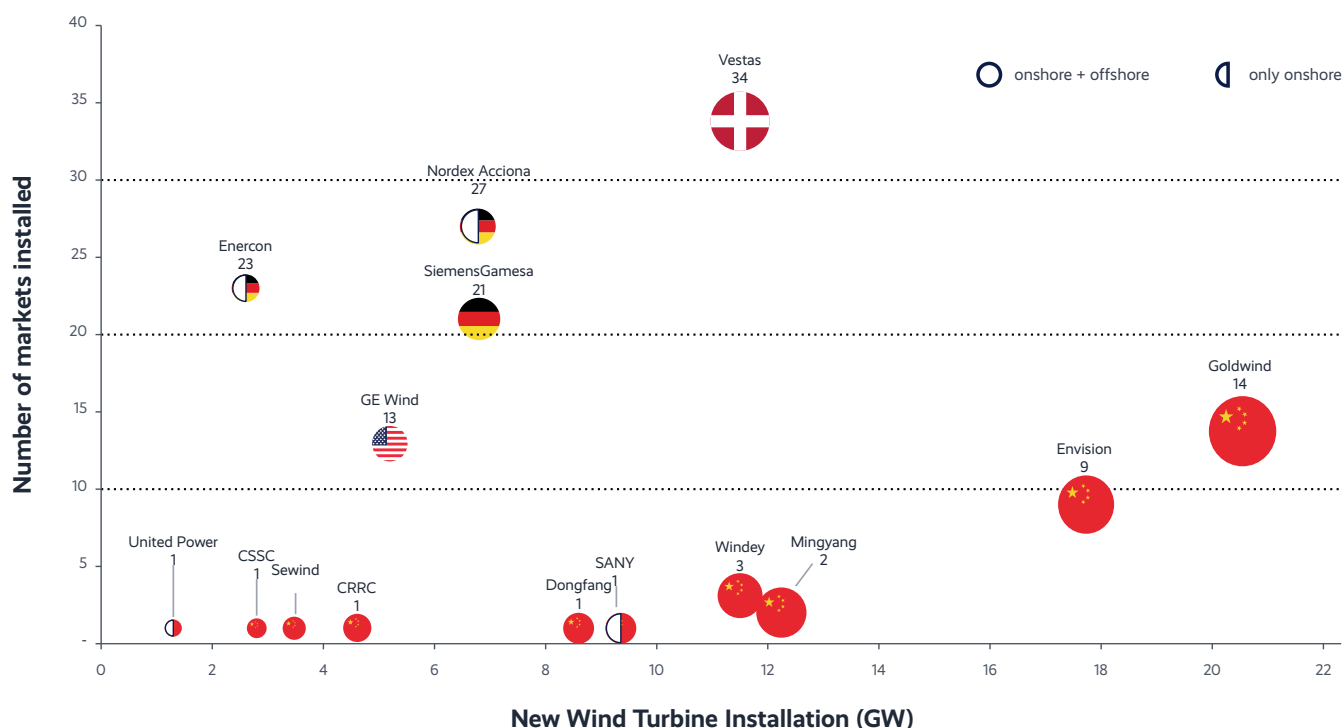
Table 3: Value Capture for G8x 2.0 MW Gamesa (Spain) turbine, 2008

Component	Supplier	Supplier HQ Country	Estimated Cost as % of Total Inputs	Cost of Component	Gross Margin	Estimated Value Capture
Tower	Gamesa	Spain	26.3	\$708,785	23%	\$163,021
Rotor blades/hub/bearings	Gamesa	Spain	24.8	\$668,091	23%	\$153,661
Gearbox	Gamesa	Spain	12.91	\$347,925	23%	\$80,023
Power converter	Gamesa	Spain	5.01	\$135,020	23%	\$31,054
Power transformer	ABB	Switzerland	3.59	\$96,751	23%	\$19,737
Generator	Gamesa	Spain	3.44	\$92,708	23%	\$21,323
Main frame	Gamesa	Spain	2.8	\$75,460	23%	\$17,356
Pitch bearings	Fundicion Nodular del Norte	Spain	1.33	\$35,844	23%	\$8,244
Pitch drivers	Various	n.a.	1.33	\$35,844		n.a.
Cables, screws, etc.	Various	n.a.	2	\$53,900		n.a.
Main shaft	Various	n.a.	1.91	\$51,475		n.a.
Nacelle housing	Various	n.a.	1.35			n.a.
Brake system	Various	n.a.	1.32	\$35,574		n.a.
Yaw bearings	Various	Spain	1.25	\$33,688	23%	\$7,792
All other	Various	n.a.	10.67	\$287,557		n.a.
Totals			100	\$2,695,000		

Source: Dedrick and Kraemer (2011, 6)

The geographical distribution of manufacturing activity provides an important indication of where value may be retained. Countries hosting many manufacturers or the largest manufacturers have greater potential to retain profits, technological capabilities, skilled employment, supplier industries, and tax revenues associated with the sector. In 2024, 29 manufacturers installed 23,098 new wind turbine units globally, adding 127 GW of new wind power capacity (Global Wind Energy Council, 2025). Of these manufacturers, 18 were based in the Asia Pacific region, eight in Europe, two in the US, and one in the Middle East. Furthermore, China accounted for nine of the 15 top wind turbine producers, with Chinese companies Goldwind, Envision, Mingyang, and Windey, occupying the top four positions. The Danish firm Vestas ranked fifth, ahead of Siemens Gamesa (Spain/Germany), GE Vernova (United States), and Nordex (Germany). A second set of Chinese firms, CSIC Haizhuang, Dongfang Electric, SANY, and Shanghai Electric, ranked above the bottom three firms, Suzlon, Enercon (Germany), and Hitachi Energy (Switzerland/Japan) (see Figure 7). These figures demonstrate that the manufacture of wind turbines — and therefore a substantial share of the value generated in the sector — is highly concentrated in a relatively small number of countries, particularly China.

Figure 7: Top 15 Wind Turbine OEMs' new installations in 2024



Source: Global Wind Energy Council (GWEC), 2025

Employment provides another important indication of where some of the benefits associated with wind energy production are being retained, because countries hosting manufacturing, engineering, and associated service activities generally retain a larger share of labour income and related multiplier effects. By 2021, the onshore and offshore wind sector employed 1.4 million people globally. Asia accounted for 57%, with China alone contributing 48%. Europe accounted for 25% and the Americas 16%, while Africa and Oceania combined accounted for only 2% (ILO and IRENA, 2022). Although detailed employment data specific to wind energy remains limited for Africa, the continent's negligible

share of global employment reflects its relatively weak participation in higher-value manufacturing, engineering, and technological activities.

While manufacturing output and employment provide useful proxies for value capture, they do not necessarily indicate where profits are ultimately retained. Ownership structures, intellectual property rights, and corporate governance also shape value capture, with lead firms frequently capturing a disproportionate share of profits through their control over technology, brands, product design, and system integration. As data on these aspects was not available for this review, further research in this area could help to shed more light on global value capture patterns.

Nevertheless, taken together, these indicators suggest that value capture in the global wind energy industry remains highly concentrated. Africa's absence from the ranks of the world's leading wind turbine manufacturers, together with its extremely small share of global renewable energy employment, suggests that the continent currently retains only a limited proportion of the economic benefits associated with producing wind turbine systems. Rather than participating extensively in higher-value manufacturing, engineering, and technological development, African countries continue to occupy positions largely characterised by the extraction of raw materials and the importation of higher-value manufactured products. The following section examines South Africa's position in this global distribution of value capture by considering which activities are undertaken domestically, who owns and controls those activities, and the extent to which the resulting economic and social benefits are retained within the country.

4.3.2. Value capture in South Africa

The global perspective above highlights the extent to which ownership, control over technology and markets, and the organisation of production influence where value is ultimately captured. The question for South Africa is therefore not simply how much wind energy activity takes place domestically, but how much of the value generated through these activities is retained within the South African economy and who benefits from it. Evidence presented below suggests that a significant proportion of the economic value generated in South African wind energy production networks is ultimately captured by global firms. However, limited and fragmented data makes it difficult to determine precisely how much value is retained domestically or how it is distributed among firms, workers, government, and communities. The analysis should therefore be understood as indicative rather than a comprehensive accounting of value capture in the sector.

South Africa has significant opportunities to increase domestic value capture, particularly through the localisation of activities identified in the previous sections. Greater domestic production of towers could increase the share of expenditure retained in South Africa while strengthening manufacturing capabilities, developing local suppliers, and improving employment levels and quality. Additional potential exists through the production of tower internals, foundations, and balance-of-plant components, as well as through the provision of transport logistics and the development of enhanced recycling capabilities. However, the way production is organised shapes whether these activities will generate further domestic value capture and strengthen linkages between wind energy projects and the wider South African industrial base.

The potential for wind turbine production to generate domestic value capture is illustrated by the localisation requirements associated with Bid Window 5 of the REIPPPP. As shown in Table 4, the programme identified a range of inputs and activities for which local content commitments were required, many of which have the potential to be supplied by South African firms.

Table 4: Inputs required for REIPPPP Bid Window 5

Input	Quantity
Steel plates	80,000 –100,000 tonnes
Steel for anchor cages	4,000 tonnes
Rebars for foundations	6,500 tonnes
Structural bolts	3,500 tonnes
Paint	640,000 litres
Industrial gases	200 tonnes
Internal aluminium platforms	500 tonnes
Electrical cables	36,800 metres
Power cables	240,000 metres

Source: Rivett-Carnac (2022, 14)

This demonstrates how wind energy procurement can create backward linkages between renewable energy projects and domestic manufacturing and service industries. Where these inputs are produced domestically, a greater share of project expenditure has the potential to generate and retain value in South Africa, while also supporting local employment, supplier development, and the development of productive capabilities. However, local content requirements alone do not guarantee domestic value capture, as this also depends on the competitiveness, ownership, technological capabilities, and linkages of domestic firms.

The potential for domestic value capture also extends beyond productive activities. The ownership and institutional arrangements governing wind energy projects provide additional mechanisms through which some of the value generated by renewable energy investment can be retained and distributed domestically. In particular, the REIPPPP incorporates requirements and commitments relating to South African ownership, including B-BBEE participation; contributions to socio-economic and enterprise development; and community participation. These mechanisms represent distinct channels of domestic value capture from those associated with domestic production, and their effectiveness in retaining and distributing value is considered alongside productive activities below. The following discussion first reviews and critiques the ways in which value capture has been measured by official sources in the South African context. The subsequent analysis uses three approaches to

assess value capture:

- considering firm ownership patterns;
- examining trade balance dynamics; and
- assessing the distribution of employment, including who gains access to jobs.

The section concludes with suggestions for improving the measurement of value capture.

Existing measures of value capture used in South Africa

Value capture is commonly assessed through economic indicators such as profits, value added, wages, employment, ownership, and tax revenues. However, assessing the developmental contribution of renewable energy also requires consideration of the broader social and environmental outcomes associated with its deployment. The South African government's indicators capture some of these outcomes, but they provide an incomplete picture of who benefits from the transition, how benefits are distributed, and whether renewable energy contributes to broader social and environmental objectives.

Specifically, the South African government evaluates the REIPPPP primarily through indicators such as the number of firms in the sector, impact on employment, socio-economic benefits and enterprise development, added energy capacity, B-BBEE procurement spending as a proportion of total procurement, and local content spending (IPP Office, 2023). These indicators give the picture outlined in Box 3.

Box 3: Reported REIPPPP benefits

According to the 2nd quarter IPPPPP report of 2023 (DMRE, 2023), South Africa claimed over 90 firms (both local and foreign) in operation, with about 80,000 job years created in construction and operations. The estimated economic contributions stood at R3 billion for social and economic development, R87.5 billion in B-BBEE procurement spending — equivalent to 76% of total procurement — and over R70 billion in local content expenditure (representing 49% of total project value realised). On top of that, the sector generated over 105,000 GWh of energy — enough to supply nearly 32 million people — offsetting 101.4 million tonnes of CO₂ and saving 120 million kilolitres of water.

However, the metrics give only a partial picture of development because they focus on immediate project outputs rather than long-term structural transformation. They reveal relatively little about domestic technological capabilities, functional upgrading, ownership, value capture, or the quality and sustainability of employment. This section critically examines the government's principal indicators of success from a value capture perspective.

a. Economic indicators

By emphasising growth in the number of participating firms, employment creation, B-BBEE procurement, enterprise development, and local content expenditure, government indicators can overstate the extent to which renewable energy procurement has promoted sustainable industrial development and inclusive value capture. While these indicators demonstrate increased participation in the renewable energy sector, they provide only limited insight into who ultimately captures value and whether domestic industrial capabilities are being strengthened.

Foreign firms continue to dominate higher-value activities, while local firms remain concentrated in lower-value functions, constrained by OEM preferences for proven international suppliers, dependence on imported components, limited technological upgrading, and procurement uncertainty that discourages long-term investment (Baker and Sovacool, 2017; Rivett-Carnac, 2022). Employment is largely measured in job-years, masking the temporary nature of construction employment, interruptions created by stop-start procurement rounds, and the quality and duration of jobs created. Similarly, B-BBEE procurement, enterprise development, and local content expenditure assessments measure spending rather than capability development or ownership transformation. These indicators have also been criticised for weak implementation, opportunities for fronting, elite capture, and limited broad-based economic transformation (Freund, 2007; Ponte et al., 2006; Francis and Valodia, 2022; Jeffery, 2017; Daily Maverick, 2025). Recent proposals to weaken local content provisions in South Africa's procurement framework further illustrate the fragility of these gains (SAPVIA, 2025).

b. Social and environmental indicators

Measurement limitations are particularly important when considering social and environmental value capture. The technocratic manner in which environmental value is measured — through indicators such as carbon emission reductions, additional electricity generation capacity, and water savings — provides only a partial assessment as it overlooks the broader political economy of South Africa's energy system.

Despite rapid growth in renewable energy capacity and improvements in electricity supply — including 100 consecutive days without load shedding in 2024 (Bloomberg, 2024) — coal remains the dominant source of electricity generation. Successive IRPs and the Energy Action Plan continue to prioritise energy security alongside decarbonisation, extending the operating lives of coal-fired power stations and, in some cases, relaxing environmental regulations to maintain coal-based electricity generation (SA Government, 2024). As the IRP Review notes, renewable-only pathways do not currently provide the required security of supply and remain the costliest option to implement (SA Government, 2024). Consequently, renewable energy has supplemented rather than fundamentally displaced coal, helping explain why South Africa's greenhouse gas emissions in 2020 remained above their 2000 levels, despite recent declines (SA Government, 2023).

Similarly, increases in installed generation capacity do not necessarily translate into improved welfare or energy access. Millions of South Africans remain unable to afford electricity despite being connected to the grid, while electricity tariffs increased by 264% between 2011 and 2024, placing growing pressure

on households, agriculture, manufacturing, and small businesses (Siweya, 2024). Although government has expanded rooftop solar incentives and free basic electricity programmes, fewer than one million of the approximately 11 million eligible households receive free electricity, while the allocated 50 kWh per month falls far below typical household consumption (Earthlife Africa, 2024; Tatham, 2025). Rooftop solar subsidies have similarly been more accessible to wealthier households, reinforcing existing inequalities (Jacobs, 2024).

Although renewable technologies consume substantially less water than coal-fired electricity generation, continued reliance on coal means that many environmental costs — including high water consumption, pollution, acid mine drainage, and unequal water pricing — remain largely unchanged (Centre for Environmental Rights, 2018, 2026). Consequently, measuring success primarily through installed capacity, emissions reductions, or water savings risks overstating the developmental achievements of the energy transition while overlooking affordability, equity, and the persistence of structural dependence on coal.

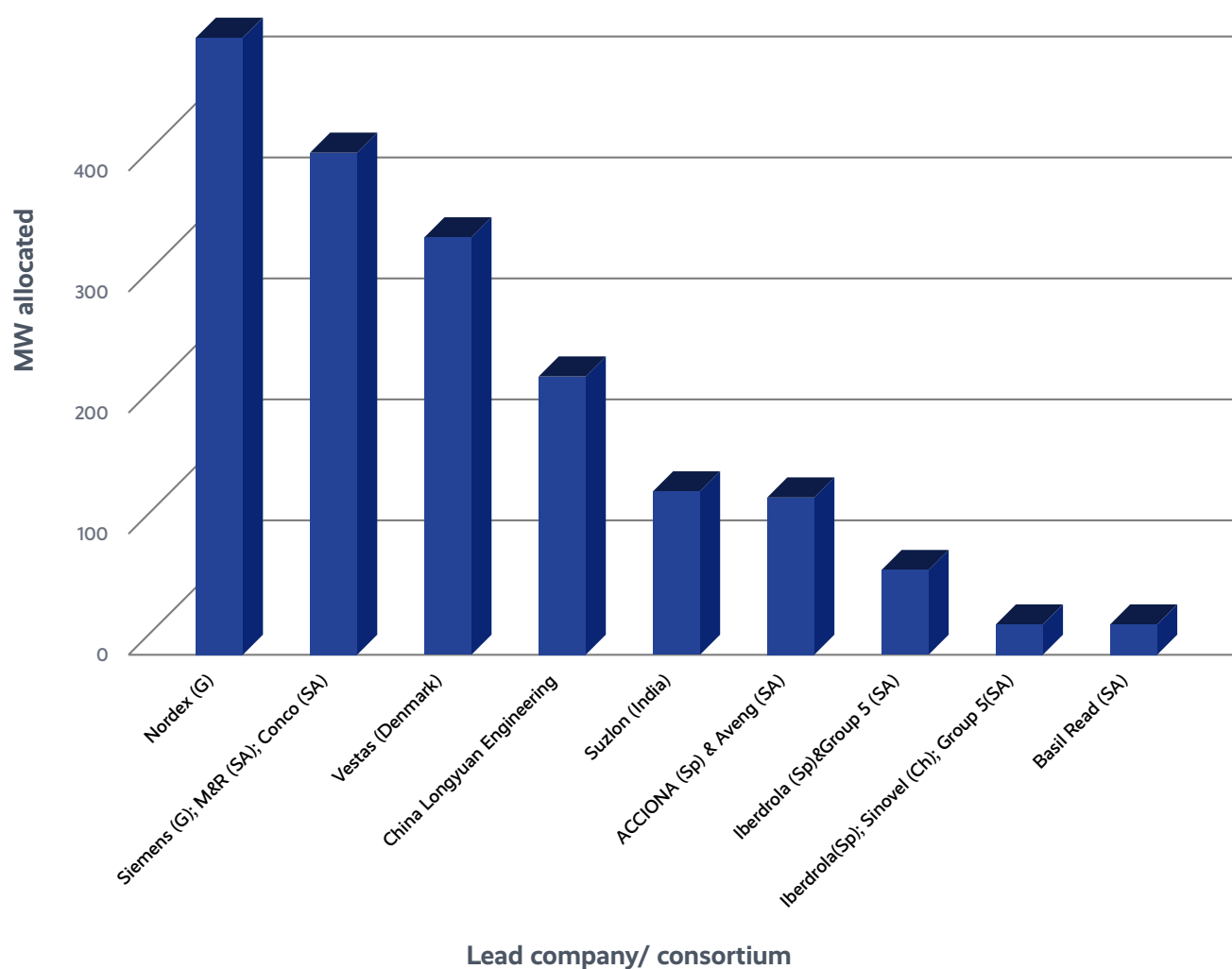
Alternative ways to assess value capture in South Africa

Publicly accessible data to measure economic value capture directly in terms of profits, value added, or tax revenues is not available in South Africa. Consequently, the foundational data regarding true surplus value and economic rents remains entirely inaccessible to researchers. As proxies, this section relies on data on ownership patterns and trade balances for key wind energy components. Together, these indicators provide useful — although imperfect — insights into where value is retained in South Africa's wind energy production networks. However, these available metrics show foreign dominance and reliance on imports, driven by price-centric public procurement, which consistently favour foreign suppliers over local manufacturers. Similarly, comprehensive data related to social value capture is limited. Consequently, access to jobs is used as a proxy in this section.

a. Firm ownership

Ownership structures provide one indication of value capture because profits, dividends, intellectual property income, and strategic decision-making generally accrue to the owners of firms participating in the production network. Although detailed ownership data for all wind energy projects is not publicly available, evidence from the REIPPPP shows that foreign firms have historically dominated the sector. As illustrated in Figure 8, EPC contract allocations during Bid Windows 1–3 were concentrated among a relatively small group of predominantly foreign firms.

Figure 8: Contracts for EPC firms for Wind Energy Rounds 1–3 of the REIPPPP



Source: Baker and Sovacool (2017, 7)

More recent projects suggest that the role of South African firms in project delivery may be expanding, although evidence remains limited. Three wind farms awarded under Bid Window 5 and announced as commercially operational in a December 2025 media statement from the IPP Office (Ministry of Electricity and Energy, 2025), each with a contracted capacity of 140 MW, appear to be relying on higher levels of local suppliers. One of these projects, San Kraal WEF, led by EDF Renewables (the South African subsidiary of French utility EDF), contracted Goldwind (China) to supply and install the wind turbines, while the balance-of-plant works were undertaken by the South African consortium of Concor and OptiPower (EDF Power Solutions, 2025). The other two projects, Brandvalley Wind Farm and Rietkloof Wind Farm, both developed by Red Rocket Energy (South Africa), used Vestas turbines and South African firms Power Construction and Besamandla to undertake the balance-of-plant and grid connection works (Arnoldi, 2025; Energize, 2025). These projects suggest increasing participation by domestic engineering and construction firms in downstream project delivery, although the most technologically sophisticated elements of the projects continue to be supplied by foreign firms.

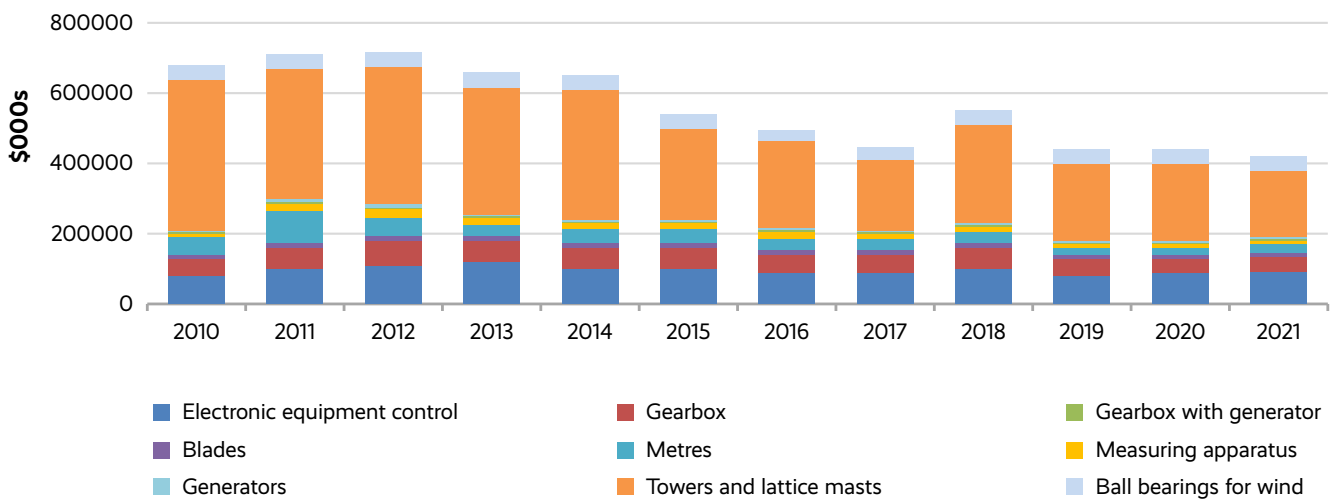
Information on the identities of suppliers of tower packages and their component parts is considerably more limited. While the existence of firms capable of supplying towers, tower internals, steel, fasteners, coatings, and other components is well documented (see Section 4.1), publicly available information does not systematically identify which suppliers were contracted for individual projects. Consequently, it is not currently possible to assess the extent to which these firms capture value in South Africa's wind energy production networks.

One important challenge is that global OEMs and EPC contractors frequently procure components through long-established international supplier networks rather than developing new domestic supplier relationships (Gereffi et al., 2005; Lewis, 2007; Baker and Sovacool, 2017). This pattern is reinforced by a tendency towards vertical integration among lead firms (Baker and Sovacool, 2017; Lewis and Wiser, 2007). Rather than specialising in a single stage of the value chain, many global OEMs combine turbine manufacturing with other activities across the production network, including EPC services, technology provision, project development, and operations and maintenance (Baker and Sovacool, 2017). This concentration of activities within the same firms can increase their ability to retain and capture value across multiple stages of the production network, potentially limiting the share available to independent domestic suppliers.

b. Trade balance: imports and exports

Trade data provides an indication of South Africa's capacity to manufacture, assemble, and export some wind turbine components but also reveals the country's continued and substantial reliance on imports. Between 2010 and 2022, South Africa spent approximately R30 billion on wind turbines (SAREM, 2024). Figures 9 and 10 present the value of exports and imports, respectively, for the principal wind turbine components.

Figure 9: Main exports of onshore wind components, 2010 to 2021 (\$000s)

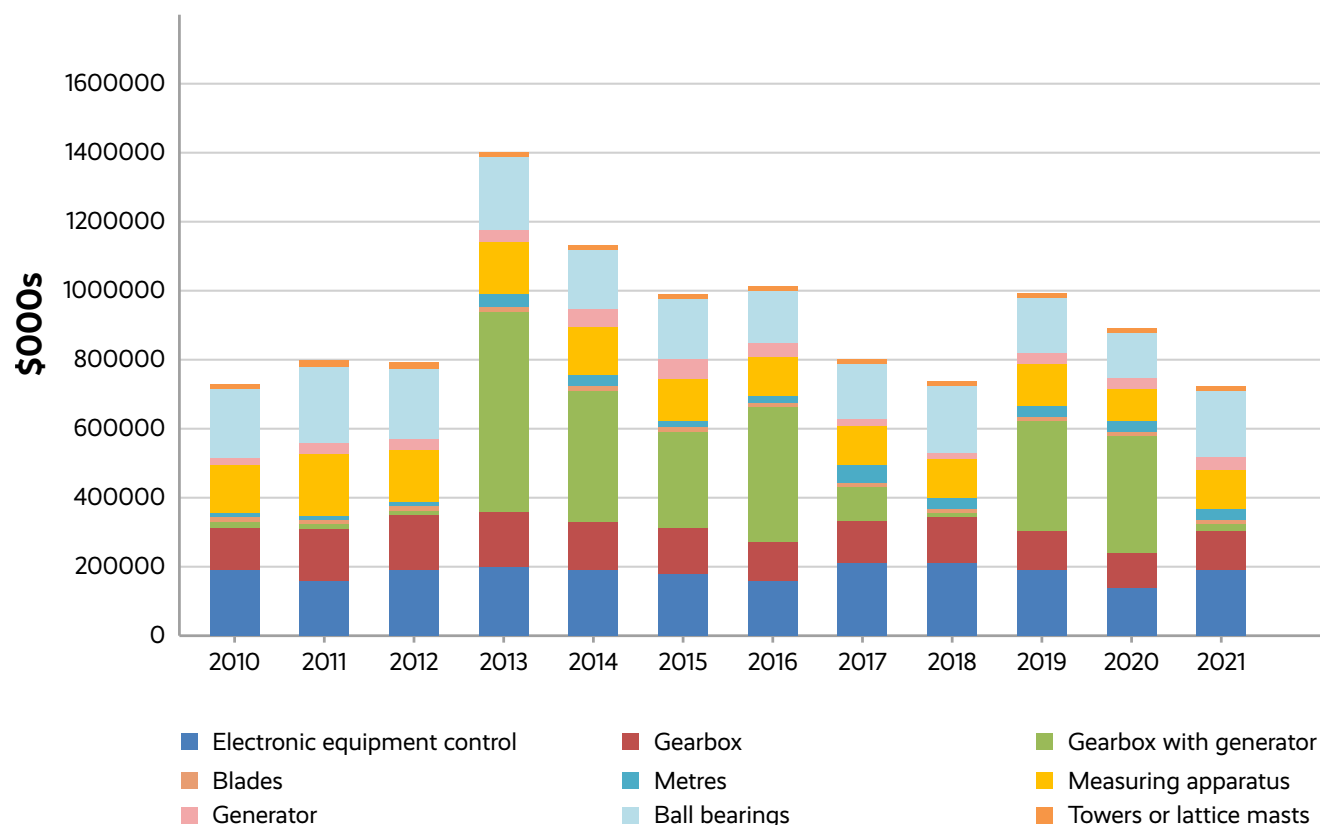


Source: Rivett-Carnac 2022, p. 18

Figure 9 demonstrates that South Africa possesses some capacity to manufacture or assemble wind turbine components for export markets. The existence of these exports indicates that domestic firms possess capabilities in selected manufacturing activities and that there is demand for these products

beyond the domestic market. When production takes place domestically, these activities can contribute to value capture through manufacturing, employment, transportation and logistics services, and related business activities. Figure 10, however, shows that South Africa continues to import a significant amount of these components from other countries, particularly from China and Europe, highlighting the continued dependence of the domestic industry on foreign suppliers.

Figure 10: Main imports of onshore wind components, 2010 to 2021 (\$000s)



Source: Rivett-Carnac (2022, 18)

Comparing the export and import data also suggests that South Africa functions as a transit point for some wind turbine components. However, the extent to which these exports reflect domestic manufacturing, assembly, or simple re-exporting remains unclear from available data. This limits the extent to which trade statistics can be used to measure domestic value capture directly. Nevertheless, the data provides useful evidence of the structure and technological depth of domestic production.

Although South Africa has demonstrated the capability to manufacture concrete towers, continued dependence on imported towers, and particularly imported electromechanical components suggests that domestic industrial capabilities remain concentrated in selected segments of the value chain. This is particularly evident for gearboxes, where imports consistently exceed exports by a considerable margin, reflecting continued dependence on foreign suppliers for one of the most technologically sophisticated components of a wind turbine.

Nevertheless, the trade data also reveals important opportunities. The existence of exports demonstrates that South African firms have developed capabilities in selected manufacturing activities and that

regional and international demand exists for these products. This provides a platform for expanding domestic manufacturing and supporting further industrial upgrading.

At the same time, the persistent excess of imports over exports indicates that a significant share of expenditure associated with renewable energy investment is spent on products manufactured outside South Africa. According to SAREM (2024, 18), South Africa recorded negative trade balances across several renewable energy technologies in 2022, including “US\$683 million for lithium-ion batteries, US\$327 million for solar panels, US\$573 million for inverters, and US\$1.6 million for transformers”. These trade deficits illustrate the scale of expenditure on imported renewable energy technologies and point to opportunities to increase domestic manufacturing, employment, and productive capabilities through greater localisation and upgrading.

c. Access to jobs

Unpacking employment is important to understanding social value capture because the creation of jobs does not necessarily mean that the benefits of employment are distributed equally. Value may be created through employment in wind energy production networks, but questions of value capture concern who has access to these opportunities, what types of jobs they obtain, and the quality, remuneration, security, and duration of those jobs.

Gender is an important dimension of social value capture. Existing research indicates that women remain underrepresented in technical and higher-skilled positions in renewable energy and are more likely to be concentrated in lower-paid and supporting roles, such as secretaries, phone operators, and sanitation workers (IRENA, 2020; Lebrun and Nagel, 2022). As of March 2026, only 19% of job opportunities in REIPPPP have gone to women (DMRE, 2026).

The analysis in this paper is necessarily limited because systematic, gender-disaggregated data on employment by occupation, skill level, remuneration, and employment duration is not available for the South African wind energy sector. However, examining gendered access to employment provides an initial indication of the distribution of social benefits generated through participation in the GPN and highlights an important dimension of value capture that is not captured by local-content expenditure or ownership indicators.

4.3.3 Measuring value capture going forward

Overall, the findings suggest that assessing the developmental contribution of the wind energy transition requires greater attention to who owns firms, where profits and income accrue, how domestic productive capabilities develop, and who benefits from the employment and other social benefits generated through participation in the GPN. More systematic firm-level, worker-level, and community-level data on profits, ownership, value added, procurement, employment, employment quality and distribution, and other social outcomes would strengthen assessments of value capture. Ultimately, accumulating this detailed data would help identify policy interventions capable of increasing the share of value retained in South Africa, while ensuring that its benefits are more broadly distributed.

4.4 What does this tell us about value in South Africa's wind GPNs?

Taken together, the findings suggest that localisation should not be understood simply as increasing the amount of economic activity that takes place in South Africa. Rather, the developmental significance of localisation depends on whether participation enables domestic firms and workers to build capabilities, move into more sophisticated activities, retain a greater share of the value generated, and ensure that the benefits of participation are broadly distributed. The following sections therefore turn to the power relations and forms of embeddedness that help explain why these opportunities have, to date, been only partially realised.

5. POWER IN WIND TURBINE GPNS IN SOUTH AFRICA

The preceding sections explained where value is created, how it can be enhanced, and how it is captured in South Africa's wind turbine production network. However, these outcomes are not determined by production capabilities or market forces alone. They also reflect the unequal distribution of power among firms, governments, financiers, workers, and other actors participating in the network. Understanding these power relations is essential to explaining why localisation has expanded participation without necessarily producing sustained domestic upgrading and value capture. This section explores power in South Africa's wind turbine GPN, focusing on its corporate, institutional, and collective dimensions, and examines how these forms of power shape domestic firms' and workers' ability to participate in, upgrade in, and capture value from wind turbine production networks.

5.1. Corporate power

Corporate power operates through three levers: technological power, network power, and market power. Together, these forms of power determine which firms participate in production networks, which activities they perform, and the extent to which technological capabilities and value remain concentrated in a relatively small number of lead firms. This section discusses each of these dimensions of corporate power and demonstrates how they shape the position and bargaining power of South African firms in the GPN.

5.1.1. Technological power

Global OEMs exercise technological power through their ownership of intellectual property, accumulated engineering capabilities, proprietary product designs, and continuous investment in R&D. These capabilities underpin the design and manufacture of wind turbines deployed in South Africa and other major markets. Ownership of patents and other forms of intellectual property enables OEMs to generate rents through licensing agreements while simultaneously strengthening their ability to secure projects and attract finance, as discussed below in the institutional power section.

Control over intellectual property also allows OEMs to determine who may manufacture their products and under what conditions. They may grant or refuse production licences, specify technical standards, or charge exorbitant fees for the use of their technologies and designs. Consequently, even when local firms develop the technological capabilities to manufacture components, participation in particular production networks frequently depends on obtaining approval from the OEMs. This constrains opportunities for domestic firms to move beyond assembly into higher-value manufacturing and design activities, pushing firms in the Global South into importation and assembly, thereby sustaining existing unequal economic exchanges that favour Global North countries and firms (Baker and Wlokas, 2015).

Technological power is further reinforced through continuous innovation. Leading OEMs can render existing technology obsolete through technological advances, thereby excluding firms in the Global South which are still using older technology (Leigland and Eberhard, 2018). OEMs can also use economies of scale and lower production costs to outcompete local manufacturers. For example, China's overproduction in recent years of renewable energy technologies (such as solar PV, EVs, and batteries) has led to a drastic reduction in the price of these technologies. This drives down profits for firms in countries producing these technologies at higher production costs (IEA, 2024).

These dynamics illustrate that technological power is not limited to control over existing technologies; it also derives from the ability of lead firms to innovate, reduce costs, and determine the technological trajectory of the industry. The technological power of global firms therefore restricts South African firms' ability to move into higher-value activities and limits domestic value capture.

5.1.2. Network power

Lead firms derive power not only from the technologies they own but also from their ability to coordinate extensive GPNs. Long-standing relationships with suppliers, financiers, logistics providers, engineering firms, certification bodies, and EPC contractors enable these firms to rapidly assemble project consortia when procurement opportunities arise. These established relationships reduce transaction costs, increase investor confidence, and create significant barriers to entry for new domestic firms.

Nordex provides an example of this form of power. A German company operating in over 40 countries, it combines turbine manufacturing with project development, construction, servicing, and long-term maintenance. It also coordinates an extensive network of global suppliers providing key components such as converters, gearboxes, and generators. This network enables Nordex to mobilise complete project delivery teams across multiple markets, including South Africa, where it operates nine wind farms (Nordex, n.d.).

The ability of lead firms to coordinate these networks also determines which domestic firms participate in production networks and which do not. Decisions regarding subcontracting influence not only which local firms receive contracts but also whether technological capabilities are transferred to domestic firms or retained in the OEM's existing supplier networks. In addition, OEMs accumulate power from owning firms operating in South Africa and from retaining internal control over multiple stages in the production network.

Closely related is the practice of sourcing components through long-established international supplier relationships rather than developing new domestic supplier networks, as discussed above. Such procurement strategies limit opportunities for local firms to enter higher-value manufacturing activities and can reduce the potential for localisation to generate sustained capability development.

5.1.3. Market power

Corporate power is ultimately reflected in market concentration. In South Africa, local firms often compete against each other in the sale and distribution of imported products rather than in

manufacturing major wind turbine components. This is because imported components enjoy a dominant position in South Africa, making it difficult for locally manufactured components to compete.

This concentration is evident in the amount of capacity installed by the leading OEMs. For example, as of August 2024, Vestas accounted for an estimated 1.5 GW, or 43%, of the total wind power installed or under construction in the country (Vestas, 2024). Similarly, Nordex has installed over 1 GW, representing more than 30% of the country's wind capacity, through the construction and operation of wind farms (Nordex, n.d.). Goldwind, which operates in more than 40 countries across six continents, has also expanded its presence in South Africa, recently securing the contract to supply 39 turbines for the Overberg Wind Farm project, potentially the country's largest wind energy project (White, 2025). Together, Vestas and Nordex account for over 70% of South Africa's installed wind capacity, even before taking into account Goldwind's expanding market share.

The concentration of market share among a small number of multinational firms strengthens their bargaining position throughout the production network. Their scale, financial resources, technological capabilities, and established customer relationships make it difficult for domestic firms to enter higher-value manufacturing activities or challenge their market position. As a result, South African firms remain concentrated in lower-value segments of the value chain, limiting opportunities to increase domestic value creation and capture.

Market concentration therefore reinforces the technological and network power of global OEMs. Firms that control a large share of the market are also better positioned to shape supplier relationships, determine procurement practices, and influence the terms under which domestic firms participate in the GPN. Taken together, technological, network, and market power help explain why South African firms can participate in the wind energy GPN while remaining concentrated in activities with relatively limited opportunities for upgrading and value capture.

5.2. Institutional power

Institutional power refers to the ability of states, financial institutions, and other governing institutions to shape the rules, incentives, and governance arrangements that determine how GPNs operate. Unlike corporate power, which derives from firms' ownership of technology, market position, and network relationships, institutional power stems from the authority to regulate markets, coordinate industrial development, allocate public resources, influence investment decisions, and shape national objectives. Institutions determine the conditions under which firms enter and compete in production networks, the incentives available for localisation and technological upgrading, and the criteria by which industrial development is evaluated.

In South Africa's renewable energy sector, there are two groups of actors who play a large role in exercising institutional power: public institutions and financial institutions. Public institutions — including national, provincial, and local government departments, and intergovernmental organisations — shape industrial development through legislation, industrial policy, public procurement, regulation, licensing, trade measures, and systems used to monitor and evaluate policy outcomes. Financial institutions — including commercial banks, development finance institutions, export credit

agencies, and international climate finance initiatives — exercise institutional power by determining which firms, projects, and technologies gain access to capital and under what conditions. Together, these institutions shape participation in renewable energy production networks, influence opportunities for localisation and technological upgrading, and affect the extent to which renewable energy contributes to decent work and broader industrial development.

The remainder of this section examines these two sources of institutional power. It first considers how public institutions shape participation, industrial development, and the measurement of development outcomes, before examining the role of financial institutions in structuring investment, firm participation, and industrial upgrading.

5.2.1. The roles of public institutions

The roles of public institutions can be classified in multiple ways. Three are outlined here:

- creating the rules of participation
- directing industrial development through policy interventions
- shaping how development outcomes and policy success are understood and measured.

Creating the rules of participation

The rules governing participation in South Africa's wind turbine production networks are shaped by institutions operating at both international and domestic levels. Together, these institutions establish the legal, regulatory, and policy environment in which firms compete, invest, and organise production. These rules do not determine outcomes by themselves, but they establish the conditions under which corporate power is exercised and domestic firms seek to participate, upgrade, and capture value.

At the international level, institutional power is exercised through global trade rules, intellectual property regimes, and industrial policies implemented by foreign governments. Existing international trade agreements, particularly those administered through the World Trade Organisation (WTO), seek to protect innovation and investment through the international intellectual property rights (IPR) system, including patents, industrial designs, trademarks, and licensing arrangements. While these frameworks encourage technological innovation, they also reinforce the advantages of established OEMs by restricting South African firms' ability to manufacture or adapt proprietary technologies without authorisation. As discussed in the previous section, ownership of intellectual property therefore complements corporate technological power by determining who may participate in higher-value manufacturing activities.

At a global level, governments in other countries exercise institutional power through the implementation of industrial policies. Countries such as China, Germany, Denmark, Spain, and the United States have actively supported their renewable energy industries through subsidies, cheap loans, public procurement, export support, tax incentives, and other industrial policies (Chen, 2015; Graham et al., 2021; Lewis, 2007). These interventions have enabled firms in these countries to accumulate technological capabilities, expand manufacturing capacity, reduce production costs through economies of scale,

and strengthen their positions in GPNs. Consequently, firms operating in South Africa compete not simply against foreign companies but against firms supported by powerful state institutions in their home countries. A key example is China, with its policies to support low-cost production, such as those described in Box 4.

Box 4: Chinese policies supporting low-cost production

In 2008, China launched its Five-Year Solar Plan, which included incentives such as subsidies and cheap loans for solar PV manufacturers. Over the following years, China rapidly expanded its manufacturing capacity, while module prices declined dramatically. Between 2008 and 2011, the price of a Chinese solar PV module fell from approximately EUR 3 per watt peak³ (Wp) to EUR 0.40 per Wp, while manufacturing capacity increased approximately tenfold. These developments contributed to a 75% decline in global prices (Chen, 2015).

However, the dominance of Chinese solar panels in the EU market raised concerns among EU solar panel producers over unfair competition. In 2012, the German solar manufacturing giant, Solarworld, petitioned the European Commission (EC) to commence an anti-dumping and anti-subsidy inquiry against China (Plasschaert, 2016). The EC concluded, “The fair value of a Chinese solar panel sold in Europe should be 88% higher than the price at which it is sold” (Chen, 2015, unpaginated).

Following this, in 2013, the EU raised the duty on Chinese imports from 11.8% to 47.6%. China retaliated with the commencement of an anti-dumping and anti-subsidy investigation of EU wine imports, while also threatening similar investigations on luxury cars. The enormous financial stakes involved in this dispute, estimated to be EUR 1 billion a day in China-EU trade, forced the two parties into negotiations rather than wage a full-scale trade war (Chen, 2015; Hooijmaaijers, 2021; Plasschaert, 2016). The EU is China’s largest trading partner, while China is the EU’s second largest trading partner. Further disputes with China emerged from other countries such as the United States and Canada, which imposed tariffs on imported Chinese solar technology. Despite all these challenges, prices remained low and all parties settled their matters through negotiation and compromise.

In South Africa, global reductions in the price of key renewable energy technologies also led to reductions in the cost of imported commodities, and eventually in the cost of power procured by Eskom from IPPs. Price is an important factor in competitive bids. For example, the competitive price of Chinese steel makes Chinese imports more attractive than locally produced steel for use in wind turbine towers supplying electricity to Eskom (Rivett-Carnac, 2022).

³ A watt-peak (Wp) is the maximum power output a solar panel can produce under standard test conditions.

This example illustrates how institutional and corporate power exercised outside South Africa can shape the competitive conditions facing domestic manufacturers. The availability of lower-cost imported inputs can reduce project costs and electricity prices, but can simultaneously weaken the competitiveness of domestic manufacturers and constrain opportunities for localisation.

Governments can also exercise institutional power through control over strategic resources. In this area, China has also played a prominent global role. China's dominant position in the production and processing of many critical minerals used in renewable energy technologies — including rare earth elements and other key inputs — has become an important source of geopolitical and industrial influence. By combining resource control with export policies and industrial strategy, China has strengthened the competitive position of its renewable energy industries while influencing the availability and cost of critical inputs in GPNs (Kalantzakos, 2020; Sanchez-López, 2023; Bofo et al., 2024). Recent export restrictions on selected critical minerals illustrate how resource governance can be used to shape GPNs and industrial competition. These developments have intensified global efforts to secure alternative sources of critical minerals, particularly in Africa and South America (Lunde Seefeldt, 2020; Global Witness, 2023).

For South Africa, this highlights that mineral endowments alone are insufficient to generate industrial development. Institutional power lies in how governments use resource policy, beneficiation strategies, and industrial policy to convert natural-resource advantages into localisation, technological upgrading, and domestic value capture (Andreoni and Roberts, 2022).

The Chinese experience illustrates how industrial policy can fundamentally reshape GPNs. Through sustained state support, Chinese firms dramatically expanded production capacity while reducing manufacturing costs, transforming China into the world's largest producer of renewable energy technologies. These developments have had direct implications for South Africa, lowering the price of imported renewable energy components while simultaneously increasing competitive pressures on domestic manufacturers. Institutional decisions taken outside South Africa therefore have important consequences for localisation, technological upgrading, and value capture in South Africa's renewable energy sector. Institutional power is therefore exercised not only through rules governing firms in South Africa, but also through policy decisions made by states that occupy powerful positions elsewhere in the GPN.

Within this global context, domestic institutional power also plays a critical role in shaping firms' legal, regulatory, and policy environment. In South Africa, the state establishes this environment through policies on energy, industry, procurement, investment, labour, and local economic development that influence the conditions under which domestic and global actors participate in renewable energy production networks. These institutions help determine who can participate in the sector, the obligations attached to participation, the conditions under which investment takes place, and the requirements that firms must meet when supplying renewable energy projects.

The development of South Africa's renewable energy sector is traceable to the 2003 White Paper on Renewable Energy, which identified renewable energy as a strategic priority and established a policy basis for encouraging investment. This was followed by the launch of the Renewable Energy Feed-in Tariff (REFIT) in 2009, which attempted to encourage private investment through long-term electricity purchases at pre-determined tariffs. Although REFIT showed signs of progress in attracting several developers, its implementation was constrained by bureaucratic difficulties and regulatory uncertainty (Lawrence, 2020). The subsequent development of the IRP 2010 and REIPPPP established a more durable institutional framework for renewable energy investment.

REIPPPP formally replaced REFIT in 2011 and introduced competitive procurement for privately generated renewable electricity. Importantly, participation in the programme was subject not only to technical and financial requirements but also to broader economic development conditions, including requirements for local content, employment creation, B-BBEE, and socio-economic development. These provisions formed part of the institutional conditions governing how firms participate in renewable energy production networks and how projects are organised in South Africa.

The institutional environment is also shaped by broader industrial policy. The Industrial Policy Action Plan (IPAP), for example, sought to promote industrial diversification, manufacturing development, beneficiation, employment creation, and the expansion of opportunities for Black-owned enterprises. It provided a broader policy framework using public procurement, government-private sector partnerships, local production, and export promotion to support structural transformation. Renewable energy therefore became embedded not only in energy policy but also in wider efforts to reshape the structure of the South African economy.

More recently, SAREM has sought to strengthen this connection between renewable energy deployment and industrial development. SAREM explicitly links renewable energy deployment with manufacturing development, technological upgrading, skills development, industrial transformation, decent work, and a just transition. It therefore represents an evolution from policies concerned primarily with increasing renewable electricity generation towards a broader institutional framework in which renewable energy is also viewed as an opportunity for localisation and industrial development.

Taken together, these international and domestic institutions establish important rules governing participation in South Africa's wind turbine production networks. These rules shape who can participate, the conditions attached to investment and production, and the obligations firms must meet. However, the existence of these institutional arrangements does not by itself demonstrate that they have produced localisation, technological upgrading, or domestic value capture. The extent to which this happens also depends on the specific policy instruments through which the state seeks to influence investment, firm behaviour, and the development of industrial capabilities. These instruments are examined in the following section.

Directing industrial development

Creating the rules under which firms participate in renewable energy production networks is only one dimension of institutional power. States also exercise power by actively directing industrial development through a range of policy instruments that influence firm behaviour, investment decisions,

technological upgrading, and market outcomes. These instruments determine whether renewable energy investment merely creates electricity generation capacity or also contributes to broader objectives such as localisation, technological upgrading, industrial diversification, employment creation, and a just transition. The ability of the state to direct industrial development depends not only on the design of individual policies but also on their implementation, coordination, and predictability over time.

Five principal mechanisms can be identified in South Africa's actions to support industrial development related to producing renewable energy systems:

- supporting value enhancement
- shaping trade rules and market structures
- using public procurement strategically
- providing public finance and industrial incentives
- regulating and licensing.

Together, these instruments influence both the opportunities available to domestic firms and the extent to which value created in renewable energy production networks is retained in the South African economy.

a. Supporting value enhancement

Supporting firms to acquire technological capabilities is one of the state's most important industrial functions. The Department of Higher Education and Training has implemented various training initiatives to support skills development through Sector Education and Training Authorities (SETAs), including the Energy and Water SETA (EWSETA) and the Manufacturing, Engineering and Related Services SETA (merSETA). However, these skills development initiatives largely focus on installation, maintenance, and operational skills rather than advanced manufacturing, engineering design, R&D, and product innovation. Consequently, while the programmes support renewable energy deployment, they provide only limited support for meeting SAREM's manufacturing ambitions.

In addition, REIPPPP and B-BBEE frameworks require and incentivise investment in skills development and broader economic development activities. However, evidence from REIPPPP projects indicates that financial commitments to skills development do not necessarily translate into effective local capability development, particularly where local skills shortages, fragmented governance, and limited institutional capacity constrain implementation (Borchardt, 2025).

The government is also taking measures to encourage technology transfer from global firms. REIPPPP local content rules can create incentives for local sourcing, supplier development, skills transfer, and technological upgrading. Existing research provides evidence of localisation and domestic participation under REIPPPP, but offers more limited evidence on the extent to which these requirements have generated sustained technology transfer and technological capability development in domestic firms (Baker and Sovacool, 2017; Ettmayr and Lloyd, 2017; Larsen and Hansen, 2022; Morris et al., 2020). Global firms are also evaluated on the Enterprise and Supplier Development element in their B-BBEE scorecards, creating incentives to support and develop Black-owned enterprises within and beyond

their supply chains. However, the extent to which these initiatives generate sustained technological upgrading among renewable energy suppliers remains poorly documented.

Another mechanism is the National Industrial Participation Programme (NIPP), which requires foreign companies awarded large public contracts to undertake domestic economic activities, such as technology transfer, investment in local R&D, and the establishment of joint ventures. However, evidence of its impact on renewable energy manufacturing capabilities is limited.

More recently, SAREM has sought to create a predictable long-term pipeline of renewable energy demand that can incentivise investment in domestic manufacturing capabilities, while explicitly targeting the development of local skills and technological innovation. Given its recent implementation, however, its effectiveness in generating new manufacturing capacity and technological upgrading remains to be assessed.

Finally, government supports localisation through publicly funded research and innovation programmes. The Council for Scientific and Industrial Research (CSIR) plays an important role in building the scientific and technical knowledge base underpinning the renewable energy sector through research on wind resources, grid integration, energy system modelling, and renewable energy planning. For example, joint CSIR research has demonstrated that South Africa possesses world-class wind resources capable of supporting large-scale deployment of wind energy while maintaining system reliability (CSIR, n.d.; Knorr et al., 2016). The South African National Energy Development Institute (SANEDI) complements these efforts by supporting energy innovation, coordinating renewable energy research programmes, maintaining knowledge platforms such as the Wind Atlas for South Africa, and facilitating collaboration between government, industry, and research institutions. These initiatives can contribute to the knowledge and capability base required for value enhancement, although their direct contribution to commercial manufacturing upgrading remains difficult to establish from the available evidence.

b. Shaping trade rules and market structures

Another way that the state shapes the growth of the renewable energy industry is by determining the competitive environment in which firms operate through trade rules and market structures. Instruments such as local content requirements, tariffs, technical standards, customs regulations, and procurement rules influence the relative competitiveness of domestic and imported products. International experience shows that such measures have been able to support the development of the wind industry in China, the US, the EU, India, Japan, Australia, and other countries (Chen, 2015; Graham et al., 2021; Insights, 2022; Lewis, 2007).

In South Africa, these powers are exercised primarily through preferential procurement legislation, tariff and customs measures administered by the International Trade Administration Commission (ITAC), technical standards, and local content designation policies. Together, these instruments are intended to encourage domestic manufacturing while reducing dependence on imported renewable energy equipment.

The clearest evidence of their effects can be found in the local content requirements under the REIPPPP, while the specific effects of tariffs, customs measures, and technical standards on domestic wind manufacturing remain less systematically documented. Available evidence from South Africa suggests that local content requirements under the REIPPPP created incentives for domestic participation, but their effects have been less extensive than intended, because some of the conditions required for effective local-content policy were not in place (Ettmayr and Lloyd, 2017). Larsen and Hansen (2022) similarly find that localisation has progressed furthest in wind-tower production, while localisation of blades and nacelles has remained more limited, reflecting differences in the technological and governance characteristics of these components.

These findings suggest that trade and procurement measures can create opportunities for localisation, but their effects depend on the productive capabilities of domestic firms and the characteristics of the activities being targeted. They therefore illustrate an important distinction between institutional power and institutional effectiveness: the state may possess the authority to shape competitive conditions, but the resulting industrial outcomes depend on how these instruments are designed, implemented, coordinated, and enforced.

c. Using public procurement strategically

Public procurement provides one of the state's strongest mechanisms for shaping renewable energy production networks because it can create predictable demand for renewable energy technologies and associated manufacturing, construction, transport, and engineering services. Since 2011, the REIPPPP has generated substantial investment in renewable energy projects while using procurement conditions to influence how projects are developed and where socio-economic benefits are generated. Importantly, the suspension of procurement between 2015 and 2019 demonstrated that inconsistent procurement undermines investor confidence, supplier development, and localisation efforts (Morris et al., 2020). Stable procurement programmes are therefore essential for sustaining domestic manufacturing capabilities.

Public procurement can also be used to direct expenditure towards domestic firms through local-content requirements and related socio-economic conditions. However, implementation of South Africa's local content policies has often been weak. Local firms face difficulties competing with foreign companies on quality and price, and meeting inflexible procurement regulations, while existing systems for enforcing compliance with local content requirements are inadequate (Baker and Sovacool, 2017; Rivett-Carnac, 2022; Wilhelm, 2017). As discussed earlier, the tendency of global OEMs and EPC contractors to source components through established international supplier networks further limits opportunities for domestic supplier development, even where local content requirements exist.

Evidence from South Africa also suggests that the effectiveness of procurement conditions depends on the characteristics of the products being localised. Larsen and Hansen (2022) show that localisation has been most successful in wind tower manufacturing because tower production involves comparatively mature technologies and more codified production processes than components such as blades or nacelles. By contrast, higher-value components remain more tightly governed by global OEMs through proprietary technologies and established supplier networks. This suggests that public procurement is most likely to support industrial development when procurement conditions are aligned with the

technological and governance characteristics of individual components rather than applied uniformly across the entire value chain. Procurement can create the market conditions for domestic participation, but sustained upgrading requires these programmes to be combined with measures that build domestic capabilities and supplier relationships.

d. Providing public finance and industrial incentives

The strategic deployment of financing is another way that the state can influence the industry. The financing role of the South African government encompasses diverse instruments, such as targeted incentives and subsidies. Specifically, the state offers financing options designed to lower barriers for advanced industrial production, such as the Black Industrialist Programme, the Manufacturing Competitiveness Enhancement Programme (MCEP), Special Economic Zones (SEZs), and the Critical Infrastructure Programme (CIP) (SAREM, 2024). Together with broader initiatives supporting the Just Energy Transition — including Technology Innovation Agency (TIA) grants intended to commercialise emerging clean technologies — these programmes seek to reduce investment risks, encourage local production, and create opportunities for domestic firms to expand their technological and organisational capabilities.

Evidence from the broader industrial-policy environment suggests that such instruments can generate measurable economic outcomes. The World Bank's 2026 review of South Africa's SEZ programme reports that operational SEZs have generated R14.8 billion in revenue and more than 30,000 jobs, although it also identifies significant scope to improve the programme's performance and its wider contribution to industrialisation (World Bank, 2026).

Moreover, the South African government provides social grants to vulnerable households who supply the labour needed by the industry. In this way, the state subsidises the private sector in terms of the social reproduction needed to create a labour force, as discussed further in Section 6. Such broad-ranging financial support can help the industry to grow in multiple ways.

e. Regulating and licensing

Finally, institutional power is exercised through regulation and licensing. The South African state shapes the environment in which manufacturers operate through company registration requirements, environmental approvals, labour legislation, customs administration, technical standards, product certification, and investment regulations. These frameworks influence the cost, speed, and certainty of investment, affecting firms' willingness and ability to manufacture locally. Where regulatory requirements are unclear, approvals are delayed, or policy arrangements change unpredictably, they can increase investment risks and weaken incentives for firms to develop domestic production capabilities. Regulation of electricity generation also influences the timing and scale of renewable energy projects, thereby affecting demand for domestically manufactured wind turbine components.

Recent reforms illustrate the importance of these regulatory conditions: raising the licensing-exemption threshold for embedded generation and streamlining environmental authorisations were intended to reduce barriers and accelerate renewable-energy investment (Government of South Africa, 2021; Department of Environment, Forestry and Fisheries, 2020). Conversely, regulatory burden and policy

uncertainty have been identified as constraints on renewable-energy deployment (IMF, 2022). Collectively, these regulatory systems shape the competitiveness of South African firms and the prospects for localisation. They also demonstrate that institutional power can operate through both the presence of regulation and the predictability and administrative capacity with which regulation is implemented.

Shaping how development is measured

Institutional power also extends to determining how the success of industrial policy is measured (Hermanus and Kamanzi, 2026). By defining policy objectives and selecting the indicators used to assess progress, the state influences which outcomes are prioritised and which are made visible. For example, the choice of objectives and measures shapes how industrial performance is understood and can create challenges for efforts to promote localisation, domestic value creation, and value capture, as discussed in Section 4.3. In this sense, measurement is itself a form of institutional power. What institutions choose to measure influences what counts as policy success.

This exercise of measurement fundamentally exposes the underlying friction within state institutional design during a green transition. Public monitoring frameworks remain structurally tethered to tracking immediate, quantifiable utility metrics—such as total electricity generated, water savings, carbon emissions mitigated, or aggregate spend headcounts—rather than actively fostering deep, long-term industrial capacities, secure job tenures, and equitable gender distribution. Ultimately, this structural asymmetry demonstrates that policy priorities are heavily skewed toward immediate utility targets and transactional compliance over systemic local industrial development.

5.2.2. The roles of financial institutions

Financial institutions constitute a second group of institutional actors that shape renewable energy production networks by determining which firms, projects, and technologies gain access to capital and under what conditions. These financing requirements can favour large, established multinational firms with proven track records, while limiting opportunities for smaller domestic firms and manufacturers that may struggle to satisfy bankability and financing criteria (Baker and Sovacool, 2017). Through commercial lending, development finance, export credit, investment guarantees, and climate finance, they influence participation in GPNs, the pace of technological upgrading, and opportunities for localisation.

In South Africa, the Just Energy Transition Investment Plan (JET-IP), developed under the Just Energy Transition Partnership (JETP), directs investment towards specific technologies and priorities, thereby shaping the trajectory of the country's energy transition (Baloyi, 2022). At the project level, commercial banks and development finance institutions assess the financial viability and risks of proposed projects and impose requirements for bankability before providing finance. For domestic manufacturers, these requirements can be particularly significant because establishing production capacity often requires substantial upfront investment, while firms without an established track record or strong financial position may face greater difficulty securing commercial finance.

The REIPPPP provides a further example of how financial requirements shape firm participation. Firms must provide financial guarantees before bids are accepted, meaning that access to sufficient financial resources is a prerequisite for competing for procurement contracts (Morris et al., 2020). Financial institutions therefore influence the production network not only through the capital they provide but also through the criteria they use to assess firms and projects. These criteria can affect which actors enter the network, the scale and type of investment undertaken, and the extent to which domestic firms are able to develop productive capabilities and participate in higher-value activities.

Financial institutions do not simply enable renewable energy projects; they also help shape the structure of the production network and the distribution of opportunities for localisation and domestic industrial development. Where financing criteria favour established firms, imported technologies, or short-term project bankability over domestic capability development, financial institutions may reinforce existing corporate power and constrain the potential for localisation to produce sustained value enhancement and capture. Conversely, appropriately designed development finance can help address the capital constraints that currently limit domestic firms' ability to invest in new technologies, expand production, and move into higher-value activities.

5.3. Collective power

Collective power refers to the ability of organised groups to influence production networks through coalition-building, advocacy, negotiation, and collective action. Unlike corporate power, which derives from ownership and market position, or institutional power, which derives from formal rules and public policy, collective power emerges when groups organise to influence firms, governments, and broader development outcomes. In South Africa's wind energy production network, the principal sources of collective power include business associations, coal sector interests, trade unions, civil society organisations (CSOs), and host communities.

These actors do not possess equal resources or access to decision-making, and their interests may also conflict. Collective power is therefore exercised through struggles over the direction, distribution, and consequences of the energy transition. In the South African wind GPN, collective actors can reinforce existing corporate and institutional power, but they can also challenge it by seeking to influence localisation, industrial development, employment, environmental outcomes, and the distribution of benefits.

5.3.1. Business associations

Providing firms with a collective voice in policy processes, the South African Wind Energy Association (SAWEA) has pushed for government policy to better support localisation in wind energy value chains through establishing predictable policies and ensuring that energy policies and industrial policies are aligned (Morris et al., 2022). With membership consisting primarily of global OEMs, developers, EPC contractors, financiers, and service providers, SAWEA plays the leading representative role in the sector. Through policy engagement, information sharing, and advocacy for a renewable energy roll-out, SAWEA seeks to shape the policy and regulatory environment in which members operate. In doing so, it converts the interests and resources of individual firms into a collective industry voice, thereby reinforcing the corporate power of its members in negotiations with government.

For example, in 2025 SAWEA submitted 14 formal policy and regulatory responses to key institutions, including the DEE, NERSA, Eskom, National Treasury, the IPP Office, ITAC, and environmental authorities, addressing issues including electricity market reform, grid capacity allocation, congestion curtailment, transmission planning, environmental permitting, cost-recovery mechanisms, and carbon markets (SAWEA, 2026). This illustrates how business associations attempt to exercise collective power by influencing the rules and conditions governing participation in the GPN. Their influence can support industry growth and create a more predictable environment for investment, but it also means that policy debates are shaped by an organised industry constituency whose members include many of the global firms that already possess substantial corporate power. Collective business power therefore has the potential to reinforce existing patterns of corporate influence, even where it advocates localisation and industrial development.

5.3.2. Coal sector interests

Actors in the coal sector have collectively sought to influence the pace and direction of South Africa's energy transition, generally advocating a slower transition that protects coal-dependent industries, employment, and existing institutional interests (Bookbinder, 2025). In South Africa, coal remains the main source of energy, despite the growing adoption of renewable energy technologies. The coal sector employs over 90,000 workers and makes a significant contribution to the country's export revenue. This explains the government's classification of coal as a critical mineral in the country's critical minerals strategy. Importantly, energy and mining companies enjoy a symbiotic relationship: mining companies supply coal to electricity producers, while electricity producers supply power to the mines. This creates what scholars have described as the minerals-energy complex (Baker, 2015; Eberhard, 2007; Lawrence, 2020).

A transition away from coal therefore threatens established economic relationships, employment, investment, and institutional interests. Coal sector actors have consequently used their collective influence to resist or moderate aspects of the transition that threaten these interests. Their longstanding position in South Africa's political economy gives them considerable capacity to shape energy-policy debates and the pace at which renewable energy displaces existing forms of generation. This illustrates that collective power can constrain localisation and industrial transformation in renewable energy not only through opposition to particular technologies, but also through efforts to preserve existing production networks and institutional arrangements.

5.3.3. Trade unions

Although union representation in renewable energy manufacturing remains limited, organised labour continues to exercise significant influence over South Africa's broader energy transition. Trade unions have consistently argued that renewable energy expansion should be accompanied by secure employment, industrial development, and decent work (NUM, 2023). To this effect, the Congress of South African Trade Unions (COSATU), the country's largest trade union federation, developed the Just Energy Transition Blueprint for Workers, outlining measures to link decarbonisation with localisation, industrial policy, and worker protection. Unions also exercise collective power through political mobilisation, policy advocacy, bargaining, and engagement with the state and Eskom.

Unions' influence therefore extends beyond the workplace to broader debates over the pace and form of the energy transition. For example, COSATU has used its position as a major national labour federation to advocate for a transition that combines decarbonisation with industrial development, localisation, and worker protection. Trade unions therefore provide an important counterweight to corporate and institutional power. Their collective power can push the GPN towards forms of value creation and capture that prioritise employment quality, worker protection, and domestic industrial development rather than simply increasing renewable energy capacity or reducing the cost of electricity. However, the limited presence of organised labour in renewable energy manufacturing constrains their ability to influence how value is distributed in the production network itself.

5.3.4. Civil society organisations

CSOs provide an important countervailing force in renewable energy production networks by advocating for environmental protection, social justice, community participation, and inclusive development. For example, the IEJ has been involved in promoting localisation and decent work objectives in SAREM (IEJ, 2021). Organisations such as GreenCape, Groundwork, 350.org, African Just Transition Network, Sustainable Energy for All, and RES4Africa engage government and industry on issues including climate change, local content implementation, community participation, and the social consequences of energy transition.

Through research, advocacy, coalition-building, and public scrutiny, these organisations contribute expertise and alternative perspectives to policy debates that might otherwise be dominated by corporate and state actors. Their collective power is primarily exercised through their ability to influence public discourse, provide evidence, mobilise constituencies, and hold firms and government accountable for their commitments. In doing so, CSOs can challenge narrow measures of success based on investment, installed capacity, or expenditure, and promote broader understandings of localisation, value capture, environmental justice, and decent work. However, their ability to influence actual investment and production decisions remains dependent on their access to decision-makers and their capacity to build alliances with more powerful actors.

5.3.5. Host communities

Evidence suggests that the developmental benefits generated by community trusts — and their influence over project governance and local development outcomes — vary considerably across REIPPPP projects, despite the intention that these arrangements ensure that local populations share in the benefits of renewable energy investment (Baker and Wlokas, 2015; McDaid, 2016; Okbandrias, 2022). The ability of host communities to exercise meaningful collective power depends not only on formal ownership arrangements but also on their organisational capacity, access to information, governance arrangements, and ability to negotiate collectively with developers and government. Host communities therefore constitute a distinctive source of collective power because they are directly affected by renewable energy developments while also having formal channels for participation through community ownership trusts.

Collective action can provide an additional source of leverage where formal participation does not translate into meaningful influence. Where local people perceive that employment opportunities, benefit-sharing arrangements, or consultation processes are inadequate, collective action can delay projects, reshape negotiations, and increase pressure on developers and the state to respond to community demands (McDaid, 2016). However, as with other forms of collective power, the ability of communities to influence outcomes varies considerably. Unequal access to information, organisational capacity, and resources can limit their bargaining position, while weak governance in community institutions can reduce the extent to which benefits are broadly distributed.

5.3.6. Implications of collective power

Taken together, these examples demonstrate that collective power is an important but highly uneven force in South Africa's wind turbine GPNs. Business associations can strengthen the influence of firms, while coal-sector interests can constrain the pace and direction of transition. Trade unions, civil society organisations, and host communities provide potential counterweights by advocating localisation, decent work, environmental protection, and more inclusive forms of value capture.

However, these actors do not possess equivalent resources, access, or bargaining power. Collective power therefore does not automatically produce more inclusive outcomes. Instead, its effects depend on which actors are able to organise effectively, gain access to decision-making processes, and build alliances with other sources of power. The distribution of collective power helps explain why commitments to localisation and a just transition can coexist with continued corporate concentration, imported technologies, uneven employment outcomes, and limited domestic value capture.

5.4. What do these power relationships tell us about localisation in South Africa's wind GPNs?

Taken together, the analysis shows that the distribution of corporate, institutional, and collective power strongly shapes localisation outcomes in South Africa's wind turbine GPN. Global OEMs retain substantial influence through their control over technology, supplier networks, and markets, while public and financial institutions shape the conditions under which firms can participate and invest. Collective actors provide important potential counterweights, but their ability to influence outcomes varies considerably.

These unequal power relations help explain why participation by South African firms has not necessarily translated into sustained technological upgrading, higher-value activities, or broader value capture. Rather than being determined by the availability of domestic productive capabilities alone, localisation is shaped by the ability of different actors to influence the organisation and governance of the GPN. Localisation therefore depends not only on building domestic productive capabilities, but also on the capacity of public institutions and collective actors to influence how GPNs are organised and how their benefits are distributed. Where global firms retain control over technology, markets, and established supplier networks, and where institutional and collective actors have limited capacity to alter these arrangements, localisation can increase participation without fundamentally changing

South Africa's position in the GPN. Conversely, stronger institutional coordination and collective capacity could create greater opportunities for domestic upgrading, value capture, and decent work.

These dynamics also point to the importance of examining how power is embedded in the wider relationships connecting firms, institutions, workers, and territories. The following chapter examines the forms of embeddedness that shape how actors participate in South Africa's wind GPNs and how these contextual constraints influence the possibilities for localisation and upgrading.

6. EMBEDDEDNESS IN WIND TURBINE GPNS IN SOUTH AFRICA

Beyond the independent operation of power dynamics, firms' opportunities are also determined by how they are embedded in networks, territories, and societies. Embeddedness is not simply a matter of where firms are located or with whom they have relationships. It also reflects the nature and depth with which these positions influence the resources firms can access, their capacity to exercise agency, and their prospects for industrial upgrading and localisation. In this sense, embeddedness helps explain why some forms of participation generate viable avenues for value capture while others reproduce dependence on more powerful actors. Accordingly, this section examines how network, territorial, and societal embeddedness influence the overall potential for expanding domestic production of wind energy components in South Africa.

6.1. Network embeddedness

As outlined above, network embeddedness refers to the “degree of connectivity within a GPN, the stability of its agents' relations and the importance of the network for the participants” (Henderson et al., 2002, 452). The extent and nature of these relationships strongly influence firms' opportunities to upgrade, access technology, secure contracts, and capture value. Importantly, however, embeddedness within a network does not necessarily imply equal access to these resources. Relationships within GPNs can be highly asymmetrical, with lead firms retaining greater control over technology, procurement, information, and markets. Network embeddedness must therefore be considered alongside the power relationships examined in Section 5.

For South Africa, the key issue is not simply whether firms participate in production networks, but how they participate. Firms embedded primarily as importers, distributors, or installers remain confined to lower-value activities, whereas firms embedded in innovation, supplier-development, and technology networks may be more likely to develop domestic manufacturing capabilities and generate decent work. The depth and character of network embeddedness therefore influence whether participation provides a pathway towards upgrading or instead reinforces firms' dependence on global lead firms. Following a presentation of key relationships in Box 5, this section distinguishes between global and domestic forms of network embeddedness.

Box 5: Characterising relationships in South Africa's Wind GPN

The relationships between South Africa's wind energy GPN actors — the state, global firms, local firms, financiers, workers, and communities — are unequal but highly interdependent. Key relationships are:

- **State – OEMs and project developers:** This is primarily a relationship of market creation, regulation, procurement, and bargaining. The state depends on private developers and OEMs to produce the energy to address the energy crisis, whilst demonstrating its commitment to the Copenhagen Accord by increasing the contribution of renewable energy to the country's electricity supply. The OEMs and project developers depend on state procurement for market access.
- **State – financial institutions and financiers:** This is primarily a relationship of risk governance and investment mobilisation. Financial institutions and financiers depend on the state to provide a sufficiently predictable regulatory, procurement, and policy environment. Conversely, the state relies on financiers to provide the capital necessary for renewable energy generation.
- **OEMs – local firms:** This is primarily a relationship of asymmetric technological and market power. Dominant Chinese, EU, and US OEMs dominate GPNs, own intellectual property, lead R&D, and control prices. Local firms, lacking capital and technological expertise, depend on these OEMs for access to technology, finance, markets, and procurement. These relationships prioritise profitability. If more profitable, OEMs regularly import, often from their own subsidiaries. However, global OEMs rely on local partners and suppliers to enable project developers to satisfy local content and B-BBEE criteria mandated by government tenders.
- **Financiers – firms:** This is primarily a relationship of discipline, conditionality, and exclusion. Finance has the power to impose conditions for project bankability and exclude non-complying actors. In the bidding process, the IPP Office expects a bid from a project developer to include a financial guarantee. To secure this backing, developers must force global OEMs and local suppliers to comply with the financiers' conditions. Local firms or unproven technologies failing to meet these stringent criteria face exclusion.
- **State – local firms:** This is a relationship of procurement, regulation, and policy certainty. The stop-start nature of the state procurement programme creates uncertainty and risk, in a context where the wind sector survives almost exclusively on state procurement. This relationship has implications for both economic and social outcomes, directly

impacting industrial investment plans, the survival of local firms, and worker livelihoods. Through local content and B-BBEE mandates, the state establishes explicit policy goals intended to support and develop these local firms. However, local suppliers remain highly vulnerable to shifts in state regulatory enforcement and procurement consistency.

- **Firms – workers, families, and host communities:** This is primarily a relationship of employment, livelihoods, labour conditions, and social licence. Workers, families, and communities depend on global and local firms for jobs and development. This relationship is fraught with expectation and potential confrontation, taking place in a context already inflamed by poor service delivery, poverty, unemployment, and violent crime (see Section 6.3). At the same time, firms depend on localised labour forces and stable community relations to ensure uninterrupted project execution.

These relationships demonstrate that network embeddedness in South Africa's wind GPN is characterised by both interdependence and asymmetry. Actors depend upon one another to sustain the production network, but lack equal capacity to determine the terms of these relationships. This distinction is important because the developmental effects of embeddedness depend not simply on whether relationships exist, but on what firms and other actors are able to access through them, and on who retains control over the resources, knowledge, and decisions that shape production.

6.1.1. Global network embeddedness

Global network embeddedness provides firms with access to technologies, markets, finance, knowledge, and strategic partnerships that support industrial upgrading. As discussed above, international experience demonstrates that successful renewable energy manufacturers have deliberately strengthened their global embeddedness through buyer-supplier relationships, acquisitions and joint ventures, and participation in global associations. These forms of embeddedness can provide channels through which firms gain access to technologies, capabilities, markets, and knowledge that are difficult to develop independently. However, the developmental benefits depend on the nature of these relationships and on whether they enable firms to acquire capabilities or simply extend their participation in lower-value activities.

Buyer–supplier relationships constitute one of the most important forms of global network embeddedness because they determine which firms participate in production networks and the activities they carry out. Long-term relationships between OEMs, EPC contractors, and component suppliers facilitate knowledge exchange, technical learning, and repeat contracts that can support industrial upgrading.

At the same time, these relationships can reinforce dependence as lead firms retain control over product design, technology, procurement, and specifications.

In South Africa, however, firms are embedded in these networks primarily as contract manufacturers operating under OEM specifications, rather than as technology owners or system integrators. Local manufacturers such as DCD Wind Towers and GRI Towers have supplied towers for multinational OEMs under the REIPPPP, but design, engineering, intellectual property, and procurement decisions remain concentrated in the lead firms, limiting opportunities for technological upgrading and independent supplier development (Baker and Sovacool, 2017; Morris et al., 2020). As a result, localisation has largely occurred in OEM-controlled buyer–supplier relationships, with domestic firms undertaking manufacturing while higher-value activities remain concentrated in global lead firms (Larsen and Hansen, 2022).

This illustrates an important distinction between participation and upgrading. South African firms have become embedded in GPNs, but the depth of that embeddedness remains limited where firms undertake production without gaining control over design, technology, procurement, or market access. Their network relationships therefore create employment and domestic production opportunities, but do not necessarily enable them to move into higher-value activities or increase their bargaining power in the GPN.

At the same time, South Africa's comparatively stronger manufacturing base in Southern Africa creates opportunities for firms to develop longer-term regional buyer–supplier relationships, as renewable energy deployment expands across the continent. Building regional production networks could therefore provide an important stepping stone towards deeper integration into global renewable energy value chains and potentially create opportunities for domestic firms to broaden their capabilities, diversify their markets, and reduce dependence on individual global OEMs.

Interfirm relationships external to buyer–seller links are also important in this network. Acquisitions and joint ventures have become important mechanisms for acquiring technological capabilities and expanding global networks. As discussed in Section 4.2, Chinese and Indian firms have used acquisitions, joint ventures, and overseas research networks to gain access to technology, intellectual property, engineering capabilities, and international markets (Lewis, 2007; Windtech International, 2011; Weston, 2016; Cheng et al., 2024; Suzlon, 2024; Cretini et al., 2025). By contrast, apart from buyer–supplier relationships, South African firms have participated in GPNs primarily through licensing agreements and partnerships with multinational OEMs rather than through outward acquisitions or technology-seeking investments. This reflects the country's more limited financial and technological capabilities.

The comparison is significant because it illustrates that different forms of network embeddedness provide different possibilities for upgrading. Relationships that give firms greater access to technology ownership, R&D capabilities, and international markets can potentially strengthen their position in the GPN, whereas relationships centred primarily on contract manufacturing may leave firms dependent on decisions made by global lead firms.

Participation in international industry associations further strengthens network embeddedness. Organisations such as the Global Wind Energy Council, that represents 1,500 firms in over 80 countries,

including China, the US, EU, and India, draw members from manufacturers, project developers, component suppliers, research organisations, and wind and renewable energy associations, connecting these organisations to create global knowledge flows (GWEC, 2025). Through initiatives such as Africa WindPower, they also facilitate collaboration between governments, investors, and firms seeking to develop renewable energy industries across Africa. South African organisations, including the South African Wind Energy Association (SAWEA), participate in these international networks through GWEC membership, providing domestic firms with opportunities to engage with global industry developments, policy discussions, and potential technology and investment partners (GWEC, 2025; SAWEA, 2025).

However, participation in industry associations should not be equated with technological or productive upgrading. Whether these connections translate into new capabilities or contracts depends on firms' resources and their position in the wider GPN.

These experiences suggest that localisation is not achieved through domestic investment alone. Rather, successful localisation depends on firms becoming strategically embedded in global innovation and supplier networks through long-term buyer–supplier relationships, technology partnerships, joint ventures, research collaboration, and international business networks that enable domestic firms to upgrade into higher-value manufacturing, engineering, and design activities. For South Africa, the challenge is therefore not simply to increase the number of connections between domestic and global firms, but to deepen the forms of embeddedness through which domestic firms can access technology, knowledge, markets, and decision-making capabilities. In this respect, network embeddedness represents both an opportunity for upgrading and a potential mechanism through which existing power asymmetries can be reproduced.

6.1.2. Domestic network embeddedness

While global relationships provide access to technology and markets, domestic network embeddedness determines whether these opportunities translate into local industrial development. Businesses' operations can depend on how their relationships with local actors are structured, including the development of formal and informal relationships, trust building, and whether they gain access to knowledge about opportunities. Domestic network relationships can connect firms to other manufacturers, suppliers, universities, research institutions, government agencies, financiers, industry associations, workers, and communities. These relationships can be important for sharing information, identifying procurement opportunities, developing suppliers, accessing skills and finance, and coordinating investments across the domestic economy.

However, available data does not provide adequate insight into the nature of domestic relationships. More research is needed to better understand how these relationships influence firms. This represents an important limitation, particularly because strong domestic networks may be necessary to translate participation in global GPNs into broader industrial linkages and value capture in South Africa. Further research is needed to examine the density and quality of relationships among domestic firms and between firms and public institutions, research organisations, financiers, workers, and communities, and to assess whether these relationships facilitate knowledge sharing, supplier development, technological upgrading, and more stable employment.

The evidence presented above suggests that South African firms are often embedded in global networks through relationships in which key decisions remain controlled by global OEMs. Understanding whether domestic networks can compensate for, complement, or reinforce these external dependencies therefore requires greater attention to the territorial and societal relationships in which firms are embedded. The following sections examine these dimensions of embeddedness.

6.2. Territorial embeddedness

As already noted, territorial embeddedness refers to how firms “absorb, and in some cases become constrained by, the economic activities and social dynamics that already exist in ... places” (Henderson et al., 2002, 452). Relations that a foreign firm develops with local companies, suppliers, competitors, consumers, workers, communities, and state authorities significantly influence their success or failure (Han et al., 2023). Firms also become territorially embedded through their alignment with local economic, institutional, social, and cultural conditions, their use of local suppliers and labour, and their interaction with regional institutions. Territorial embeddedness therefore complements network embeddedness: while network embeddedness concerns the relationships through which firms participate in production networks, territorial embeddedness concerns the extent to which those relationships become rooted in the economic, institutional, social, and physical characteristics of particular places. Strong territorial embeddedness can generate local supplier development, technological learning, and employment opportunities, whereas weak territorial embeddedness limits localisation and reduces the long-term developmental benefits of renewable energy investment (Henderson et al., 2002).

This distinction is important for understanding localisation in South Africa’s wind turbine GPN. A firm may be strongly connected to GPNs while remaining only weakly embedded in the South African economy. For example, an OEM may establish a local operation, employ workers, and procure some goods and services domestically, while continuing to rely on established global suppliers, technologies, and knowledge networks. In such cases, production is geographically located in South Africa without necessarily generating the deeper local linkages required for sustained industrial upgrading and domestic value capture. Territorial embeddedness therefore provides a means of assessing not simply whether production occurs in South Africa, but whether global production activities become sufficiently rooted in local economic and institutional systems to generate longer-term developmental effects.

In South Africa, territorial embeddedness is shaped in important ways by state policy. Through REIPPPP, government has sought to embed renewable energy investment in the domestic economy by requiring developers to meet local content and B-BBEE obligations, thereby encouraging relationships with local firms and communities (Leigland and Eberhard, 2018; Morris et al., 2020; Ettmayr and Lloyd, 2017; Hansen et al., 2020). As of 2021, wind IPPs reported R24.5 billion in local content expenditure and R29.8 billion in procurement from B-BBEE-compliant businesses during construction and operations (IPPO, 2022). These figures indicate substantial domestic expenditure and demonstrate the capacity of procurement requirements to encourage firms to establish local economic relationships.

However, expenditure alone does not demonstrate deep territorial embeddedness. It does not necessarily indicate whether relationships with local suppliers are long-term, whether knowledge and

technology are transferred, or whether domestic firms develop capabilities that enable them to move into higher-value activities. The institutional power of the state therefore plays an important role in creating the conditions for territorial embeddedness, but the extent to which these conditions generate sustained local capabilities depends on how these relationships develop over time.

In addition, the South African government has also attempted to strengthen regional industrial capabilities through the establishment of SEZs, such as Atlantis SEZ in Western Cape, which combines manufacturing incentives with industrial infrastructure, supplier development, and logistics support. Atlantis SEZ has successfully attracted two wind sector manufacturers, one specialising in wind towers and the other in wind tower internals. Incentives including tax concessions, customs relief, VAT exemptions, and employment support are intended not simply to attract individual investments but also to foster regional manufacturing clusters, supplier linkages, and industrial capabilities that can support localisation over the longer term (Investment Analysis, 2025). The significance of such initiatives therefore lies not only in attracting firms to a particular territory but in whether they contribute to the development of a broader regional industrial ecosystem in which firms can access suppliers, infrastructure, skills, knowledge, and markets.

Territorial embeddedness also extends beyond institutional relationships to include the physical characteristics of the places in which production occurs. The need for wind that is strong, consistent, and appropriately distributed in terms of speed and direction determines the location of a wind farm. Given the bulky nature of the towers, the location of a wind farm, in turn, can influence the location of the factory that manufactures the towers, because proximity can reduce transport and logistics costs (Cetinay et al., 2017). Consequently, wind farms have been established in the Eastern Cape, Western Cape, and Northern Cape, where wind conditions are most favourable (Labuschagne, 2023).

Territorial embeddedness is also shaped by infrastructure. Transmission capacity affects whether wind resources can be connected to the electricity system, while roads, ports, and logistics infrastructure affect the feasibility and cost of transporting bulky wind turbine components. The South African government has acknowledged that insufficient grid capacity in high-wind regions has constrained further renewable energy investment (Energize, 2024b; Africa, 2024). Other important factors influencing where manufacturing and wind farm development can occur include land characteristics to support wind towers, protected areas and natural habitats, land-use regulations, proximity to ports and transport corridors, and road infrastructure (Cetinay et al., 2017). These physical and infrastructural conditions mean that the territorial distribution of wind energy production is not simply a consequence of corporate decisions. It is also shaped by the characteristics and capacities of particular places.

This creates an important potential link between the geography of renewable energy deployment and industrial localisation. Where wind resources, infrastructure, manufacturing capabilities, and supplier networks become concentrated in the same territories, opportunities may emerge for stronger regional production clusters. Such clustering can reduce transaction and transport costs, facilitate repeated interactions between firms, support knowledge exchange, and make it easier for workers and suppliers to develop sector-specific capabilities. Conversely, where renewable energy projects remain disconnected from local manufacturing and supplier ecosystems, the physical presence of wind farms may generate relatively limited longer-term industrial effects. Territorial embeddedness

is therefore strongest where renewable energy investment becomes connected to the wider productive capabilities of the territories in which projects are located.

For global firms, becoming territorially embedded depends on more than locating production facilities or establishing a formal local presence in South Africa. While the state has sought to foster deep territorial integration through mechanisms including REIPPPP procurement, local-content requirements, SEZs, and supplier-development programmes, the evidence suggests a clear distinction between formal compliance and deeper structural embeddedness. The extent to which these measures have generated the dense supplier networks, knowledge linkages, skills formation, and institutional capabilities required for deep territorial embeddedness remains uneven, as illustrated by the evidence discussed above. Consequently, where these deeper linkages remain weak, renewable energy investment may enter South Africa without producing the sustained localisation, upgrading, and domestic value capture required for broader industrial transformation.

This distinction also reinforces the central argument of this report. Localisation is not simply a question of increasing the proportion of renewable energy expenditure that occurs in South Africa. It depends on whether production becomes embedded in territories in ways that strengthen domestic firms, workers, skills, infrastructure, and institutions over time. Territorial embeddedness therefore helps explain why similar levels of local expenditure can produce different developmental outcomes and why the long-term contribution of wind energy to South Africa's industrial transformation depends on the depth and durability of local linkages.

6.3. Societal embeddedness

Societal embeddedness concerns how firms are connected to the broader social, institutional, and cultural environments in which they operate. Unlike network embeddedness, which concerns relationships between firms, or territorial embeddedness, which concerns location-specific institutions and resources, societal embeddedness emerges from the characteristics of workers, households, and communities that sustain production. Where network embeddedness asks how firms are connected in production networks, and territorial embeddedness asks how firms relate to and become rooted in particular places, societal embeddedness asks how production is connected to the social relations and conditions that sustain workers, households, and communities. This includes labour conditions, as well as the unpaid or underpaid work of caring, educating, and daily social reproduction that support workers and subsidise capitalist production.

This subsection of the paper adopts a social reproduction approach to examine the extent to which societal context shapes companies and how, in turn, companies affect workers' ability to sustain themselves, their households, and the future labour force. This perspective draws attention to forms of work and social infrastructure that are essential to production but are often excluded from conventional measures of industrial performance and value capture.

In the context of localisation, societal embeddedness helps explain why expanding manufacturing capacity alone is insufficient unless industrial development also strengthens decent work, gender

equality, and workers' ability to reproduce themselves and future generations. A wind manufacturing sector may therefore become locally established without necessarily becoming socially embedded in ways that strengthen the workforce and communities on which its longer-term development depends.

6.3.1. Labour conditions and decent work

Research on renewable energy has largely concentrated on employment numbers and skills requirements rather than the quality of jobs created (Rutovitz, 2010; Bohlmann et al., 2019; Briggs et al., 2022). Yet localisation depends not only on creating jobs but on creating employment capable of attracting, retaining, and upgrading skilled workers. The quality of employment therefore matters not only as a social outcome of localisation but also because it affects a firm's ability to build and retain productive capabilities. Stable employment, adequate wages, skills development, worker representation, and workplace protections can help firms attract and retain workers while supporting the accumulation and reproduction of skills required for technological upgrading. Conversely, precarious employment can weaken workers' incentives and ability to invest in sector-specific skills and undermine the longer-term development of domestic productive capabilities.

The ILO (2013) identifies employment creation, workers' rights, social protection, and social dialogue as the foundations of decent work. South African scholars expand this through the Decent Work Deficit Index, incorporating labour market security, employment security, skills reproduction, representation, income security, and workplace protection (Webster et al., 2008; Mohlakoana et al., 2024). Together, these frameworks provide a way to explore social value through the creation of decent work, shifting the analytical focus from the mere quantity of jobs created to the structural quality and security of employment.

In South Africa, the wind sector is very new, so there is currently limited research that examines working conditions specifically in wind turbine manufacturing. The broader South African labour regime nevertheless provides an important indication of the conditions into which renewable energy manufacturing is being introduced. South Africa's labour market presents significant challenges for achieving decent work. Despite progressive labour legislation (Pons-Vignon and Anseeuw, 2009), research across mining, agriculture, clothing, waste management, and logistics documents a growing trend towards precarious employment, characterised by insecurity, subcontracting, casualisation, and low wages (Webster et al., 2008; Webster et al., 2009; Benya, 2015; Kenny, 2026). The persistence of racialised and gendered unemployment further weakens workers' bargaining power (Gradín, 2019). These wider labour market conditions shape the environment into which renewable energy manufacturers enter.

The stop-start nature of wind sector procurement may reinforce these pressures by producing fluctuations in demand for workers and suppliers. Where firms cannot rely on a stable pipeline of projects, they have weaker incentives to maintain permanent workforces, invest in worker training, or develop long-term employment relationships. Without deliberate policy interventions linking localisation to decent work, there is little reason to expect that expanding renewable energy manufacturing will automatically produce better-quality employment than exists elsewhere in the economy. Indeed, if localisation is pursued primarily through short-term project procurement and

cost competition, there is a risk that employment growth will occur without corresponding improvements in employment security, wages, skills reproduction, or worker voice.

This creates an important link between societal embeddedness and the upgrading argument developed earlier in the report. Technological and productive upgrading requires firms to accumulate capabilities, and these capabilities depend partly on the availability and retention of skilled workers. Decent work can therefore contribute to localisation not simply by improving workers' welfare, but by supporting the stable reproduction of the skills and knowledge on which domestic industrial capabilities depend.

6.3.2. Gender and social reproduction

Societal embeddedness also leaves firms dependent on the ability of households to reproduce the labour force across generations. Social reproduction encompasses the unpaid and underpaid activities of caring, cooking, cleaning, childrearing, and community support that enable workers to return to work each day while raising future workers (Budlender, 2010; Posel, 2025). In South Africa these responsibilities remain highly gendered. Although the government has introduced policies promoting women's participation in the energy sector — including the Women Empowerment and Gender Equality Strategy, REIPPPP economic development requirements, and the Just Energy Transition Framework — women remain underrepresented in engineering, technical, and leadership positions, while continuing to shoulder most unpaid care work (WEGE Strategy, 2021–2025; GIZ, 2024; IRENA, 2025).

This situation creates a potential contradiction in localisation strategies. On the one hand, renewable energy manufacturing can create opportunities for women to enter new industrial occupations. On the other hand, if women continue to bear a disproportionate share of unpaid care and domestic work, they may face greater constraints in accessing, retaining, and progressing in technical and higher-value occupations.

These inequalities are reinforced by broader conditions of poverty and inadequate public services. Low wages, unemployment, and rising indebtedness force many households to rely on borrowing, informal savings schemes, social grants, and family support to sustain daily life (James and Rajak, 2014; Mazenda and Mushayanyama, 2024; Zyambo et al., 2025; Jacobs, 2026). At the same time, limited childcare provision and persistent gender inequalities mean that much of the cost of reproducing labour continues to be borne privately by women (Ashley-Cooper et al., 2019; Posel, 2025). Consequently, localisation strategies that expand manufacturing without addressing wages, care responsibilities, and gender inequality risk reproducing existing patterns of exclusion rather than supporting a genuinely just transition.

The implications extend beyond participation rates. Where women are concentrated in lower-paid, less secure, or supporting occupations while men remain disproportionately represented in technical, engineering, and managerial positions, the distribution of the benefits of industrial upgrading remains unequal. Gender therefore needs to be considered not only in terms of the number of women employed in renewable energy, but also in terms of occupational segregation, wages, employment security, access to training and advancement, and the distribution of unpaid work that enables participation in the labour market.

From a social reproduction perspective, the issue is therefore not simply whether renewable energy manufacturing creates employment for women, but whether the organisation of production changes the conditions under which women and men are able to participate in and benefit from industrial development. Without such changes, the expansion of domestic manufacturing may depend upon the continued provision of largely invisible and unpaid reproductive labour, while women's ability to participate in, remain in, and advance within the sector remains constrained.

6.3.3. Community conditions

Finally, firms are embedded in the communities in which workers live and from which labour is drawn. The conditions of housing, transport, schools, healthcare, electricity, water, and public services influence firms' ability to attract and retain workers while also affecting labour productivity. These conditions are therefore not external to industrial production; they form part of the social infrastructure through which labour is reproduced and made available to firms. In South Africa, these foundations of social reproduction remain fragile. Persistent service delivery failures, electricity shortages, high unemployment, poverty, and periodic community protests create an unstable environment for industrial development (SAHRC, 2018; Laher, 2009; Nyamnjoh, 2006; Choane et al., 2011). In this context, achieving local community acceptance and securing a stable social licence to operate depend heavily on how transparently firms navigate these localised socio-economic crises and distribute project benefits.

Labour market statistics illustrate these wider structural constraints. In 2024, only around 41% of the working-age population was employed, and more than 76% of unemployed people were in long-term unemployment. For those who were employed, median monthly earnings remained around R6,000, with many workers also lacking access to pensions, medical aid, and other employment benefits (Stats SA, 2024).

Such conditions shape both workers' livelihoods and firms' ability to build a stable and skilled workforce. High unemployment may provide firms with access to a large pool of potential workers, but this does not necessarily translate into the skilled, secure, and productive labour force required for sustained industrial upgrading. These conditions weaken workers' ability to reproduce themselves and their households while limiting the supply of skilled labour needed for industrial upgrading. They may also increase workers' dependence on households, social grants, informal support networks, and other forms of unpaid or underpaid social reproduction. From the perspective of localisation, societal embeddedness therefore highlights that sustainable manufacturing development depends not only on attracting investment but also on strengthening the wider social conditions that sustain workers and communities.

6.3.4 What does societal embeddedness tell us about localisation?

Societal embeddedness determines whether localisation produces genuinely transformative industrial development. Manufacturing can increase domestic production without necessarily improving workers' livelihoods, skills, or capacity to participate in and benefit from industrial upgrading. Similarly, host

communities may experience renewable energy investment without meaningfully integrating into the social and economic relationships surrounding projects. Consequently, local residents may not obtain potential benefits, such as sustained employment, skills development, and participation in decision making.

Ultimately, sustainable industrial operation is dependent on becoming deeply integrated into local social structures to secure worker cooperation and community acceptance. Wind turbine manufacturing depends on workers, households, and communities to reproduce the social conditions required for production, while the organisation of production simultaneously shapes those very environments. From this perspective, the success of South Africa's localisation strategy depends not only on increasing domestic production, but also on structuring the industry to actively sustain and upgrade the human and community infrastructure on which its long-term development relies.

6.4 What does embeddedness tell us about localisation in South Africa's wind GPNs?

The analysis of network, territorial, and societal embeddedness shows that localisation depends not only on whether firms operate in South Africa. Localisation is shaped by how firms are connected to the wider production network, the places in which they operate, and the workers and communities that sustain production. These forms of embeddedness are therefore important in determining whether participation in wind energy production networks becomes rooted in South Africa and contributes to sustained industrial upgrading.

Global network relationships can provide access to technology, markets, and knowledge, but where South African firms remain embedded primarily as contract manufacturers or lower-value suppliers, opportunities for upgrading and value capture remain constrained. Moreover, as the preceding analysis of power demonstrated, firms do not enter these relationships on equal terms. Domestic firms may become deeply embedded in global networks while remaining dependent on lead firms for technology, procurement, and market access.

Territorial embeddedness of wind energy firms within South Africa can strengthen opportunities for local firms. This alignment is optimised when stable demand, adequate infrastructure, local suppliers, appropriately skilled workers, and supportive institutions reinforce one another. However, weak grid capacity, procurement uncertainty, and limited industrial capabilities create persistent constraints. Societal embeddedness further demonstrates that localisation does not automatically translate into decent work or more equitable outcomes. Insecure employment, gendered divisions of labour, inadequate social infrastructure, and community pressures frequently limit the developmental benefits of industrial expansion. Consequently, while the way that firms embed in societies holds the potential to improve local environments, without targeted interventions it often reproduces existing vulnerabilities instead.

Thus, deeper embeddedness does not necessarily produce positive developmental outcomes. Its effects depend on the nature of the relationships through which firms, territories, workers, and communities are connected to the GPN. Taken together, these facets of embeddedness suggest that

localisation is most likely to generate sustained developmental benefits when firms are more deeply connected to domestic and regional production networks, when investment is anchored in supportive territorial industrial ecosystems, and when the social conditions underpinning production are strengthened. The objective is therefore not simply to increase the presence of manufacturing activities in South Africa, but to deepen the quality of domestic participation by strengthening technological capabilities, supplier linkages, skills, decent work, and the retention and distribution of value.

Embeddedness therefore helps explain both the opportunities for, and the constraints on, increasing domestic value creation, value enhancement, and value capture in South Africa's wind energy GPNs. It also demonstrates that localisation, upgrading, and value capture are shaped by the interaction between where production takes place, how firms are connected to one another, who has power in those relationships, and the social conditions that sustain production. Understanding these interconnections is essential to assessing whether South Africa's participation in wind GPNs can evolve from isolated assembly towards a more sustained process of domestic industrial development and value capture.

7. CONCLUSION AND RECOMMENDATIONS

The imperative to decarbonise the global economy to mitigate climate change has spurred rising demand for wind energy technologies and related manufacturing capabilities in South Africa. This expansion raises questions about value — its creation, enhancement, and capture. This paper has examined how these dynamics are shaped by power relations and different forms of embeddedness in GPNs, and what this means for localisation and decent work. Drawing on an extensive review of academic and policy literature, this paper draws the following conclusions about the developmental implications of South Africa's participation in global wind energy production networks.

7.1. Localisation has expanded participation but not transformed value capture

The expansion of renewable energy has created new opportunities for domestic participation in South Africa's wind manufacturing sector, including the establishment of local production facilities, supplier development initiatives, and employment creation. However, localisation has been largely confined to lower-value manufacturing and assembly activities, while high-value functions such as technology development, product design, engineering, and intellectual property remain concentrated in global lead firms. As a result, South Africa has increased participation in renewable energy production networks without fundamentally altering where value is created, enhanced, and captured.

These outcomes should not be understood simply as a failure of localisation. South African firms have developed capabilities in selected manufacturing and service activities, and there are opportunities to build on these capabilities through stronger domestic and regional production linkages. The central challenge is therefore to move from participation towards sustained capability development and greater domestic value capture, rather than treating participation itself as evidence of industrial transformation.

7.2. Power shapes localisation outcomes

Localisation outcomes are shaped by the exercise of corporate, institutional, and collective power. Global OEMs and large project developers influence supplier selection, technology standards, and access to markets through their control of production networks. At the same time, the South African state exercises institutional power through industrial policy, public procurement, localisation requirements, and regulation. Collective actors — including business associations, trade unions, civil society organisations, and host communities — also influence sector development, although with varying degrees of success. Localisation therefore emerges as a politically contested process rather than an automatic outcome of renewable energy investment.

These forms of power also interact. Corporate power can be reinforced by institutional arrangements and established global networks, while state and collective actors can attempt to reshape these relationships and the distribution of benefits. The extent to which localisation produces upgrading

and domestic value capture therefore depends not only on the capabilities of South African firms, but also on their relative power in the GPN.

7.3. Embeddedness determines opportunities for upgrading

Successful localisation depends on how firms are embedded in GPNs. Network embeddedness provides access to technology, markets, and learning opportunities but can also lock firms into lower-value activities. Territorial embeddedness determines firms' access to infrastructure, industrial policy, procurement opportunities, and specialised production locations. Societal embeddedness influences the availability, stability, and reproduction of labour through labour market conditions, gender relations, public services, and community wellbeing. Weaknesses in any one of these dimensions constrain industrial upgrading and the long-term development of domestic manufacturing capabilities.

Importantly, these forms of embeddedness are not separate from power relations. Rather, they shape the relationships through which power is exercised and determine whether firms, workers, and communities are able to benefit from participation in GPNs. Localisation is therefore influenced not simply by where production is located, but by the depth and character of firms' connections to global networks, local territories, and the social conditions that sustain production.

7.4. Localisation requires productive capabilities

Localisation cannot be achieved through local procurement requirements alone. Sustainable industrial development which can enable increased domestic value capture requires deliberate investment in technological capabilities, including supplier upgrading, R&D, and workforce skills. Additionally, firms can better enhance their capabilities when they have access to finance, long-term policy certainty, stable demand, and effective implementation of industrial policy, all of which can be supported by stronger linkages between global lead firms and domestic suppliers and better coordination between public institutions. However, the development of capabilities is itself shaped by the unequal power relations and forms of embeddedness identified in this paper. Localisation therefore needs to be understood as a non-linear process of capability development rather than simply the relocation of production or expenditure into South Africa.

7.5. Measuring localisation differently

Localisation should be evaluated using broader measures than those currently employed in policy. Indicators such as local content expenditure, numbers of firms, employment created in job years, installed renewable energy capacity, and carbon reductions capture important aspects of the transition but provide only a partial picture of industrial development. Problematically, the current measurement system shapes policy and therefore limits localisation benefits, as the metrics used for success determine what interventions are prioritised.

Greater attention should instead be given to domestic value capture, technological upgrading, local ownership of productive capabilities, job quality, gender equality, skills development, and the capacity of renewable energy industries to support long-term structural transformation. Metrics related to such factors could provide a more meaningful assessment of whether localisation contributes to

inclusive industrialisation rather than simply expanding participation in GPNs through connections that do not support sustainable local development.

This is particularly important because what is measured influences what becomes visible as a policy success. Measuring localisation primarily through expenditure, procurement, installed capacity, or job-years can therefore obscure whether productive capabilities are being developed, whether value is being retained domestically, and whether employment and other benefits are distributed equitably.

7.6. Final reflections and implications

Ultimately, the renewable energy transition is not only an environmental transition but also an industrial, political, and social transformation. Whether countries such as South Africa can use this transition to build domestic productive capabilities, create decent work, and achieve equitable development depends not simply on entering production networks, but on reshaping the value distribution, power relations, and forms of embeddedness that govern GPNs. Consequently, localisation should be judged not by the volume of production or expenditure located domestically, but by whether participation in GPNs contributes to sustained value enhancement and value capture, including the creation of decent work and a more equitable distribution of the benefits of industrial development.

Realising this form of transition requires simultaneous attention to what firms do, who controls the activities in which they participate, how they are embedded in global and domestic networks, and how production is situated within particular territorial and social conditions. Crucially, these dimensions interact. Unequal power can limit access to upgrading opportunities, while firms' connections to territorial and societal conditions determine the extent to which industrial participation produces sustained developmental benefits.

Looking forward, several areas warrant continued policy development and research. These include deepening domestic linkages across renewable energy manufacturing value chains linking wind towers, tower internals, steel, cement, and related inputs; creating more stable and predictable procurement systems capable of sustaining long-term industrial investment; improving the effectiveness and inclusiveness of B-BBEE and localisation policies; developing more meaningful measures of employment that capture the number, duration, quality, and security of jobs rather than measures such as job-years alone; strengthening skills development in host communities to support sustained local participation; and expanding research, development, and innovation systems that enable domestic firms to progressively move into higher-value and more technologically sophisticated activities. Navigating these priorities reopens debates on the state's role in an energy transition. While maximising value capture requires robust public steering, calls for intervention must grapple with past challenges of public-sector energy provision.

These priorities should be pursued as interconnected elements of a broader industrial strategy rather than as isolated interventions. Together, these areas point towards a conception of localisation that extends beyond the localisation of expenditure or production towards the development and retention of productive capabilities, decent work, and more equitable forms of value capture in South Africa's renewable energy production networks.

REFERENCES

- Aeckert. 2024 '[Nordex Group Obtains Order for 336 MW in South Africa](#)', *Nordex SE*, 26 March.
- African Union (2024) [Africa's Green Minerals Strategy \(AGMS\)](#). (Accessed 22 March 2025).
- Andreoni, A. and Roberts, S. (2022) [Geopolitics of critical minerals in renewable energy supply chains: assessing conditionalities on the use of technology, market capture and the implications for Africa](#). African Climate Foundation.
- Arnoldi, M. (2025) [Red Rocket starts operations at two 144 MW wind farms](#). *Engineering News*, 16 May 2025.
- Baker, L. (2015) '[The evolving role of finance in South Africa's renewable energy sector](#)', *Geoforum*, 64, pp. 146–156.
- Baker, L. and Sovacool, B.K. (2017) '[The political economy of technological capabilities and global production networks in South Africa's wind and solar photovoltaic \(PV\) industries](#)', *Political Geography*, 60, pp. 1–12.
- Baker, L. and Wlokas, H.L. (2015) [South Africa's renewable energy procurement: a new frontier?](#). Cape Town: Energy Research Centre, University of Cape Town.
- Barnes, J., King, M., Ndlovu, M., Carstens, K., Marais, O., Ellis, S. and Kirsten, D. (2023) *Manufacturing Localisation Potential in Renewable Energy Value Chains: Wind Energy Localisation Potential*. LSF.
- Barrientos, S., Gereffi, G. & Rossi, A. (2011) '[Economic and social upgrading in global production networks: A new paradigm for a changing world](#)', *International Labour Review*, 150(3–4), 319–340.
- BBC (1960) '1960: scores die in Sharpeville shoot-out', *BBC*.
- Bloomberg (2024) '[South Africa loadshedding: Eskom marks 100 days of steady electricity supply](#)', *Bloomberg*, 5 July (Accessed 18 August 2024).
- Boafo, J., Obodai, J., Stern, E. and Nkrumah, P.N. (2024) 'The race for critical minerals in Africa: a blessing or another resource curse?', *Resources Policy*, 93, 105046. DOI: [10.1016/j.resourpol.2024.105046](#).
- Bookbinder, R. (2025) '[Politicising energy transitions: the political economy of reducing dependence on coal in South Africa's minerals energy complex](#)', *Environmental Politics*, 34(6), 1000–1021.
- Borchardt, S.P. (2025) '[Dust in the wind: Renewable energy and the limits of South Africa's developmental state](#)', *New Agenda: South African Journal of Social and Economic Policy*, 2025(99), 38–62.
- Centre for Environmental Rights (2018) '[Water costs, impacts of coal-fired power grossly underestimated in electricity planning](#)', *Centre for Environmental Rights*. (Accessed 6 October 2025).
- Centre for Environmental Rights (2026) '[Government Appeals Landmark Youth Climate Court Victory as #CancelCoal Case Returns to Court](#)', *Centre for Environmental Rights* (Accessed 22 August 2026).
- Cetinay, H., Kuipers, F.A. and Guven, A.N. (2017) 'Optimal siting and sizing of wind farms', *Renewable Energy*, 101, pp. 51–58. DOI: [10.1016/j.renene.2016.08.008](#).
- Chang, H.-J., Hauge, J. and Irfan, M. (2016) [Transformative industrial policy for Africa](#). Addis Ababa: Economic Commission for Africa.
- Chen, Q., Yang, H., Liu, T. and Zhang, L. (2016) 'Household biomass energy choice and its policy implications on improving rural livelihoods in Sichuan, China', *Energy Policy*, 93, pp. 291–302. DOI: [10.1016/j.enpol.2016.03.016](#).
- Chen, Y. (2015) [EU-China solar panels trade dispute: settlement and challenges to the EU](#). European Institute for Asian Studies.

- Cheng, Y., Wang, Y., Hu, H., Wei, W. and Muralidharan, E. (2024) [Goldwind: merger and acquisition integration of emerging market multinational enterprises in developed markets](#). Ivey Publishing.
- Cretini, I.O., Robert, V. and Vázquez, D. (2025) 'Mergers and acquisitions, knowledge base and technological trajectories: an exploratory study in the wind energy sector', *Innovation and Development*, 15(2), pp. 335–361. DOI: [10.1080/2157930X.2024.2350829](#).
- Choane, M., Shulika, L.S. and Mthombeni, M. (2011) 'An analysis of the causes, effects and ramifications of xenophobia in South Africa', *Insight on Africa*, 3, pp. 129–142. DOI: [10.1177/0975087814411138](#).
- Cock, J. (2011) '[Contesting a “just transition to a low carbon economy”](#)', *Global Labour Column*. Johannesburg: University of the Witwatersrand.
- Cock, J. (2018) '[Contesting the colour of a Just Transition in South Africa](#)', University of the Witwatersrand, 24 April.
- Coe, N.M., Dicken, P. and Hess, M. (2008) '[Global production networks: realizing the potential](#)', *Journal of Economic Geography*, 8(3), pp. 271–295.
- COSATU (2011) '[A just transition to a low-carbon and climate-resilient economy](#)' (Accessed 14 September 2025).
- Crabtree, C.J., Zappalá, D. & Hogg, S.I. (2015) 'Wind energy: UK experiences and offshore operational challenges', *Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy*, 229(7), 727–746. DOI: [10.1177/0957650915597560](#).
- Crouse, G. (2025) '[Yes Stephen, there is a direct link between BEE and state capture](#)', *Daily Maverick*, 9 July (Accessed 6 October 2025).
- CSIR (n.d.) [The WASA Download Site](#). (Accessed 4 August 2026)
- Davidson, B. (2023) 'Labour on the leading edge: A critical review of labour rights and standards in renewable energy', *Energy Research & Social Science*, 97, 102928. DOI: [10.1016/j.erss.2022.102928](#)
- Dedrick, J. and Kraemer, K.L. (2011) [Value capture in the global wind energy industry](#). Personal Computing Industry Center, University of California, Irvine.
- Department of Environment, Forestry and Fisheries (2020) [Environment, Forestry and Fisheries on scrapping of environmental authorisations in South Africa](#).
- Deutsche Windtechnik (2023) '[Our independent service is now available worldwide](#)'. (Accessed 11 August 2026).
- DMRE (2023). [Independent Power Producers Procurement Programme \(IPPPP\): An Overview as at 30 September 2023](#).
- DMRE (2026) [Independent Power Producers Procurement Programme \(IPPPP\): An Overview as at 31 March 2026](#).
- Eberhard, A. (2007) '[The political economy of power sector reform in South Africa](#)', *The Political Economy of Power Sector Reform*, pp. 215–253.
- Eberhard, A. (2011) '[The future of South African coal: market, investment and policy challenges](#)', *Program on Energy and Sustainable Development*, pp. 1–44.
- EDF Power Solutions. (2025) EDF power solutions achieves COD on 140MW San Kraal wind farm advancing the completion of the 420MW Koruson 1 project. *EDF Power Solutions*, 12 December 2025. https://southafrica.edf-powersolutions.com/https-southafrica-edf-powersolutions-com-edf-power-solutions-achieves-cod-on-140mw-san-kraal-wind-farm-advancing-the-completion-of-the-420mw-koruson-1-project/?utm_source=chatgpt.com (Accessed 2 August 2026)
- EDF Power Solutions (2025) [EDF power solutions achieves COD on 140MW San Kraal wind farm advancing the completion of the 420MW Koruson 1 project](#) EDF Power Solutions, 12 December 2025. (Accessed 2 August 2026). '[Opinion | Electricity is back, but who can afford it? The unseen crisis of South Africa's energy landscape](#)', *Earthlife Africa* (Accessed 6 October 2025).

- Energize (2024a) '[EWSETA launches specialised training initiatives for renewable energy and water management](#)', Energize (Accessed 14 September 2025).
- Energize (2024b) '[Wind energy faces structural and regulatory challenges, but we are working on them — Ramokgopa](#)', Energize, 8 October (Accessed 12 June 2026).
- Energize (2025) '[First Bid Window 5 wind farms reach commercial operation](#)'. (Accessed 2 August 2026).
- Erero, J.L. (2023) '[Impact of loadshedding in South Africa: a CGE analysis](#)', *Journal of Economics and Political Economy*, 10, pp. 78–94.
- ESI Africa (2024) '[REIPPPP: grid challenges in SA limit rollout of new energy projects](#)', ESI Africa, 23 December.
- Eskom (2023) *First respondent's answering affidavit: Part A in the case United Democratic Movement and 18 others v Eskom Holdings SOC Limited and seven others*. Case number 2023/005779.
- Ettmayr, C. and Lloyd, H. (2017) 'Local content requirements and the impact on the South African renewable energy sector: a survey-based analysis', *South African Journal of Economic and Management Sciences*, 20(1), p. 11. DOI: [10.4102/sajems.v20i1.1538](#).
- Francis, D. and Valodia, I. (2022) '[Black Economic Empowerment \(BEE\) in South Africa: introduction and a review of the labour market literature](#)', *Transformation: Critical Perspectives on Southern Africa*, 109, pp. 1–20.
- Freund, B. (2007) 'South Africa: the end of apartheid and the emergence of the “BEE elite”', *Review of African Political Economy*, 34, pp. 661–678. DOI: [10.1080/03056240701819533](#).
- Fu, X. and Zhang, J. (2011) 'Technology transfer, indigenous innovation and leapfrogging in green technology: the solar-PV industry in China and India', *Journal of Chinese Economic and Business Studies*, 9, pp. 329–347. DOI: [10.1080/14765284.2011.618590](#).
- Gereffi, G., Humphrey, J. & Sturgeon, T. (2005) 'The governance of global value chains', *Review of International Political Economy*, 12(1), 78–104. DOI: [10.1080/09692290500049805](#).
- GIZ (2024) [The South African-German Energy Programme \(SAGEN\) – IV](#). Pretoria: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.
- Ghani, E. and O'Connell, S.D. (2016) '[Can services be a growth escalator in low-income countries?](#)', *Revue d'économie du développement*, 24, pp. 143–173.
- Global Witness (2023) '[An unjust transition? The new rush for lithium in Africa](#)', Global Witness, 14 November (Accessed 20 March 2025).
- Government of South Africa (2021) [President Cyril Ramaphosa announces significant step in reforming electricity sector](#).
- Graham, J.D., Belton, K.B. and Xia, S. (2021) '[How China beat the US in electric vehicle manufacturing](#)', *Issues in Science and Technology*, 37, pp. 72–79.
- GWEC (2025) '[Wind turbine suppliers deliver new record volume despite difficult year full of diverse challenges](#)', *Global Wind Energy Council*, 16 May (Accessed 23 June 2025).
- Helfat, C.E. and Peteraf, M.A. (2003) 'The dynamic resource-based view: Capability lifecycles'. *Strategic management journal*, 24(10), 997–1010. DOI: [10.1002/smj.332](#).
- Hanto, J., Krawielicki, L., Krumm, A., Moskalenko, N., Löffler, K., Hauenstein, C. and Oei, P.-Y. (2021) '[Effects of decarbonization on the energy system and related employment effects in South Africa](#)', *Environmental Science & Policy*, 124, pp. 73–84.
- Henderson, J., Dicken, P., Hess, M., Coe, N. and Yeung, H.W.-C. (2002) 'Global production networks and the analysis of economic development', *Review of International Political Economy*, 9, pp. 436–464. DOI: [10.1080/09692290210150842](#).
- Hermanus, L., & Kamanzi, B. (2026) South Africa Renewable Energy Policy Scan: Critical insights and questions for localisation and decent employment. IEJ.

- Hess, M. (2004) “Spatial” relationships? Towards a reconceptualization of embeddedness’, *Progress in Human Geography*, 28(2), pp. 165–186. DOI: [10.1191/0309132504ph479oa](https://doi.org/10.1191/0309132504ph479oa).
- Hooijmaaijers, B. (2021) ‘The EU-China solar panel dispute’, in Hooijmaaijers, B. (ed.) *Unpacking EU policy-making towards China: how member states, bureaucracies, and institutions shape its China economic policy*. Singapore: Springer, pp. 51–88. DOI: [10.1007/978-981-15-9367-3_3](https://doi.org/10.1007/978-981-15-9367-3_3).
- IEA (2024) [Global Critical Minerals Outlook 2024](#). International Energy Agency.
- IEA (2025) ‘[Electricity](#)’, *Global Energy Review 2025*, International Energy Agency (Accessed 14 September 2025).
- IEJ (2021) [SAREM: Challenging Privatisation, Centring Public Ownership and Decent Work](#). Climate, Energy and Infrastructure Series Policy Brief #2.
- IEJ (2026) Conceptual Framework for the Just Energy Transition: Localisation, Decent Work, Small Medium and Micro Enterprise, and Sustainable Livelihoods Project.
- ILO and IRENA (2022) [Renewable energy and jobs: annual review 2022](#). Geneva and Abu Dhabi: International Labour Organization and International Renewable Energy Agency (Accessed 8 April 2025).
- International Monetary Fund (2022) *South Africa: Selected Issues*. IMF Staff Country Report No. 2022/038. DOI: [10.5089/9798400201318.002](https://doi.org/10.5089/9798400201318.002).
- Investment Analysis (2025) ‘[Solar factory in a South African SEZ](#)’, PV knowhow.
- IPPO (2022). [REIPPPP focus on wind: as at 31 December 2021](#).
- IRENA (2025) [Renewable energy: a gender perspective. Second edition](#). Abu Dhabi: International Renewable Energy Agency.
- Jacobs, S. (2024) ‘[Rooftop solar in South Africa has more capacity than Eskom’s largest power station](#)’, *Daily Investor* (Accessed 6 October 2025).
- James, D. (2014). “Deeper into a hole?” Borrowing and lending in South Africa’, *Current Anthropology*, 55(S9), S17–S29. DOI: [10.1086/676123](https://doi.org/10.1086/676123).
- Jeffery, A. (2017) [EED is for real empowerment, whereas BEE has failed](#). Johannesburg: South African Institute of Race Relations.
- Kalantzakos, S. (2020) ‘The race for critical minerals in an era of geopolitical realignments’, *The International Spectator*, 55, pp. 1–16. DOI: [10.1080/03932729.2020.1786926](https://doi.org/10.1080/03932729.2020.1786926).
- Knorr, K., Zimmermann, B., Bofinger, S., Gerlach, A-K., Bischof-Niemz, T. & Mushwana, C. (2016). [Wind and Solar PV Resource Aggregation Study for South Africa: Final report](#).
- Labuschagne, H. (2023) ‘[All 34 wind farms providing power to South Africa](#)’, *MyBroadband*, 16 August.
- Labuschagne, H. (2025) ‘[South African solar panel company investigated over Chinese imports](#)’, *MyBroadband*, 10 May (Accessed 14 May 2025).
- Laher, H. (2009) *Explaining xenophobic violence*. Pretoria: University of South Africa.
- Larsen, T.H. & Hansen, U.E. (2022) ‘Sustainable industrialization in Africa: the localization of wind-turbine component production in South Africa’, *Innovation and Development*, 12(2), 189–208. DOI: [10.1080/2157930X.2020.1720937](https://doi.org/10.1080/2157930X.2020.1720937).
- Lawrence, A. (2020) *South Africa’s energy transition*. Cham: Springer International Publishing. DOI: [10.1007/978-3-030-18903-7](https://doi.org/10.1007/978-3-030-18903-7).
- Lewis, J.I. (2007) ‘[Technology acquisition and innovation in the developing world: wind turbine development in China and India](#)’, *Studies in Comparative International Development*, 42, pp. 208–232.
- Leigland, J. and Eberhard, A. (2018) ‘Localisation barriers to trade: the case of South Africa’s renewable energy independent power program’, *Development Southern Africa*, 35(4), pp. 569–588. DOI: [10.1080/0376835X.2018.1487829](https://doi.org/10.1080/0376835X.2018.1487829).
- Lewis, J.I. (2007) ‘[Technology acquisition and innovation in the developing world: wind turbine development in China and India](#)’, *Studies in Comparative International Development*, 42, pp. 208–232.

- Lewis, J.I. and Wiser, R.H. (2007) 'Fostering a renewable energy technology industry: an international comparison of wind industry policy support mechanisms', *Energy Policy*, 35, pp. 1844–1857. DOI: [10.1016/j.enpol.2006.06.005](https://doi.org/10.1016/j.enpol.2006.06.005).
- Lipták, B. (2025) '[Generating successful wind turbine optimization](#)', *Control*, 28 January. (Accessed: 16 August 2026).
- Lunde Seefeldt, J. (2020) Lessons from the lithium triangle: Considering policy explanations for the variation in lithium industry development in the "lithium triangle" countries of Chile, Argentina, and Bolivia. *Politics & Policy*, 48(4), 727–765.
- Mabunda, M.V., Mukonza, R.M. and Mudzanani, L.R. (2023) 'The effects of loadshedding on small and medium enterprises in the Collins Chabane local municipality', *Journal of Innovation and Entrepreneurship*, 12, 57. DOI: [10.1186/s13731-023-00327-7](https://doi.org/10.1186/s13731-023-00327-7).
- Malange, T. (2023) 'Loadshedding and healthcare: salt in the wound?', *South African Medical Journal*, 113(2), p. 52. DOI: [10.7196/SAMJ.2023.v113i2.431](https://doi.org/10.7196/SAMJ.2023.v113i2.431).
- McDaid, L. (2016) [Renewable Energy Independent Power Producer Procurement Programme Review 2016: A critique of process of implementation of socio-economic benefits including job creation](#). Alternative Information Development Centre.
- Mezzadri, A. (2021). A value theory of inclusion: Informal labour, the homemaker, and the social reproduction of value. *Antipode*, 53(4), 1186–1205
- Ministry of Electricity and Energy (2025). [Media Statement: Announcement of Pre-Qualified Bidders Under the First Stage of the Independent Transmission Projects \(ITP\) Procurement Programme and Additional Preferred Bidders Under Bid Window 7 of the Renewable Energy Independent Power Producer Procurement Programme](#).
- Minnar, A. (2005) 'Victimization and rights of foreign migrants in South Africa', in Davis, L. and Snyman, R. (eds) *Victimology in South Africa*. Pretoria: Van Schaik Publishers, pp. 291–306.
- Molteno, F. (1979) 'The uprising of 16th June: a review of the literature on events in South Africa 1976', *Social Dynamics*, 5(2), pp. 63–90. DOI: [10.1080/02533957908458236](https://doi.org/10.1080/02533957908458236).
- Morris, M., Robbins, G., Hansen, U.E. and Nygaard, I. (2020) [Energy and industrial policy failure in the South African wind renewable energy global value chain: the political economy dynamics driving a stuttering localisation process](#). PRISM Working Paper 2020-3. Cape Town: Policy Research on International Services and Manufacturing, University of Cape Town.
- MyBroadband (2020) '[How the government crushed a great renewable energy company](#)', *MyBroadband*, 24 August (Accessed 12 June 2026).
- Ndasana, M., Vallabh, D. and Mxunyelwa, S. (2022) 'Understanding the service delivery protests in South Africa: a case study of Duncan Village', *Africa's Public Service Delivery and Performance Review*, 10, 7. DOI: [10.4102/apsdpr.v10i1.644](https://doi.org/10.4102/apsdpr.v10i1.644).
- Ndlovu, N. (2024) '[10 biggest wind energy projects in South Africa](#)', *TechCentral*, 22 February (Accessed 18 September 2025).
- NUM (2023) '[NUM demands a lengthy delay in the implementation of just energy transition](#)', *National Union of Mineworkers*, 10 February (Accessed 19 June 2025).
- Nordex (n.d.) '[\(37\) Nordex Energy South Africa: overview](#)', *LinkedIn* (Accessed 10 December 2025).
- Nyamnjoh, F.B. (2006) [Insiders and outsiders: citizenship and xenophobia in contemporary Southern Africa](#). Dakar: CODESRIA Books.
- Okbandrias, M. (2022) '[Development of Community-Owned Renewable Energy \(CORE\) in South Africa](#)', in *Environment, Climate, and Social Justice: Perspectives and Practices from the Global South*, pp. 99–116.
- Pearse, R. & Bryant, G. (2022) '[Labour in transition: A value-theoretical approach to renewable energy labour](#)', *Environment and Planning E: Nature and Space*, 5(4), 1872–1894.

- Plasschaert, S.R.F. (2016) [Assessing the solar energy dispute between the European Union and the People's Republic of China](#). Brussels: European Centre for International Political Economy.
- Ponte, S., Roberts, S. and van Sittert, L. (2006) [To BEE or not to BEE? South Africa's "Black Economic Empowerment" \(BEE\), corporate governance and the state in the South](#). DIIS Working Paper 2006:27. Copenhagen: Danish Institute for International Studies.
- Rivett-Carnac, K. (2022) [Insights into the wind energy value chain in South Africa](#). Trade and Industrial Policy Strategies (TIPS) (Accessed 18 March 2025).
- Roebeck, T. (2024) [Wind power's increasing contribution to the South African economy](#), *Engineering News*, 19 September (Accessed 17 September 2025).
- SAWEA (2026) [Annual Report 2025: From Gridlock to Growth](#).
- SAHRC (2018) [Community protest pamphlet: revised 20 March 2018](#). South African Human Rights Commission.
- SAPVIA (2025) [State of South African manufacturing, its potential and resources required for further development of PV value chains](#). South African Photovoltaic Industry Association (Accessed 16 September 2025).
- SAREM (2024) [South African Renewable Energy Masterplan: an inclusive industrial development plan for the renewable energy and storage value chains by 2030](#). South African Renewable Energy Masterplan (Accessed 18 March 2025).
- SAWEA (2024) [Jobs of the future: how the wind industry ushers in new opportunities](#), *South African Wind Energy Association*, 16 July (Accessed 17 September 2025).
- Siweya, K. (2024) [Electricity burden stressed](#), *AgriSA* (Accessed 6 October 2025).
- Siyobi, B. (2023) [The state of the Renewable Energy Independent Power Producer Procurement Programme: where to from here?](#), *Good Governance Africa*, 13 December.
- South African Government (2019) [Integrated Resource Plan 2019](#). Government Gazette No. 42778, 18 October.
- South African Government (2023) [South Africa's fifth biennial update report \(BUR-5\) to the United Nations Framework Convention on Climate Change](#). Pretoria: Department of Forestry, Fisheries and the Environment.
- South African Government (2024) [Integrated Resource Plan 2023](#). Government Gazette No. 49974, 4 January.
- Statista (2024) [South Africa: fossil CO₂ emissions 1970–2023](#), *Statista* (Accessed 12 June 2026).
- Stats SA. [Labour Market Dynamics in South Africa, 2024](#). (Accessed 20 June 2026).
- Stats SA (2026) *Electricity, gas and water supply industry, 2024*.
- Suzlon (2024) [Suzlon secures order for their 3 MW series turbines from Juniper Green Energy Private Limited of 504 MW](#), *Suzlon*, 22 May (Accessed 12 June 2026).
- Tatham, J. (2025) [Casting some light: how Free Basic Electricity has improved household welfare](#), *Econ3x3*, 20 August (Accessed 12 June 2026).
- UNCTAD (2023) [World Investment Report](#).
- UNECA SRO-SA (2025) [Recent economic and social conditions in Southern Africa](#). E/ECA-SA/ICSOE.XXX/2025/2. 31st Session of the Intergovernmental Committee of Senior Officials and Experts of Southern Africa, Ezulwini, Eswatini, 29–31 October.
- United Nations (2022) [Secretary-General's remarks to high-level opening of COP27 — as delivered](#), *United Nations*, 7 November (Accessed 13 November 2025).
- United Nations Sustainable Development Group (2025) [Decoding Africa's energy journey: three key numbers](#), *United Nations Sustainable Development Group* (Accessed 13 November 2025).
- Vestas (2024) [Vestas wins 144 MW order in South Africa](#), *Vestas*, 7 August (Accessed 12 June 2026).
- Weston, D. (2016) [Goldwind launches Danish unit as revenues leap 70%](#), *Windpower Monthly*, 3 March (Accessed 12 June 2026).
- White, R. (2025) [Goldwind to supply one of South Africa's largest wind farms](#), *Windpower Monthly*, 14 March (Accessed 12 June 2026).

- Wilhelm, J. (2017) [*South Africa's local content policies: challenges and lessons to consider*](#). Pretoria: Trade and Industrial Policy Strategies.
- Windtech International (2011) '[Siemens and Shanghai Electric agree on strategic wind power alliance for China](#)', *Windtech International*, 9 December (Accessed 12 June 2026).
- World Bank (2026) [*Special Economic Zones in South Africa: Policy Review - Overview*](#).
- Zhang, F. and Gallagher, K.S. (2016) 'Innovation and technology transfer through global value chains: evidence from China's PV industry', *Energy Policy*, 94, pp. 191–203. DOI: [10.1016/j.enpol.2016.04.014](#).
- Zhang, X., Chang, S., Huo, M. and Wang, R. (2009) '[China's wind industry: policy lessons for domestic government interventions and international support](#)', in *International support for domestic climate policies in developing countries*. Abingdon: Routledge, pp. 553–564.