

SOLAR PANELS AND INVERTERS: POTENTIAL AND OBSTACLES IN SOUTH AFRICA

Background Paper

By
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EXECUTIVE SUMMARY

This paper develops a foundational analysis of the solar and inverter industries in South Africa. It aims to build a robust basis for the localisation of the renewable energy manufacturing production network in a manner that supports decent work creation, gender equity and the inclusion of SMEs. We use the GPN framework to analyse the South African solar industry in more depth, while incorporating concepts from other theoretical traditions focused on industrial policy and social reproduction (Henderson et al. 2002; IEJ 2026). We examine patterns of how value is created, enhanced and captured in the solar and inverter production networks. We also look at the types of power exercised within the sector and how they shape value creation and capture in the production network, the way it is embedded both in wider productive systems, in the South African national context, and in systems of social reproduction. This is done through desktop analysis drawing on existing literature databases.

Both the solar panels and inverter industry are currently structured in relatively similar ways. Foreign imports largely from China dominate the sector at the expense of domestic manufacturers. However, South Africa has industrial potential to manufacture both components of solar systems. There are multiple sources of demand for solar systems. These include utility scale systems deployed through public private partnerships, private utility scale systems, and smaller scale private systems both on and off grid. Additionally there are other sources of demand for inverters outside of the renewable energy sector.

For solar PVs, there are two firms manufacturing panels within South Africa ArtSolar and Seraphim. For inverters there are four firms RWW engineering, Microcare, Ariogenix and MLT. These create value through producing for the South African market. Subcomponents (such as solar cells) may be imported but assembly, lamination wiring, testing and sourcing of some subcomponents, (such as framing and wiring) is typically performed locally. Value capture within the sector is difficult to trace without detailed financial information of the various firms involved within the production network. However some trends can be seen. Profits for solar manufacturers internationally are high but have been declining rapidly due to intense competition. South Africa, along with many other global South countries remain exporters of critical materials while importing finished industrial products, creating the potential for unequal exchange. Further private partners and financiers in public private partnerships are able to capture significant value from the state and potentially final energy users through derisking policies and long term offtake agreements.

Numerous actors wield power within the GPN. Power relating to the supply of renewable energy components must be contextualized within the wider political struggles of South Africa's energy transition. First there has been a struggle over the pace of South Africa's energy transition, both over the phase out of old fossil fuel plants and bringing new renewable capacity online. Second, there has been a struggle over the liberalisation of the energy sector. Local manufacturing has suffered as a result of the liberalisation of the sector as many industrial policy tools have been removed. It is in

the shadow of these larger power blocks that the specific political tensions of subcomponent manufacturing emerge. Here the central struggle is between importers and manufacturers. Liberalisation of the sector has undermined or removed many of the industrial policies which would aid local manufactures. A number of actors, including local manufactures, state departments, organised labour and civil society all have interests in expanded localisation and opposing the liberalisation of the sector. However, these power groups have many diverging interests including different compromises they are willing to accept , and remain disorganised. This appears to be the current balance of power shaping the renewable energy subcomponent manufacturing sector.

The manufacturing firms are embedded into the wider productive network as well as the local areas they produce in. Technologically they depend on international partners, both for manufacturing equipment as well as to produce technologies to specific standards under franchise to international partners. They are linked to a range of state actors, in particular the Industrial Development Corporation (IDC) which has acted as a key financier. The firms have been located in established industrial centers of South Africa, Johannesburg's East Rand, Gqeberha, and Pinetown Durban. These have an established industrial workforce sustained in peripheral informal settlements and dilapidated urban centers. They also benefit from the industrial infrastructure of these areas including transport system, electrical and water provision, and availability of business services. Although some special economic zones exist nearby, none of the firms are located in an SEZ.

The sector could be expanded within South Africa, and create more decent work if supported by a range of industrial and social policies. First, more ambitious and progressively expanding local content requirements. Second, the development of a national system of innovation to support local industry. Third, linking industrial policy drives efforts to create decent work.

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LIST OF ABBREVIATIONS

COSATU	Congress of South African Trade Unions
CPUT	Cape Peninsula University of Technology
CSIR	Council for Scientific and Industrial Research
DBSA	Development Bank of Southern Africa
DEE	Department of Energy and Electricity
DMRE	Department of Mineral Resources and Energy
DTI	Department of Trade and Industry
DTIC	Department of Trade, Industry and Competition
DWCP	Decent Work Country Programme
EPC	Engineering Procurement and Construction
EWSETA	Energy and Water Sector Education and Training Authority
FEDUSA	Federation of Unions of South Africa
GEAR	Growth, Employment and Redistribution
GIWUSA	General Industries Workers Union of South Africa
GPN	Global Production Network
GVC	Global Value Chain
ICC	International Code Council
IDC	Industrial Development Corporation
IDZ	Industrial Development Zone
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IEJ	Institute for Economic Justice

IPAP	Industrial Policy Action Plan
IPP	Independent Power Producer
IPPO	Independent Power Producer Office
KZN	KwaZulu-Natal
LCCU	Local Content Compliance Unit
MACUA	Mining-Affected Communities United In Action
MCEP	Manufacturing Competitiveness Enhancement Programme
MEC	Minerals-Energy Complex
NBI	National Business Initiative
NEDLAC	National Economic Development And Labour Council
NEDO	New Energy and Industrial Technology Development Organisation
NUMSA	National Union of Metalworkers of South Africa
OECD	Organisation for Economic Co-Operation And Development
OEM	Original Equipment Manufacturer
PERC	Passivated Emitter and Rear Cell
REI4P	Renewable Energy Independent Power Producer Procurement Programme
SAFTU	South African Federation of Trade Unions
SAICWU	South African Industrial Commercial and Allied Workers Union
SANEDI	South African National Energy Development Institute
SAPVIA	South African Photovoltaic Industry Association (Sapvia)
SARATEC	South African Renewable Energy Technology Centre
SAREM	South African Renewable Energy Masterplan
SEMI	Semiconductor Equipment Manufacturers' Institute
SEZ	Special Economic Zone
STEM	Science, Technology, Engineering and Mathematics
UL	Underwriters' Laboratories

1. INTRODUCTION

Climate change and other forms of environmental degradation pose a growing international threat to human and planetary wellbeing. Responses to this require large-scale technological, political, and economic revolutions. One part of this process is the deployment of renewable energy.

There has been intense global economic competition to dominate these growing industries, often leaving developing countries behind and risking deindustrialisation. The new production networks often transfer value from the Global South, through industrial structures heavily concentrated in China and the Global North, and are dominated by power structures far outside the control of many of those affected in the Global South.

There is a growing body of academic literature and wider media discussion on the local manufacturing of renewable energy in South Africa which ranges from neoliberal rejection of nearly all industrial policy (Murray 2017), to acceptance of moderate and constrained industrial policy (SAPVIA 2026), to the push for large-scale and ambitious industrial policy in the sector (Congress of South African Trade Unions (COSATU) 2022). It includes abstract models that simply assume a degree of local manufacturing in estimating job creation (Hanto et al. 2021) through to detailed case studies of specific industries and firms (GIZ 2024; Rivett-Carnac 2022).

This literature reflects the wide variety of current economic and popular thought on industrialisation and its link to development and assesses the extent and type of industrial policy appropriate to support the sector. This includes analysis of the linkages between the sector and other developmental objectives, such as decent work creation, gender equity, and SMME participation (Hermanus 2022; Tait et al. 2013).

This paper examines this literature to contextualise and guide a range of interviews with different stakeholders which will be used for further research including case studies and policy orientated documents. It aims to provide a foundation for further research, identify gaps in the current literature concerning different aspects of the Global Production Network (GPN), and highlight the information needed to guide policies that support structural transformation and wider developmental objectives in an ecologically sustainable manner. This analysis focuses on South Africa and the key locations from which South Africa's renewable energy imports come.

The paper focuses on solar panels and inverters. Both are imported into South Africa in large volumes, and South Africa has some existing local manufacturing and export capability for each product. They therefore provide useful cases for examining the opportunities and obstacles involved in increasing localisation in South Africa's renewable-energy sector.

We use the GPN framework to analyse the South African solar industry in more depth, while incorporating concepts from other theoretical traditions focused on industrial policy and social reproduction (Henderson et al. 2002; IEJ 2026). We examine patterns of value creation, enhancement

and capture, the types of power exercised within the sector, and the way it is embedded both in wider productive systems, in the South African national context, and in systems of social reproduction.

The next section sets out the methodology, explains the selection of solar panels and inverters, and introduces the analytical framework used in the paper. The subsequent sections examine value, power and embeddedness within the solar-panel and inverter production networks, before the conclusion draws together the main findings and areas for further research.

2. METHODOLOGY AND ANALYTICAL FRAMEWORK

This section explains how the study was conducted, why solar panels and inverters were selected, and how the Global Production Network framework is used to organise the analysis. It first describes the sources and research methods, then explains the criteria for component selection, and finally sets out the concepts of value, power and embeddedness used in the remainder of the paper.

2.1 Methodology

This paper is based on desktop research using secondary quantitative and qualitative sources. It combines trade-data analysis, a review of academic and grey literature, and provisional mapping of the firms, institutions and organisations involved in South Africa's solar-panel and inverter production networks.

The quantitative analysis draws on trade data for 2012–2023 to examine the value and origin of South African imports and the value and destinations of South African exports. This data is used to assess the extent of import dependence and its sources as well as existing exports.

The analysis supplements sometimes limited trade data with academic research, government and industry reports, development-agency studies, company information and other grey literature on manufacturing capability, employment, technology, industrial policy and working conditions.

The paper also uses publicly available data to construct provisional maps of the firms and institutions involved in the production networks. These maps identify relationships for further investigation; they don't claim to provide a complete account of the network.

Sources of data on employment and job quality are particularly uneven. They are used to identify broad patterns and gaps requiring further research.

Taken together, these sources provide a preliminary picture of the structure of the production networks, while also identifying relationships and outcomes that require additional research.

2.2 Component selection

We selected the components for this study on the basis of two criteria:

1. The products are imported into South Africa in large volumes, measured in monetary terms; and
2. South Africa has some existing local manufacturing and export capability for each product.

We first consulted UNCTAD trade data from 2012 to 2023. This shows the total value of different component categories imported and exported globally, and has specific data available on South

Africa's imports and exports. However, this data has limitations: it is heavily aggregated into broad categories; it only shows existing South African exports; and it does not contain data on domestic consumption or production of non-traded goods. So it was necessary to supplement it with literature on existing and potential component manufacturing opportunities in South Africa. We also gathered some grey literature about labour intensity and job quality, but it was limited and often not comparable across components.

Based on these criteria, solar panels¹ and inverters were identified. Local manufacturing or assembly capacity already exists to a significant degree for both of these products, and both constitute high proportions of the value of a complete solar system (US Department of Energy 2024). Other potential areas for localisation not selected for this study (due to limited capacity) include the assembly of mounting structures and trackers (including fasteners) and the manufacture of AC/DC cables, both of which show high growth potential. These have substantial local demand, and base production requirements that can be met locally, which gives them high potential for localisation (Rivett-Carnac 2022).

Having identified panels and inverters as strategically significant, import-dependent products, the next subsection sets out the framework used to examine where value is created and captured and how the relevant relationships are governed.

2.3 GPNs for solar energy

We use specific theoretical categories of the GPN framework to analyse the South African solar production network in greater detail. We begin by looking at value. Here, we build on an understanding of value developed in the conceptual framework. The Institute for Economic Justice (IEJ), defines value as:

The social relationships under capitalism which determine the use, distribution and accumulation of resources and labour, by socially coordinating the production and distribution process between firms and consumers. This can be observed through examining the dual flows of money in one direction and embodied resources and labour in the other direction, throughout the global network. (IEJ 2026, 6)

We also draw on the following definitions of value creation and value enhancement from the conceptual framework, which come from the work of Mezzadri (2021), Henderson (2002), and the IEJ (2026).

Value creation is the process of organising real resources to produce commodities and enable capital accumulation (Mezzadri 2021). This includes organising paid and unpaid labour and natural resources, in households, firms and states. (IEJ 2026, 14)

¹ There is a wide range of solar panel technologies. These have differing costs, efficiencies and specialised features, making them suitable for different applications. However the industry has come to be dominated by monocrystalline polysilicon technology, which has rapidly gained market share over polycrystalline alternatives, which are less technologically difficult to produce but less efficient at generating power (Ndubuisi and Avenyo 2024).

and

Value enhancement refers to the dynamic processes which shape value creation (Henderson 2002). These include the ways in which firms learn, the role of states in supporting localisation through industrial policy, and the restructuring of social reproduction that is linked to localisation. (IEJ 2026, 14).

In the following sections, we focus on the particular ways in which value is created, enhanced, and captured in the solar PV and inverter GPN. Although social reproduction, state governance, and economic participation are deeply intertwined with capitalist systems of value, we discuss them in later sections to avoid duplication and maintain alignment with the conceptual categories of the GPN framework.

After it is created and enhanced, value can be captured by a range of different actors throughout the production network, often far removed from its initial creation. Monopoly rents on new technologies or scarce resources, trading rules, and network structures can all be used to capture value, either at the site where it is created or elsewhere. Even value enhancement is no guarantee that those who enhance value will capture it, as new technologies and techniques can quickly diffuse around a highly competitive supply sector, leaving the value to be captured upstream.

We build on the definition of value capture established in our earlier conceptual framework.

Value capture refers to the uneven way in which value is distributed in GPNs. There is an uneven, contradictory, and contested set of social entitlements to the value created within RE-GPNs. These are connected to established social relations, many of which appear to be the natural results of inevitable economic laws. These naturalised social entitlements include profits, rents, interest, wage gaps, and taxes, in addition to patriarchal distributions of resources within households and communities. These forms of value capture are linked to actors' participation in value creation and enhancement within RE-GPNs, but their exact level is determined as much by class struggle as by pure market laws. These entitlements can appear in monetary form or as entitlements to concrete things like leisure time, safe working environments, and electricity. Depending on what entitlements are prioritised, these can result in high inequality and poverty, or contribute to more equitable forms of development. (IEJ 2026, 18)

We begin by looking at the forms of value captured by workers, households, and communities. We also look closely at value capture by firms within the production network. To do this, we draw on a range of historical theories on uneven exchange and examine how these may relate to the solar production network, given the limited information about profits, tax revenues, and so on derived from the sector. It is unclear from the literature how profits and value are distributed and captured within renewable energy GPNs.

The analysis of value capture has gone through a range of developments, often linked to changes in the global economic and political system. One important strand of this literature examines how

processes of value capture can result in value being transferred from one country or region to another. There are a range of forms of value drain which can occur between countries, typically between the Global South and North, although potentially similar dynamics may be emerging between China and other Global South countries.

Briefly, in the colonial and early neocolonial period the price of goods from the Global South compared with the Global North was completely disproportionate to the labour time used in the production of each. Many early development economists, from both Marxist and other heterodox schools, identified this unequal exchange as both a source of Global South underdevelopment and Global North wealth. In early periods this was linked to the deindustrialisation of the Global South, with Global North industries protected both from producers in the South and from rival industrial powers. This was partially challenged in both the Global South as well as former socialist countries through attempts at industrialisation linked more closely to import substitution protection of local markets, and more or less systematic attempts at delinking.

These patterns of value capture and industrialisation shifted with the rise of neoliberalism. With the shift in the balance of forces resulting from the fall of the USSR, an overall defeatism set in throughout much of the Global South. This led to the collapse of many Global South industrialisation attempts based on import substitution models. Austerity policies drove down domestic demand in many markets, and trade and financial liberalisation destabilised industrial structures. In parallel to this, new possibilities for export-oriented industrialisation arose. Previously Japan, Taiwan and South Korea had all benefited from western markets in their industrialisation². However, neoliberal restructuring created new possibilities for how the South could be industrialised, in strict subordination to the needs of Northern markets. The power of Northern labour unions to resist such a move was broken, and new information and shipping technologies allowed for the remote management of production networks and the vertical disintegration of supply chains.

This accelerated the value drain from the Global South. Its mode partly changed from unequal exchange of final commodities to participation in production networks in which the Global South produced intermediary goods while final markets were dominated by western brands. They extract significant rents from this position. In general, this shift towards the export of manufactured goods from the Global South did not alter the nature of unequal exchange. However, in certain instances it did enable significant industrialisation and economic upgrading, partially overcoming the patterns of underdevelopment associated with this unequal exchange. In most cases, such export-oriented industrialisation does little for auto-centred development. Global South industrial wages are too low to generate domestic demand. Export-orientated industrialisation has done little to improve labour conditions in the global South. This is due to the way in which labour struggles and political consciousness and organisation amongst workers has been contained in SEZ within the global South. The nature of the industrialisation disorganises rather than develops the sovereignty of states and the development of key capabilities, which may have enabled further development, is stalled. Despite this, China was able to utilise the demand from this unequal exchange to rapidly develop its own

²Typically, Japan is characterised as Global North due to its earlier industrialisation and imperial ambitions, while its former colonies of Taiwan and South Korea are considered Global South.

local market and increasingly build sovereign capacity along a range of industries. Additionally, the Global North has lost its industrial dominance across many industries.

That is, although economically the value drain still occurs on a large scale to the Global North, politically the power granted through monopoly of industrial production is gone, replaced by a dominance over finance, intellectual property and access to wealthy Northern markets.

Thus we may see a period where the spread of manufacturing, and its consequences for declining imperial power projection and rising multipolarity, may precede a decline in unequal exchange. Taking over a few isolated technical tasks does not break uneven exchange. Countries that do this just end up supplying high tech products at low prices. Only taking a set of complex technical tasks which has the actual capacity to shift the balance of forces (that is delinking) has the true potential to break the drain of value by breaking the power structures on which this extraction depends. Energy sovereignty has the potential to be such a key pillar, by breaking dependency and increasing global bargaining power and ability to resist exploitative global arrangements of neocolonialism.

The next section applies these concepts first to workers and firms involved in creating and enhancing value, and then to the distribution of value among workers, firms and the state.

3. VALUE WITHIN THE GPN

This section examines how value is created, enhanced and captured across the solar-panel and inverter GPNs. It first looks at the roles of workers and firms in production and technological development, and then examines how the resulting value is distributed among workers, households, firms and the state.

3.1 Value creation and enhancement: workers

Value is created by workers in a range of production processes in the solar production network. These include initial labour in mining; management of large chemical industrial processes for initial beneficiation; electronic and mechanical assembly of subcomponents and larger systems (Baker and Sovacool 2017); construction work involving the initial set up of power plants, or smaller commercial, domestic, or community systems; and transport work, maintenance work, and work involved in recycling, such as disassembly and sorting of subcomponents. The solar value chain is expected to create between 55,600 and 93,400 gross jobs in South Africa by 2030 (NBI 2024).

Workers also play key roles in value enhancement as they engage in individual and collective skills development (Andreoni and Chang 2017). There is a wide range of projects aimed at skills development for the solar sector within South Africa, although many of these target skills involve installation and maintenance, rather than assembly or other manufacturing sectors.

Although both universities and TVETs in South Africa offer a range of courses and qualifications relating to fossil fuel and renewable energy systems, there is a need for further development of training around renewable technologies, including governance and finance skills for a just transition (BRICS Energy Research Cooperation Platform 2023). The Energy and Water Sector Education and Training Authority (EWSETA) has been collaborating with the South African Photovoltaic Industry Association (SAPVIA) to map future skills needs. Other training organisations include the South African National Energy Development Institute (SANEDI), the South African Renewable Energy Technology Centre (SARATEC) at the Cape Peninsula University of Technology (CPUT), and the Green Solar Academy, but many of these focus on residential installation (GIZ 2024).

Women face a more difficult role in value enhancement, as they often lack skills, qualifications, and training, and have more responsibility for care work and limited mobility. Further, the industry appears to have many barriers, including gender bias in promotion, inflexible working hours, and lack of skills qualifications and training (Ferroukhi et al. 2021; López and Baruah 2021). Many women in the field identify limited skills and training as the most significant barrier. However, in Africa and Asia, there is also a tendency for middle-class women to study science, technology, engineering, and mathematics (STEM) subjects at a university level and then join companies in entry-level and mid-level technical positions (Baruah 2017).

3.2 Value creation and enhancement: firms

Value is created by a wide range of private firms participating in renewable energy production networks in South Africa. This participation involves mobilising capital from commercial and developmental banks, grants, and equity investors; establishing sites of production such as factory plants and construction sites; and hiring workers, organising subcontractors, and sourcing subcomponents and raw materials. In this section we trace how firms engage with each other across the production network to create value and how tasks are vertically or horizontally disaggregated or concentrated. Much of the process occurs outside South Africa, with China having a particular dominance, though some sections have been partially localised. We are particularly interested in global sources of supply which eventually meet South African demand.

3.2.1 The production process

South Africa depends on importing a range of raw materials that are required for the different products and subcomponents. In the solar PV system, the most significant of these is high-grade silica, whose extraction takes place in Germany, the United States, Japan and China. Additionally, copper, aluminium, and steel are required for other subcomponents (Ndubuisi and Avenyo 2024). For inverters, raw materials include copper, steel, and aluminium (WHC solar 2025; Rivett-Carnac 2022).

As of 2020, Chinese firms have gained ground in manufacturing equipment both for solar cells and modules, though they do not completely dominate either sector (Horii 2021). Previously, production of manufacturing equipment for solar panels was dominated by companies from the Global North, such as the American AMTECH and the Swiss Meyer Burger. However, since 2010, these have been challenged by a growing number of Chinese competitors, such as Jingsheng Mechanical & Electrical Co., Ltd (JSG), and Shenzhen S.C. These companies initially manufactured parts and subsystems for other equipment but later began to offer their own complete turnkey solutions.

Chinese firms have gained significantly from skills and knowledge transfer in their industrial development. In terms of explicit knowledge flows, Chinese firms have built on a range of earlier patents developed in the United States, Europe, and Japan. Tacit knowledge has been developed through company acquisitions and staff movements, with many Chinese firms hiring foreign and foreign-trained staff across a range of senior positions (Zhou et al. 2018). Skills development has also been driven by an active talent policy across a range of national and regional Chinese state institutions (Zhang et al. 2023).

Subcomponent manufacturing for solar PV modules is dominated by processing of polysilicon into ingots, which are then sliced into wafers. Prominent firms in this sector include: Tongwei (China), GCL-Poly (Hong Kong, China), Wacker (Global), Daqo New Energy (China), Xinte Energy (China), and East Hope (China, Mongolia and Kazakhstan) (Milroy 2025; Ndubuisi and Avenyo 2024). The processing of silica into complex polysilicon products represents the highest value addition in the GPN, and it requires specialised skills, equipment, and technology (GIZ 2024). These are also highly energy- and capital-intensive processes. Other important subcomponents/subsystems include copper wiring, backing sheets, covers, and frames. For inverters, subcomponents include enclosures, circuit boards, transformers, and other electronic and magnetic equipment (WHC solar 2025; Rivett-Carnac 2022).

Some subcomponents, such as copper wiring and aluminium or steel framing, are produced locally in South Africa (Rivett-Carnac 2022).

Much of the assembly of these components into complete products is dominated by foreign firms, often large, vertically-integrated OEMs. Key OEMs for the solar PV sector are identified in Table 1 below.

Table 1: Major global suppliers and OEMs for solar panels

Supplier	Capacity (Shipments in GW in 2023)	Founding	Manufacturing Location	Other important localities
Tongwei Solar (TW Solar)	65.5	2006	6 Chinese bases	Exports to 40 countries, with major markets including Europe and Australia
Jinko Solar	60.2	2006	China, Vietnam, Malaysia and the US	Presence in over 160 countries
LONGi Green Energy Technology	58.4	2000	China, Vietnam, and Malaysia	-
Trina Solar	55.5	1997	Founded in China	Installations in over 100 countries
JA Solar	51.2	2005	12 bases globally	Over 20 branches globally
Aiko Solar	36.7	-	Multiple bases in China	-
Canadian Solar	30.7	2001	Global footprint including a large Chinese base and growing presence in the USA (Norman 2025a)	"Subsidiaries in over 24 countries"
Astonergy	19.5	-	-	-

Source: (Milroy 2025)

Table 1 shows that most of the largest suppliers are Chinese and their shipment volumes indicate very high economies of scale. This makes it hard for South African producers to gain entry.

This subsection has described a global concentration of equipment, technology, advanced components and assembly capacity which forms the competitive environment within which South African firms operate.

3.2.2 The industry in South Africa

The current solar panel industry in South Africa is essentially limited to final assembly, installation and maintenance. One South African firm, ARTSolar, and one local subsidiary of a Chinese company, Seraphim, assemble solar systems locally, using both imported and locally manufactured components. ARTsolar carries out the laminating, testing, and framing of PV modules (ARTsolar 2025). Their value creation is limited to these low-value activities, which are not as labour-intensive as manufacturing, which happens outside the country. Reliance on low-value activities also limits profits, job opportunities, and technological transfer. However, there is significant potential to increase participation in activities across the value chain. Seraphim built a USD \$14 million factory for solar panel assembly in 2018 (Seraphim 2018).

Exact employment figures for ARTSolar are difficult to ascertain and depend on the scale of production at any given time, which can be extremely erratic. However, the Industrial Development Corporation (IDC) claims that:

“The direct local employment created as a result of the upgrade is in excess of 200 jobs, with a further 1,100 indirect jobs. The installation and commissioning process of the 325MW line has already contributed to sustaining almost 100 jobs of local service providers. (IDC 2022).”

While a range of inverter manufacturing exists in South Africa, there is potential to increase local firms' participation in the sector, as there are still many imported inverters. Currently, South Africa imports about 90% of inverters, with only 10% supplied locally (GIZ 2024). Inverter standards for REI4P projects require testing which cannot be performed locally (Rivett-Carnac 2022). Inverters differ in size, quality, certification specifications, and durability, and South African PV manufacturers tend to produce lower-end, smaller inverters. This constrains high-value production in the domestic industry (Rivett-Carnac 2022; GIZ 2024). In earlier bid windows, some European multinationals initially planned or actually established inverter manufacturing facilities in South Africa. However, they closed due to market uncertainty. There may be a possibility of persuading them to return, with more stable bid windows opening up (GIZ 2024). In addition, many subcomponents of inverters are imported, although one local company, MicroCare, uses many more local subcomponents (Rivett-Carnac 2022).

The industry is dominated by Chinese firms but has a significant European presence (WHC Solar 2025). Key OEMs include WHC, Sungrow (China), SMA (Germany), SL Power Electronics, Firmer, TMEIC, GInlong, Growatt, Solar Edge, and Sineng (WHC solar 2025; Rivett-Carnac 2022). Four South African inverter manufacturers build inverters using both domestic and imported components: RWW Engineering, MLT, Microcare, and arioGenix.

There is a fragmented network of importers of both solar panels and inverters. Complete units are brought into South Africa by a wide range of importers. For inverters, importers include: Allsolar, ACDC Dynamics, Goodwe, ZRW Mechanika, Valsa, Huawei Technologies Africa, IBC Solar, Sinetech, Santerno South Africa, Schneider Electric, ABB, and Siemens. For solar panels they include: EasyPower, Green Energy SA, GX energy, SegenSolar, Canadian Solar, JinkoSolar IBC Solar, Valsa, Renewsys, Rubicon Renewables, SetSolar, Sinetech, and Suntech (Rivett-Carnac 2022; SAPVIA 2026).

Once the panels and inverters are imported or locally manufactured, the products go into the deployment value chain (Rivett-Carnac 2022). For larger systems, they are typically deployed by engineering procurement and construction (EPC) companies, which often subcontract to a range of specialists for different tasks. For smaller projects such as home installations, smaller firms are used, generally without any further subcontracting.

Solar energy is generated and supplied through four main channels:

- 01 **The Renewable Energy Independent Power Producer Procurement Programme (REI4P):** this is the largest system through which energy is sold to the state. It is a utility-scale programme in which power is purchased by the state through auctions. This programme supports private generators through long-term guaranteed offtake agreements with the state. Contracts are given to private generators based on an auction mechanism, which has gone through a number of bidding windows. Criteria for selecting winning bidders include price, as well as local content and community development. The industry is heavily dominated by a collection of foreign firms, but a smaller number of domestic firms exist (often as junior partners).
- 02 **Embedded generation:** this is the second way power is purchased by the state, without either an auction or long-term guaranteed offtake agreement. Often it takes the form of grid-connected households and firms using some energy from their solar system themselves, selling some back to the state (particularly at peak times), and buying some at off-peak times. This prosumer (producer and consumer) model reduces the amount of private storage needed considerably. There are no local content requirements for the embedded generation market. A proposal for an import tariff of 10% on solar panels was put forward in 2019 (GIZ 2024). However, it was only implemented in 2024 and was paired with a rebate that effectively cancelled it out. It is also unclear whether the tariff level of 10% is sufficient to protect local production for the private market, even if the rebate scheme was dropped (EE Business Intelligence 2024a).
- 03 **Sales between private companies:** these typically take place through wheeling, where power is transmitted through the national grid but purchased directly by private consumers. This is a rapidly growing sector, linked to ongoing efforts at liberalising the energy transmission market. The same limitations to industrial policy apply to this sector as to embedded generation.
- 04 **Off-grid systems:** these are more typical in remote rural areas where grid transmission is difficult. They typically require much more storage, which is relatively expensive. Due to South Africa's extensive transmission and distribution network, with high rates of electrification,

this option is relatively rare in South Africa, so its peculiarities are less important to the overall market for solar components in the country.

EPCs and installers extend their participation and value capture beyond construction by also performing operations and maintenance (Morris et al. 2020).

Recycling of solar panels is still an undeveloped industry for two main reasons: many installations are only recently decommissioned or are yet to be decommissioned; and the vast majority of decommissioned solar panels are not recycled. However, plans exist to increasingly recycle decommissioned panels. Research and development on cost reduction remain ongoing (GIZ 2024). Recycling of inverter components is possible, using technologies similar to those used for other electronic waste (GIZ 2024).

A key challenge is the existence of highly competitive international markets and rapid technological developments with which local competitors must be able to keep pace. In this context, value enhancement is a key strategy for competitiveness in the sector. This requires continual reinvestment in technological capabilities. Currently, the largest firm globally in the sector, a Chinese firm, Tongwei Solar, has gained a competitive edge in the global market by pioneering industrial-scale production of monocrystalline solar panels, combined with Passivated Emitter and Rear Cell (PERC) technology, to improve efficiency by reducing energy losses. This increased energy conversion efficiency (the proportion of solar energy converted into electricity) from between 18.6% and 19.9% to between 19.6% and 21.3% (Horii 2021). Following this, Jinko Solar, another top solar manufacturer, has been developing cells with a 24.58% efficiency, using n-type TOPCon cells (Chen et al. 2021). Other Chinese solar manufacturers have been unable to compete technologically with the front-runners. They have relied on more established relationships in export markets, as the technological front-runners have won domestic Chinese state contracts (Horii 2021).

Research, design and development for both components are dominated by China and Europe, with a smaller but globally significant role played by the United States and Canada. These activities are supported by national and international systems of innovation (GIZ 2024), including universities, original equipment manufacturers (OEMs),³ and state institutions. China has increasingly come to dominate downstream manufacturing processes, as well as research and design (Huang et al. 2016).

Technologically, South African solar assembly is currently in line with the newest high-end technological advances and is compliant with standards required for the REI4P programme (Engineering News 2025). However, local inverter manufacturing is less competitive for utility-scale installations, with an additional barrier of compliance with international standards. According to GIZ:

While MLT and Microcare developed the capacity to produce grid-tied inverters they discontinued these products due to the costs of complying with European Union (EU) electromagnetic interference standards (GIZ 2024, 31).

³ The OEMs in the solar PV module and inverter GPNs are discussed in more detail in the section on foreign manufacturing.

The critical factors in developing competitive solar manufacturing appear to be the following: first, large markets are needed to establish significant economies of scale;⁴ and second, cheap energy is required for competitive polysilicon manufacturing. While critical minerals may confer some advantage, they do not seem to have a determining role in establishing successful solar manufacturing.

South Africa therefore possesses some assembly and inverter capability. However, its progression into higher-value production is constrained by uncertain demand, limited certification capacity, reliance on imported components, and the scale and technological advantages of international firms.

3.3 Value capture: workers

Under ideal conditions, workers capture value through wages, while households and communities capture value through the goods and services that workers are able to purchase with those wages. Households and communities also benefit from electricity access.

A range of different measurements for job creation within the renewable energy sector exists, using different methodologies, datasets, and reporting in different ways (Hermanus 2022). These can be difficult to compare, but when viewed together can provide a useful, if somewhat confusing, baseline for guiding coordination between labour and localisation policy in the sector:

- The Independent Power Producers Office (IPPO) estimates that 101,948 job years have been created by combined IPPs up to the last quarter of 2025, producing 8,135 MW of capacity (which generated 148,242 GWh) of electricity. This would suggest an employment intensity of 12.53 job years per MW of capacity. This measurement includes non-renewable and renewable IPPs, without disaggregation (DEE 2025).
- The Local Content Compliance Unit (LCCU) has estimated the manufacturing jobs that could be created by localising fasteners, steel, towers, steel ropes, transformers, and cables in both wind and solar farms. They found that 5 GW of onshore wind could produce 23,600 direct jobs and 24,570 downstream jobs, while 5 GW of solar could bring 16,200 jobs. This would be 4.72 direct jobs and 4.95 indirect jobs per MW of wind capacity, and 324 jobs per MW of solar capacity, just from manufacturing these components locally.
- A 2021 SAPVIA study found 17 full-time equivalent jobs were created per MW of utility-scale solar power installed (Hermanus 2022)

In terms of the quality of jobs, existing research shows a growing tendency towards precarious work (for example, Baruah 2017). Working conditions are highly uneven across the sector globally. While some decent working conditions exist in high-value-added parts of the value chain, particularly in the Global North, in many places job quality is extremely poor. This includes conditions for mineral extraction and manufacturing work (Davidson 2023; Shirley et al. 2019). Marginalised groups are often more prone to becoming included in solar value chains under poor conditions. For example, many women are employed in the sector for last-mile sales and installation in outlying rural areas.

⁴ China built a successful solar sector relying on both domestic and international demand, allowing for significant economies of scale. In contrast, South African industries have struggled without policies for the creation of a stable pipeline of demand. This is discussed in more detail in Section 5.2 below.

Value capture is not determined only by wage levels and employment conditions; it also depends on who gets access to jobs and how income and care responsibilities are distributed within households. Value capture by households and communities from the solar energy industry is uneven, especially along gender lines. Data from Organisation for Economic Co-operation and Development (OECD) countries gives insights into the gender inequalities within the parts of the solar PV GPN located in Global North countries. Approximately 20-25% of jobs are held by women. These are dominated by sales and administration, with STEM-related fields representing a smaller portion. Technical STEM-related jobs typically offer higher wages but show less gender diversity (Baruah 2017). Such disparities are often linked to lower female participation in STEM education. However, it appears that significant early career obstacles further limit women's participation in these roles, even after pursuing STEM education (Pearl-Martinez and Stephens 2016). Further education alone appears to be less of a barrier outside large Global North economies: India and China both have a relatively high percentage of female engineering graduates, along with many former USSR countries which, however, are slowly reverting to lower gender equality levels (Baruah 2017).

In South Africa, however, there is limited available data or research on some of these topics, particularly the intra-household distribution of income from renewable energy work. Income from renewable energy-related work often goes to supporting a range of care needs for social reproduction, including food, utilities, and housing, children's education, and medical expenses. Wages can often be spent very unevenly on household and community needs; in most cases, non-wage sources of income supplement workers' wages to enable households and communities to meet their needs (Naidu 2023). These included pensions and grants, informal work, income from microenterprises, and credit.

Although research on the intra-household distribution of income directly from the solar industry is lacking, general trends among working-class South African households reveal some key features (low rates of union formation and paternal support for children, proliferation of intergenerational households, and a reliance on both income from wages and grants to meet family needs) which are likely replicated in households where members work in the solar industry. According to Moore (2020), South Africa is characterised by high rates of women bearing primary responsibility both for direct care provision and financing of care for children, elders, and disabled persons in households. There are low marriage and union formation rates, and men often bear little responsibility for financial obligations to wider kinship networks, compared with women. There are many multigenerational households, and grandmothers, as well as mothers, play a very active role in childcare. Many households containing employed members still rely on grants, such as childcare grants, and experience various forms of poverty (Moore 2020). Additionally, household needs are sometimes met through informal (and exploitative) credit arrangements. Further research would be needed to understand whether households implicated in renewable energy value chains display differing characteristics of intra-household distribution income.

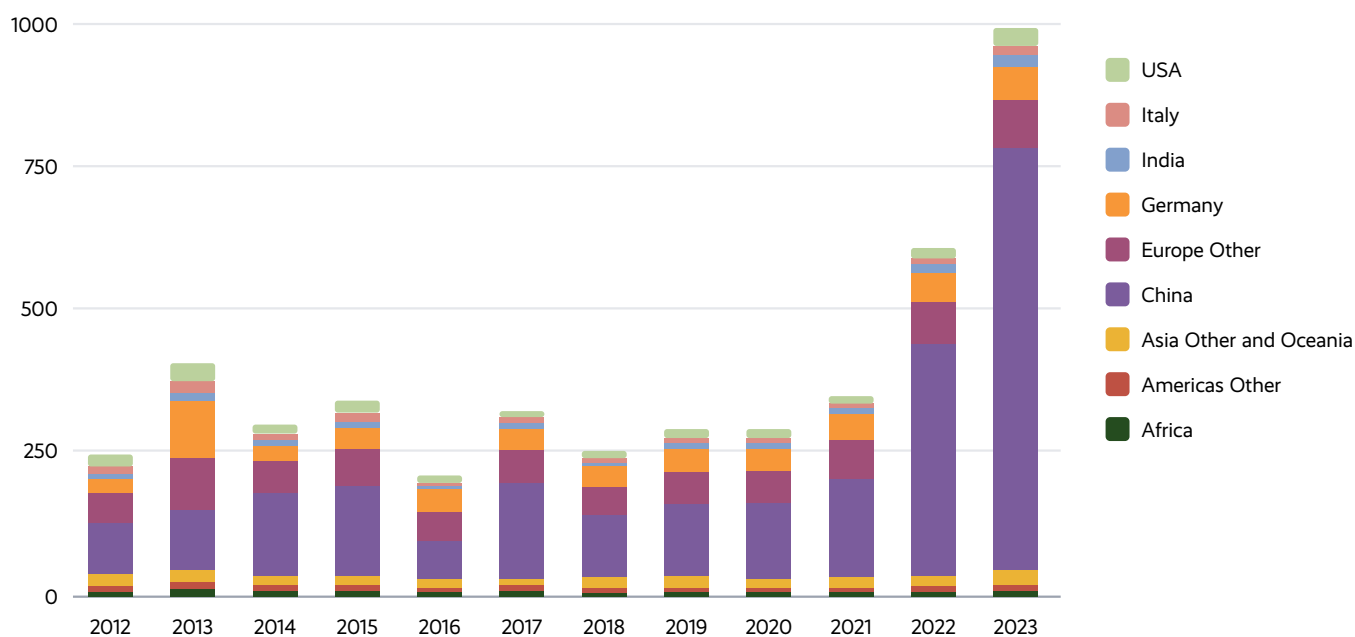
2.4 Value capture: firms

From the GPNs above, we argue that firms in Europe and China capture the most value. The first reason for this is their position as OEMs. The second is that manufacturing and related activities are higher value, creating more jobs. Firms in African countries are often limited to sales, installation, and maintenance (Bhamidipati et al. 2021). The third reason is that these firms receive favourable treatment

in their countries of origin, including policy support and knowledge production supporting technological advancement and innovation.

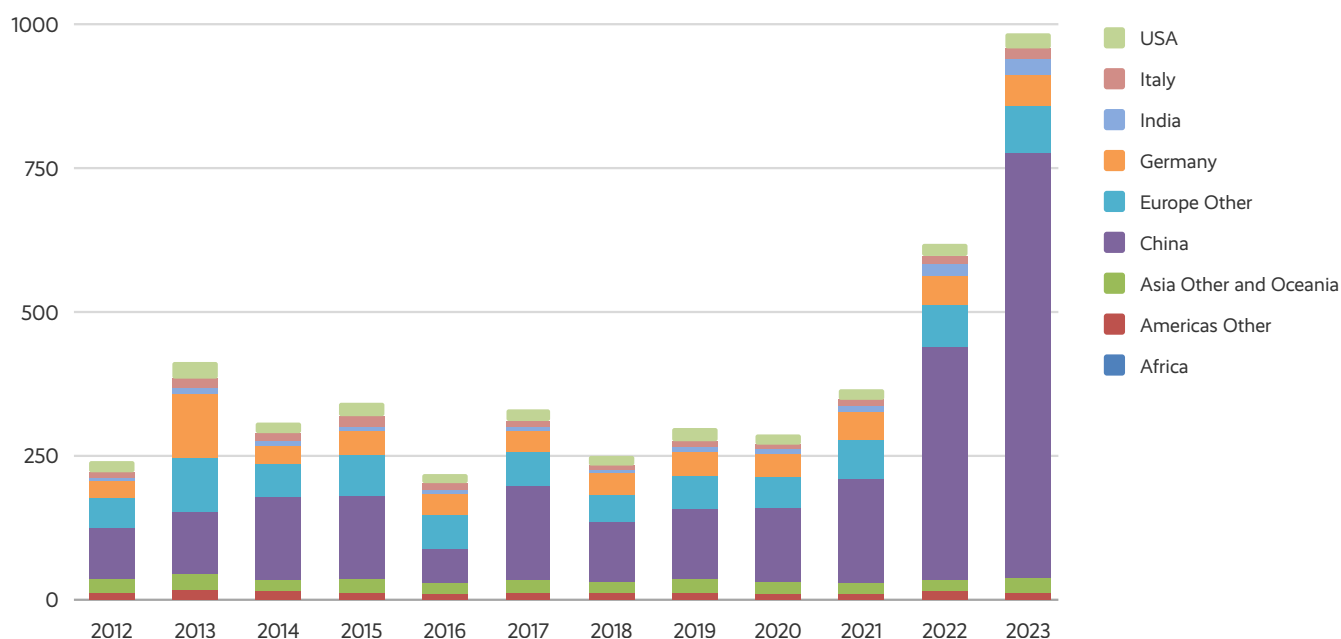
The high proportion of imports to South Africa indicates significant room to expand South African production to meet local demand, creating and capturing more value locally for both domestic firms and workers. This is shown in Figures 1 and 2 below, which identify inverter and solar PV imports to South Africa by country of origin respectively. This value is lost in South Africa and gained in the country supplying the solar panel.

Figure 1: Inverter imports to South Africa by country of origin, 2012 to 2023 (\$ millions)



Source: UN 2025

Figure 2: Solar PV imports to South Africa by country of origin, 2012 to 2023 (\$ millions)



Source: UN 2025

Figures 1 and 2 show that imports of both inverters and solar panels rose sharply in 2022 and again in 2023. China accounts for the majority of those increases. Some Chinese manufacturers supplying early REI4P bid windows included “Suntech, Yingli Solar, Trina Solar, Jinko Solar, Build Your Own Dreams, and Renesola” (Baker and Sovacool 2017). In addition, Tongwei Solar has partnered with Hexing (a multinational already manufacturing smart meters in South Africa) to expand its access to the South African market (PV Magazine 2023).

Historically, high-tech value chains have been characterised by high value capture⁵ through technological rents for research and design stages carried out in the Global North. However, China has invested heavily in indigenous research and design capabilities since 2000 (Bai et al. 2024) and shows increasing technological dominance in the field (GIZ 2024). However, industries involved in final sales in the Global North continue to capture high value. There are also medium levels of value capture carried out by higher-end manufacturing and intermediate firms in older and more western-aligned industrial states in East Asia (Japan, Taiwan, and South Korea). This is followed by lower levels of value capture by lower-end Chinese, and other East Asian manufacturing (Vietnam, Cambodia, Bangladesh, and Indonesia) and low value capture for resource extraction.⁶ Again, there has been a significant shift as manufacturing has moved from earlier Asian tigers to China. For example, China appears to be rapidly gaining dominance in energy storage manufacturing, posing a great risk to other competitors in South Korea (Reuters 2025; Davies et al. 2025). Horii (2021) documents the changing patterns of industrial dominance within the sector. From 2005 to 2017 the industry in East Asia shifted its center from Japan to its former colonies (Taiwan and South Korea), and onto China. Meanwhile manufacturing in the United States and Europe while still significant in 2011 had all but disappeared by 2017.

However, high levels of subsidisation and state procurement mean that it is difficult to determine where profits from sales end and subsidies start, making it all the more difficult to trace patterns of corporate value capture.

The industry is dominated by very large vertically-integrated multinational firms, with smaller firms finding it difficult to break in. It is not clear from existing research how this affects profit distribution, as a full overview of the profitability of the different areas in the value chain is not available. However, there are some clear indications of forms of unequal exchange and hyper-exploitation within the sector, creating forms of value capture for lead firms. First, there are forms of hyper-exploitation in the extraction of critical minerals that cheapen input costs for lead firms.⁷ Second, last-mile distribution of many solar products in rural areas is dominated by a highly feminised workforce of precarious, self-exploiting, female micro-business owners, who often work extremely long hours in hazardous conditions (Baruah 2017). This allows lead firms to benefit from extremely low distribution and sales costs in certain areas.

⁵ Value capture can be measured in a range of ways, including prices, labour time embodied in production, and raw resources and ecological destruction embodied in production. These often show similar patterns (Dorninger et al 2025). Two measures of value capture used in a key study on Apple's value chain (which informs much of the literature) are Gross Profit Margins and Operating Profit Margins (Clelland 2014).

⁶ Exact details and geographies differ across GPNs in different sectors.

⁷ Multinational companies exploit resource-rich countries through securing generous incentives/concessions on taxes, the environment and labour laws: Fraser and Lungu (2007) describe Zambia's case.

However, many solar manufacturers are not particularly profitable, as intense price competition has drastically reduced revenues. For example:

- Tongwei Solar saw a year-on-year decline of 47.25% in profits in 2023. To maintain profitability, Tongwei has adopted a range of strategies. They have increased production and sales, significantly even as prices have fallen; they have heavily invested in updating technology, with their mass production cells reaching an efficiency of 26%; and they have rapidly reduced input and production costs below many competitors in the industry (EnergyTrend 2024).
- Jinko Solar saw a 98.78% decline in net profits year on year, from 2023 to 2024 (Norman 2025b), although it has remained profitable with a gross margin of 10.9% (JinkoSolar 2025). Jinko is investing heavily in new technologies, hoping to reach 27% efficiency for its panels by the end of 2025. Additionally, they are rapidly phasing out older production lines. They are also investing in greater automation and process optimisation (JinkoSolar 2025).
- Longi has also managed to remain profitable and has invested in developing new technologies and expanding new production lines. They particularly emphasise the mechanical properties of their panels, highlighting that they are more robust and have a longer lifespan, as well as the development of bifacial technologies (Longi 2024).
- Trina Solar remained profitable, focusing heavily on R&D investment and partnering with a range of international universities. They have established a wide range of patents related to TopCon solar modules (Trina Solar 2024).
- JA Solar's income fell by 14.02% in 2024. Its strategies also included a focus on R&D, expansion of sales, and a reliance on vertical integration to cut costs (Bhambhani 2025).
- Canadian Solar's profits fell 30.1% year on year. The company is vertically integrated and operates downstream as an EPC for a range of solar and storage projects globally (Canadian Solar 2024).

However, a range of large manufacturers, including Trina Solar, Jinko Solar Tongwei, and JA Solar, have also agreed to limit price competition and contain production (JinkoSolar 2025). This initiative was led by a Chinese state ministry and involved plans for an orderly phase-out of old technology and a limit on new capacity installations (apart from those showing new technological developments) (Xiao 2025). This may stabilise both profitability and price decreases across the industry, and may provide some measure of relief for South African companies struggling to keep up with the price war in the sector.

Two other vehicles of value capture are likely sources of value drain from the productive elements of the South African economy in the solar GPN: capital flight and financial benefits from high risk-to-reward terms offered to tempt private finance into the sector through state derisking. The degree to which multinational companies with South African subsidiaries repatriate profits is also unclear. However, profit repatriation is highly likely given patterns in other sectors throughout Africa, as well as South Africa's lack of capital controls and weak ability to prevent tax avoidance by large multinational corporations (Ashman et al. 2011). Although there have been clear discussions of the role of finance in REI4Ps (Baloyi and Krinsky 2022), there is little information about the forms of financing present in other sections of the value chain, particularly in local manufacturing.

Firm-level value capture is therefore concentrated among companies which control key elements of technology, scale, components and markets. For South Africa, the main concern is limited domestic control of high-value activities and potential additional drain through finance and profit repatriation.

2.5 Value capture: states

State value capture often involves a compromise, as industrial policy measures often reduce a state's ability to capture value from domestic firms and transfer value towards them. For example, tax incentives in South Africa, such as those offered in special employment zones (SEZs), reduce the amount of value captured by the South African state (Baker and Sovacool 2017). In fact, fears of excessive corporate value capture or rent-seeking are generally linked to a range of industrial policy measures, including tax incentives, subsidies, and protection of local markets. However, these dangers must be weighed against the high potential benefit of successful industrial policy. Two common approaches are often suggested to navigate this tension. The first is to develop a strong state which can resist corporate lobbying for interventions that do not advance broader developmental objectives. The second is to design initial industrial policy instruments that align corporate interests and wider state industrial policy instruments, thereby avoiding such contradictory lobbying efforts (Khan 2015).

We have not been able to find details of the tax revenue for different sections of the value chain. However, much of it is heavily subsidised both on the demand and supply sides (GIZ 2024). Up until 2008, Europe played a dominant role in demand-side policies, such as feed-in tariffs. However, after the financial crisis, many European countries scaled back their demand-side subsidies, while China drastically scaled up its own, to make up for lost export earnings. Since then, China has reevaluated and reduced its demand-side policies, particularly as falling solar generation costs have improved competitiveness. Supply-side subsidies have included state investment in research and development, supply of key enabling infrastructure, and subsidisation or state guarantees for developmental finance (Zhi et al. 2014; Bai et al. 2024).

The state may also gain from access to cheaper electricity resulting from declining costs of solar generation. In 2025, solar power contributed 6,492 GWh out of a total of 218,601 GWh of energy available for distribution (Eskom 2025). In addition, the (IPPO) reported in 2021 that solar PV IPPs had contributed to a 22.7 Mt CO₂ emissions reduction, that Black South African ownership accounts for 37%, with community ownership (as a subset) at 8%, and that 50% of project spending was on local content. This amounted to R48.8 billion, with 3.8% or R1.3 billion going to women-owned vendors (IPPO 2021).

This could help reduce fiscal burdens associated with significant energy subsidies. However, it remains unclear if this benefit can be realised by the state, given the privatised and financialised social relations under which the technology is being incorporated into the grid (AIDC 2020).

Overall it is difficult to understand clearly the state's role in value capture within the sector, as both the state and private firms stand to benefit significantly but also spend significant amounts on the sector. A privatised and financialised route can allow the state to benefit from immediate service provision, but in the long term it creates obligations to continue to buy from private contractors. An industrial policy-focused approach requires more significant initial outlays but can result in long-term benefits if some initially supported industries mature and ultimately contribute significantly to state revenue, as well as other state objectives such as economic development and employment creation. Whether these potential public benefits are realised depends not only on policy design but also on the balance of power among firms, state institutions, workers and communities. The next section moves from the distribution of value to the power relations that shape it.

4. POWER IN THE GPN

The GPN is not simply a narrowly economic structure. The economic relationships within it are governed by a dynamic set of power relations which shape economic control in the system. Workers are in a constant battle over wage levels and working conditions, and firms compete economically and pursue political strategies to advance their interests. Often firms can crystallise into factions of capital attempting to steer wider systems of accumulation at a national or international level.

Within South Africa, capital is largely split into different factions with often contradictory relations with the state, popular forces, and international capital. This division weakens its power and reduces the ambition and effectiveness of its political projects. Projects of long-term national capitalist development give way to unsustainable projects, often entirely dominated by personal enrichment at the expense of both national and wider class interests.

Organised labour is a potential counterweight to corporate and state power, but neoliberalism has drastically weakened its power. While it is organised and significantly unionised, liberalised trade, financial and macroeconomic policy have created unemployment and large reserve armies of labour, which serve to discipline labour as a class. Further, significant divisions within the South African labour movement, as well as the embourgeoisement and potential embourgeoisement of its leaders, weaken its power and its political will to drive a transformative economic project of green development. Meanwhile, international political forces are in a flux, marked by the rise of China, and to a lesser extent other Global South nations, alongside the desperate violence of the US's attempts to manage its imperial decline, with the ongoing complicity and complacency of much of the rest of the Global North. This rivalry may create room for the South African energy transition to benefit, but it also creates grave dangers.

This section looks at the corporate power of firms, the institutional power of states and other governing bodies, and the collective power of workers, communities and organised social forces.

4.1 Corporate power

One of the most common frameworks for understanding corporate and state power in South Africa has been that of the Minerals-Energy Complex (MEC). This framework holds that a set of highly interconnected industries, including mining, beneficiation, energy production, and increasingly finance, have formed a coordinated system of capital accumulation, with significant and coordinated policy influence over the state (Fine and Rustonjee 1996; Ashman et al. 2013; Newman 2019).

The different firms within the MEC have exercised corporate power in a variety of ways, both today and historically. These have included significant donations to political campaigns (Mathe et al. 2023), and the direct integration of many politicians into the interests of the MEC through ownership (or family ownership) of interests within the sector. Further, given the MEC's large share of GDP, export revenue, and employment, it is politically difficult to oppose policy recommendations which favour

it. It is argued that this has distorted industrial policy towards these sectors and hampered industrial diversification, particularly into light industry (Ashman et al. 2013). Initially formed as an analysis of the early colonial and later nationalist government, this framework has been updated by a range of authors who examine its continued legacy in post-apartheid South Africa (Ashman et al 2013; Newman 2019). Here, a central focus has been on how the changing interests of the MEC may have driven some elements of South Africa's neoliberal agenda, particularly financialisation.

We use this analysis here to understand how corporate power has been formed and wielded in South Africa's renewable energy rollout. It highlights a range of features. The first is the considerable political influence of firms and individuals which are heavily invested in fossil fuel value chains. This has often been seen as a key force slowing down the renewable energy rollout, and prioritising public investment in a range of fossil fuel-based solutions (Burton et al. 2022; InfluenceMap 2023). These include: a range of politically-tied interests in coal provision to Eskom; potential private interests in revenue from state companies involved in Eskom's diesel purchases, which were above market prices; and potential new interests in state revenue linked to gas sales to Eskom (Mathe et al. 2023). This could crowd out renewable investment, limit public renewable investment, and channel public finances towards potentially stranded assets.

The second is the significant role played by a range of existing MEC companies in investing in new renewable energy technologies. This includes Sereti Green's investment in a collection of REI4P projects, Sasol's investment in green hydrogen, and a range of mining companies' investments in renewable generation capacity for embedded generation (and potentially wheeling). While this represents a positive transformation of technological choice for investment for a range of these companies, it raises a number of concerns:

- These companies' diversified portfolios may be used to greenwash their continued highly-polluting activities, creating a positive image of these companies' role in the energy transition (Mathe et al. 2023). So, Sereti is heavily invested in coal mining, while Sasol operates notoriously polluting coal-to-liquid fuel plants. At the same time, most companies across the sector have opposed any measures to penalise fossil fuels, such as a carbon tax, while investing in considerable advocacy in support of an expansion of renewables, along with increased privatisation (InfluenceMap 2023).
- These companies were part of fossil fuel value chains which had deep political connections. Mike Teke, Seriti Resources CEO, is an ANC donor, and Anna Mokgokong, the chairperson, was involved with the Karpowership project.⁸ These companies may seek to extend such influence to gain favourable treatment from the state in the new renewable sector.
- Many of these companies have a history of poor labour practices and community engagement. This has continued, with intense contestation over community funds (Baker 2015a, 2015b).

However, several fissures may have emerged in the MEC which prevent it from acting as a unified force in shaping the way in which renewable energy has been integrated into the South African economy. At the heart of the MEC is an integrated system in which significant profits can be made along the entire value chain, from fuel extraction through to energy generation and its use in energy-intensive industries. This forms a coordinated production system, which is often supported

⁸ Karpowership was a proposed IPP project to moor ships running gas power generators off the South African coast. The project was eventually abandoned amid fears of environmental damage, high costs, and corruption (Mathe et al. 2023).

by policies which support the entire system. These includes policies such as: loose environmental regulations; subsidies across the system; labour discipline (Benya 2015); regional subimperialism to defend mineral rights and cheapen labour (Matin 2013); heavy transport systems; state management to coordinate the system; export parity pricing on key final outputs of the complex (notably steel) (Fine 2018); and an education system capable of producing engineers and managers.

However, there are also potential challenges in how the surplus is distributed within the system, particularly in pricing between nodes. This contest over the surplus took place with fossil fuel-based power generation, through pricing of intermediate goods in the MEC. The emerging Black elites linked to the state (state bourgeois class) have been integrated unevenly into the MEC, with the most direct access for those parts embedded in the state, or reliant on state procurement, compared to those sectors which underwent early privatisation. This uneven integration has resulted in diverging interests within the overall accumulation system. While more established new elites, who were more thoroughly integrated into the MEC, have interests in the functioning of the whole, those who are only temporarily integrated into part of the system have more interest in proverbially killing the golden goose.

We suggest that two different factions of politically connected Black capital have emerged. The first, more systematically integrated into the MEC (containing figures such as Cyril Ramaphosa and Patrice Motsepe) have interests across the MEC, which gives them a class interest in the smooth functioning of the entire system. The second, linked to Zuma and state capture, have narrower interests, often simply involving profiting from state contracts in ways which jeopardise the running of the MEC as a whole. One example of this is that prices in the electricity system have risen dramatically, while the reliability of the electricity supply has plummeted. Coal prices have been rising due to an increase in exports as well as a range of irregular contracts with politically-connected suppliers. Diesel contracts were agreed at high prices during loadshedding (South Africa's system of rolling blackouts to reduce demand in the grid). Meanwhile, Eskom is increasingly signing contracts with large energy users for relatively cheap access to electricity (Yelland 2025; Roff and van Doesburgh 2025).

Accompanied by continual reduction in renewable generation and storage costs, this appears to have driven the part of the MEC dependent on cheap energy (the energy-intensive users) to move towards increasing interest in private generation and a shift to renewables. It may also have delayed public renewable investment, as large parts of the state bourgeois class have depended on irregular fossil fuel procurement. For example, Gwede Mantashe, the minister of Mineral Resources, has played a significant role in lobbying for expanded fossil fuel exploration, including both coal and gas (Mathe et al. 2023). Additionally, Eskom heads, such as Collin Matjila, Matshela Koko, and Anoj Singh, and private firms, including Trillian, ABB, and McKinsey, were heavily implicated in state capture (Godinho et al. 2018; Mathe et al. 2023).

In contrast, the corporate powers driving the expansion of renewable energy are far less embedded in the South African state. They appear to be primarily driven by interests in the privatisation and liberalisation of South Africa's energy sector, with environmental concerns simply providing an opportunity (albeit one with a progressive aspect) for this agenda, rather than being the main goal. Among the domestic classes, interests in privatisation may be linked to the IPPs and EPCs themselves. However private interests involved in IPPs may still play a role in the state even if they are unable,

unwilling or simply find it unnecessary to rely on expanding state capacity to support their own accumulation.

The frequent movement of high-level state employees between the public and private sectors illustrates the close relationship between state energy institutions and private renewable-energy capital. This may result in direct payback — policymakers being rewarded for policies with high-paying jobs after leaving the public sector. But it may also simply reflect the general nature of their class consciousness while in office. Additionally, it may reflect a genuine shared skills base, in which skills and knowledge in the public and private sectors substantially overlap. One example is Jan Oberholzer, a former Chief Operating Officer of Eskom. He is now chair of Mulilo Energy, which has won a significant portion of new storage IPPs (Business Tech 2025). Another example is André de Ruyter, a former CEO of Eskom, who had previously been a senior executive at Sasol, one of the largest emitters of greenhouse gases globally. His tenure at Eskom was marked by a move towards market liberalisation and greater procurement of private renewable energy generation, and this has continued after his departure. Further, he made a series of controversial allegations of corruption and organised crime operating within Eskom and its various suppliers, including allegations against two unnamed ministers (Bloom 2023). This again points to fractures in the political cohesion of the MEC between those benefiting directly from provision of fossil fuel infrastructure at inflated costs, those requiring a stable Eskom, including those benefiting from supplying renewables.

Interests in privatisation, as with neoliberalism more generally, cannot be reduced to immediate opportunities for profit-making. Rather, the weakening of popular developmental projects and the advancement of wider imperial and class interests have often been central objectives, with direct accumulation opportunities being a secondary benefit. Privatisation (particularly of a vital system such as energy infrastructure) is not simply a question of efficiency, quality of service, or profit and loss; it fundamentally alters the balance of class power in a country by allowing capital strikes to cripple vital infrastructure. It also weakens the sovereignty of the state as it builds key dependencies on imports and multinational corporations which can be weaponised against the state's sovereign decisions. This, of course, is precisely in the interests of imperial capital and the domestic compradorial classes. IPPs, EPCs, financiers and importers of renewables are not the originators of neoliberal policy in South Africa; they are only opportunistic beneficiaries extending existing neoliberal policy trends into new frontiers. The underlying power that makes this possible is more historically rooted in the macro-power structures which drove earlier pushes for neoliberalism in South Africa. These include trade liberalisation, financial liberalisation and the ongoing battle for privatisation across almost every sector of the South African economy.

It is important, though difficult, to assess the interests of the energy-intensive users within this ongoing struggle. These are a core group within the MEC that consume a significant portion of South Africa's energy. On the one hand, they benefit from heavily subsidised prices from Eskom; this gives them a clear interest in Eskom's long-term viability. On the other hand, they have often been enthusiastic about liberalisation options within the energy markets, looking to diversify their energy supply. As most of their pricing arrangements with Eskom are undisclosed, it is difficult to tell if their interest in wheeling and other forms of liberalisation aligns with their long-term interests in reducing energy costs. Alternatively these may be motivated by involvement with IPPs and EPCs, attempts to discipline Eskom and reduce any potential cross subsidisation of poor South Africans. Finally this

support for liberalisation may simply reflect concerns that they lack the long term influence to ensure Eskom's viability.

Whatever the case, there appears to be a general private sector consensus on the privatisation and liberalisation agenda, beyond the narrow state bourgeois faction described above. They have been uninterested in driving state policy towards generating domestic profits in the renewable energy manufacturing sector. Short-term concerns over price, speed, and perceived reliability have often trumped concerns about local manufacturing for renewable energy installations. This has created a larger policy environment in which solar EPCs, OEMs, and investors have shared interests with energy-intensive users in limiting and evading policies which promote local content (Baker and Sovacool 2017).

Corporate power has therefore supported the expansion of renewable energy generation while limiting the extent to which that expansion builds domestic manufacturing capability.

4.2 Institutional power

In South Africa, the just transition is governed by a proliferation of institutions. Many of these are old, with their roots in the apartheid era MEC; some are very young, initiated specifically to deal with the transition. These operate in a wider international institutional environment, including governance linked to international financial agreements in the energy transition, trade relations such as the WTO, and international limitations on technology transfer such as intellectual property regimes. Additionally, there are a number of states which regularly project the power of their state-level institutions beyond their national borders, to benefit their interests in the South African just transition.

This section looks at institutional power first in South Africa and then in other states.

4.2.1 Institutional power in South Africa

Institutional power can be understood through a Marxist analysis of the bourgeois state, even where it incorporates international and non-state elements. In this view, the state does not simply serve as an instrumental implementation of the will of the dominant bourgeois faction. Rather it serves to organise and reconcile the interests of various bourgeois factions, while fragmenting popular interests and reconciling them with bourgeois interests (Moyo and Yeros 2011). Here we see a continuation of the struggle between different bourgeois factions emerging in contestation over the state, through struggles between and within different organs of state and political parties.

At the level of party politics, the ANC, the dominant party, remains divided between the two factions of politically connected Black capital. There have also been splits and new parties emerging from the ANC. These parties actively challenge the ANC from the perspective of economic populism. This has resulted in parties such as MK, which is allied with the new state bourgeois faction, with direct interests in using the state to further their interests in the fossil fuel value chain. Additionally, there is a range of smaller centre-right to far-right parties currently in coalition government with the ANC. These parties generally strongly favour privatisation of Eskom. Most have also adopted some positive

framing of the need for an energy transition, although they do not appear to have it as a political priority (Mileham 2023; VFplus 2024). Gayton Mckenzie from the Patriotic Alliance is an exception to this tendency, having interests in a number of gas deals (Mathe et al. 2023).

The interests of the emerging state bourgeoisie are most strongly represented in the executive branch of the state. In 2019, Gwede Mantashe took the leadership of the Department of Mineral Resources and Energy (DMRE) (Groenendaal 2022). The DMRE has often been reluctant to advance the energy transition. Many of its officials have expressed concerns about foreign impositions driving the transition, feeling that this created a threat to national economic development, sovereignty, and particularly emerging Black mining capital (Chilenga-Butao and Holland 2024). However, partially due to the dramatic failures of loadshedding and excessive corruption related to coal contracts, the DEE was formed by President Ramaphosa in 2024, by splitting up the DMRE. Kgosisentsho Ramokgopa was placed in charge of the new department, and direct control was removed from Gwede Mantashe (EE Business Intelligence Issue 2024a). In this role, Minister Ramokgopa was given power over:

policy, regulation and planning of midstream and downstream gas supply, and for coal-fired, gas-fired and diesel-fired, nuclear, hydro and renewable power generation, transmission and distribution. This includes oversight of Eskom and municipal electricity distribution (EE Business Intelligence Issue 2024b).

The change in leadership appears to have been linked to a rapid expansion in the rolling out of private renewable contracts through the IPPO (Green Building Africa 2022).⁹ This can be interpreted as a shift of power away from the state bourgeois faction and towards those favouring greater privatisation and a shift towards renewables. Although this appears far from an outright defeat, it is a move towards a moderation of the state bourgeois faction's influence.

Neoliberalism, including both privatisation and derisking, are most strongly championed by the National Treasury, which has also played a key role in driving policy towards both greater renewable procurement and a range of energy sector liberalisations. These include the completion of Eskom's unbundling and the creation of a wholesale electricity market. Institutionally, this has been driven through Operation Vulindlela, which also sits within the Presidency and works closely with the National Energy Crisis Committee (National Treasury 2025)

Industrial policy initiatives in South Africa sit uncomfortably between the two major tendencies. While they are rhetorically championed by the state bourgeoisie, they lie outside of their core economic interests, and appear to be used more for political legitimacy. While the RET faction has no core interests within manufacturing, the privatisation faction retains some residual interests in localisation, if only to prevent public antagonism. However, in practice they evade and water down localisation policy where possible. This leaves labour, and the smaller faction of manufacturing capital, between a rock and a hard place: side with those who don't want renewables, or those who don't want public ownership. The alternative is to forge a new path with the few allies left and hope to build a popular national coalition capable of advancing a publicly owned, nationally manufactured renewable industry,

⁹ The REI4P programme was active in its first years, then stalled, and was then reactivated. There were four bidding windows between 2011 and 2015, with the government stalling the programme between 2016 and 2021 when no new clean energy auctions were held. In addition, round four power purchase agreements from the fourth bidding window were only signed in 2018. The programme was finally brought back onstream in 2021.

while gathering allies from both other camps along the way, and containing defection. There is some working-class influence over state policy. The ANC has had an alliance for many decades with COSATU, South Africa's largest trade union federation, which may provide a foundation for such a new policy direction.

These current contentions over industrial policy can be better understood by contextualising them in a historical perspective. Following apartheid, South Africa went through a period of limited and uncoordinated industrial policy interventions, before the development of an industrial policy framework created greater coordination. The early interventions were driven by a state-wide liberal economic policy known as Growth, Employment and Redistribution (GEAR), which was largely inspired by the Washington Consensus. However, a more coordinated vision for industrial policy emerged in 2007 with a piece of legislation, the National Industrial Policy Framework, and an outline for its implementation in the Industrial Policy Action Plan (IPAP); this received a number of updates in the following years. This policy was proposed by the Department of Trade and Industry (DTI). It was an attempt, with limited success, to create industrial policy coordination across a range of other state departments and institutions. It established much of the foundational legislation for the use of public procurement to drive local industry (including for renewable energy), and it pushed the IDC to orient towards developmental finance, and away from pseudo-commercial lending. It also pushed for a more expansionary push in South Africa's macroeconomic policy, although this was largely unsuccessful due to the National Treasury's opposition to state intervention through industrial policy measures (Zalk 2014).

Within the renewable energy sector, one particular policy instrument emerged as the dominant industrial policy tool over the past decade of renewable energy rollout: the local content policies contained within the REI4P. The policy control provided through the REI4P auction process has given the programme some potential to drive local manufacturing. However, delayed bid windows have deterred a range of local and foreign investors from setting up local manufacturing to meet demand from the REI4P programme (GIZ 2024). The bid windows are controlled through the IPPPO, which is governed by three institutions: the Development Bank of Southern Africa (DBSA), the DEE, and the National Treasury (DEE 2025). With pressure from the National Energy Crisis Committee (also headed by Ramakgopa and located in the Presidency), a broad set of new auctions was initiated (EE Business Intelligence Issue 2024a). These included REI4P Bid Windows 5 and 6, as well as Risk Mitigation IPPs, which combine solar PV, wind, and storage (Smith 2024; Mathe et al. 2023). In Bid Window 5, local content requirements were dropped to 30% to ensure projects came online quickly, to reduce loadshedding (Norman 2023). However, they were raised again in Bid Window 6 to 40% (Groenendaal 2022). In Bid window 7, the local content requirements were 38% (DMRE, DSI and DTIC 2025). So, although legal challenges to local content requirements emerged after the Constitutional Court declared the 2017 Preferential Policy Procurement Framework Regulation invalid and unconstitutional (GIZ 2024), this does not appear to have significantly reduced local content requirements for upcoming bid windows. However, local content requirements can be evaded through transfer pricing (Baker and Sovacool 2017). Additionally, there appears to be a weak enforcement mechanism for ensuring that local content requirements are observed (Artsolar (Pty) Ltd v Latimer and Others 2025).

Developmental finance has supported individual manufacturers but has not established a coherent industry. There has been state support through the IDC for subsidised finance to some local renewable

manufacturers/assemblers. It advanced approximately R90 million to ARTsolar to establish a local manufacturing/assembly plant for solar panels (Bracken 2025). It also invested R153 million in Seraphim in 2019 (IDC 2019). This appears to be related to the setup of their local subsidiary factory in Gqeberha (Parnell 2018). It has also listed on its website a range of other funding opportunities related to the sector, although the exact beneficiaries are unclear (IDC 2025). These include the Manufacturing Competitiveness Enhancement Programme (MCEP): Energy Resilience Transition Fund - Infrastructure Programme, valued at R50 million, and the AFD Green Energy Fund, valued at R1 billion.

There is poor integration and limited development of a national system of innovation (Baker and Sovacool 2017). The Council for Scientific and Industrial Research (CSIR) has led a number of research initiatives to support the green transition and localisation of renewable technologies (Roro 2018). It has established a solar PV lab to provide accredited testing of solar cells and support the industry. It is unclear from the current literature how firms have connected with local universities and other national systems of research and skills development.

These existing policy measures may be bolstered by other industrial policy tools, as well as greater enforcement, through the South African Renewable Energy Masterplan (SAREM). SAREM was released in April 2025 (DMRE et al. 2025). It involved consultation with a wide range of actors, including many state departments (most notably DEE, DTIC, Department of Science and Innovation, and the DMRE). Also included was a diverse range of industry actors and associations, including IPPs, EPCs, and local manufacturers, as well as organised labour and civil society. Much of the organisation for the research in SAREM was done by GreenCape, which is an independent non-profit with links to many state departments and private sector actors (Groenendaal 2025). SAREM centres on expanding renewable energy generation driven by the private sector (brought in through liberalisation and derisking). This is paired with growing electricity demand from green hydrogen production and electric vehicles. This is meant to create a market for the outputs of a strategy to localise the production of a range of key elements. The plan points to a selection of existing manufacturing capabilities which could be expanded and improved, including in solar panel manufacturing (or assembly and lamination), construction of frames, cables, fasteners, inverters, transformers, switchgears, and combiner boxes. The plan also focuses heavily on skills development. A project management group is soon to be appointed to oversee the implementation of SAREM (PMG 2025).

Additionally, institutional power is used in governance of labour conditions and social reproduction. One key state initiative regarding decent work is the 2010 South African Decent Work Country Programme (DWCP). This was updated in 2016. The programme was developed by the National Economic Development and Labour Council (NEDLAC) with the aim of promoting key strategic advances for decent work, rather than ensuring a complete legal guarantee of decent work. Gender equity is largely addressed through the Women Empowerment and Gender Equality Bill (2013), which promotes women's economic empowerment. Additionally, a later policy, the Strategy for Economic Empowerment of Women, Youth, and Persons with Disabilities was developed in 2024 (Hermanus and Kamanzi 2026).

However, this does not mean that state power is always exercised progressively on labour issues or gender policy. State violence is often used to control labour protests, such as in the infamous Marikana massacre, and austerity policies deeply undermine gender equality by increasing the private care

burden faced by households (Benya 2015). Although SAREM does include nods to the concept of decent work, this is not clearly defined in the document, nor are there clear frameworks for counting the actual jobs created in the sector or monitoring their quality, although COSATU and the IEJ have previously lobbied for these to be included in the plan (Hermanus and Kamanzi 2026).

In summary, South Africa possesses many of the institutions required for localisation, but they do not yet operate as a coordinated system.

4.2.2 Institutional power in other states

The South African solar industry has been shaped by the power that competing states have wielded through their industrial policy. This has resulted in competitive advantages which South Africa has often been unable to match, alongside large amounts of imports into South Africa.

Several foreign states support their local solar industries which export to South Africa. Most imports into South Africa come from countries with very significant industrial policies for the solar industry. This includes support for R&D, subsidies and subsidised finance, and government procurement to support their own local industries (Rodrik 2014). Early examples of green industrial policies emerged in Germany in the 1970s and the United States since 1992 (GIZ 2024). This led to early technological dominance but has since been outpaced by other countries, notably China.

China's dominance has resulted from sustained and coordinated state intervention. China's emphasis on solar PV as a target for industrial policy emerged in the early 2000s (Bai et al. 2024). It began with an export orientation, supplying solar panels to large markets such as the EU and the US. The Chinese industry initially benefited from a trend towards vertical disintegration within the industry, as solar PV manufacturing equipment was separated from PV manufacture. China initially imported manufacturing equipment and so was able to become a competitive exporter long before localising its production. After 2008, China moved towards extensive domestic demand, including specific incentives for more high-end products. This helped build a significant technological advantage (Horii 2021). More recently, state subsidies have been reduced, but the mature industry remains globally competitive. Additionally, there have been Chinese state-led measures to reduce the intense price competition in the sector, such as raising barriers to entry to build new manufacturing capabilities and reducing export tax rebates (JinkoSolar 2025).

Other states which have recently implemented ambitious industrial policies for solar PV have combined a number of interventions. India has used local content requirements as well as local subsidies and rising import duties. Türkiye paired a demand-side policy of feed-in tariffs with local content requirements. This first drove local assembly but has since developed component manufacturing capacity, driven by a state tender (GIZ 2024).

Additionally, outside manufacturing, state support can also play a key role in building industries: for example, the EPC Enel, which has won a range of REI4P contracts in South Africa, began as an Italian state-owned company (Soda and Carlone 2013). It is now the most significant private sector power distributor, and also controls a global portfolio of renewable power generation projects, through its subsidiary, Enel Green Power (Mathe et al. 2023).

This brief review of institutional power in other states shows that successful localisation has not come from isolated incentives, but from coordinated interventions sustained over long periods.

4.3 Collective power

Collective power refers to a wide variety of ways in which different groups organise collectively to wield power within GPNs (Henderson 2002). In the South African solar sector, this appears through a range of collective institutions: firms coordinate their corporate interests through associations; workers organise through unions and federations; and communities and civil society organise around social and environmental issues.

The most significant business association in the solar industry, SAPVIA, is dominated by non-South African firms (Chinese, European, and Canadian), although it also includes many local firms (SAPVIA 2025). Its membership includes foreign OEMs such as Jinko Solar, Canadian Solar, and Trina Solar; IPPs such as Enel (Italy), Scatec (Norway), and Mainstream (Ireland); EPCs, such as Daisy Energy and Juwi; and financiers such as Nedbank.

SAPVIA has advocated for a fairly ambitious set of industrial policies for the South African solar sector, including suggestions for local production and potential export of polysilicon products (potentially, green polysilicon), inverters, mounting systems, trackers, cabling, and balance of plant equipment. It proposes the use of policy instruments including state procurement, tariffs, SEZs, tax incentives, developmental finance, support for skills development, development of better testing capabilities, and state coordination of private investors (GIZ 2024).

SAPVIA, as an industry association, is more invested in merchant and financial capital than in industrial capital. Given that many of its member bodies are merchants themselves, some scepticism is warranted when assessing its support for large-scale industrial policy.

Direct manufacturing work within the sector is not unionised and this is a key stumbling block to the realisation of decent work in the sector. Challenges to unionisation exist, including the work-to-order nature of procurement in the sector, the temporary nature of construction jobs, and the remote working locations. However, organising the sector should be a priority for existing unions to prevent the interests of workers from going unrepresented and the potential loss of membership during the transition from unionised carbon-intensive jobs to renewable energy jobs that are currently not covered by unions.

However, organised labour still plays a significant role. Trade unions have extensive membership in other parts of the economy (particularly the energy sector), formal representation in governance bodies such as NEDLAC, as well as connections to the ANC and, thereby, penetration into the state. They can also often wield legal power to protect workers' interests. COSATU is the largest federation of trade unions in South Africa with 1.8 million members (COSATU 2025). Other large union federations — FEDUSA (representing 617,000 members (FEDUSA 2025)) and SAFTU — contain several affiliates which may be able to play a role in organising activities in the sector, or are active in similar sectors. These include the National Union of Metalworkers of South Africa (NUMSA); the South African

Industrial Commercial and Allied Workers Union (SAICWU), and the General Industries Workers Union of South Africa (GIWUSA). However, many of the sectors which these unions organise are carbon-intensive, which means that they have an interest in protecting coal-linked jobs (Baker et al. 2015). A range of other civil society organisations also play a role in the just energy transition more broadly. Mining Affected Communities United in Action (MACUA), for example, plays a role both in mediating ongoing coal and gas mining and their potential phase-out, and in labour and community struggles around the extraction of minerals used in the solar value chain, such as those used in steelmaking. Additionally, smaller local organisations may play an important role, particularly at installation sites, such as in the case of community protests at the Leorisfontein wind farms (Malope 2022).

To advance a just transition which includes localisation, decent work and social development, it is vital to build collective and institutional power and political will. It is important to forge a coalition that includes workers, affected communities, and manufacturing capital, whilst countering corporate power opposed to decent work and localisation. It is necessary to understand where interests align and how the balance of power can be shifted to benefit workers, while working within the constraints of the heavily coal-backed and financier-backed energy economy.

The balance of collective power helps explain why South Africa has expanded renewable generation without building a strong domestic manufacturing base. The next section examines how these power relations are embedded in firm networks, territories and systems of social reproduction.

5. Embeddedness

The productive elements of the solar GPN are embedded, throughout, in a wider range of political and social institutions at national and regional levels and interact with a range of other actors. They are rooted in communities and households, which serve as systems of social reproduction of labour power. This can be understood through the GPN categories of social embeddedness and geographic embeddedness. These forms of embeddedness exist as contested and compromised relationships; for example, communities often conflict with firms over issues such as local job creation, labour standards, and environmental concerns. They also include finance, state regulation, the effects of international agencies, such as the World Bank and World Trade Organisation, and trade unions, civil society, and academia.

This section examines three related forms of embeddedness. Network embeddedness concerns the connections between firms and other actors within the production network. Territorial embeddedness concerns the industrial regions, infrastructure and local economic conditions in which firms operate. Social embeddedness concerns the households, communities and public services that sustain workers and are affected by production.

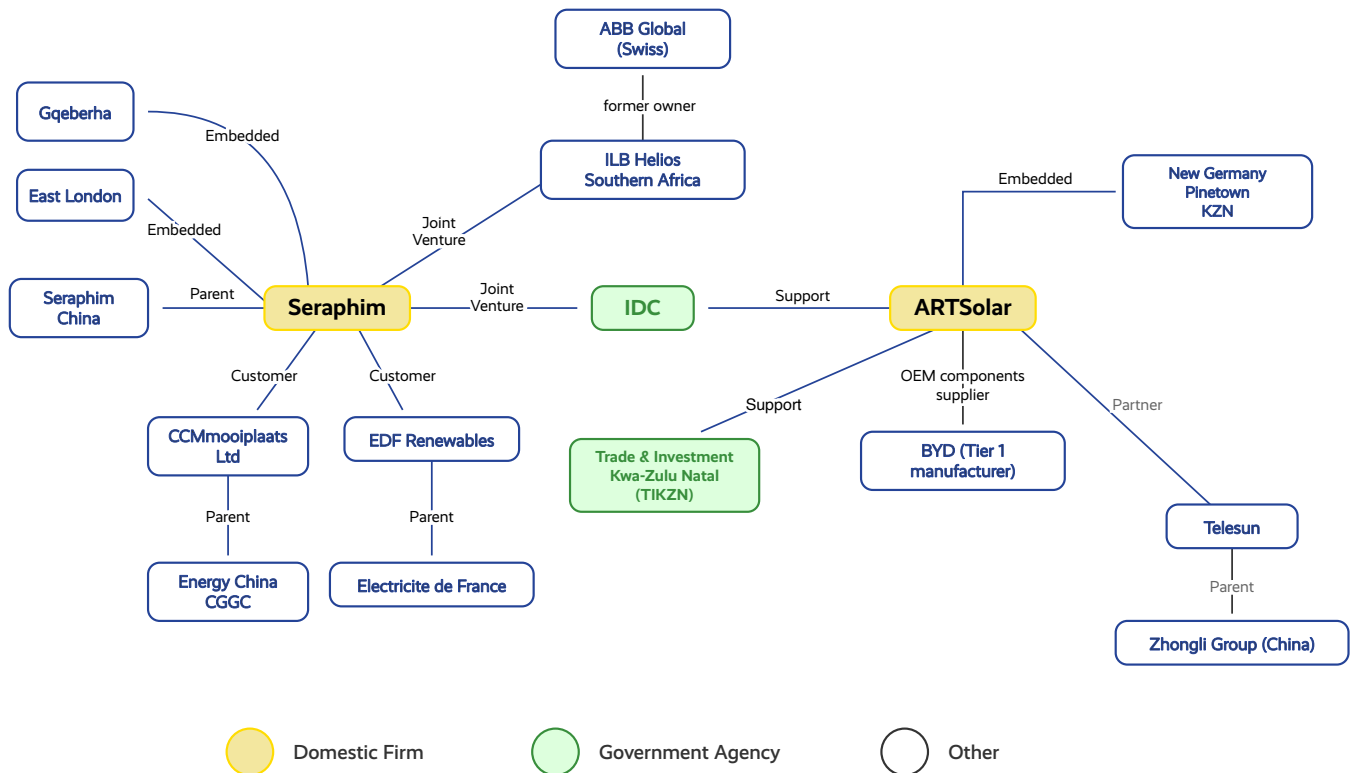
5.1 Network embeddedness

Network embeddedness refers to “the connections between network members regardless of their country of origin or local anchoring in particular places” (Henderson et al 2002, 453). As a concept it can be used to examine how local South African manufacturers are connected to international firms including financiers, and suppliers of intellectual property, training, raw materials and subcomponents, and manufacturing equipment. This can show pathways for value enhancement and capture and ways to shift power within the GPN to favour South African manufacturers.

Additionally, relationships with international partners who contribute manufacturing equipment and intellectual property rights are often key. Finally, tight integration with national systems of production and innovation have served as key advantages in other competitive countries in the sector, although these are underdeveloped with South Africa.

Figures 3 and 4 below map the relationships for the solar and inverter manufacturers.

Figure 3: Local solar PV GPN actors

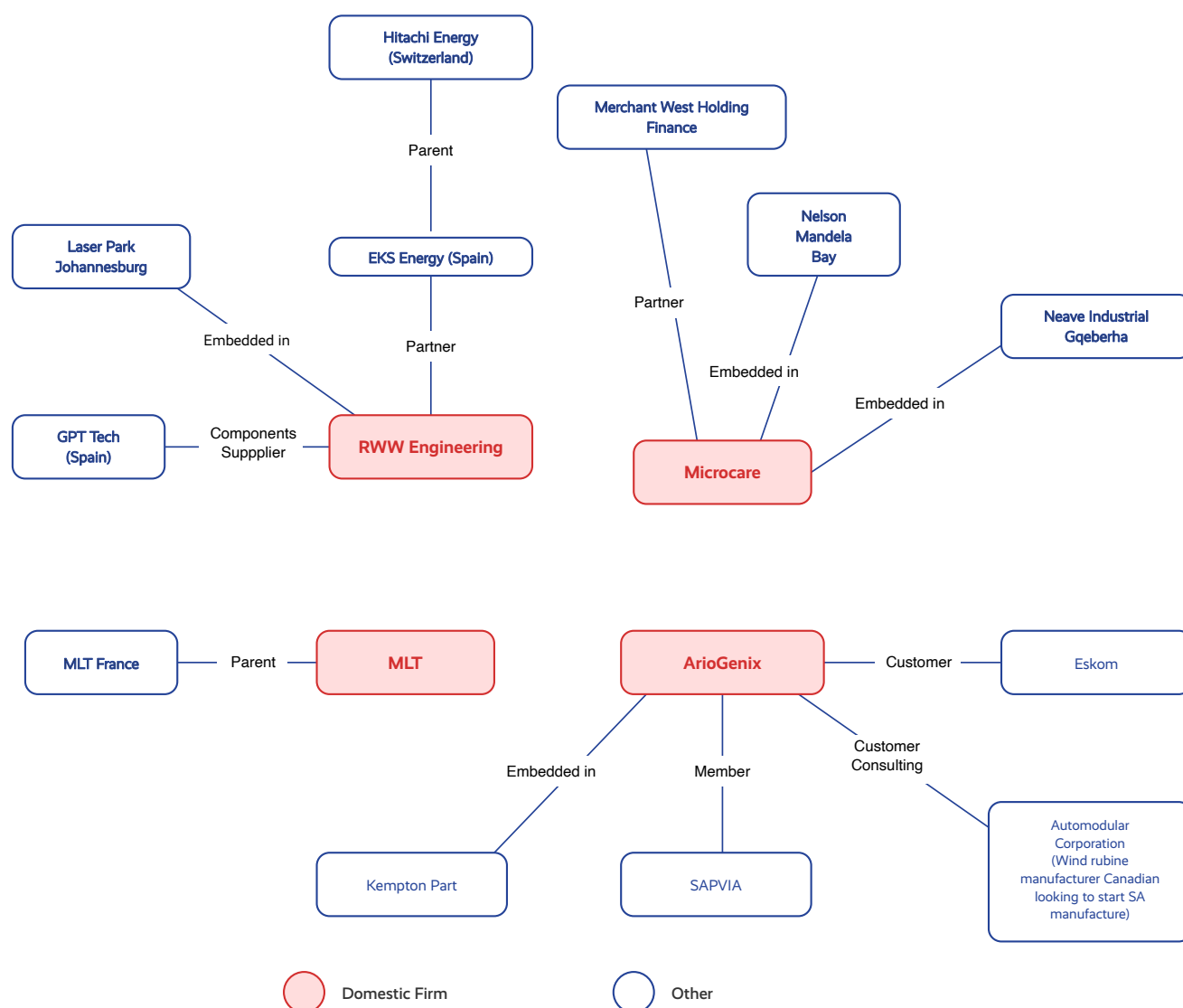


Sources: Seraphim Solar 2018, Artsolar 2025; Green Building Africa, 2019

Figure 3 outlines the existing connections that have been identified within the South African solar industry. While global lead firms linked to local firms Seraphim and Telesun most likely play a dominant role in R&D, component supply, and sourcing of raw materials, it remains to be seen whether the local companies, or other local or foreign firms also bear responsibility for these aspects of the supply chain. Some of the connections are clear, but interviews and further research (beyond desktop research) are needed to understand more fully how these firms fit into the global value chain.

Figure 4 identifies several key actors in the South African inverter GPN.

Figure 4: Local inverter GPN actors



Sources: Rivett-Carnac 2022; MLT power 2025; RWW 2025; Sapvia 2025; Microcare 2025

Figure 4 shows strong connections with international partners for all existing manufacturers as well as embeddedness in existing South African industrial areas. A range of European lead firms had previously set up or planned to set up South African manufacturing, but were discouraged by the slow and interrupted roll out of REI4P bid windows (Rivett-Carnac 2022).

However this level of embeddedness compared unfavourably with many foreign competitors, whose tighter embeddedness confers greater competitiveness and value creation and capture. Across all major solar manufactures and exporting countries, private firms have been embedded in a wider national system of innovation, which has enabled this value enhancement.

- China had already begun increasing its number of related patents in 2003; however, links between universities and industry were weak (Huang et al. 2016). In 2004, increased demand saw a rapid increase in prices for high-purity solar crystals. These were initially imported, but firms rapidly invested in attempts to localise and cheapen this raw material. This included imports of foreign

technology and experts, but it appears that the ultimate solution emerged from adaptations from China's existing semiconductor industry.

- Germany also invested heavily in developing a system of innovation; however, German firms were unable to retain the first mover advantages this created. Germany's heavy investment was in demand-side policies to stimulate growth of the local industry, along with a wide range of supply-side policies and integration with local universities. However, it was unable to overtake the earlier innovators of Japan and the United States or its later competitor in China (Quitow 2015).
- In Japan, research was driven by industry, including "AIST (national research institute), several universities, Mitsubishi, Kyocera, Hitachi and Sharp Corp" (Vasseur et al. 2013, 203). Research is often subsidised by a government agency, the New Energy and Industrial Technology Development Organisation (NEDO).

Firms are located largely in China and the European Union, as a result of industrial policy efforts such as subsidisation, state finance, research support and protection, economies of scale, and access to cheap electricity (GIZ 2024).

Local assemblers depend on international lead firms for technology, components and market access. Seraphim's international parent company, and ARTsolar's international partner TELESun, are both international lead firms in the industry. They likely play a key role in the supply and sourcing of raw materials for their domestic partners/subsidiaries. Still, it remains to be seen whether other local or non-South African firms also bear responsibility for some of these aspects of the supply chain. Additionally, neither the length and quality of inter-firm and public-private relationships nor the exact details of their linkages (co-ownership, training and technology transfer) are clear from current literature.

The internal and external connections within the production network shown in Figure 4 above can be used as a starting point to trace patterns of value, power, and embeddedness. More connections exist which are not included. Component suppliers, and the producers or owners of R&D related to inverter manufacturing, could not be identified at this stage. Locating the key sources of raw minerals to actual South African manufacturing is not possible without further research.

Particular patterns of embedding may play important roles in SMME survival strategies (IEJ unpublished). A range of smaller firms can exist as close subsidiaries of larger firms, benefiting from the economies of scale/scope established by their larger partner firms and the wider network. This appears to be the case in OEMs' installation of REI4P projects, which involve a wide range of subcontracted activities for SMMEs (Rivett-Carnac 2022). Additionally, local manufacturers/assemblers benefit from close relationships with larger international partners and suppliers. Another option is for small firms to compete directly with large, more technologically sophisticated firms based on close local connections, looser regulations, and higher rates of exploitation. Finally, small firms may survive because of the small niches in which they exist, which larger firms do not find profitable to access. This may be the case, for example, for small-scale solar installers in rural areas.

In summary, South African manufacturers are connected to wider international and domestic networks. However, the available evidence suggests that these connections provide access to

technology, components, and markets but generally do not transfer control over high-value functions such as research and development, intellectual property, and component production.

4.2 Territorial embeddedness

Territorial embeddedness refers to the way in which firms “become embedded ... in the sense that they absorb, and in some cases become constrained, by the economic activities and social dynamics that already exist in ... places.” (Henderson et al. 2002, 452). This places the manufacturing firms in the context of the industrial regions in which they are located, showing how they depend on interlinkages and co-inputs for production required by other industrial firms. It contextualises the solar sector within the wider history of South Africa's regional industrialisation. This shows the numerous policy attempts made to drive industrialisation on a more local (subnational level) as well as how this compares unfavourably with other more competitive countries in the sector.

South African solar-panel and inverter manufacturers are embedded in the old manufacturing strongholds of South African industry, often linked to ports and sites of social reproduction for South Africa's industrial working class, such as Johannesburg's East Rand, Pinetown near Durban, and Gqeberha, a legacy of South Africa's auto industry. Seraphim manufactures solar panels in factories in Gqeberha and KuGompo (Seraphim Solar 2018), both in the Eastern Cape, while ARTsolar produces panels in New Germany in KwaZulu-Natal (KZN) (ARTsolar 2025). In inverter manufacturing, RWW Engineering manufacturing facilities are in Laser Park, Johannesburg, in Gauteng (RWW Engineering); ArioGenix is in Kempton Park, also in Johannesburg (Ario 2026). Microcare has a plant in Neave Industrial in Gqeberha, in the Eastern Cape (Microcare n.d.).

Special Economic Zones (SEZs) often play an important role in territorial embeddedness. However, while South Africa has one SEZ which aims to drive green development, it is currently not linked to any solar panel or inverter manufacturers. South Africa has a long history of attempts to use SEZs as part of its industrial policy. These were initially termed Industrial Development Zones (IDZs) under a DTI programme started in 1993 (Qumba 2023). The first four IDZs were Coega, Richards Bay, East London and OR Tambo International Airport. The terminology and governance were changed to SEZs with the passing of the Special Economic Zones Bill in 2014 (Chongsheng 2024). This was followed by the development of a number of newer SEZs: Saldanha Bay Dube TradePort, Maluti-a-Phofung, Musina-Makhado, and Atlantis. There are plans for several future SEZs which have not yet been opened, including the Wild Coast SEZ (Mthatha, Eastern Cape), the Gauteng Science and High-Tech Hub, Tubatse, Bojanala, and Upton (Dube et al. 2020).

Although the solar PV and inverter manufacturers are not located in SEZs, three particular SEZs may be useful to examine in terms of their current and potential future territorial embeddedness. The Coega and East London SEZs are close to Microcare and Seraphim and may have provided some regional advantages to clustering. Similarly, Dube Tradeport is located in Durban near ARTsolar, and the OR Tambo SEZ is located close to RWW Engineering and ArioGenix. Meanwhile, the Atlantis SEZ near Cape Town has been attempting to develop as a specifically green SEZ, which may help anchor the future solar industry in the country.

However, like other industrial policy efforts in South Africa, many SEZs have faced challenges of poor

governance, conflicting interests in governance, lack of a unified national industrial policy, and poor coordination with other policies such as macroeconomic policy (discussed above). Additionally, SEZs seem constrained in their ability to offer optimal business conditions, including cheap rental, subsidised utilities, and good public transport from population centres for a large labour pool (Chongsheng 2024).

The Coega IDZ was a relatively successful project, driving industrialisation and job creation, although it did not yield the height of job creation anticipated. It was the earliest IDZ in South Africa, established in 2000, with close links to the Ngqura deep water port (Chongsheng 2024). It created many decent jobs: about 30% of households with employed members at the SEZ said they could pay their bills, with another 44% saying that they could afford it but struggled a little. However, over half of these households had to borrow within twelve months to meet daily expenses. 44% of the workers in the SEZ were women, showing a rough gender parity (Chongsheng 2024, 315). Labour conflicts have arisen over temporary employment, with disgruntled former employees organising protests outside the SEZ. Coega has used South African labour law, unlike some international SEZs, which maintain their own unique, often more liberalised labour laws.

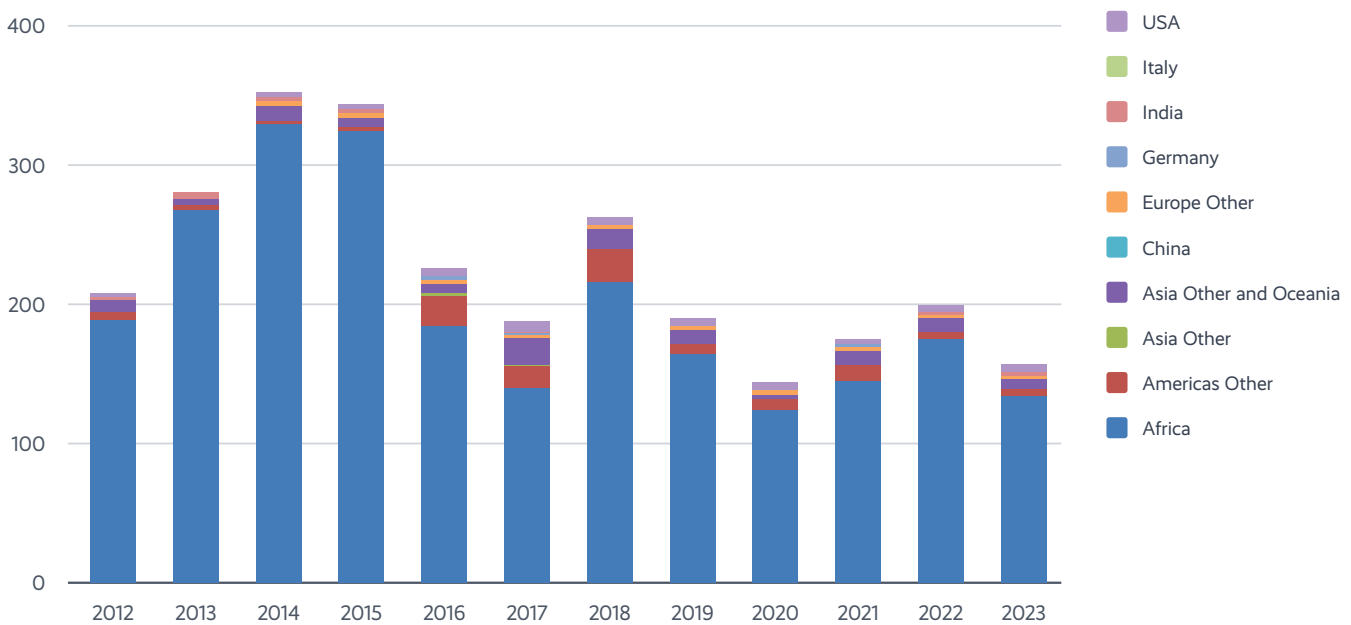
Coega SEZ included industrial linkages with the auto sector as well as metal and chemical heavy industries. However, it was saddled with a confusing governance structure, with seemingly overlapping mandates from a range of national and local government departments. Nevertheless, the industries located in the zone appeared well embedded in the local economy, often buying large amounts of their inputs, including business services, from companies in the surrounding area.

Many of South Africa's SEZ are located by its eight large ports — Richards Bay, Durban, East London, Ngqura (Coega), Gqeberha, Mossel Bay, Cape Town, and Saldanha. These are key to sourcing raw materials and subcomponents for solar PV and inverter manufacture and assembly. However, their poor operation may hinder the local industry. They are all managed under a subsidiary body of Transnet, the parastatal associated with the bulk of transport and logistics run by the South African government. Of these, Durban is the most significant, accounting for two-thirds of traffic. Port infrastructure has been poorly maintained, with many South African ports ranking low on a dashboard of indicators, according to the World Bank (World Bank 2024). Many South African ports rely on old equipment, such as tugboats, with Mossel Bay and East London's fleet being particularly antiquated, while others lack tugs or other equipment needed to berth larger container ships safely. Further, shortages of skilled staff appear to be an issue across the country (Mthembu and Chasomeris 2023). However, South Africa has seen recent significant improvements in port capacity, with improvements in ranking for Cape Town, Coega and Durban. There has also been a shift towards corporatisation and privatisation, with a suggestion to bring in the private sector at Durban's container terminal (World Bank 2025). Ports in neighbouring countries still rank poorly by global standards, but better than many South African ports. This includes Walvis Bay in Namibia, and Maputo and Beira in Mozambique (World Bank 2024). The operational state of ports could further reduce South African manufacturers' competitiveness in attempts to find export markets on the continent.

Land freight transport is dominated by roads, with the share of rail declining steadily. South Africa has “approximately 254,000 km for roads and 20,000 km for rail network” (Mokobori et al. 2022, 1). Road transport appears to be cheaper and faster than rail in most instances, although its overuse has

considerably increased congestion, road damage and road accidents, as well as leading to a deterioration of rail infrastructure due to underuse. The bulk of IPP solar PV deployment is concentrated in the Northern Cape, some distance from domestic manufacturers seeking to gain an advantage (DEE 2025). Additionally, transmission infrastructure in the Northern Cape is limited (Pulitzer Center 2024). Next, we examine how particular export markets appear to play a role in locating some productive capacity within South Africa. We also examine some of the adverse effects which may be linked to the solar value chain. Figure 5 below shows South African exports of solar cells and panels by destination.

Figure 5: South African solar cell and panel export by destination, 2012 to 2023 (\$ millions)

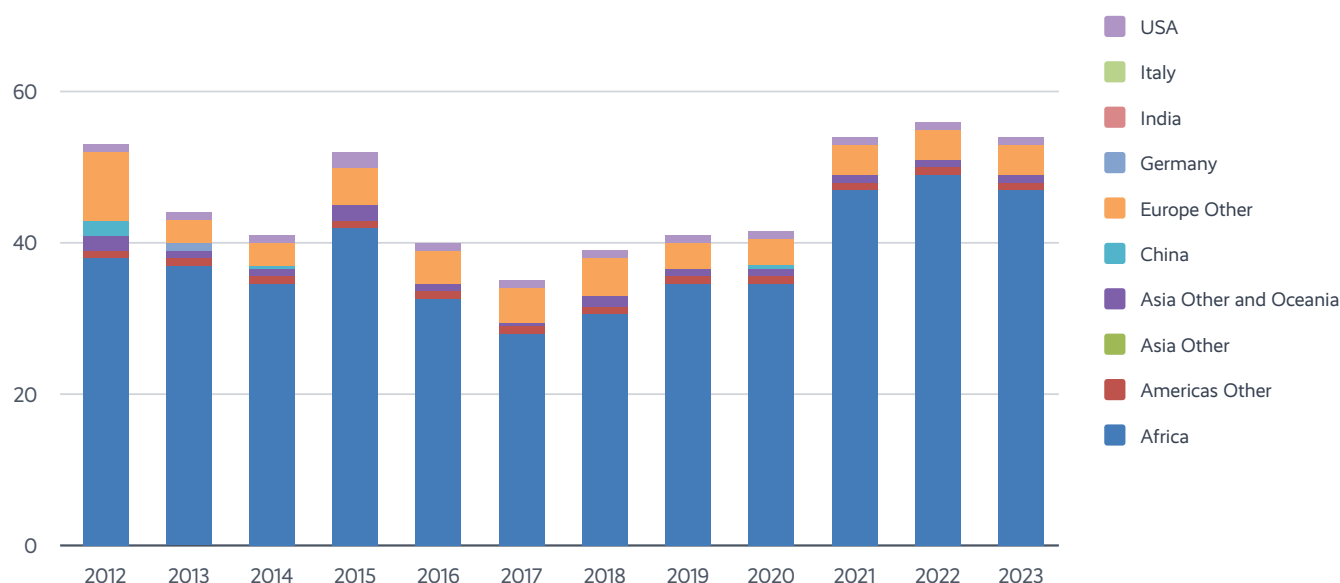


Source: UN Comtrade 2025

Figure 5 shows that the South African solar industry maintains some export capability. This is largely reflected in exports to the rest of Africa. This is likely due to exports of goods which have undergone final assembly in South Africa. Further, these exports are likely to be dominated by small-scale technologies, below state-of-the-art utility-scale requirements (GIZ 2022).

Figure 6 shows that African countries (which can be disaggregated) also form the main export market for South African inverters, with Europe a small but significant additional market.

Figure 6: South African inverter export by country 2012 to 2023 (\$ millions)



Source: UN Comtrade 2025

The export to Africa of inverters suitable for smaller-scale systems (GIZ 2024) may form a viable expanding market for South African manufacturers, with the potential for increased solar installation across the continent in the upcoming years. The majority of subcomponents used in the industry for locally manufactured inverters are imported. However, one firm, Microcare, sources a significant majority of subcomponents locally (Rivett-Carnac 2022). This shows the potential for greater localisation of subcomponent manufacture in South Africa.

The potential for increasing localisation in South Africa depends on a range of geopolitical factors, including a number of state/national actors. Opportunities may emerge due to increasing tensions between China and Western markets. Both America and Europe are looking to diversify supply chains away from China.¹⁰ Additionally, many Chinese firms are to some extent building production facilities in other countries in order to circumvent high trade barriers placed on direct Chinese exports to many Western markets (GIZ 2024). South Africa's renewable energy policy is also heavily shaped and constrained by the set of international lenders who have financed the just energy transition. This includes the EU, UK, France, Germany and the US, with Germany being the largest lender by a considerable margin (Livia unpublished). However, a strategy which depends on Western 'friendshoring' may be hazardous. It is not clear that South Africa will end up on this list of Western friends, given its participation in BRICS and ongoing pursuit of the ICJ case against Israel. Further, at least given US leadership, friendshoring appears unplanned and fickle, with large tariffs imposed sporadically on supposed allies.

¹⁰ For example, recent battery manufacturing facilities have been set up in Morocco, as Europe seeks to diversify supply chains and Chinese firms move production to new countries to maintain access to western markets.

4.3 Social embeddedness

Production in the solar panel and inverter value chains is embedded in a range of local communities. Here, we will list some of the sites of production of both solar panels and inverters, in order to identify surrounding sites of social reproduction which may be of particular importance to the production networks. However, this list is not exhaustive and may be expanded as additional information about companies' manufacturing and management sites becomes available, based on interviews. More distant sites of social reproduction may be important where significant internal or international migration occurs in the labour force.

The industrial centres in which solar-panel and inverter manufacturers are located are surrounded by a range of semi-formal or informal urban settlements, and rural communities from where workers often commute daily. These commutes are often extremely long and can be expensive and hazardous for workers, as well as creating forms of time-poverty (Kerr 2017). This situation has long-term historical roots, with Black, Indian, and Coloured racially oppressed groups forcibly removed from city centres under apartheid (Pirie 2003; Maharaj 2024). However, these semi-migratory labour patterns have been recreated in post-apartheid South Africa, as areas closer to industrial work still often remain unaffordable to many workers (Shah and Sturzenegger 2024). Although these communities demonstrate a range of forms of social reproduction, they share many similarities.

These companies often draw on existing pools of labour, organised into existing industrial proletarian forms of social reproduction (Cherry 1992). This form of social reproduction is maintained for much wider industrial bases in the area, of which solar panel and inverter manufacturing form a small part (Nel et al. 2003; Kaziboni 2018). In addition, increasing urban migration has occurred in the post-apartheid era. So workers and working-class communities are able to move closer to work opportunities. Still, many workers remain in the peripheries of important areas, in degraded urban infrastructure or informal settlements. These housing arrangements contain a mix of single-worker households as well as some forms of family settlement, showing varying patterns of household formation (Posel 2020). Housing conditions often remain poor. Much formal housing is rented rather than owned by workers. Specifically, flats are often heavily sublet, to the point where workers share rooms such as kitchens and bathrooms (Ballard et al. 2021, Chipeta et al. 2022, Ndaba et al. 2024).

Within these housing arrangements, socially reproductive tasks, including care and housework, are often carried out by women (Posel 2025). Care work tasks are also often unequally distributed generationally as well as by gender. In certain households, older children and elderly household members may take on many forms of household and care work (Hendricks et al. 202; Posel 2025).

This distribution of labour also exists among workers who live in semi-migratory patterns, with nuclear family members located in other places: children may stay with grandparents or other relatives. Such patterns are also common in these industrial zones among African international migrant workers, who often travel long distances during leave to visit family. This is a legacy of the apartheid labour system that has continued in post-apartheid South Africa (Posel 2020). The specific proportion of migrant workers in solar manufacturing remains to be determined by further research.

Both public and private healthcare systems which provide healthcare for workers struggle to cope.

Public provision has been hampered by national austerity, as well as forms of local and municipal mismanagement. Public healthcare facilities often face staffing shortages and poor infrastructure. Private healthcare facilities are often unaffordable to workers and are not generally covered by work-based healthcare benefits (Burger and Christian 2020).

While some educational facilities exist locally, often more educated workers are tied to labour migration systems. They come from other parts of the country (urban centres) with more developed educational infrastructure (Allais et al. 2021). This can create tensions and divisions within the labour force, as more skilled and managerial staff often come from outside local communities

There is significant contestation around initiatives of solar IPPs aimed at community development. These show that there is little community value captured through these engagements. Some problems include failures to set up community trusts, low employment footprints in surrounding areas, poor-quality employment opportunities, and relatively little skills development (Nkoana 2018).

Aside from providing jobs, aiding industrialisation and providing energy, the solar production network can have a range of adverse social and environmental consequences across the value chain. The mining of critical minerals for the industry often happens under highly exploitative and conflict-ridden conditions (Fraser and Lungu 2007; War on Want 2015). Processing of silica into complex polysilicon products is highly energy-intensive; it is generally performed with cheap, coal-based energy in China, rather than green energy (GIZ 2024). Installation can often cause issues as well, such as green land grabs (Klingler et al. 2024). Additionally, large migrant populations of male construction workers for short-term construction jobs in installation can integrate poorly into local communities. So the industry is faced with numerous contentious issues and struggles in the geographies in which it is embedded.

In summary, the solar transition is embedded in unequal systems of labour migration, gendered care, overloaded public services, and contested community relationships. Localisation should therefore be assessed not only through output, investment and employment figures, but also through how the social and environmental costs and benefits of production are distributed.

6. CONCLUSION

Overall, the paper finds that there is limited local participation in both solar-panel and inverter industries, concentrated mainly in assembly, installation and maintenance. Import dependence means that much of the manufacturing value is captured outside South Africa. Corporate interests have largely supported a shift to renewable energy, but not domestic manufacturing. Industrial-policy institutions exist but are fragmented and weakly coordinated. Labour and community organisations remain too weak or fragmented to ensure that localisation produces decent work and broader social benefits. The result is that production is often accompanied by relatively poor working conditions and conditions of social reproduction.

There is significant potential to increase job creation and job quality within these industries, though there are many challenges to this, due to significant international pressure and competition, limited domestic policy space, and a lack of mass political will and organisation to ensure public benefits from the new industries.

Domestic capacity exists for more significant participation across both solar panels and inverters, which could be easily increased to meet local demand with the enforcement of existing protective measures. South Africa has industrial regions, ports, skills, firms and regional export markets that could support localisation. Additionally, South Africa is a viable manufacturing site for a range of further inputs and subcomponents for both systems which could be realised with greater support. However, domestic firms are not embedded in systems of innovation, finance, supplier development, and stable demand. The industry also relies on unequal systems of labour migration, unpaid care and overloaded public services.

The social and developmental effects of localisation cannot be assessed only through investment, output or employment figures. The industry is embedded in unequal systems of labour migration, gendered care work, overloaded public services and contested community relationships. Future industrial policy must therefore combine increased domestic production with enforceable standards for decent work, training, community participation, and environmental protection.

Further research is needed to establish the detailed ownership and supplier relationships within the production networks, the sources of technology and components, the distribution of profits and tax revenues, the quantity and quality of employment, and the social effects of the industry.

The potential exists from South Africa's long industrial history and progressive workers movements to steer a new course towards a green structural transformation. It comes not from an idealistic dream, but from identifying the elements for constructing a new, more just and ecologically sustainable society from the very bones of the old unequal fossil state. This requires building power across different sectors of society, and linking the project of transition to renewable energy to a just reindustrialisation of South Africa.

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