GREENING SOUTH AFRICA'S INDUSTRIAL POLICY

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ABBREVIATIONS

AMSA	ArcelorMittal South Africa
APDP	Automotive Production and Development Programme
BEV	Battery Electric Vehicle
BF	Blast Furnace (technology)
CBAM	Carbon Border Adjustment Mechanism
DMRE	Department of Mineral Resources and Energy
EAF	Electric Arc Furnace (technology)
EU	European Union
EV	Electric Vehicle
GDP	Gross Domestic Product
GH2	Green Hydrogen
GHG	Greenhouse Gas
ICE	Internal Combustion Engine
IDC	Industrial Development Corporation
IPAP	Industrial Policy Action Plan
IRP	Integrated Resource Plan
JETP	Just Energy Transition Partnership
JET IT	Just Energy Transition Investment Plan
NEV	New Energy Vehicle
NIPF	National Industrial Policy Framework
OEMs	Original Equipment Manufacturers
PGMs	Platinum Group Metals
PHEV	Plug-in Hybrid Electric Vehicles
REI4P	Renewable Energy Independent Power Producer Procurement Programme
RIS	Reimagined Industrial Strategy
SAREM	South African Renewable Energy Masterplan
SSEG	Small-scale Embedded Generation
TSA	Tourism Satellite Account
US	United States
VRFB	Vanadium Redox Flow Battery
WTO	World Trade Organization

1. INTRODUCTION

Countries that have achieved high income levels have undertaken processes of structural transformation through which unemployed or under-employed people are transferred from low to higher value-adding sectors. Structural transformation has traditionally been associated with industrialisation through high levels of fixed investment in manufacturing and its enabling infrastructure. There are virtually no countries that have achieved high levels of income and decisive poverty eradication without industrialising (Commission on Growth, 2008; Diao, McMillan and Rodrik, 2019)[1]. Similarly, industrialisation has not taken place without active industrial policies (Cherif and Hasanov, 2019).

Historically, industrialisation has been achieved through fossil-fuel intensive energy sources, production processes and products, which have generated the bulk of the stock of greenhouse gas (GHG) emissions in the atmosphere. There is thus a strong positive historical correlation between gross domestic product (GDP) per capita and CO2 emissions per capita.[2] High-income western industrialised countries account for more than 50% of the stock of GHGs in the atmosphere: the United States (US) (25%) and European Union (EU)-28 economies (22%) are responsible for the 47% of cumulative emissions.[3]

Large industrialising countries, particularly China and India have become substantial GHG emitters over recent decades in absolute terms. However, advanced economies have the highest share of per capita GHG emissions. The US consumes 16.5t per person of CO2 and the EU 10.5t. This is compared to China (7.2t) and India (1.7t), while Africa consumes a mere 0.9t per person (Zalk, Keane and Nater, 2024). South Africa's per capita emissions are 6.7t. Furthermore, when emissions embedded in imports are considered, advanced economies account for even higher levels of emissions(Oqubay, 2024).

South Africa's post-apartheid economy has been characterised by low fixed investment, anaemic economic and employment growth and enduring socio-economic exclusion and inequality. There has been limited structural transformation; that is sub-optimal growth of productive sectors that directly and indirectly stimulate higher value-addition, employment, and foreign exchange earnings, in sectors that with lower than average carbon intensity (Andreoni *et al.*, 2021b).

South Africa remains a highly carbon-intensive economy, despite declining emission intensity (Winkler and Black, 2021; Montmasson-Clair and Patel, 2024). This reflects the continued weight of an overwhelmingly coal-based electricity system[4] together with carbon-intensive mining and heavy industries, a so-called Minerals Energy Complex (MEC) set of industries (Baker and Burton, 2024). Despite undergoing significant changes in its composition, South Africa remains roughly as reliant on exports of MEC products as it was in 1994, accounting for approximately 60% of all merchandise exports (Andreoni *et al.*, 2021a).

Oqubay (2024) and Lebdioui (2024) both argue that, despite African countries contributing a small fraction of the world's GHG emissions, the only viable *long-term* development path for African countries is to embrace green structural transformation. Neither fossil-fuel based industrialisation, nor a "grow now, clean up later" development path are optimal in the long term. This is, inter alia, because of the increasing cost and difficulty of financing fossil fuel projects, inevitable carbon taxes on exports, and the danger of getting stuck in dead-end industries. While the fundamental objective of industrial policy remains productive transformation the same, it needs to adapt (Oqubay, 2024, p.4).

[1] The only exceptions are some single commodity exporters and offshore tax havens (World Bank, 2008).
[2] https://ourworldindata.org/grapher/co-emissions-per-capita
[3] https://ourworldindata.org/contributed-most-global-co2
[4] Despite a rising share of renewables over recent years.

Oqubay thus defines green industrial policy as "government intervention to build a carbon-neutral economy and accelerate structural transformation and economic catch-up". The scope of industries across which green industrial policy needs to operate is also broader. This paper argues that this scope includes manufacturing and related services; agricultural modernisation; green and other critical minerals; and the infrastructure necessary for green growth.

South Africa, albeit more than other African countries, has contributed a nominal amount to the global stock of GHG emissions. However, it is imperative that it shifts to a green industrialisation path, for two main reasons. First to avert looming risks arising from fundamental geo-political and economic shifts in the global economy. Second, to take advantage of opportunities this shift presents for South Africa's industrialisation. Greening industrialisation and industrial policy represents an opportunity for South Africa to shift from fossil-fuel intensive stagnation to a higher value-added, labour-absorbing and less carbon-intensive economy.

Section 2 of the paper deals with shifting global geo-political and economic context.

2. THE GLOBAL CONTEXT: ADVANCED AND DEVELOPING COUNTRIES

Significant reconfiguration of global value chains is underway linked to the direct and indirect impacts of climate change. These processes are driven by a confluence of geo-political, economic and technological contestation (Davies, 2022; Zalk, Keane and Nater, 2024).

2.1. The international geo-political and economic context

African countries, including South and Southern Africa are projected to be most adversely impacted by climate change. The direct impacts of climate change are already manifesting themselves through amplification of cyclical weather patterns in the form of extended droughts and more severe floods (Trisos *et al.*, 2022). Agriculture and agrarian populations are particularly affected, including potential adverse impacts on food security. Climate induced costs place additional burdens on heavily indebted African countries. This hampers the economic prospects of the region, which South Africa has become increasingly export reliant on.

Indirectly "green policy spillovers" from various unilateral measures introduced by advanced economies, especially those from the EU and the US, which are increasingly being felt by developing countries including African economies (Maimele, 2023). These measures reflect a combination of objectives including: responses to climate change, seeking to reclaim lost industrial and technological capabilities, energy security, and defence considerations. Large-scale subsidies, such as those introduced in the US through the Inflation Reduction Act and in the EU via the Green Deal Industrial Plan, have been driving significant market shifts toward climate technologies. However, smaller, heavily indebted countries, many of them South Africa's trading partners on the continent, face severe fiscal limitations in responding. "Green" and other trade barriers, as well as proliferating private sustainability standards, will have knock-on trade and investment effects.

A series of EU green trade policies, including the Carbon Border Adjustment Mechanism (CBAM), are scheduled to take effect over the next few years. CBAM, which imposes levies on heavy industry products based on embedded carbon, is projected to disproportionately impact certain African countries including South Africa, Mozambique, Nigeria and a number of North African countries, notably Morocco (Guepie *et al.*, 2023; Maimele, 2023). Such measures are expected to expand globally as other countries develop their own CBAMs in response to the EU's. In addition to CBAMs a slew of sustainability related regulations, including the EU's Deforestation Directive, the Sustainable and

Circular Textiles Strategy, and the Corporate Sustainability Due Diligence Directive will impose additional costs on a range of sectors exporting to the EU (Zalk, Keane and Nater, 2024).

The second Trump administration has ushered in a new phase of complexity and uncertainty into the international climate, trade and finance arena. This includes through withdrawal (again) from the Paris climate agreement and a flurry of unpredictable trade measures which fundamentally fly in the face of World Trade Organization (WTO) rules. One outcome of this new trade order, that could provide temporary breathing room for African countries on CBAMS, is that the EU may delay CBAM implementation during the Trump administration for fear of retaliation if it is imposed on US goods. One consequence of the US blocking of appointments of new judges to the WTO's Appellate Body (the final adjudicator of WTO trade disputes) since the first Obama administration has rendered the body inoperative. Hopewell (2024) points out that one outcome of this unilateral US action is the opening of trade policy space for developing countries.

2.2. Developing country responses and options

A number of other developing countries have adopted or are adopting industrial policy measures aimed at capturing a share of the value and employment in low carbon value chains.

China has been the first mover, embedding low carbon manufacturing sectors in its five-year plans since the late 2000s (Hector, 2025). This has been motivated by a combination of considerations: energy security, seizing the manufacturing opportunity in these products, international climate commitments and domestic air pollution concerns (Shetty, 2024). Other major developing countries including Indonesia, India, and Brazil are implementing or developing green industrial policy interventions (Thomas, 2023; Ganesan et al., 2014; Presidência do Brasil, 2024). Selected African countries have also begun to develop industrial policy interventions in the low carbon space including Ethiopia, Morocco and South Africa (Oqubay, 2024).

South Africa has, however, been slow out of the starting blocks in terms of designing, resourcing and implementing industrial strategies at scale, that respond to and realise opportunities arising from the global green transition. Green IP offers an opportunity to recalibrate SA's structural transformation trajectory, drawing on lessons from other countries.

3. SOUTH AFRICA: THE CLIMATE AND INDUSTRIAL STRUCTURE INTERFACE

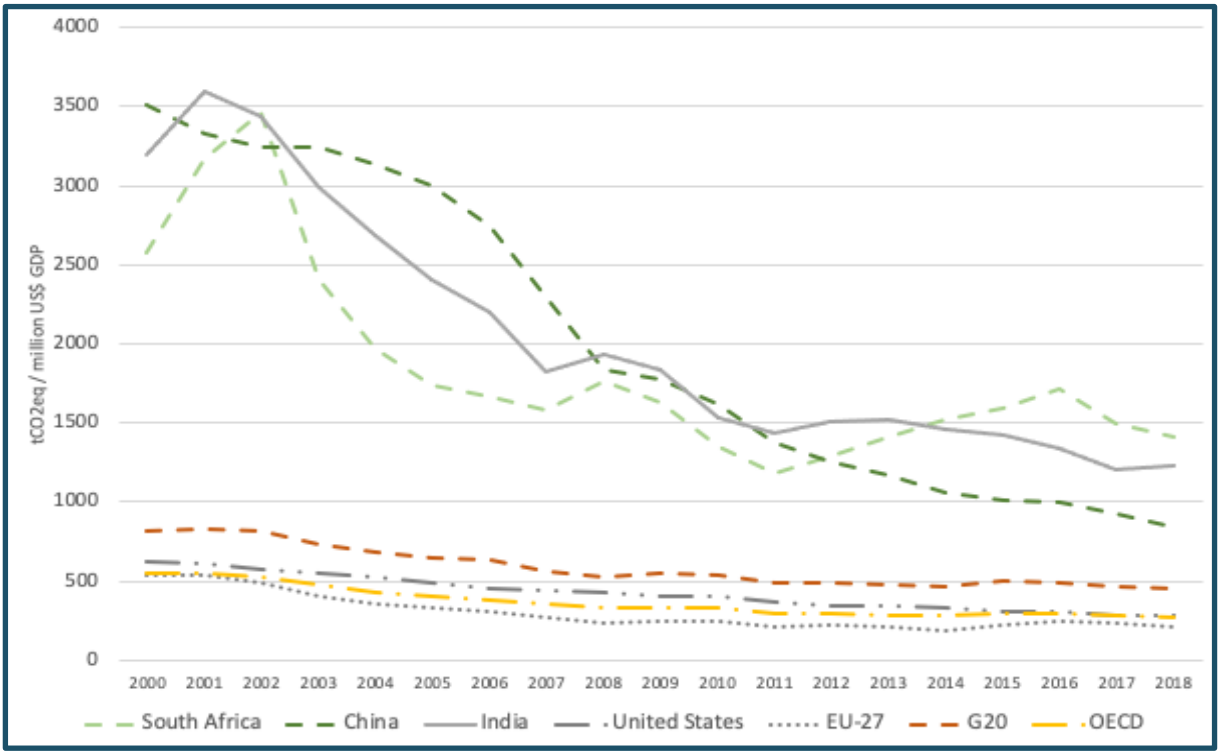
South Africa has contributed a fraction of the GHG stock in the atmosphere. As of 2022 its annual share of GHG emissions was 1.06%.5 Figure 1 shows that the emission intensity of the South African, Chinese and Indian economies have all undergone a substantial decline in emission intensity between 2000 and 2018, converging rapidly towards advanced OECD and EU levels6. South Africa's energy intensity continued to decline through to at least 2021 (Montmasson-Clair and Patel, 2024, p.5).[7] Declining energy and emissions intensity has been driven by dramatic electricity price increases, lower demand for electricity, increased energy efficiency and the rising share of renewables in the national energy mix.

[5] https://ourworldindata.org/grapher/annual-share-of-co2-emissions?tab=chart&country=ZAF

[6] Measured by tons of CO2 equivalent for all GHGs, per millions of US$ GDP in purchasing power adjusted terms.

[7] Measured by MJ of energy supply per thousand Rand of GDP.

Figure 1: South Africa's emission intensity (tons of CO2-eq, all GHGs, per million US$ of GDP purchasing power parity)



Source: Winkler and Black, 2021, p.10.

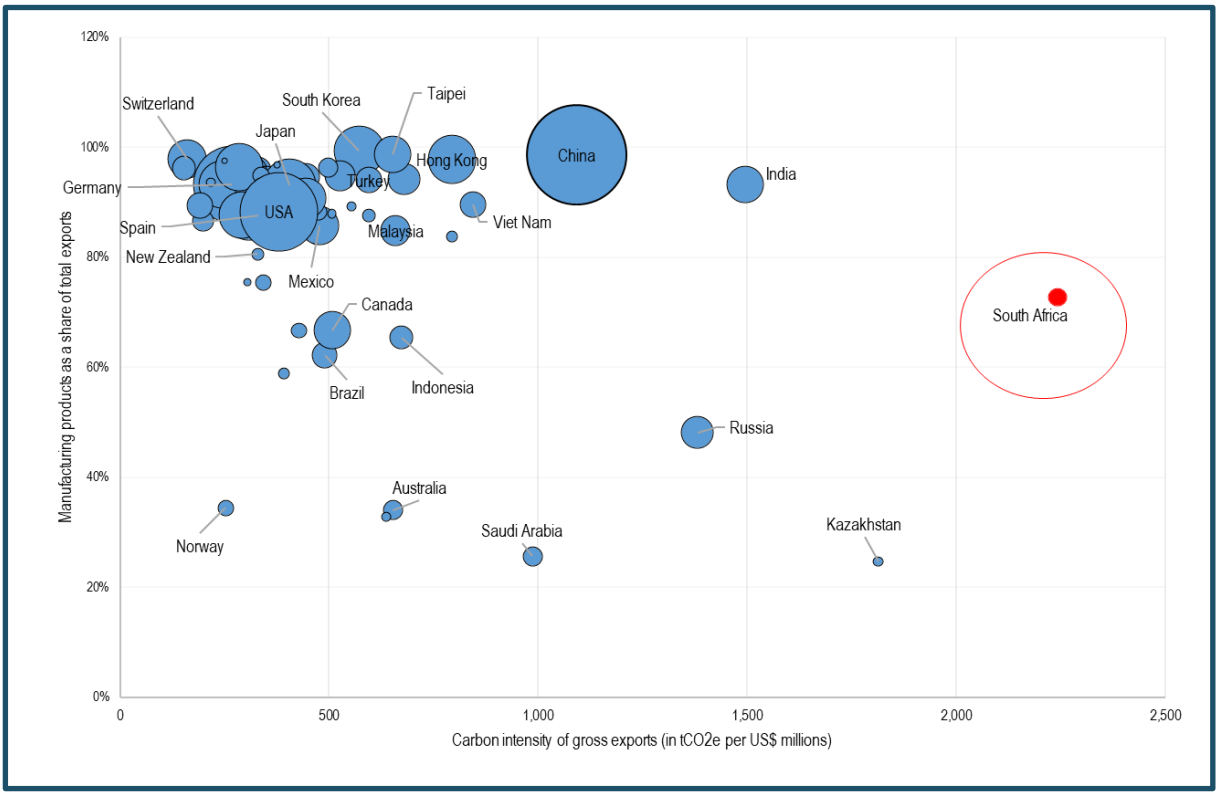
Along with China and India, South Africa's emission intensity still requires considerable declines to fully converge with advanced economy levels and ultimately to net-zero in terms of its Nationally Determined Contributions commitments. In 2023 per capita terms South Africa is ranked 28th in GHG emissions intensity.[8]

Internally, emissions are geographically concentrated in historical industrial areas, notably Mpumalanga and the Vaal triangle. In line with global trends South Africa's top 10% of the income distribution are likely to disproportionately contribute to per capita emissions as the largest consumers of energy-intensive goods and services. Together with GHG emission comes high levels of air pollution and environmental degradation with adverse impacts on surrounding communities (Baker and Burton, 2024).

However, due to the carbon intensity of its coal-dominated energy system and MEC products in its export basket, South Africa's exports are particularly carbon-intensive (Figure 2). In the medium to long term, South Africa is subject to a number of direct and indirect climate risks. Direct risks include those associated with rising temperatures, and increased frequency and severity of droughts and floods. The agricultural sector is particularly exposed to these direct risks. Indirect risks include policy spillover effects and shifts in consumer demands. A range of carbon-intensive South African products are potentially vulnerable to CBAMs. More generally, exports to the EU will be impacted by the wide range of sustainability-linked directives. The automotive industry, which recently celebrated a century of production in South Africa, needs to transition from internal combustion engine (ICE) vehicles to electric and other low-carbon vehicles. Long-haul tourism will increasingly come under threat as pressure mounts to lower air transport emissions.

[8] https://worldpopulationreview.com/country-rankings/carbon-footprint-by-country#title

Figure 2: Carbon intensity of manufacturing exports by country



Source: Montmasson-Clair, 2020, in Maimele, 2023.

However, the green transition also represents an opportunity for South Africa to address long-standing weaknesses and make the shift to a climate-compatible, more jobs rich and value-adding industrial structure.

4. THE EVOLUTION OF SOUTH AFRICAN INDUSTRIAL POLICY AND GREEN INDUSTRIALISATION

South African industrial and related policies have been slow to engage with the direct and indirect implications of climate change. Policy has reflected both significant continuity with apartheid era patterns together with more recent recognition of and engagement with the need for a shift towards greening structural transformation. However, this policy shift has been slow, uneven and sometimes contradictory.

4.1. Apartheid-era industrial policy

The roots of South Africa's carbon-intensive industrial structure lie in apartheid-era industrial policy. On the one hand, there was a relatively coherent programme of developing cheap coal-based electricity, mining and capital-intensive mineral-processing industries: the so-called MEC sectors (Fine and Rustomjee, 1996; Freund, 2018). Mining also benefitted from lowly paid workers through the migrant labour system (Lipton, 1989). This resulted in a manufacturing sector dominated by heavy industries producing semi-processed metal and chemical products. The former included steel, other ferrous metals and aluminium. The latter involved the production of petro-chemicals from coal and fertiliser production. On the other hand, policy with respect to more labour intensive, value-adding and less carbon-intensive sectors did not reflect any coherent strategy of import substituting industrialisation. That is a coherent shift from production of consumer goods for the domestic market through to deepening of capital goods production and on to establishing export competitiveness in

more labour-intensive (and less carbon-intensive) downstream sectors. Rather downstream sectors benefitted from "protection on demand" in the absence of well-articulated industry competitiveness strategies, with few if any conditionalities attached (Fine and Rustomjee, 1996; Freund, 2018).

4.2. 1990s trade and industrial policy

Immediate post-apartheid trade and industrial policy reflected significant continuity in supporting the expansion of the MEC while slashing tariffs on more labour-intensive, value-adding and relatively low-carbon sectors, which were ill-prepared for shock exposure to import competition. Over the 1990s large expansions of MEC projects were supported by generous tax incentives, funding by the Industrial Development Corporation (IDC) and cheap electricity (Andreoni *et al.*, 2021c; Zalk, 2016). A less visible form of support has been the turning of a blind eye to mounting environmental degradation and GHG emissions of heavy industry, externalising these costs to surrounding communities (Baker and Burton, 2024). However, a concurrent de-emphasis by the state, since the early 1990s of fixed investments by State-Owned Enterprises (SOEs) Eskom and Transnet would ultimately come to undermine these MEC industries. Particularly damaging has been the electricity supply crisis that has prevailed since 2008, and the deterioration of rail and port services on which MEC industries rely for exports.

4.3. The National Industrial Policy Framework and Industrial Policy Action Plans

The National Industrial Policy Framework (NIPF) (the dtic, 2007), South Africa's first formal post-apartheid industrial policy, was adopted by Cabinet in 2007. It emphasised industrial policy as an economy-wide imperative requiring commitment and coordination across economic policy spheres and public entities, including: infrastructure, innovation, skills development and macroeconomic policy. It broadened the scope and scale of policy tools than had previously been considered, including: development finance, public procurement, and trade policy measures. Implementation was informed by annual three-year rolling Industrial Action Plans (IPAPs).

Initially the NIPF and IPAP did not engage much with environmental considerations or climate change. However, implicit in the NIPF's emphasis on diversifying South Africa's manufacturing base towards more labour-intensive and less energy-intensive industries was a shift to lower carbon production. From 2011/12 onwards IPAPs reflected rising concerns with climate change and the need for a transition to a lower carbon economy. This included the prospects of "eco-protectionism" from advanced economies, including in the form of border adjustment taxes. IPAPs established an explicit focus on green industries, highlighting manufacturing opportunities linked to solar water heaters, and inputs into wind and solar photovoltaic projects. The role of the National Cleaner Production Centre was scaled up to promote greater energy and water efficiency and cleaner waste management. They also anticipated the need to shift production from internal combustion to electric vehicles (EVs), but without corresponding adaptations to support production of EVs.

However, there has also been significant continuity of support for capital- and emission-intensive industries with a corresponding lack of support for more labour-intensive sectors. This has partly been a function of patterns of industrial financing, both on- and off-budget. The 12i tax incentive was skewed towards large capital- and energy-intensive projects although grant-based incentives were more oriented towards labour-intensive industries (DPME, 2018). There has been significant continuity in the IDC's support for capital-intensive industries, albeit with important shifts, as elaborated below. After a brief period of increases in grant-based incentives, budgetary allocations have in real terms been in decline in constant terms since 2014 (Makgetla, 2023).

The manner in which energy policy has been conducted has been profoundly damaging to manufacturing in general as well as undermining of green industrialisation. The failure to invest in electricity infrastructure over the 1990s and 2000s culminated in an extended energy crisis with its combination of uncertainty of supply and a 484% increase in the wholesale price of electricity between 2008 and 2021 (Montmasson-Clair and Patel, 2024, p.5). Development and implementation of energy policy over the post-apartheid period has been slow and characterised by a great deal of uncertainty. An integrated resource plan (IRP), integrating renewables into the energy mix for the first time, was only published in 2010. The Renewable Energy Independent Power Producer Procurement Programme (REI4P) was only published in 2011.

The opportunity presented by the REI4P programme to build an industrial base in producing components into renewables projects was undermined. A significant contributor to sub-optimal localisation has been low levels of commitment to localisation in the REI4P in core renewable sub-systems. Stop-start procurement induced by long delays and uncertainties around Bid Windows 4 and 5 (which were only concluded in 2018 and 2022 respectively), deeply compromised investments, leading to a number of plant closures of firms that had invested in anticipation of domestic demand from the REIFP. This was compounded by Eskom's refusal to sign power purchase agreements for successful bidders, between 2015 and 2018.

Lack of commitment by SOEs more generally to localisation and downstream manufacturing development was amplified by their re-purposing to serve the interests of the State Capture project (Zalk, 2021; Bhorat *et al.*, 2017).

4.4. A Reimagined Industrial Policy and Sectoral Masterplans

The direction of industrial policy espoused by the dtic shifted from 2019 under the banner of a Reimagined Industrial Strategy (RIS). The RIS was not embodied in any comprehensive policy documents but rather a loose and shifting set of statements made in annual performance plans, reports, presentations and Ministerial speeches.

The cornerstone of industrial policy under the RIS has been the development and implementation of sectoral Masterplans led by the dtic. The Masterplan approach has involved negotiation of social compacts between business, government and labour, aimed at raising growth, investment, empowerment and employment in targeted sectors. Masterplans were supposed to have been informed by robust empirical analysis of the sectors involved. In practice, however, the depth and quality of such analysis has varied widely (Makgetla, 2024).

As the lead exponent of the Masterplan approach the dtic had published seven by the end of 2023 for: Automotives, Poultry, Retail-Clothing Textile Footwear Leather, Sugar, Forestry, Steel and Metal Fabrication and Furniture.

The Masterplan approach was intended to be replicated across multiple sectors under the leadership of a range of other government departments. Masterplans for Cultural industries (Sports, Arts and Culture) and Tourism were published. The intention to develop Masterplans for a range of other sectors were proposed but not concluded (in some cases they were not initiated) including: Plastics, Chemicals, Renewable energy, Aerospace and defence, Mining and beneficiation, Gas, Health economy, Cannabis, Film and animation, Medical products and Construction (Makgetla, 2024). The Agriculture and Agro-processing Master Plan, led by the Department of Agriculture, Land Reform and Rural Development was published in 2022. However it lacked the support of labour and has not been meaningfully implemented (Sihlobo, 2024).

Masterplans developed and implemented (to a greater or lesser extent) by the dtic have largely represented efforts at "defensive" industrial policy. That is a focus on sectors which are in distress or

grappling with import competition. While such interventions are important they are not balanced out by strategies for sectors with good growth prospects including the ability to compete robustly with imports and grow exports.

Several masterplans directly or indirectly have a bearing on green industrialisation. While the Automotive Masterplan was published in 2018 a major policy gap was its lack of provision for electric and other new energy vehicles, amid rising international demand for EVs. A New Energy Vehicle (NEV) strategy was developed and published in 2023, with initial budgetary support measures announced in 2024 (National Treasury, 2024). Further gaps were identified, namely lack of provision for hybrid vehicles and suboptimal fiscal support for NEV investment. Recent amendments to the Automotive Production and Development Programme (APDP) have been introduced to incorporate hybrid vehicles and the Minister of Finance announced tax incentives to support NEV production in his October 2024 budget policy framework (Scott, Fyfe and Geel, 2025).

The South African Renewable Energy Masterplan (SAREM), led by the Department of Mineral Resources and Energy (DMRE), focuses chiefly on building manufacturing capacity to feed into renewable energy plants. The SAREM was finally approved by Cabinet in early 2025, 14 years after the flagship REI4PP programme began in 2011 (DMRE, 2025).

Also led by DMRE is a Critical Minerals Strategy. Many of these minerals are inputs into low carbon value chains such as rapidly growing lithium-ion batteries and EVs as well as the more slowly emerging hydrogen economy. While mining and processing of critical minerals are themselves necessarily capital- and energy-intensive they could unlock downstream value-addition and employment directly and indirectly. While it was reported to be at an advanced stage of development in 2023, to date no draft has been released Republic of South Africa, 2025). A Water and Sanitation Industry Masterplan similarly has not been concluded (Montmasson-Clair and Patel, 2024).

Amid falling budgetary allocations for industrial financing, the IDC has taken on a substantial role in supporting Masterplans and projects linked to the emerging green economy. The IDC and the Development Bank of Southern Africa played an important initial role in co-funding renewable projects together with the private sector, contributing to the demonstration of the viability of renewables at scale (Mail & Guardian, 2022). Formally IDC's performance has been based on a broad-ranging matrix of key performance indicators and targets including localisation, employment and empowerment. In practice, however, the pre-eminent indicator used to assess and communicate its performance by the Ministry of Trade and Industry has been the levels of funding approved and disbursed (the dtic, 2024). The push to maximise disbursements has had some unintended consequences. These include continuity of support for large capital-intensive projects relative to more labour-intensive sectors and projects. Incentivisation of IDC management to engage in more pro-active project and sector development efforts has been inadequate. A particular gap has been the relative neglect of the pool of established medium-sized manufacturing firms with the potential to rapidly expand value-added and employment.

The IDC has played the leading role in developing South Africa's Green Hydrogen (GH2) Commercialisation Strategy which features prominently in South Africa's Just Energy Transition Partnership (JETP) and Just Energy Transition Investment Plan (JET IP) (Presidential Climate Commission, 2022b). Potential opportunities for GH2 cited include direct exports (particularly to Europe) and various GH2 powered or derivative products including: green ammonia for fertilisers, green iron and steel, aviation fuel, bunkering fuel for shipping, and to power medium and heavy vehicles such as buses and trucks. However, commercialisation of hydrogen economy technologies is proceeding more slowly than anticipated worldwide, including green hydrogen and fuel cells with the

International Energy Agency downgrading its forecasts of green hydrogen growth in 2024 (Bindman, 2024).

A range of other industrial policies have had a bearing on greening manufacturing. Restrictions on the export of scrap metal, although aimed chiefly at clamping down on infrastructure damage, have important environmental benefits as processes to produce products such as steel and aluminium from scrap are far less energy (and hence emissions) intensive than primary metal production. The National Cleaner Production Centre has supported the introduction of circular economy principles for manufacturing firms. Standards setting bodies such as the South African National Accreditation System have established standards supportive of the green economy including energy efficiency standards for buildings and appliances and have an important role to play in developing standards for industries such as green hydrogen.

4.5. Greening South African industrialisation: tentative but inadequate steps

While Masterplans, other industrial policy interventions, and policy towards productive sectors more generally have gradually engaged to a greater extent with green structural transformation considerations, there are significant weaknesses. While policy documents such as the Just Transition Framework (Presidential Climate Commission, 2022a) begin to frame South Africa's path to a net-zero economy there is no overarching framing of how South African industrial policy should advance green structural transformation.

Masterplans which have both been concluded and are, to a greater or lesser degree, under implementation have played an important role in preventing deeper de-industrialisation and have recorded some successes. However, the Masterplan approach reflects significant weaknesses. There appear to be no clear criteria according to which sectors are chosen for masterplan development. Consequently, there are significant gaps in masterplan coverage of major parts of manufacturing while relatively niche subsectors have been chosen for masterplan development. The most glaring gap is the absence of a masterplan or strategy for the chemicals (petro-chemicals, bulk chemicals and specialty chemicals), fertiliszer, plastics and rubber value chains. The capacity and levels of commitment of multiple government departments to concluding and implementing masterplans is highly uneven. This is reflected by slow progress across masterplans such as the SAREM, Critical Minerals, Water and Sanitation and Agriculture and Agro-processing. International experience reflects that for industrial policy in general and green industrial policy in particular to succeed requires substantial resourcing and active support by relevant government departments and public enterprises.

5. CONSIDERATIONS FOR GREENING SOUTH AFRICAN INDUSTRIAL POLICY

Greening structural transformation and industrial policy represents an opportunity to address deep-seated structural weaknesses in South Africa's economic trajectory. This involves a relative shift toward greater labour- (and less carbon-) intensity, value-addition, exports and broader economic inclusion.

Industries most obviously associated with the green transition include componentry feeding into renewable energy plants, battery minerals and assembly, new energy vehicles, and green hydrogen. However, even if rapid growth is achieved in these new industries, this will be off a low base and insufficient to catalyse the broader employment, value-addition and inclusion required for South Africa's development. For instance, manufacturing linked to South Africa's solar photovoltaic value chain directly employs around 3 000 workers (GIZ, 2024).

Thus an economy-wide perspective is required across productive sectors that include agriculture, mining, light and medium-manufacturing, heavy industries, and tourism. Examining the relative

labour- and carbon-intensity among sectors at a disaggregated level provides a useful basis for identifying priority sectors for green industrial policy.

5.1. Sectoral labour- and carbon-intensity of the South African economy

Drawing on methodologies developed and data derived by Wills (2022) and Tregenna (2010), Figures 3 to 6 illustrate the sectoral relationship between labour- and carbon-intensity in the South African economy[9]. Examining the nexus of sectoral labour- and carbon-intensity provides a useful basis to focus on two pressing objectives of green structural transformation in South Africa: to generate employment at scale and de-carbonise the economy.

Figure 3 ranks sectors according to two criteria: labour intensity on the horizontal axis, and carbon-intensity on the vertical axis. The further to the right the sector is, the greater its labour intensity. Sector carbon-intensity on the vertical axis is ranked in reverse order. That is the lower a sector sits on the vertical axis the greater its carbon-intensity and the higher it is the lower its carbon-intensity.

Figure 3 is divided into a matrix is of four quadrants based on the relative labour- and carbon-intensity of each sector. This categorisation is intended as an indicative guide to which sectors should receive attention for the purposes of greening structural transformation. In particular it is aimed at assisting in identifying sectors which are both relatively high in labour-intensity and low in carbon-carbon intensity. It also assists in identifying upstream sectors whose role is important in a value chain, but whose growth prospects and that of the value chain as a whole are threatened by their relatively high carbon-intensity.

It is important to emphasise that this categorisation is not intended to be used mechanistically but rather as a guide, taking into account other structural transformation factors not explicitly evident from the matrix. The focus is on tradeable sectors which generally have greater prospects for productivity and the growth in exports needed to alleviate the balance of payment constraint to growth (Cramer, Sender and Oqubay, 2020). Also important are sectoral prospects for increasing economic inclusion. For instance, there is a particular premium on identifying sectors with growth in regions where poverty is most acute. Extreme poverty in South Africa is concentrated amongst women in rural areas, particularly those former Bantustans areas (Sender, 2016).

Quadrant 1 (Q1) (Figure 4) encompasses sectors which are both relatively labour-intensive and low-carbon intensity. Q1 includes a number of relatively labour-intensive manufacturing sectors. These include Clothing, Textiles, Footwear and Leather; Food; Metal products; Machinery and equipment; Electrical machinery; Professional/Scientific equipment; Wood products; Printing/recorded media and Motor vehicles/parts. Manufacturing jobs are important inter alia because they have disproportionately high indirect employment multipliers. For each manufacturing

[9] Methodology based on Wills, 2022.

- Labour intensity based on Tregenna, 2010, composite index
  - Labour / Capital
  - Labour / Value-Added
  - Employment Multipliers
  - Reverse ranking (45 = lowest, 1=highest)
- Carbon intensity based on Reeler (2021)
  - Log of carbon intensity
  - Reverse ranking (2.2 = lowest, 0 = highest)

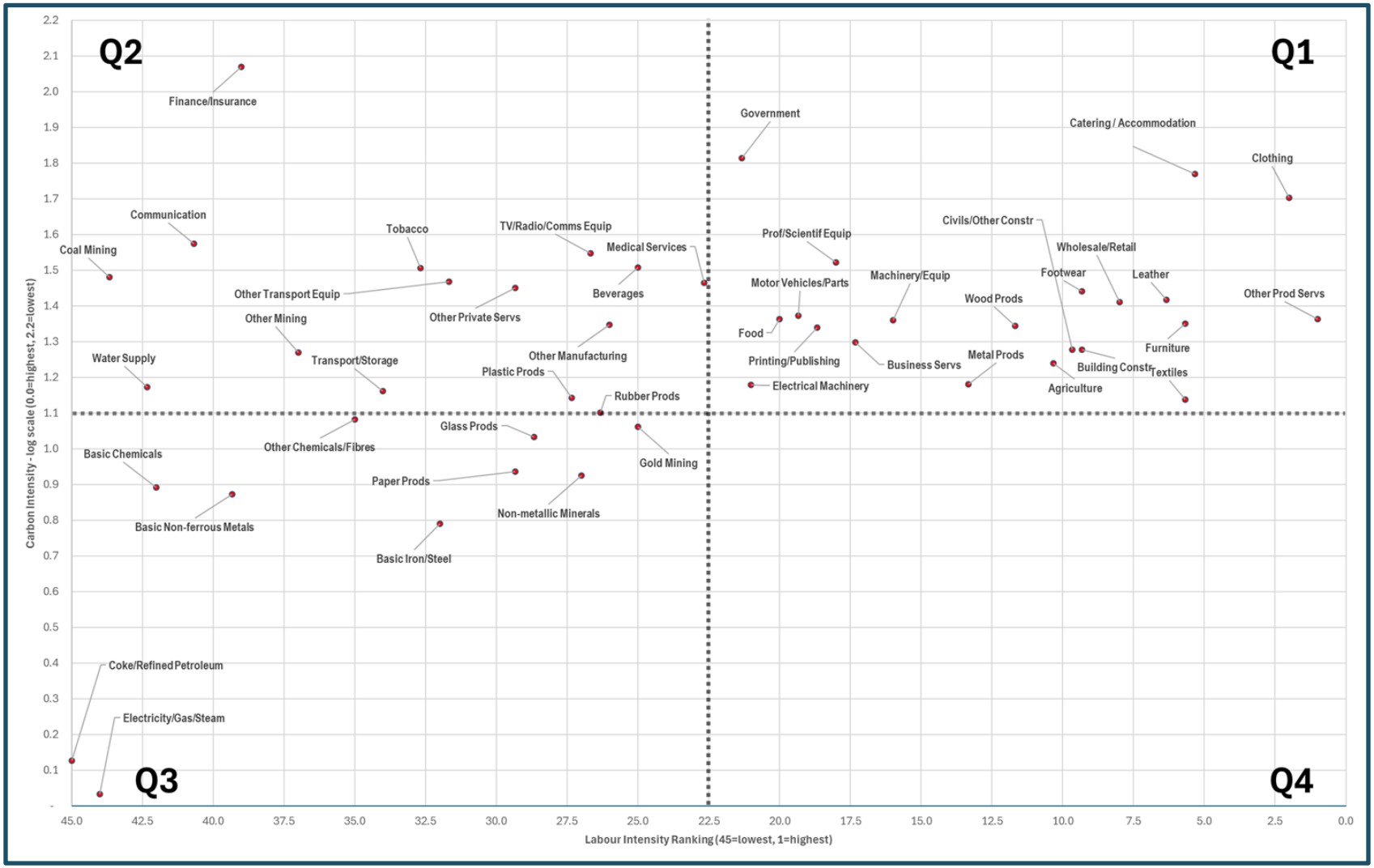
job created an estimated 3.8 jobs are created elsewhere in the economy. Q1 also includes Agriculture and Tourism.[10]

Q2 (Figure 5) captures sectors of relatively low carbon-intensity but also relatively low labour-intensity. It is important to note considerable variation within quadrants. Beverages, rubber products, other manufacturing and plastics are much closer to the labour-intensive Q1 than sectors such as coal and other mining which have very low levels of labour-intensity. These include: Beverages; Rubber products; Plastic and rubber products; TV/Radio/Comms/Prof equipment; Other transport equipment and Other manufacturing. It is significant to note substantial variation in labour intensity within Q2. Industries including Beverages, Other Manufacturing, Rubber products; TV/Radio/Comms/Prof equipment and Plastic products have a labour intensities close to the boundary of Q1. Taking into account manufacturing's high average indirect employment multiplier, manufacturing sectors in Q1 and Q2 are important potential sources of employment expansion with relatively limited increases in carbon emissions.

Q3 (Figure 6) contains the most carbon-intensive sectors, which are also largely low in labour-intensity. Q3 includes sectors that make the biggest contribution to South Africa's carbon-emissions and are the most difficult to decarbonise. These include Electricity, Petrochemicals and Basic metal production. These sectors directly and indirectly drive the high carbon-intensity of South Africa's merchandise exports which are subject to risks of CBAMs and shifting consumer demands. Capital and emissions-intensive chemical and metals sectors are also the bedrock of industrial value chains extending through to downstream sectors including metal products, machinery and equipment and plastics. South Africa's carbon-emissions are very highly concentrated at the firm level. 10 firms are responsible for more than 60% of South Africa's GHG emissions with two firms alone accounting for 42.5% of emissions: Eskom (39%) and Sasol (13.5%). Twenty-seven energy intensive firms account for the bulk of South Africa's emissions (Appendix: Table A2). Medium-term decarbonisation strategies for carbon-intensive sectors therefore necessarily require the reorientation of the strategy and investment decisions of South Africa's largest industrial firms.

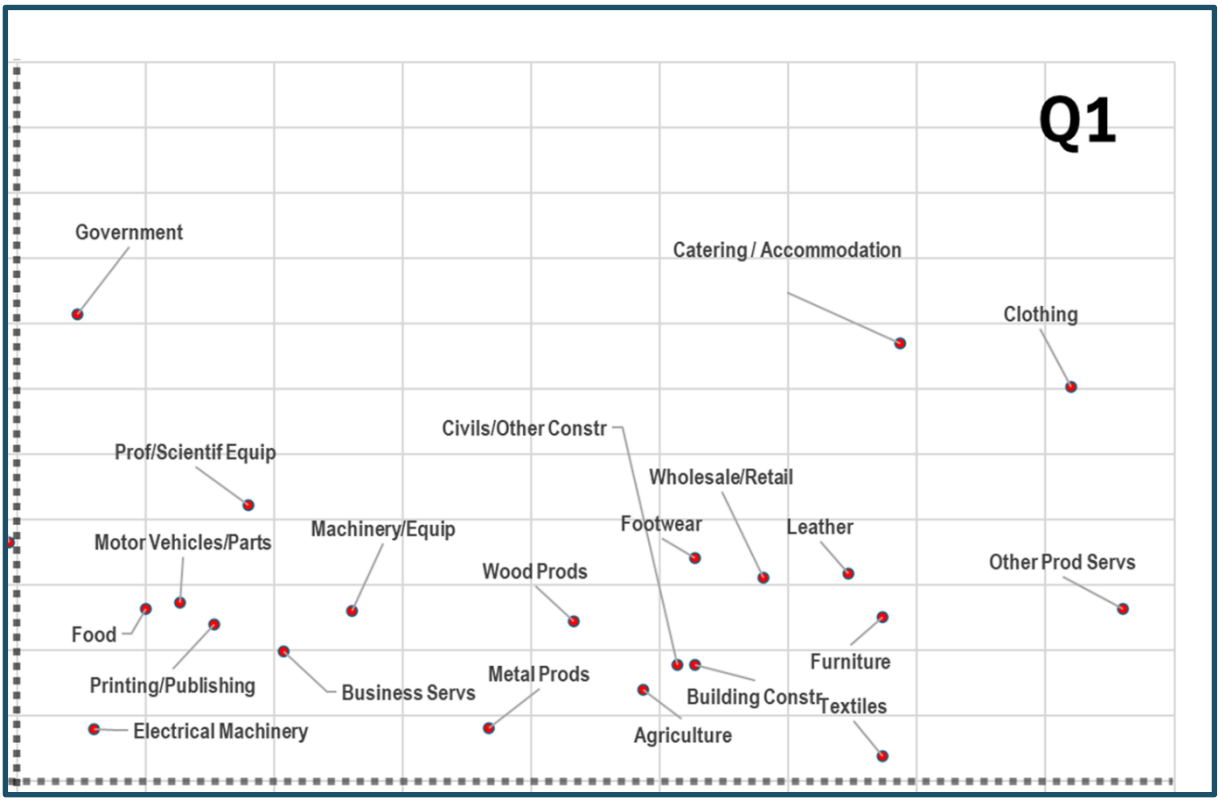
[10] The Catering and Accommodation sectors are considered a proxy as there is no distinct sectoral classification for Tourism.

Figure 3: South Africa's sectoral labour and carbon-intensity



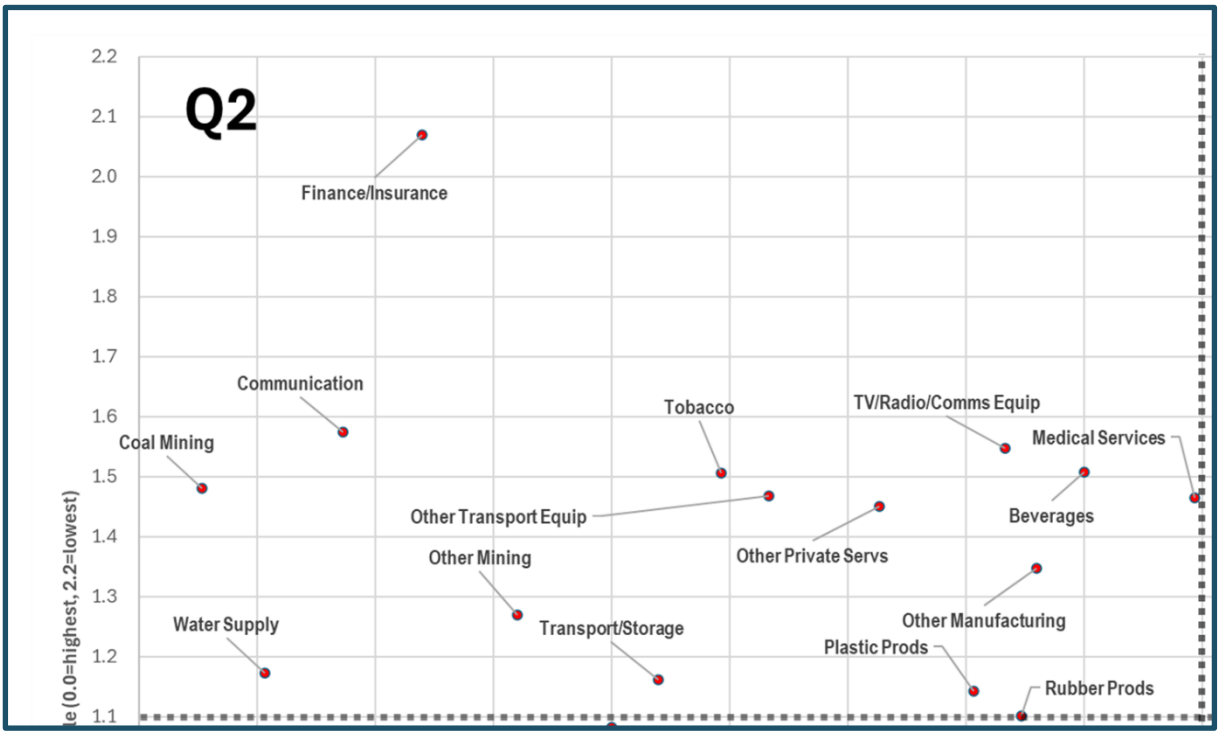
Source: Author based on Wills, 2022, and Tregenna, 2010.

Figure 4: High labour-intensity / low carbon-intensity



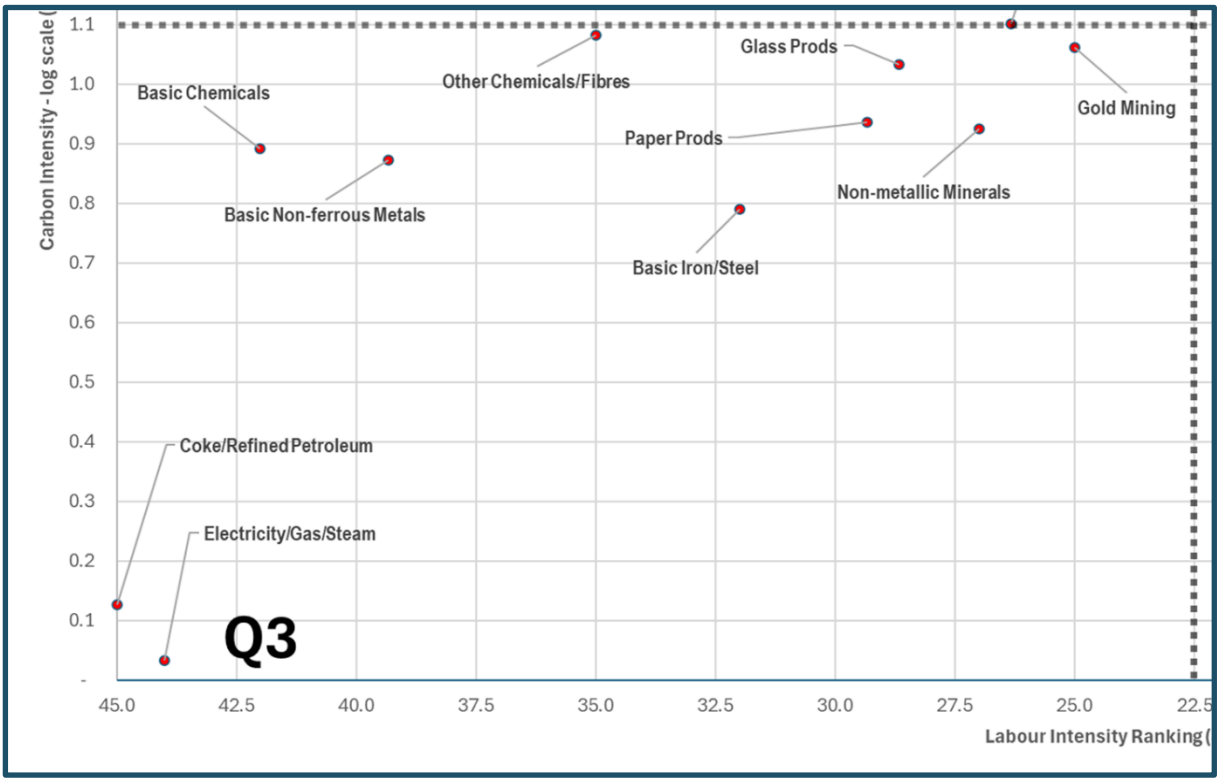
Source: Author based on Wills, 2022, and Tregenna, 2010.

Figure 5: Low labour-intensity/low carbon-intensity



Source: Author based on Wills, 2022, and Tregenna, 2010.

Figure 6: Low labour-intensity/high carbon-intensity



Source: Author based on Wills, 2022, and Tregenna, 2010.

6. GREEN INDUSTRIAL POLICY: SECTOR AND VALUE CHAIN OPPORTUNITIES AND CHALLENGES

Green industrial policy requires an economy-wide approach across productive sectors. Three elements are important. First, supporting the growth of established sectors that are directly and indirectly more labour-intensive and value-adding, can expand exports and broader economic inclusion while significantly lowering the carbon-intensity of the economy. These largely fall withing Q1 (Figure 4) and the right-hand side of Q2 (Figure 5). Particularly important is to identify sectors or sector groupings that are not only relatively low in carbon-intensity, are well established in terms of large numbers of people employed, and have a track record of expanding jobs (or could do so with appropriate policy support). Second, supporting nascent industries producing low-carbon products and those important for the green transition. Third, reorienting South Africa's carbon-intensive heavy industries to grow jobs where possible and minimise job losses while ensuring value chain linkages maximise jobs in downstream sectors.

Table A1 in the Appendix sets out headline statistics about levels and of employment by sector and their growth over the decade 2013 to 2023. It is important to note that there are significant data gaps and limitations. Comprehensive sectoral censuses are relatively infrequently conducted. Employment in tourism relies on assumptions made in the tourism satellite account. Emerging green manufacturing is not captured as distinct sectors in national statistics. However, these gaps are partly filled by industry compiled data and industry specific studies.

6.1. Agriculture, the "industrialisation of freshness" and agro-processing

Agriculture and agro-processing do not receive much attention as potential "green" growth industries. Furthermore, agriculture has often been overlooked in the development literature as a "backward"

sector without much scope for value-addition and the creation of decent jobs commonly associated with structural transformation (Cramer and Chisoro-Dube, 2021).

However, South Africa's agri-sectors in fact present considerable opportunities for relatively low-carbon growth of employment, value-addition and exports as well as greater economic inclusion. The Agriculture and Food sectors both fall within the high labour-intensity/low carbon-intensity Q1 (Figure 4), while Beverages lies at the more labour-intensive end of Q2 (Figure 5). As reflected in Appendix A1 both agriculture and agro-processing sectors have recorded increases in employment over the decade 2013 to 2023[11]. Employment growth rates discussed below refer to the change in employment over this decade, unless otherwise specified.

Over this period total Agricultural employment grew by 9.6%, Food by 18.1% and Beverages by 1.5%. When variations within these sectors are taken into account, substantial growth opportunities are evident.

Agriculture employed 977 577 workers in 2023, having grown by 9.6% since 2013. Employment growth in agriculture has largely been driven by the horticultural segment. This is even as increased mechanisation has limited job growth in the field crops sector. Cramer and Sender (2019) argue that far from being "backward", horticulture can be described as the "industrialisation of freshness" involving the development of sophisticated cultivation and cold-chain capabilities required to deliver high-value products such as fresh fruit to export markets. Horticulture is also very labour-intensive. Whereas field crops typically require the cultivation of 100 hectares to create one job, horticulture generates at least one job per hectare (Zalk, 2019). That is horticulture is at least 100 times more labour intensive than field crops. Employment growth in South Africa's export-oriented horticulture sector has far outstripped the agriculture average. For instance employment in South Africa's largest horticulture industry: citrus more than doubled from 56 902 jobs in 2009 to 125 000 in 2019 (Chisoro-Dube, Landani and Roberts, 2020). Horticultural farming takes place in areas where poverty is most intensely concentrated: namely rural former homeland areas. It creates employment for the poorest demographic: rural women. The industry also provides important lessons for inclusion with the Citrus Growers Association channelling 20% of its resources to support emerging black commercial farmers. This confluence of positive outcomes has been described as "a growth coalition that works (Chisoro-Dube and Roberts).

Food, beverages and tobacco employed 317 973 workers in 2023 with employment growing by 15.3% since 2013. Employment growth was achieved despite difficulties in the Poultry and Sugar sectors (both subject to their own "defensive" masterplans). Furthermore, the largest segment: Other food products, employing 144 638 workers in 2023 grew most robustly, by 27.1% despite the lack of any overarching strategy to support this segment. Food products has thus been a particular blind spot of industrial policy despite substantial research pointing to opportunities for growth in agro-processing. Research informing proposals for agro-processing growth in the Agricultural and Agro-Processing Master Plan included supplier development and localisation, building on the findings of the Competition Commission's Supermarket Retail Enquiry recommendations for expanded routes to domestic markets (Competition Commission, 2019); establishing an Agro-processing Financing Programme by the dtic and IDC to support SMMEs in general and black industrialists in particular; and the scaling up of high-growth medium sized firms with good growth prospects, and supporting export expansion (DALRRD, 2022).

[11] All further references to employment growth rates in this section cover the decade 2013-2023 unless otherwise indicated. The data source is Quantec's South African Standardised Industry Database.

Ferrous metals, steel, metal products and machinery

The iron ore, steel, metal products and machinery sectors collectively make up a large chunk of South Africa's productive sector employment. The major downstream segments of the value chain: metal products; machinery and equipment; and electrical machinery fall into the high labour-/low carbon-intensity (see Q1 Figure 4). These downstream sectors accounted for 356 375 jobs in 2023. With the exception of Structural metal products, these downstream sectors have grown employment by between 10.6% and 17.8%. A substantial part of the job growth in machinery subsectors can be attributed to the competitive capabilities built in mining and mineral processing machinery, with their ability to export offsetting weak domestic demand. The expansion of critical mineral projects in South Africa and on the rest of the continent and beyond represent an important potential opportunity to sustain and grow the mineral-related machinery sector. Continued employment expansion of these sectors should be supported by growth in the domestic, regional and broader export markets. Structural metal products, however, underwent a precipitous decline of 45.4%.

Conversely Basic iron and steel (and non-ferrous metals) fall in the low labour-/high carbon-intensity (see Q3 Figure 6). Employment fell by a dramatic 36.3%. The large job losses in Basic iron and steel and Structural metal products are due primarily to lack of demand due to low infrastructure investment. Revival of public infrastructure investment is thus essential to reverse these declines. The most immediate opportunity is to fast-track investment in grid infrastructure needed to connect renewables projects in the Eastern and Northern Cape to the national grid, linked to local content measures to stimulate a revival of structural metal steel product employment in particular (Makgetla, 2025). Infrastructure investment combined with local content measures could serve to catalyse a rapid recovery of a significant part of the job losses in structural metal products in particular.

Moreover, South Africa's steel sector faces multiple overlapping problems. Long-term underinvestment by dominant steel producer ArcelorMittal South Africa (AMSA) has resulted both in high costs of production and environmental degradation. Historically AMSA has exercised its monopoly pricing power in a manner which has hampered downstream competitiveness of steel consuming sectors (Rustomjee, Kaziboni and Steuart, 2018; Zalk, 2017). AMSA is the third largest GHG emitter in South Africa (Appendix Table A2), with production based on aged carbon-intensive blast furnace technology. Over recent years a number of mini-mills have entered or expanded their footprint, supported by the IDC, to produce long products such as rebar for the construction industry. This together with oversupply of cheaper Chinese steel has eroded AMSA's dominance, particularly in long products, culminating in the threatened closure of its deteriorating Newcastle plant. However, AMSA retains its dominance in more technically demanding flat products such as hot rolled coil.

In the medium-term policymakers need to look beyond special pleading to protect inefficient and dirty primary steel production. Rather, a dedicated strategy for the greening of iron and steel production can act as a springboard to address the interlinked industry challenges of competitiveness and high carbon-intensity. A core element of such a strategy is a shift from creaking and dirty blast furnace (BF) technology to far more energy-efficient and cleaner modern electric arc furnace (EAF) technology. EAFs using scrap steel as an inputs require as little as 10% of the energy of blast furnaces and produce 13% of the emissions of BFs (International Energy Agency, 2020). Hence, continuity of export restrictions on scrap metal exports are justified, inter alia, on environmental grounds.

Reliance on scrap alone is insufficient, with a shift required to the production of green (or greener) directly reduced iron. South Africa's excellent solar resources lend themselves to supplying at least a part of the energy supply needed for both iron and steel production. Fully green steel iron and steel awaits further technological development and commercialisation, including but not limited to green hydrogen (Trollip, McCall and Bataille, 2022). As the EU and other jurisdictions roll out CBAMs, greener

iron and steel production could become an increasing competitive advantage in accessing these markets. Of particular importance is to attract EAF investment combined with rolling mills to produce flat steel products such as hot rolled coil.

CBAMs pose similar challenges to the aluminium sector, including South Africa's South 32 and Mozambique's Mozal smelter.[12] Aluminium is both extremely energy- (and hence carbon-) intensive and metal needed for the green transition due to its lightness, durability and conductivity. Aluminium demand is likely to be robust during the green transformation but will be even more difficult than steel to decarbonise (Monaisa and Montmasson-Clair, 2023).

Chemicals and plastics

Petroleum products, chemicals, rubber and plastics employed 210 478 people in 2023. Basic and other chemicals are both capital- and carbon-intensive. Employment in Basic chemicals fell dramatically by 29.3% with other subsectors recording varying degrees of employment growth: Other chemicals: 11%; Rubber products: 3.4%, and Plastic products: 15.4%).

Arguably the preeminent challenge for South Africa's manufacturing sector is how to ensure an economical and environmentally sustainable transition of South Africa's largest manufacturing company: petrochemicals producer Sasol. Sasol is South Africa's largest industrial company, by far the largest petrochemicals and basic chemicals producer, and South Africa's biggest GHG emitter after Eskom. It accounts for 14.5% of national GHG emissions, chiefly from its Secunda coal to liquid fuels (50%) and chemicals operations (40%). It employs 24 000 people, is a substantial exporter, and has a widespread impact on downstream chemicals and plastics sectors. Outside of liquid fuels it produces plastic raw materials based on ethylene and propylene, ammonia and other chemicals. These flow to multiple downstream sectors, notably the relatively labour-intensive plastics sector (Crompton, Young and Hahn, 2024). Sasol's monopoly position in a number of these products has hindered the competitiveness of downstream sectors such as plastics (Mofo, 2020). There is thus a critical need for a national strategy for Sasol's medium- to long-term restructuring. This includes to what extent and how green hydrogen may play a role in decarbonising parts of Sasol's operations and how its industrial capabilities could be harnessed to enter new greener value chain segments.

Fertilisers comprise another major part of the chemicals value chain and are strategic for food security and agricultural growth. Like petrochemicals, the sector is dominated by a handful of firms: Sasol, Foskor and Omnia. Options to decarbonise fertiliser production need to be explored including through the production of green ammonia as a green hydrogen derivative. One area for exploration is the feasibility of Foskor producing battery grade phosphates that feed into LFP lithium-ion batteries.

The downstream plastics sector has significant potential to further expand employment. This depends partly on the rate of growth for industries it serves, such as packaging and automotives. The plastics sector will increasingly have to engage with mounting regulatory and consumer concerns in the domestic and export markets. This includes rising concerns with respect to single use plastics and microplastics. A further area for exploration and diversification is into bioplastics and aviation fuel as a source of demand for South Africa's troubled sugar sector (Lowitt, 2020).

New energy vehicles

Automotives assembly, componentry and the broader transport equipment sector employs 143 265 people. Motor vehicles posted a 6.7% increase in employment, Parts and accessories 7.7% and Other transport equipment: 24.9%. In the face of an international shift to electric vehicles, South Africa

[12] As Mozal accounts for approximately 30% of Mozambique's exports a slump in its exports will severely constrain foreign exchange earnings Mozambique needs to purchase South Africa imports.

lagged in finalising a NEV strategy. In addition to political inertia, the automotive industry contributed to delays by tabling an unrealistic strategy that was both fiscally and politically implausible. A NEV strategy was finalised in December 2023. The recent announcement by the Minister of Finance of a tax incentive for electric and hydrogen-powered vehicles as a new provision under Section 12v of the Income Tax Act (National Treasury, 2024). However, a major gap in the NEV strategy has been its exclusion of both "mild" and plug-in hybrid electric vehicles (PHEVs). This is important, not least because recent European uptake figures, South Africa's largest export market, indicate that demand for hybrids remains more robust that previously forecast with a corresponding less rapid uptake of pure battery electric vehicles (BEVs). Amendments to include hybrid vehicles are being contemplated, but have not been finalised (International Trade Administration Commission, 2024).

A key challenge facing the NEV sector is the need to concurrently promote domestic EV adoption and purchase of locally produced EVs and to roll out a charging infrastructure for NEVs in a fiscally constrained context. This requires efforts beyond simply implementing the NEV strategy. One proposal is to offer low interest loans for purchase of EVs, drawing on concessional JETP financing (Montmasson-Clair, 2022). Another involves promoting hubs and corridors along predictable routes that can be adopted by vehicle fleets. Examples include electrification of bus rapid transit systems, delivery vehicles and inter-city routes, and linking these to domestic assembly[13]. Production of two- and three-wheelers for the domestic market and for export to the rest of the continent should be explored. Any consumer tax incentives or low interest loans for the purchase of NEVs should be linked to domestically produced vehicles.

Renewable components

Domestic production of renewables componentry has largely been driven by local content requirements attached to South Africa's REIPP utility scale procurement programme. Localisation under REIPP has been undermined by a combination of policy and power purchase agreement delays, and definition of local content that includes construction and other activities that would have been undertaken domestically in any event.

However, there have been some industrial capabilities and jobs generated through efforts to localise componentry linked to South Africa's REIPP programme in solar PV and wind value chains, although quantification is incomplete. Direct manufacturing employment in the solar PV value chain has been estimated at around 3 000 (GIZ 2023).

The long-delayed South African Renewable Energy Masterplan has finally been approved by Cabinet (Creamer, 2025). Renewable energy componentry is an important opportunity over the medium-long term. It sets a target of creating 25 000 jobs in manufacturing of renewable energy and battery energy storage componentry by 2030. While not insignificant, if met the jobs target would raise overall manufacturing employment by 1.6%. This points both to the importance of growing other relatively low-carbon productive sectors and for greater ambition in renewable componentry employment.

Deepening domestic production of renewables componentry requires strengthening and adapting policy. This includes ensuring localisation remains embedded in public procurement policy and exploring the inclusion of production for exports as "deemed local content", with the objective of encouraging the integration of component suppliers into the international supply chains of original equipment manufacturers (OEMs).

Policy to support supply and demand side measures for investment in industrial capabilities linked to renewables and other low-carbon value chains needs to take into account the shift in renewable

[13] Thanks is due to Kate Rivett-Carnac for the point about the need for development of NEV charging infrastructure based on "hubs" and "corridors".

projects, particularly solar PV, from utility scale public procurement to private generation. This is both for large-scale and small-scale embedded generation (SSEG) for commercial applications and households.

SAREM calls for tax incentives such as the repurposing and revival of section 12i of the Income Tax Act for new green value chains. This could include investments in:

- Batteries for electric vehicles and storage, such as for battery grade precursors and battery production (that are not already included in S12v of the Income Tax Act) .
- Greening of iron and steel production.
- Catalytic investments in core renewable energy sub-systems (beyond shallow assembly operations).
- Green hydrogen and derivative products, and related capital goods such as electrolysers.
- Fuel cells for stationary storage and vehicles.
- Green aviation fuels
- Industrial heating projects

Consideration should be given to the extension of Section 6c of the Income Tax Act that incentivises SSEG installation with amendments to encourage domestic manufacturing, for instance by introducing a premium for domestically manufactured inputs.

Platinum group metals and the hydrogen economy

Platinum group metals (PGMs) are routinely listed as critical or transition minerals in analyses pointing out the significant share Africa has of such minerals. South Africa has 90% of the world's reserves of PGMs, with Zimbabwe the next largest on the continent (EMIS, 2024). PGMs have supplanted gold as by far the largest employer in the mining sector, accounting for 193 441 jobs in 2023.

The main source of demand for PGMs, catalytic converters for ICE vehicles, has slowed and is anticipated to stagnate as an increasing share of new vehicles purchased worldwide are EVs. Conversely, the emergence of the "hydrogen economy" as an alternate source of industrial demand for PGMs has been far slower than previously forecast. Both fuel cell vehicles and electrolysers for producing green hydrogen are growing slowly, with increasing evidence emerging that Europe's ambitious plans for green hydrogen are far from meeting initial projections (Agency, 2024).

This in turn has implications for South Africa's PGM employment, which fell over the reference period by 6.8%. The implication is that the hydrogen economy has not yet taken off. South Africa's approach to PGMs and the hydrogen economy therefore requires greater regulatory impetus and support. In particular it is in the long-term interests of PGM miners that active steps are taken to promote industrial uses for PGMs including fuel cells and electrolysers, particularly where industrial production can take place in South Africa. Such an approach would need to navigate policy options that could include giving preferential conditions to PGM miners that undertake or catalyse hydrogen-based industrial projects in South Africa, including through technology partnerships with leading international OEMs.

The critical minerals and lithium-ion battery value chain

The green transition will require a dramatic increase in a number of minerals found on the African continent and to a lesser extent in South Africa. Feedstocks for both major lithium-ion (li-ion) battery chemistries are found, to varying degrees, on the African continent: lithium manganese cobalt oxide

(LMC) and lithium iron phosphate (LFP). Projected demand increases between 2022 and 2040 for selected minerals needed to meet global decarbonisation objectives range from 130%-420% for lithium, 80%-250% for graphite, 60%-210% for cobalt, 50%-190% for nickel and 30%-80% for manganese (IEA, 2024). This opens up potential direct and indirect opportunities along critical mineral value chains. However, as outlined above the development of a national Critical Minerals Strategy is yet to be concluded.

South Africa has some critical minerals required for lithium-ion battery production and low-carbon products. These include substantial deposits of manganese and chrome. Most minerals required for li-ion batteries can be found in the Southern African region. However, there is no evident momentum around securing cross-border co-operation with the Southern African region for battery mineral and broader critical mineral development. The bulk of supplies of critical minerals in the sub-region appear to have been secured by the Chinese miners/processors and transnational commodity traders (Andreoni and Roberts, 2022). Furthermore, by far the biggest hurdle to production of li-ion batteries are the development of complex industrial capabilities at a very large scale to be able to compete, predominantly with Chinese cell producers. Production of battery cells would require enormous investment at the "giga-factory" scale.

However, due to its long mining and mineral processing history, South Africa has some advantages and capabilities relevant to producing battery grade precursor chemicals. That is the processing of battery minerals to very high-quality chemical carbonates or sulfates. This includes entrants into the battery mineral space such as Manganese Metal Company, which is scaling the production of high quality battery grade manganese. Stationery vanadium redox flow battery (VRFB) capabilities were being developed by Bushveld Energy (Moshikaro, 2023) but the prospects of success remain unclear. While they are capital and energy-intensive, these processes add substantial value to battery minerals and are necessary, but not sufficient, building blocks for battery cell production. Thus while battery cell production in South Africa is not impossible it would require enormous investment and the development or attraction of substantial industrial capabilities.

South Africa has also developed a vibrant battery assembly industry, oriented towards stationery storage solutions domestically and on the rest of the continent (Montmasson-Clair, Moshikaro and Monaisa, 2021). South Africa should seek to integrate the value chain from both the downstream and upstream direction. The latter could include exploring battery production for stationary storage, which is growing (off a low base) more rapidly than batteries for EVs and may require less demanding capabilities (Zalk, 2024).

Tourism

The tourism sector incorporates a number of features of structural transformation. Although it does not embody high productivity growth it is a major employer and significant contributor to foreign exchange as an exporter of services through foreign visitors. Tourism employment is not capture directly in the national accounts but estimated through the Tourism Satellite Account (TSA). The latest available TSA only includes estimates for 2022 of 733 385 employed, which continued to reflect the impacts of COVID-19. A not unreasonable assumption, based on recovery of domestic tourism in particular, is that by 2023 tourism employment recovered to 2019 levels of around 770000. If so employment growth since 2013 would be approximately 17% (Stats SA, 2022).

There are two main kinds of foreign arrivals: long-haul leisure arrivals, and visitors from the sub-region for business and retail. Long-haul tourism faces challenges from mounting regulatory measures and consumer awareness of the GHG from air travel. This includes measures such as the EU's ReFuelEU

Aviation Initiative that requires mandatory blending of a minimum of sustainable aviation fuels from 2025 with airlines adding surcharges to cover these costs.

A range of short- to long-term measures are needed to respond. First, South Africa should highlight its "green credentials" such as eco-tourism offerings, biodiversity preservation and decarbonisation of land transport (e.g. tourist buses on major routes). In the medium to long term, greater attention to producing sustainable aviation fuels is required. This includes expediting efforts to diversify sources of demand for South Africa's struggling sugar industry to produce sustainable biofuels combined with blending requirements for airlines. Production of e-kerosene from green hydrogen is another important avenue linked to reorientation of Sasol to lower emissions through the HyShift initiative. These measures could be funded by measures such as Singapore's recently introduced levy on all departing flights to support its adoption of sustainable aviation fuel.

7. CONCLUSION

Countries that have achieved high-income levels have undertaken processes of structural transformation historically powered by fossil fuel intensive industrialisation processes. South Africa's post-apartheid economy has underdone limited structural transformation and has been characterised by low fixed investment, weak economic and employment growth, and enduring socio-economic exclusion and inequality. Despite declining emission intensity it remains reliant on relatively carbon-intensive exports. Greening industrialisation and industrial policy represents an opportunity for South Africa to shift from fossil-fuel intensive stagnation to a higher value-added, labour-absorbing and less carbon-intensive economy.

South Africa will be impacted by both the direct and indirect effects of climate change. The indirect effects derive from geopolitical shifts towards unilateral trade measures and economic shifts towards lower carbon value chains. A number of developing countries are implementing industrial policies that take into account these overlapping changes, identifying both opportunities and impediments in the shift towards more climate-compatible structural transformation. South Africa's industrial policy has been slow to fully engage with this changing environment. Green industrial policy offers an opportunity for South Africa to address long-standing weaknesses and make the shift to a climate-compatible, more jobs rich and value-adding industrial structure.

Green industrial policy needs an economy-wide perspective approach. New low-carbon sectors certainly represent opportunities for green structural transformation, albeit off a low base. South Africa's pre-existing structural transformation challenges, particularly its extraordinarily high unemployment rate cannot be meaningfully addressed without actively promoting the growth of existing sectors which are both relatively labour-intensive and low in carbon-intensity. Carbon-intensive heavy industries which provide essential metal and chemical inputs to more labour-intensive downstream sectors need to be decarbonised to secure their viability.

Green industrial policy can unlock growth in a number of value chains in a more labour-intensive, less carbon-intensive and more inclusive way.

Policy instruments and institutions that could be brought to bear include:

- Tax incentives
- Development banks
- Green industrial hubs
- Localisation policies
- Strategic use of trade policy instruments

APPENDIX

Table A1: Employment (2023) and employment growth (2013-2023) selected sectors

Industry	2023	Change 2013-2023	% Change
Agriculture, forestry and fishing [QSIC 1]	**1,160,737**	105,148	9.1
Agriculture [QSIC 11]	**977,577**	94,042	9.6
Forestry [QSIC 12]	**119,881**	7,613	6.4
Fishing [QSIC 13]	**63,279**	3,494	5.5
Mining and quarrying [QSIC 2]	**521,149**	-51,666	-9.9
Coal [QSIC 21]	**106,232**	4,849	4.6
Gold [QSIC 23]	**103,297**	-47,273	-45.8
Metals [QSIC 24]	**275,295**	-6,713	-2.4
Iron ore [QSIC 241]	**26,442**	1,908	7.2
Chrome [QSIC 2421]	**24,305**	2,986	12.3
Copper [QSIC 2422]	**4,515**	-173	-3.8
Manganese ore [QSIC 2423]	**12,800**	1,371	10.7
Platinum group metals [QSIC 2424]	**193,441**	-13,241	-6.8
Other metallic minerals [QSIC 2429]	**13,792**	435	3.2
Other mining and quarrying [QSIC 22, 25-29]	**36,326**	-2,529	-7.0
Manufacturing [QSIC 3]	**1,538,797**	36,014	2.3
Food, beverages and tobacco [QSIC 30]	**317,973**	48,793	15.3
Meat , fish, fruit, etc. [QSIC 301]	**72,646**	8,439	11.6
Dairy products [QSIC 302]	**24,375**	-1,762	-7.2
Grain mill products [QSIC 303]	**24,343**	2,230	9.2
Other food products [QSIC 304]	**144,638**	39,137	27.1
Beverages [QSIC 305]	**47,562**	697	1.5
Tobacco [QSIC 306]	**4,408**	52	1.2
Textiles, clothing and leather goods [QSIC 31]	**90,417**	-25,895	-28.6
Textiles [QSIC 311]	**8,300**	-2,860	-34.5
Other textile products [QSIC 312]	**26,182**	-482	-1.8
Wearing apparel [QSIC 313-314]	**43,575**	-17,581	-40.3
Knitted, crocheted articles [QSIC 313]	**5,581**	-432	-7.7
Wearing apparel [QSIC 314]	**37,993**	-17,150	-45.1
Leather and leather and fur products [QSIC 315-316]	**5,779**	118	2.0
Footwear [QSIC 317]	**6,581**	-5,090	-77.3
Wood and paper; publishing and printing [QSIC 32]	**152,372**	-27,418	-18.0
Sawmilling and planing of wood [QSIC 321]	**19,254**	-7,506	-39.0
Products of wood [QSIC 322]	**36,952**	1,341	3.6
Paper and paper products [QSIC 323]	**39,997**	-10,511	-26.3
Printing , recorded media [QSIC 324-326]	**56,169**	-10,742	-19.1
Petroleum products, chemicals, rubber and plastic [QSIC 33]	**210,478**	11,526	5.5
Basic chemicals [QSIC 334]	**25,404**	-7,435	-29.3
Other chemical products [QSIC 335-336]	**75,696**	8,336	11.0
Rubber products [QSIC 337]	**15,248**	513	3.4
Plastic products [QSIC 338]	**60,552**	9,328	15.4
Other non-metal mineral products [QSIC 34]	**68,809**	-6,305	-9.2
Glass and glass products [QSIC 341]	**10,437**	-889	-8.5
Non-metallic mineral products [QSIC 342]	**58,373**	-5,415	-9.3
Metals, metal products, machinery and equipment [QSIC 35]	**356,295**	-3,412	-1.0
Basic iron and steel products [QSIC 351]	**36,006**	-13,086	-36.3
Non-ferrous metal products [QSIC 352]	**23,629**	-3,134	-13.3
Structural metal products [QSIC 354]	**44,383**	-20,163	-45.4
Other fabricated metal products [QSIC 355]	**93,591**	9,911	10.6
General purpose machinery [QSIC 356]	**67,680**	11,576	17.1
Special purpose machinery [QSIC 357]	**78,979**	14,083	17.8
Household appliances [QSIC 358]	**7,388**	-948	-12.8
Office, accounting, computing machinery [QSIC 359]	**4,640**	-1,653	-35.6
Electrical machinery and apparatus [QSIC 36]	**59,716**	7,130	11.9
Electric motors, generators, transformers [QSIC 361]	**20,452**	3,050	14.9
Electricity distribution and control apparatus [QSIC 362]	**7,464**	730	9.8
Insulated wire and cables [QSIC 363]	**5,302**	-1,309	-24.7
Other electrical equipment [QSIC 364-366]	**26,498**	4,659	17.6
Radio, TV, instruments, watches and clocks [QSIC 37]	**23,932**	2,967	12.4
Radio, television and communication apparatus [QSIC 371-373]	**8,359**	395	4.7
Professional equipment [QSIC 374-376]	**15,573**	2,572	16.5
Transport equipment [QSIC 38]	**143,265**	14,468	10.1
Motor vehicles [QSIC 381-382]	**57,264**	3,845	6.7
Parts and accessories [QSIC 383]	**62,819**	4,853	7.7
Other transport equipment [QSIC 384-387]	**23,183**	5,770	24.9
Furniture; other manufacturing [QSIC 39]	**115,541**	14,159	12.3
Furniture [QSIC 391]	**37,782**	-668	-1.8
Other manufacturing groups [QSIC 392 - 395]	**77,759**	14,827	19.1

Source: Author's calculations based on South African Standardised Industry Database.

Table A2: Firm level concentration of SA's GHG emissions

Energy Intensive Users Group

Company	Company
1 Afrisam	15 Mpact Group
2 Anglo American	16 Nampak
3 ArcelorMittal South Africa	17 Northam Platinum
4 Assmang Limited	18 Petra Diamonds
5 Cape Gate (Pty) Ltd	19 Rio Tinto
6 Evraz Highveld Steel and Vanadium	20 Samancor Chrome
7 Exxaro	21 SAPPI
8 Glencore	22 Sasol
9 Gold Fields	23 Scaw Metals Group
10 Harmony Gold	24 Sibanye Stillwater
11 Impala Platinum	25 South32
12 Manganese Metal Company (MMC)	26 Transalloys
13 Mondelez International	27 Vedanta Resources
14 Mondi Group	

South Africa's Top 10 Corporate GHG Emitters

Rank	Company Name	% of SA Emissions	Cummulative % SA Emissions
1	Eskom Holdings SOC Limited	39.0	39.0
2	Sasol Limited	13.5	52.5
3	ArcelorMittal South Africa Limited	2.8	55.3
4	South32 Limited	2.7	58.1
5	Anglo American plc	1.4	59.5
6	PPC Limited	0.8	60.3
7	Sappi Limited	0.5	60.8
8	African Rainbow Minerals Limited	0.4	61.2
9	Exxaro Resources Limited	0.2	61.4
10	Gold Fields Limited	0.1	61.5

Sources: Energy Intensive Users Group of Southern Africa https://eiug.org.za/; Centre for Environmental Rights https://fulldisclosure.cer.org.za/2019/emitters/emitters-and-emissions.

REFERENCES

Agency, I.E. (2024) *Global Hydrogen Review 2024*, Paris: International Energy Agency. Available at: https://www.iea.org/reports/global-hydrogen-review-2024.

Andreoni, A., Mondliwa, P., Roberts, S. and Tregenna, F. (2021a) *Framing Structural Transformation in South Africa and Beyond. Structural transformation in South Africa: The challenges of inclusive industrial development in a middle-income country*: Oxford University Press, p.1.

Andreoni, A., Mondliwa, P., Roberts, S. and Tregenna, F. (2021b) *Structural transformation in South Africa: The challenges of inclusive industrial development in a middle-income country.* Oxford University Press.

Andreoni, A., Mondliwa, P., Roberts, S. and Tregenna, F. (eds.) (2021c) *Structural transformation in South Africa: The challenges of inclusive industrial development in a middle-income country*: Oxford University Press.

Andreoni, A. and Roberts, S. (2022) *Geopolitics of critical minerals in renewable energy supply chains: assessing conditionalities on the use of technology, market capture and the implications for Africa*.

Baker, L. and Burton, J. (2024) 'From the minerals–energy complex to a just transition?', in Mohamed, S. and Ngoma, A. (eds.) *The Evolving Structure of South Africa's Economy: Faultlines and Futures*, pp.270.

Bhorat, H., Buthelezi, M., Chipkin, I., Duma, S., Mondi, L., Peter, C., Qobo, M., Swilling, M. and Friedenstein, H. (2017) *Betrayal of the promise: how South Africa is being stolen*.

Bindman, P. (2024) *IEA significantly downgrades green hydrogen growth forecas*t. Weekly Data. Energy Monitor. Available at: https://www.energymonitor.ai/tech/hydrogen/weekly-data-iea-significantly-downgrades-green-hydrogen-growth-forecast/

Cherif, R. and Hasanov, F. (2019) *The Return of the Policy That Shall Not Be Named: Principles of Industrial Policy*.

Chisoro-Dube, S., Landani, N. and Roberts, S. (2020) *COVID-19 impacts and COVID-19 impacts and opportunities in the citrus industry in South Africa*: Centre for Competition, Regulation and Economic Development, University of Johannesburg.

Chisoro-Dube, S. and Roberts, S. (2021) *Growth coalitions that work? We need to talk about citrus*. Daily Maverick. Available at: https://www.dailymaverick.co.za/article/2021-05-09-growth-coalitions-that-work-we-need-to-talk-about-citrus/

Commission on Growth (2008) *The growth report: Strategies for sustained growth and inclusive development.* World Bank Publications.

Competition Commission (2019) *The Grocery Retailmarket Inquiry: Final Report*.

Cramer, C. and Chisoro-Dube, S. (2021) 'The industrialization of freshness and structural transformation in South African fruit exports'. *Structural Transformation in South Africa*: Oxford University Press, pp. 120-142.

Cramer, C. and Sender, J. (2019) 'Oranges Are Not Only Fruit: The Industrialisation of Freshness and the Quality of Growth'. in Kanbur, R., Noman, A. and Stiglitz, J.E. (eds.) *The Quality of Growth in Africa*: Columbia University Press, pp. 209-233.

Cramer, C., Sender, J. and Oqubay, A. (2020) *African economic development: Evidence, theory, policy.* Oxford University Press.

Creamer, T. (2025). 'South African Renewable Energy Masterplan approved for implementation by Cabinet'. *Engineering News.* Available at: https://www.engineeringnews.co.za/article/south-african-renewable-energy-masterplan-approved-for-implementation-by-cabinet-2025-03-27

Crompton, R., Young, B. and Hahn, T. (2024) *An Analysis of South Africa's Petrochemicals and Basic Chemicals in the Context of South Africa's Energy Transition Focusing on Sasol's Secunda Coal-To-Chemicals-And-Liquids Facility*: Trade & Industrial Policy Strategies.

Davies, R. (2022) *Navigating New Turbulences at The Nexus of Trade and Climate Change: Implications and Options for Africa*. Available at: https://africanclimatefoundation.org/news_and_analysis/navigating-new-turbulences-at-the-nexus-of-trade-and-climate-change/#elementor-action%3Aaction%3Dpopup%3Aopen%26settings%3DeyJpZCI6IjM4ODMiLCJ0b2dnbGUiOmZhbHNlfQ%3D%3D (Accessed October 2023).

DALRRD. (2022) *Agriculture and Agro-Processing Master Plan "Social Compact".* Department of Agriculture, Land Reform and Rural Development.

DMRE. (2025) *Minister Kgosientsho Ramokgopa welcomes cabinet's approval of the South African Renewable Energy Master Plan*. Media Statement. Department of Mineral Resources and Energy. Available at: https://www.dmre.gov.za/news-room/post/2807

DPME. (2018) *Report on the Evaluation of Government Business Incentives*, Pretoria. Department of Planning, Monitoring and Evaluation.

Department of Trade and Industry (2007) *National Industrial Policy Framework*, Pretoria: Department of Trade and Industry. Available at: https://www.thedtic.gov.za/wp-content/uploads/NIPF_r2.pdf.

dtic (the). (2024) *Industrial Policy & Strategy Review: Transforming Vision into Action: Charting South Africa's Industrial Future*, Pretoria: Department of Trade, Industry and Competition.

Diao, X., McMillan, M. and Rodrik, D. (2019) *The Recent Growth Boom in Developing Economies: A Structural-Change Perspective*. Springer International Publishing, pp. 281-334.

EMIS (2024) *The Gold Rush for Green Minerals: Unlocking Africa's Potential*. Available at: https://www.emis.com/php/store/reports/AC/The_Gold_Rush_for_Green_Minerals:_Unlocking_Africa%E2%80%99s_Potential_en_810795516.html (Accessed: 15 May 2024).

Fine, B. and Rustomjee, B.F.Z. (1996) *The Political Economy of South Africa: From Minerals-energy Complex to Industrialisation.* C. Hurst & Co. Publishers.

Freund, B. (2018) *Twentieth-century South Africa: A developmental history.* Cambridge University Press.

Ganesan, K., Choudhury, P., Palakshappa, R., Jain, R. and Raje, S. (2014*) Assessing Green Industrial Policy: The India experience*. International Institute for Sustainable Development. Available at: https://www.iisd.org/publications/report/assessing-green-industrial-policy-india-experience

GIZ (2024) *State of South African Manufacturing, its potential and resources required for further development of PV Value Chains*, Pretoria, South Africa: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Available at: http://www.energypartnership.org.za.

Guepie, G., Macleod, J., Omojo, O., Davies, R., Van, C., Aggad, F. and Luke, D. (2023) *Implications for African countries of a carbon border adjustment mechanism in the EU.* The African Climate Foudation; LSE Firoz Lalji Institute for Africa.

Hector, M. (2025) *Greening Industrial Policy in South Africa: Insights from China, the United States and the European Union*: Trade and Industrial Policy Strategies. Available at: https://www.tips.org.za/research-archive/sustainable-growth/item/4911-tips-working-paper-greening-industrial-policy-in-south-africa-insights-from-china-the-united-states-and-the-european-union-january-2025.

Hopewell, K. (2024) 'The (surprise) return of development policy space in the multilateral trading system: what the WTO Appellate Body blockage means for the developmental state'. *Review of International Political Economy*, pp. 1-26.

IEA (2024) *Global Critical Minerals Outlook 2024.* Paris: International Energy Agency. Available at: https://www.iea.org/reports/global-critical-minerals-outlook-2024.

International Energy Agency (2020) *Steel Technology Roadmap*, Paris.

International Trade Administration Commission (2024) *Draft Regulations For The Amendment Of The Automotive Production And Development Programme Phase 2 Legislative Framework For The Inclusion Of Electric Vehicles And Associated Components.* 50832).

Lebdioui, A. (2024) *Survival of the Greenest: Economic Transformation in a Climate-conscious World.* Cambridge: Cambridge University Press. *Elements in Development Economics*. https://www.cambridge.org/core/services/aop-cambridge-core/content/view/F0A8EDD3878C262B24FAEC1A9CE1CA18/9781009500517AR.pdf/survival-of-the-greenest.pdf.

Lipton, M. (1989) *Capitalism and apartheid: South Africa, 1910-1986.* New Africa Books.

Lowitt, S. (2020) *Industrial Development Projects: Polylactic Acid (Bioplastics)*: Trade and Industrial Policy Strategies.

Mail & Guardian (2022) *Greening our future.* Special Report. Available at: https://mg.co.za/special-reports/2022-12-02-greening-our-future/

Maimele, S. (2023) *The European Green Deal (EGD) and its implications for African Trade*: Trade & Industrial Policy Strategies. Available at: https://www.tips.org.za/research-archive/sustainable-growth/green-economy-2/item/4722-the-european-green-deal-egd-and-its-implications-for-african-trade.

Makgetla, N. (2023) *Briefing Note 1: The budget and industrial policy*: Trade & Industrial Policy Strategies.

Makgetla, N. (2024) *Evaluation of the Industry/Sector Master Plan Process*: Trade & Industrial Policy Strategies.

Makgetla, N. (2025) *Options for Localising Steel Inputs for the Infrastructure Build Programme*: Trade & Industrial Policy Strategies.

Mofo, L. (2020) *Future-proofing the plastics value chain in Southern Africa*: WIDER Working Paper (9292569058.

Monaisa, L. and Montmasson-Clair, G. (2023) *South Africa's Aluminium Value Chain and Climate Change Compatibility*: Trade and Industrial Policy Strategies.

Montmasson-Clair, G. (2020) 'The global climate change regime and its impacts on South Africa's trade and competitiveness: A data note on South Africa's exports'. *Trade and Industrial Strategies, Pretoria*.

Montmasson-Clair, G. (2022) *Towards an Inclusive Rollout of Electric Vehicles in South Africa* 3/2022).

Montmasson-Clair, G., Moshikaro, L. and Monaisa, L. (2021) *Opportunities to develop the lithium-ion battery value chain in South Africa*. Pretoria: Trade & Industrial Policy Strategies.

Montmasson-Clair, G. and Patel, M. (2024) *A policy primer for green industrialisation in South Africa*: Trade & Industrial Policy Strategies.

Moshikaro, L. (2023) *A Review of the Vanadium Redox Flow Battery (VRFB) Market: Demand and Costs*, Pretoria: Trade & Industrial Policy Strategies. Available at: https://www.tips.org.za/images/Policy_Brief_A_review_of_the_vanadium_redox_flow_battery_VRFB_market_demand_and_costs_August_2023.pdf.

National Treasury (2024) *Draft Explanatory Memorandum on the Draft Taxation Laws Amendment Bill*: National Treasury.

Oqubay, A. (2024) *Green Industrial Policy and Industrialisation in Africa*.

Presidência do Brasil (2024) Brazil launches new industrial policy with development goals and measures up to 2033. Available at: https://www.gov.br/planalto/en/latest-news/2024/01/brazil-launches-new-industrial-policy-with-development-goals-and-measures-up-to-2033

Presidential Climate Commission (2022a) *A Framework for a Just Transition in South Africa.* Presidential Climate Commission.

Presidential Climate Commission (2022b) *South Africa's Just Energy Transition Investment Plan (Jet IP) for the Initial Period 2023–2027.* Presidential Climate Commission.

Republic of South Africa (2025) Minister Gwede Mantashe: Opening remarks at Investing in African Mining Indaba. Available at: https://www.gov.za/news/speeches/minister-gwede-mantashe-opening-remarks-investing-african-mining-indaba-03-feb-2025

Rustomjee, Z., Kaziboni, L. and Steuart, I. (2018) 'Structural transformation along metals, machinery and equipment value chain – developing capabilities in the metals and machinery segments'. *SSRN Electron. J.*

Scott, N., Fyfe, K. and Geel, J. (2025) *Electric vehicle tax incentive: what electric vehicle manufacturers should know Legal updates and opinions*. Werksmans Attorneys. Available at: https://www.werksmans.com/legal-updates-and-opinions/electric-vehicle-tax-incentive-what-electric-vehicle-manufacturers-should-know/

Sender, J. (2016) 'Backward Capitalism in Rural South Africa: Prospects for Accelerating Accumulation in the E astern Cape'. *Journal of Agrarian Change,* 16(1), pp. 3-31.

Shetty, R. (2024) *How China Became the World's Clean Tech Giant*. Available at: https://thediplomat.com/2024/04/how-china-became-the-worlds-clean-tech-giant/ (Accessed: 2025-01-19).

Sihlobo, W. (2024) *Why has implementing the Agriculture and Agro-processing Master Plan been so painfully slow*? Daily Maverick. Available at: https://www.dailymaverick.co.za/opinionista/2024-02-12-agriculture-and-agro-processing-master-plan-shy-it-stalled/

Stats SA. (2022) Tourism Satellite Account for South Africa, final and provisional. Statistics South Africa. Available at: https://www.statssa.gov.za/?page_id=1856&PPN=Report-04-05-07&SCH=73901

Thomas, V. (2023) A Green Industrial Policy for Indonesia. Fulcrum. Available at: https://fulcrum.sg/a-green-industrial-policy-for-indonesia/

Tregenna, F. (2010) *Sectoral Labour Intensity in South Africa*, South Africa: National Economic Development and Labour Council (NEDLAC). Available at: https://new.nedlac.org.za/wp-content/uploads/2014/10/labour_intensity_report_2010.pdf (Accessed January 2025).

Trisos, C. H., Adelekan, I. O., Totin, E., Ayanlade, A., Efitre, J., Gemeda, A., Kalaba, K., Lennard, C., Masao, C., Mgaya, Y., Ngaruiya, G., Olago, D., Simpson, N. P. and Zakieldeen, S. (2022) 'Africa'. In Pörtner, H.O., Roberts, D.C., Tignor, M., Poloczanska, E.S., Mintenbeck, K., Alegría, A., Craig, M., Langsdorf, S., Löschke, S., Möller, V., Okem, A. and Rama, B. (eds.) *Climate Change 2022: Impacts, Adaptation and Vulnerability*. Cambridge, UK and New York, NY, USA: Cambridge University Press, pp. 1285-1455.

Trollip, H., McCall, B. and Bataille, C. (2022) 'How green primary iron production in South Africa could help global decarbonization'. *Climate Policy,* 22(2), pp. 236-247.

Wills, N. G. (2022) *Mapping sectors for high employment and low carbon growth in South Africa.* Faculty of Commerce.

Winkler, H. and Black, A. (2021) *Creating employment and reducing emissions: Options for South Africa*: SARCHl Industrial Development Working Paper 2021-06.

Zalk, N. (2016) 'Selling off the silver The imperative for productive and jobs-rich investment : South Africa'. *New agenda (Johannesburg, South Africa),* 2016(63), pp. 10-15.

Zalk, N. (2017) *The things we lost in the fire: the political economy of post-apartheid restructuring of the South African steel and engineering sectors.* SOAS University of London.

Zalk, N. (2019) *Hiding in plain sight: high-value agriculture's large-scale potential to grow jobs and exports.* Econ3x3. Available at: https://www.econ3x3.org/article/hiding-plain-sight-high-value-agriculture%E2%80%99s-large-scale-potential-grow-jobs-and-exports

Zalk, N. (2021) 'Structural Change in South Africa: A Historical Sectoral Perspective'. In *Structural Transformation in South Africa: The Challenges of Inclusive Industrial Development in a Middle-Income Country*: Oxford University Press.

Zalk, N. (2024) *Africa's Development Agenda for its Critical Raw Materials: Prospects for development and integration of African battery value chains.* Berlin: Africa Policy Research Institute. Available at: https://afripoli.org/projects/green-minerals/prospects-for-development-and-integration-of-african-battery-value-chains.

Zalk, N., Keane, J. and Nater, E. (2024) *Greening African trade and industrialisation: strategic issues for the AfCFTA towards COP29.*