TRADE & INDUSTRIAL POLICY STRATEGIES

INDUSTRY STUDY

Sustainability in the Electrical Equipment Industry

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TIPS industry studies aim to provide a comprehensive overview of key trends in leading industries in South Africa. For each industry covered, working papers will be published on basic economic trends, including value added, employment, investment and market structure; trade by major product and country; impact on the environment as well as threats and opportunities arising from the climate crisis; and the implications of emerging technologies. The studies aim to provide background for policymakers and researchers, and to strengthen our understanding of current challenges and opportunities in each industry as a basis for a more strategic response.

This study assesses the degree of sustainability in the South African electrical equipment manufacturing subsector.

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ABBREVIATIONS

BCAs	Border Carbon Adjustments
CSIR	Council for Scientific and Industrial Research
CO_2e	Carbon Dioxide Equivalent
EPR	Extended Producer Responsibility
ERA	E-Waste Recycling Authority
EU	European Union
Gg	Gigagrams
GHGs	Greenhouse Gases
kV	Kilovolts
kW	Kilowatt
lm/W	Lumens Per Watt
LULUCF	Land Use, Land-Use Change and Forestry
$MtCO_2$	Megatonnes of Carbon Dioxide
PCBs	Polychlorinated Biphenyls
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme
SF_6	Sulphur Hexafluoride
SIC	Standard Industrial Classification
tCO_2e	Tonnes of Carbon Dioxide Equivalent

1. INTRODUCTION

This study assesses the degree of sustainability in the South African electrical equipment manufacturing subsector. It is the third in a series of studies on the South African electrical equipment industry. The first study provides an overview of the industry, while the second study assesses technological changes.

The electrical equipment value chain sits within the broader "metals to machinery" value chain, but also includes other materials. The value chain, drawing from Robb (2023), spans: the extraction and processing of raw materials, including metal ores for a variety of sub-products, and coal for energy and feedstock in the production of polymers for insulation; the fabrication of components, such as castings and enclosures; assembly into integrated machinery, including generators, transformers, and cabling; end-use/operation of equipment; and end-of-life disposal.

South Africa is among the most carbon-intensive economies in the world, due to its reliance on fossil fuels for energy. In 2022, South Africa's emissions (excluding land use, land-use change and forestry, or LULUCF) were 478 888 Gigagrams (Gg) of carbon dioxide equivalent (CO_2e) (DFFE, 2024). Historically, around 40% of South Africa's emissions are attributed to the production of electricity (Eskom, n.d.).[1] Although South Africa's emissions are dwarfed by other large emitters, it remains high relative to the size of the population and economy (DFFE, 2021).

In addition to the environmental and climate change impact, South Africa's reliance on fossil fuels is problematic, as greenhouse gases (GHGs), both direct and indirect, present in domestic manufactures are set to make them increasingly uncompetitive. This is set to occur as global and domestic climate policies increasingly incentivise producers to internalise the societal costs of production, which could raise operating costs and limit production. There are various efforts underway, however, that aim to enhance sustainability in the South African economy. These include measures implemented by domestic and foreign governments, as well as efforts in the private sector.

This study commences with an assessment of negative environmental impacts across the electrical equipment value chain, in an attempt to identify problem areas.[2] The following section reviews both domestic and international policies that aim to stimulate a shift towards environmentally friendlier processes, and the risks posed to the industry. It also examines industry efforts to enhance sustainability, presenting options available in South Africa and exploring the costs and benefits associated with integrating sustainable processes into the electrical equipment value chain. The fourth, and final, section concludes the study.

2. CARBON INTENSITY OF THE ELECTRICAL EQUIPMENT VALUE CHAIN

This section of the study examines the environmental impacts associated with each stage of the electrical equipment value chain, in an effort to identify particular problem areas. The analysis focuses, predominantly, on the electrical equipment value chain as it is situated within the metals to machinery value chain, but also considers other materials used in electrical equipment. A range of materials are used throughout this value chain, each with distinct resource and environmental footprints.

[1] Including LULUCF, South Africa's emissions were 435 828 $GgCO_2e$ in 2022.

[2] Electrical equipment and the associated Standard Industrial Classification (SIC) codes, as defined in the 2023 Industry Overview, include: Insulated wire and cables (SIC 363); Electric motors, generators and transformers (SIC 361); Electricity distribution and control apparatus (SIC 362); Accumulators, primary cells and primary batteries (SIC 364); Electric lamps and lighting (SIC 365).

2.1. Upstream

A variety of raw materials are required in the electrical equipment manufacturing subsector, due to the integrated nature of electrical machines. For example, raw materials required for the manufacture of castings, enclosures, and structures include iron ore and chrome ore, among others (Robb, 2023). Lithium-ion batteries, on the other hand, need lithium, graphite, manganese, nickel, cobalt, and titanium, among other things (Montmasson-Clair, Moshikaro and Monaisa, 2021). Likewise, coils, windings, cables, and wiring need copper. The polymers used in insulation rely on coal, in the case of Sasol, as feedstock in a coal-to-liquids/petrochemicals process.

Although South Africa imports some raw materials, such as alumina, a significant proportion of others are mined. The mining industry is carbon-intensive, largely due to its reliance on Eskom's coal-fired electricity and fossil fuels for transport. According to a 2018 Council for Scientific and Industrial Research (CSIR) report, mining accounts for approximately 6% of South Africa's total GHG emissions (Motaung, 2023). Later estimates suggest that mining activity generates approximately 7 $MtCO_2$ (megatonnes of carbon dioxide) – roughly 2% of the country's gross emissions (Mandela Mining Precinct and RIIS, 2024). Despite the gradual adoption of renewable energy in mining operations, the sector remains reliant on fossil fuels, with 49% of energy demand furnished by oil products and coal and the remaining 51% by electricity (DMRE, 2024).[3]

In addition to emissions, mining activities generate other environmental externalities, including land degradation, soil and water contamination, biodiversity loss, and the release of particulate matter into the atmosphere. These contribute to local environmental degradation and have broader implications for human health and ecosystem services.

Smelting and refining raw materials, whether imported or domestically sourced, is also carbon-intensive due to the reliance on fossil fuel-based energy. Iron and steel production are highly carbon-intensive, with coal, electricity, and natural gas as their primary energy sources. Similarly, the production of non-ferrous metals, including aluminium, copper, and nickel, depends heavily on coal and electricity, further contributing to the sector's carbon footprint (DMRE, 2024).

Beyond metals, the production of chemicals for the manufacture of polymers, used in insulation and enclosures, also contributes to environmental degradation in the upstream phase of the electrical equipment value chain. Sasol's coal-to-liquids operation converts coal into synthetic fuels and petrochemicals, which are used to make polymers, such as those used in wire and cable insulation. These processes are highly emissions-intensive, as coal is used as both feedstock and energy source (Crompton, Young and Hahn, 2024).

2.2. Midstream and downstream: Fabrication and assembly

The midstream and downstream segments of South Africa's electrical equipment value chain cover the fabrication of intermediate components, such as castings, and enclosures, as well as the assembly of final products, including generators, transformers, and control units (Robb, 2023). Although these stages differ in the processing, they share overlapping sustainability challenges, particularly with emissions, waste, and hazardous substances.

Emissions in fabrication and assembly processes are largely Scope 2 in nature i.e., indirect emissions from energy-intensive processes/electricity consumption, as opposed to Scope 1 (under the control of the firm directly). The fabrication stage is particularly emissions-intensive, given the energy

[3] The GHG inventory does not specifically isolate mining activity emissions (in general) although it does carve out coal mining specifically.

required for heating, shaping, and cutting materials. However, downstream assembly also consumes significant energy, especially in plants assembling large equipment.

Material waste is another issue in both fabrication and assembly. Fabrication processes, which involve cutting, drilling, or shaping, produce metal off-cuts. Similarly, assembly processes generate wiring off-cuts and packaging waste. Even when recycled, material waste retains indirect emissions due to coal-fired electricity. When improperly handled, environmental risks include soil, air and water contamination, and harmful emissions (in the case of open burning).

Both stages also involve the use of hazardous chemicals and coatings. In fabrication, surface treatments can pollute water bodies and generate emissions if not managed appropriately. In assembly, substances that are necessary for durability and product safety, including adhesives and flame retardants, pose similar environmental risks.

2.3. End-use/operation

Certain types of equipment can contribute directly to Scope 1 emissions in the use-phase – for example, diesel generators, or switchgear through fugitive emissions of sulphur hexafluoride (SF_6). Other electrical equipment used in South Africa is indirectly associated with carbon emissions due to the country's reliance on coal-fired electricity, rather than the equipment itself being inherently high-emitting. Since over 70% of South Africa's electricity is generated from coal, the emissions intensity of electrical equipment in South Africa is largely a function of the electricity mix rather than the technology itself.

Fugitive emissions, particularly of SF_6, are problematic during the operational phase of certain electrical equipment. According to Eskom's 2021 Carbon Footprint Report, fugitive SF_6 emissions from switchgear accounted for over 94% of non-combustion emissions, primarily due to leaks and failures in gas-insulated switchgear and circuit breakers across both transmission and distribution networks (Eskom, 2022). Fugitive SF_6 emissions from Eskom have shown a notable degree of variation, from 73 904 tonnes of carbon dioxide equivalent (tCO_2e) in 2020, to 52 841 tCO_2e in 2021, then to 85 762 tCO_2e in 2023 (Eskom, 2025).

Low-efficiency motors exacerbate the carbon intensity of electricity generation. Approximately 70% of the 200 000 electric motors sold in South Africa, annually, are between the 0.75 kilowatt (kW) and 11 kW size range, with half of these having no stated energy rating, which implies the lowest levels of efficiency (South African Instrumentation and Control, 2024). The low efficiency motors contribute to carbon emissions as they necessitate burning relatively more fossil fuels than in the case of motors with greater efficiency levels (South African Instrumentation & Control, 2024).

2.4. End-of-life disposal

At the end of their useful life, electrical equipment generates waste in the form of scrap metal (steel, aluminium, and copper), rubber and plastic, as well as electrical and electronic waste (e-waste), among other forms of waste.

As the South African scrap metal industry is well-established, the pollution resulting from this phase of the electrical equipment value chain is linked to the energy sources used in metals recycling as well as the emissions that result from domestic and international (export) transportation. In instances where scrap metals are not recycled or exported, but accumulate in landfills, environmental impacts include the leaching of harmful chemicals into the natural environment, and the associated health risks.

Polymer waste from the electrical equipment industry also contributes to environmental degradation in similar ways, particularly when poorly managed. Although South Africa's plastics recycling industry is not insignificant, even recycled plastics retain indirect emissions because South Africa's electricity remains largely coal-based.

Emissions specific to the industry, like SF_6 emissions, may also leak into the natural environment during the disposal phase of certain electrical equipment, such as switchgear.

3. POLICY LANDSCAPE AND SUSTAINABILITY RISKS

The policy landscape is characterised by mechanisms (domestic and international) that incentivise decarbonisation and increased energy efficiency, as well as regulatory frameworks that govern the use of materials, and end-of-life disposal. Considering the carbon intensity of the South African economy, the current policy landscape proves risky for South African entities. There are, however, various efforts aimed at enhancing sustainability in the industry. This section of the study delves more deeply into these aspects and also qualitatively assesses the costs and benefits associated with enhancing sustainability in the electrical equipment manufacturing subsector.

3.1. Border Carbon Adjustments

The global push for sustainability has led countries to implement measures aimed at preventing carbon leakage. These measures, known as Border Carbon Adjustments (BCAs), impose a charge on the CO_2e emissions embedded in imports, ensuring that imported products face a carbon price equivalent to that of the domestic market. At the forefront of these efforts is the European Union (EU) Carbon Border Adjustment Mechanism (CBAM), which seeks to align the carbon cost of imports with the price of carbon in the EU market. The EU CBAM is currently in its reporting phase, with the definitive regime set to begin in early 2026. In addition to the EU, countries such as the United Kingdom, Japan, and Canada are considering similar measures (Maimele, 2023).

As the majority of South Africa's exports of electrical equipment, in value terms, are destined for African markets, and considering that the EU CBAM does not cover electrical machinery (HS 85), the implementation of BCAs pose a small risk to the industry (Robb, 2023).[4] Failure to adapt, however, could see the industry ruled out of accessing markets with BCA measures in place, in future. Even where BCAs have not been explicitly implemented, the general shift toward greener products will render South African manufactures uncompetitive in global markets.

The EU has also taken a strong stance against SF_6, banning the gas from 2026. Under EU Regulation (EU) 2024/573, the phase-out of SF_6 will be done in stages, with a full ban on its use in new medium-voltage equipment up to 24 kilovolts (kV) taking effect from 1 January 2026. The regulation also outlines measures for managing existing SF_6-containing equipment to ensure safe handling and proper disposal (ABB, 2024). As noted, however, South Africa's electrical equipment exports to the EU are low, relative to other destinations, and entities based in South Africa have already begun using SF_6-free alternatives – detailed in Section 3.3. These regulations, therefore, are of minimal risk to the industry.

3.2. Domestic policy landscape

The relevant domestic policy environment is characterised by initiatives aimed at increasing the uptake of renewable energy in both the national grid and private entities; financial incentives aimed at reducing emissions; industry-specific initiatives to enhance efficiency of products; and regulations to manage products at their end-of-life stage.

[4] The EU CBAM does, however, cover steel and aluminium, which is present in electrical equipment.

Financial incentives include the carbon tax and the 12L Income Tax Allowance. The carbon tax levies a charge for every tonne of carbon dioxide equivalent emitted.[5] Within the context of the electrical equipment value chain, the carbon tax primarily targets operations that rely on the burning of fossil fuels, and those that are responsible for fugitive emissions.[6] The 12L Income Tax Allowance stimulates efficiency in electrical equipment by allowing qualifying taxpayers to claim a deduction for energy savings that result from activities adopted in operations (SARS, 2024). Both these measures indirectly stimulate sustainability, with the latter, potentially, also having implications for the specifications of manufactures.

In terms of policies applicable to the assembly phase of electrical equipment, in 2014, the Department of Environmental Affairs published regulations to phase out the use of polychlorinated biphenyls (PCBs), an insulating material used in transformers. Under the National Environmental Management Act No. 107 of 1998, these regulations stipulate that PCB material or PCB contaminated material may not be used after 2023, and that no person may have PCB materials, PCB contaminated material, or PCB waste (apart from disposed waste) after 2026 (Government of South Africa, 2014).

The Minimum Energy Performance Standards for electric motors is a policy that seeks to enhance sustainability in the use-phase of electrical equipment. Under the National Regulator for Compulsory Specifications Act No. 5 of 2008, the compulsory specifications for efficiency requirements for electric motors, which came into effect in mid-2025, requires that electric motors with a power rating between 0.75 kW and 375 kW, among other specifications, have an IE3 minimum efficiency rating (Government of South Africa, 2023; Government of South Africa, 2024; Odendaal, 2025). Likewise, as of 2024, general service lamps must achieve luminous efficacy of at least 90 lumens per watt (lm/W), rising to 105 lm/W in 2026 (Flash, n.d).

The Renewable Energy Independent Power Producer Procurement Programme (REIPPPP), together with recent reforms allowing for increased embedded generation, are other initiatives that will enhance sustainability in the use-phase and during assembly. Increased uptake of renewable electricity technology will reduce the indirect emissions associated with operating electrical equipment and can lower the indirect emissions in assembled products. In upstream processes, where renewable electricity replaces fossil-fuel-based electricity, indirect emissions may also be reduced, although direct fossil fuel emissions will only be affected if replaced or mitigated by renewables.

For the management of e-waste, the Extended Producer Responsibility (EPR) regulations require producers and importers to take responsibility for their products. These regulations, which came into effect in 2021, under the National Environmental Management: Waste Act No. 59 of 2008, ensure that producers are tied to organising and financing waste management systems (Government of South Africa, 2021; Petco, n.d.)

To manage scrap metal arising from the industry, South Africa has implemented various measures aimed at supporting domestic recycling, including the Preferential Price System and bans on scrap metal exports. While these efforts are commendable, it has been argued that more could be done for the recycling of copper (Slater, 2020).

3.3. Sustainability efforts in the industry

Efforts geared towards enhancing sustainability are also present across the electrical equipment value chain. In terms of the upstream segment, mining, smelting and refining operations in South Africa are

[5] Original Equipment Manufacturers only pay carbon tax directly if they operate emitting equipment that exceed tax thresholds. Eskom, however, is responsible for carbon tax on electricity generation.
[6] However, with a 2025 tax rate of R236/tCO_2e, and an expected 2026 rate of R308/tCO_2e, it is argued that South Africa's carbon tax remains too low to incentivise change (Montmasson-Clair and Patel, 2024; National Treasury, 2024).

increasing their uptake of renewable energy technology. While government is committed to decarbonising electricity generation, and individual manufacturers have integrated renewable energy technology, the contribution of renewables to South Africa's overall electricity mix, while growing, remains low.

With sustainability efforts pertaining to the use of electrical equipment, WEG supplies locally manufactured transformers that use ester oil as a coolant instead of conventional hydrocarbon-based oils (WEG, 2023). ACTOM, another South African electrical equipment manufacturer, also use ester oils in their transformers.

Also regarding the use-phase of electrical equipment, WEG supplies energy efficient electric motors to the South African market. In 2022, it was announced that Zest WEG (now WEG), commissioned an assembly line, in Johannesburg, for electric motors with efficiency ratings of IE3 and IE4 (Arnoldi, 2022). The efficiency gains offered by the motors translates into lower energy consumption and, hence, reduced costs and carbon emissions. It would also assist in preventing loadshedding, through fewer power losses.

In switchgears, Schneider Electric has developed a switchgear that uses pure air technology instead of SF_6. The Drakenstein Municipality in Paarl, Western Cape, is among the first to adopt Schneider Electric's SF_6-free RM AirSeT switchgear. The RM AirSeT switchgear also features remote monitoring, and predictive maintenance capabilities for enhanced efficiency and sustainability (South African Instrumentation & Control, 2023).

Since the publication of the EPR, large corporations have launched initiatives to curb South African e-waste. Dell Technologies, for example, has collaborated with the E-Waste Recycling Authority (ERA), and Waterfall City development partner, Attacq, in the setting up of an e-waste collection point in Johannesburg (IT Web, 2025). Likewise, major South African retailer, Pick n Pay, in collaboration with ERA and EWaste Africa, have set up e-waste collection bins at selected retail outlets (BizCommunity, 2024).

Mini mills that use scrap metal exemplify sustainability efforts in the upstream and disposal phases.

3.4. Costs and benefits associated with enhanced sustainability measures in the South African electrical equipment industry

Enhancing sustainability in South Africa's electrical equipment manufacturing subsector presents both costs and benefits across the value chain. As this industry results in negative environmental impacts across the value chain, addressing sustainability challenges would require investments in cleaner energy, materials efficiency, and waste management. While this implies increased costs in the short-run, it could lead to greater long-term benefits.

Considering the value-chain's reliance on fossil-fuel based energy, one of the major costs associated with improving sustainability is the capital investment required for decarbonisation. For example, shifting to renewables-powered mining, smelting, fabrication and assembly, and electrified transport, would involve substantial upfront costs. Similarly, implementing cleaner production techniques in the fabrication and assembly stages, such as energy-efficient machinery or alternative insulation materials, would require additional spending.

Regulatory compliance also imposes costs on manufacturers. Policies such as South Africa's carbon tax and the phasing out of hazardous substances, like PCBs, increase the financial burden on businesses. International regulations pose additional risks. While the immediate impact of the EU CBAM on South Africa's electrical equipment exports may be limited, failure to transition toward greener production could result in future trade restrictions and reduced export potential.

The benefits of enhancing sustainability are, however, also notable. Investing in cleaner production and energy efficiency can reduce long-term operating costs. In addition, the increased use of recycled materials can lower input costs and reduce environmental impacts.

Sustainability efforts also strengthen market competitiveness. As global demand shifts toward greener products, South African manufacturers that embrace low-carbon solutions will be better positioned to access high-value export markets. Furthermore, environmental and social benefits accompany sustainability improvements. Reducing emissions in mining, refining, and manufacturing helps decrease air pollution and mitigate health risks for workers and surrounding communities. Sustainable waste management, including enhanced e-waste recycling, can minimise environmental contamination and create new economic opportunities. Moreover, investments in cleaner technologies and circular economy models can stimulate job creation in industries such as renewable energy, and recycling.

4. CONCLUSION

South Africa's electrical equipment manufacturing subsector is carbon-intensive due to fossil fuel-based energy and emissions-heavy materials. Sustainability challenges span the value chain, from raw materials extraction to end-of-life disposal. While domestic and international policies pose risks, they also signal a shift towards greener manufacturing that South Africa must adapt to. While industry efforts, such as the deployment of renewable energy technology, and the use of SF_6-free switchgear, indicate progress, the value chain must accelerate decarbonisation, further adopt circular economy practices, and align with global trends, to enhance competitiveness and contribute to overall sustainability.

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