International Information and Engineering Technology Association
Advancing the World of Information and Engineering

International Journal of Sustainable Development and Planning
Vol. 20, No. 8, August, 2025, pp. 3493-3502
Journal homepage: http://iieta.org/journals/ijsdp

# A Global Assessment of Skills, Strategies, and Policy Frameworks for Sustainable Electric Vehicle Adoption in South Africa

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https://doi.org/10.18280/ijsdp.200829

**Received:** 23 June 2025
**Revised:** 1 August 2025
**Accepted:** 5 August 2025
**Available online:** 31 August 2025

***Keywords:***
*electric vehicles (EVs), global assessment, policy frameworks, strategies, skills development*

**ABSTRACT**

South Africa's automotive industry is a key pillar of its economy, contributing around 4.9% to gross domestic product and 27.6% to manufacturing output. However, the global shift from internal combustion engine vehicles to electric vehicles (EVs) presents both a challenge and an opportunity for the country considering the European Union proposed restriction on the importation of ICE vehicles, effective from year 2035, due to the urgent need to decarbonize the global economy in response to accelerating climate change and the need to preserve the ecosystem. Presently, EVs adoption in South Africa remains unexpectedly low, even as imported ones face a 7% higher tax than ICE vehicles, high upfront costs which make EVs unaffordable for most citizens, limited public fast-charging infrastructure and the country's vast geographical area which has led to range anxiety. This paper explores the current state of South Africa's EV landscape, identifies the key skills required for a just transition, and evaluates the strategic and policy frameworks necessary for developing a globally competitive EV industry. Drawing on recent studies, government documents, and automobile industry reports, the review offers analysis on how South Africa can build a resilient and inclusive EV ecosystem, as the country transits to electric mobility.

## 1. INTRODUCTION

Electric vehicles (EVs) are powered by electricity stored in batteries or fuel cells, using electric motors instead of internal combustion engines (ICE) [1]. EVs can be recharged via electrical outlets or charging stations, and offer a cleaner, more sustainable alternative to traditional fuel-powered vehicles. Key benefits include lower emissions, reduced operating costs, and a quieter, more refined driving experience [2-4]. While EVs may have higher upfront costs and limited driving range depending on the model, their adoption is expected to rise as global policies support low-emission transport [5].

Given its status as one of the continent's most industrialized economies, South Africa has a significant automotive sector, contributing about 4.9% to GDP and 27.6% to manufacturing output. However, the global shift toward EVs, driven by climate change goals and advancements in clean technology is putting pressure on traditional vehicle-producing countries like South Africa to adapt their manufacturing strategies, and to remain competitive [6]. South Africa exports about 63% of the vehicles it produces in the year 2022, making it highly vulnerable to global market shifts. Key export destinations, such as; the EU and UK, intend to phase out the sale of internal combustion engine vehicles by 2035, and are promoting EV adoption through incentives and shifting consumer preferences. This poses a huge risk to South Africa's current vehicle export profile. Given the automotive sector's long investment lead times and typical 5-7-year cycles, strategic investment decisions and actions must be made [6, 7]. Globally, the mobility manufacturing sector is experiencing one of the most significant transformations in history. Driven by the urgent need to decarbonize the global economy in response to accelerating climate change, both regulators and consumers are increasingly demanding for low or zero emission vehicles [7]. This shift encompasses a growing emphasis on EVs, alternative sustainable fuels, and hydrogen fuel-cell technologies [8].

Climate change is driving major economic shifts, even as industries and societies work to adapt and reduce its impacts. World over, the transport sector is a significant source of greenhouse gas emissions responsible for over one-third of total emissions, contributing to environmental degradation [9]. This underscores the pressing need to transition to cleaner and more sustainable modes of transport [10, 11].

In the last decade, electric mobility has emerged as a dynamic and rapidly evolving sector, motivated by advances in EV and battery technologies, improvements in charging infrastructure, and a rising focus on renewable energy [12, 13]. These developments have sparked growing interest from organizations seeking to optimize products and processes while reducing costs in this rapidly expanding industry [14]. In 2021, plug-in EVs accounted for 8.6% of global vehicle sales, while South Africa lagged significantly at just 0.1%. Boosting EV sales locally plays significant role for the survival and competitiveness of South Africa's vehicle manufacturing industry in the face of shifting global market trends [15]. Based on report from South African Automotive year 2022 Export Manual, the automotive industry plays a vibrant role in the national economy, contributing 4.3% to GDP out of which 2.4% emanated from manufacturing and 1.9% from vehicle retail. In 2021, vehicle and component exports reached R207.5 billion, accounting for 12.5% of the country's total exports and 17.3% of manufacturing output.

Interestingly, South Africa automobile exports to international markets are put at 152 and this supports 110,000 direct jobs in areas such as component production and vehicle assembly. With this ripple effect, the industry supports approximately 457,000 formal sector jobs [16]. However, to remain competitive globally, South Africa's mature automotive assembly industry must transition toward EV manufacturing in the coming years.

EV adoption in South Africa remains unexpectedly low, despite growing global momentum. Therefore, this paper aims to; examine the current state of South Africa's EV landscape, identify the key skills required for a just transition, and evaluate the strategic and policy frameworks needed to develop a globally competitive EV industry. Drawing on recent studies, government white paper, related documents, and industry reports, it provides an analysis of how South Africa can build a resilient and inclusive EV ecosystem, as it transitions to electric mobility.

### 1.1 EVs global outlook

The bullet graph in Figure 1 illustrates the global distribution of EV sales in between year 2010 to 2024, as reported by International Energy Agency. A vivid look at the data of EVs adoption in the year 2024 across major regions such as China, Europe, United States, and the rest of the world presents significant regional disparities in EV adoption. China remains the global leader in EV adoption, with approximately 11 million EVs sold in 2024, constituting about 60% of the global market. The EV growth rate is driven by vibrant government incentives, a huge domestic market, and innovative EV manufacturing capabilities. Europe follows with about 3 million EV sales, benefiting from stringent emissions regulations, subsidies, and widespread charging infrastructure. The United States contributed about 1.8 million EVs, supported by recent policy shifts, tax incentives, and Tesla's market dominance. The rest of the world, including countries in Latin America, Asia (excluding China), and Africa (excluding South Africa), collectively accounted for approximately 1.3 million EV sales [17]. BloombergNEF [18] has projected that by 2030, almost 60% of global passenger vehicle sales could be electric under aggressive policy scenarios, with two and three-wheelers electrifying even faster in emerging markets.

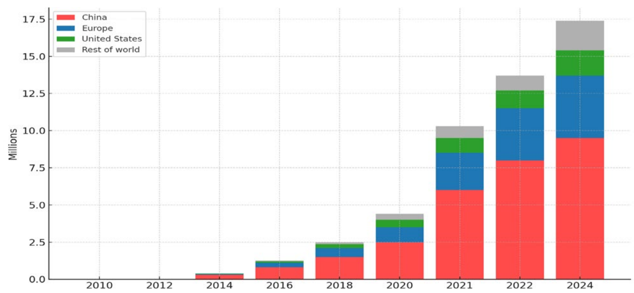


**Figure 1.** Global EVs stock by region, between 2010-2024 [17]

Conversely, South Africa, in spite of a growing interest in EVs, remains a minor player with an estimated 1,100 EVs sold in 2024. This represents only 0.0011 million units, a reflection of infrastructure challenges, limited policy support, and high vehicle costs when compare to internal combustion engine vehicles. The graph underscores the urgent need for emerging markets like South Africa to scale up EV adoption through policy reforms, public-private partnerships, investment in charging infrastructure and battery technology, to keep pace with global developmental trends.

## 2. LITERATURE REVIEW

The global transition toward sustainable transportation has placed EVs at the vanguard of policy, industrial, and environmental discourse. As nations are contending with the urgent need to minimize greenhouse gas emissions and overdependence on fossil fuels, the adoption of EVs has become a critical strategy in achieving low-carbon mobility. This literature review explores the evolving landscape of global EV adoption, examining the key drivers, challenges, and policy interventions influencing this shift.

Soares et al. [2] conducted an in-depth economic assessment of EV adoption in Brazil, highlighting the considerably lower operating costs of EVs compared to traditional vehicles, and proposed a strategic roadmap targeting key barriers such as policy frameworks, infrastructure expansion, and the promotion of biofuels and dual-fuel technologies. Das et al. [3] reported that EVs can lower $CO_2$ emissions by as much as 97% compared to petrol vehicles and 70% compared to diesel vehicles. The systematic review underscores the necessity of clean energy adoption and advanced battery technologies to ensure sustainable EV growth.

El-Iali et al. [4] presented a novel optimization approach for determining the optimal sizing of energy storage systems in plug-in fuel cell electric vehicles (PFCEVs), with the study focusing on the combined use of batteries, supercapacitors, and fuel cells to simultaneously reduce costs, $CO_2$ emissions, and the aging of components. Pennington et al. [9] gave a scoping review on health effects associated with the adoption EVs. The research findings indicated an overall positive impact on public health due to decreased air pollution, though a critical shortage of observational data quantifying these effects globally was identified, thus necessitating a call for further research into the environmental justice aspects of the EV transition.

Abdullah et al. [10] carried out assessment of long-term impact of hydrogen fuel cell vehicle (HFCV) deployment on GHG emissions across 15 G20 nations. The research findings indicated that in a high-adoption scenario, HFCVs could achieve up to a 67.09% reduction in annual emissions by 2050.

Delso-Vicente et al. [14] carried out a systematic review of literatures from 2008 to 2024 on electric and hybrid vehicles, focusing on technological advances in charging infrastructure and lithium batteries, integration with renewable energy, and related regulatory and environmental challenges.

Globally, advances in EVs are driven by certain factors. Galan and Zuñiga-Vicente [19] identified critical drivers of multi-stakeholder partnerships (MSPs) in advancing sustainable development goals within Spain's electric vehicle sector. The conceptual model presented underscores the essential roles of cooperation, trust, and commitment among stakeholders to address challenges related to charging infrastructure deployment. Arystanov et al. [20] analyzed the adoption of electric and hybrid vehicles as alternative transport solutions in Kazakhstan. The research identified critical challenges such as insufficient infrastructure and elevated costs, but also projects emission reductions of 20-40% by 2050 with widespread EV and hybrid deployment. Every change in technology comes with certain consequences.

Moreover, Adedeji [21] introduced a novel multivariable output neural network model designed to simulate plug-in hybrid electric vehicle (PHEV) fuel consumption. The model provided estimations which are essential for detailed performance analysis and regulatory impact assessments. Furtherance to this, the importance of battery technology and charging infrastructure motivated the work by Annamalai [22], and provided a comprehensive review of converter architectures and fast charging technologies for battery and plug-in hybrid electric vehicles. The study examined isolated and non-isolated converter configurations with a focus on advanced topologies, including bidirectional converters, and LLC resonant-switched converter that uses a resonant tank made up of a series inductor (L), a parallel magnetizing inductance (L), and a resonant capacitor (C), allowing soft-switching operation for high-efficiency power conversion.

On the other hand, Togun et al. [23] reviewed recent advances in fuel cell hybrid electric vehicles, highlighting improvements in energy management and powertrain technologies. The work examined challenges such as durability and system complexity, and outlining future research directions for enhancing fuel economy and performance.

Adedeji [24] presented a machine learning-based framework for modeling energy parameters in plug-in hybrid electric vehicles (PHEVs). Leveraging supervised learning algorithms, the model reportedly enhances prediction accuracy, offering a valuable tool for optimizing vehicle design and operational efficiency, while streamlining the development process.

In the area of materials needed to build EVs, Wazeer et al. [25] conducted an in-depth review of composite material applications in electric vehicles and the automotive sector. The work done emphasized the role of composites in reducing vehicle weight and enhancing energy efficiency, while discussing key technical challenges and future prospects for large-scale integration within automotive manufacturing. With respect to EVs adoption in South Africa, Showers and Raji [26] presented a review of the electric vehicle landscape in South Africa, examining the sector's current status, adoption barriers, and material constraints.

In summary, the global adoption of electric vehicles represents a multifaceted transformation driven by technological innovation, policy support, environmental imperatives, and shifting consumer preferences. While significant progress has been made, particularly in regions with vibrant regulatory frameworks and investment in charging infrastructure, several challenges remain, including high upfront costs, range anxiety, and disparities in adoption between developed and developing countries. The reviewed literatures underscore the need for continued collaboration among governments, industry stakeholders, and researchers to address these barriers and accelerate the transition towards a more sustainable and inclusive mobility future. As EV technology continues to evolve, its global impact will depend not only on innovation and technological advances but also on equitable access and strategic implementation across diverse socio-economic contexts.

While global trends in EV adoption show promising momentum, South Africa still faces unique challenges and opportunities in this transition. To better understand how these factors can be addressed, the following sections in this paper present review of the current state of EVs adoption, automotive masterplan and key policy interventions for EV adoption, skills for the just transition, strategic industrial planning that could support a more inclusive and accelerated EV transition, swot–policy impact matrix for EV adoption, investment opportunities in electric vehicle value chain, and stakeholder's roles, all within the South African context.

## 3. CURRENT STATE OF ELECTRIC VEHICLE INDUSTRY IN SOUTH AFRICA

South Africa's EV market remains in an early development stage. As of 2023, battery electric vehicles (BEVs) make up less than 0.05% of the country's total vehicle fleet. EV infrastructure, including charging stations, is still limited, and most available EVs are high-end imports, placing them out of reach for the majority of consumers. Domestic EV manufacturing is still minimal, though major automakers such as BMW and Ford have begun exploring future production possibilities within the country [27].

According to Lamprecht [28], South Africa's automotive industry is heavily dependent on exports to sustain local production. In 2022, 36.8% of the 351,785 vehicles produced were exported, generating R227.6 billion and accounting for 12.4% of the country's total export value. However, most of these exports were destined for international markets that plan to ban internal combustion engine vehicles by the 2030s. To retain access to these high-value markets and prevent the collapse of the local vehicle manufacturing sector which has supported over 116,000 formal jobs and contributes 4.9% to GDP, a transition to local EV production is essential [29].

### 3.1 Automotive masterplan and policy frameworks for EV adoption

Policy support and partnership is central to EV adoption. According to the IEA's stated policies scenario, based on current energy, climate, and industrial policies, every car used in the Europe by 2035 is expected to be electric. This projection has far-reaching implications for the global car fleet. There is general concession that electric vehicles provide significant benefits over conventional transportation, particularly in energy efficiency, emissions reduction, and environmental sustainability. In response to this, many developed countries have introduced strategic plans to advance EV technology [30].

The Department of Trade, Industry and Competition (DTIC) released a draft Green Paper in 2021, focusing on creating a roadmap for EV development. Key policy recommendations include; giving incentives for local EV production and exports, reduction in import duties and VAT for EVs, investment in charging infrastructure, establishment of public procurement programs to stimulate initial demand. The alignment of climate policy, industrial strategy, and energy policy is deemed crucial. Integrating EV goals into South Africa's Nationally Determined Contributions (NDCs) under the Paris Agreement can further expedite EVs adoption [31]. Additionally, the South African Automotive Masterplan

(SAAM) is centered on four key pillars; global competitiveness, industry transformation, sustainable development, and societal contribution. These components form the core of the Masterplan's vision, reflecting the country's aspiration to build a globally competitive automotive sector that is inclusive, environmentally sustainable, and socially impactful.

Furtherance to the above, the IEA has outlined several policy action plans for the effective transition from ICE to EV. Some of this policy actions include but not limited to policy actions to achieve the goal of supporting the transition of; EV automotive assembly, component and tooling manufacture. Other policy action plans include; facilitating the development of the battery value chain, developing and improving cost competitiveness, production, and technological capabilities, and policy actions to achieve the goal of skills development. To achieve all the outlined action plans, it is expedient for all stake-holders to show concerted efforts towards actualizing the outlined policy.

Meanwhile, the restriction on ICE vehicles by developed countries, and the European green new deal's goal of carbon neutrality by 2050, is set to intensify the demand for renewable energy use in industrial processes. These developments place strategic pressure on South Africa to transition its automotive sector toward electric vehicle (EV) production in order to safeguard critical export markets. In response, South Africa's Green Transport Strategy, which has been ratified by all provinces, aims to reduce greenhouse gas emissions from the transport sector by 5% by 2050 [32]. This alignment reflects a growing national commitment to sustainable mobility and deeper integration into the global shift toward cleaner transport systems. By embedding environmental targets within its transport policy framework, South Africa is positioning itself not only to meet domestic sustainability goals but also to remain competitive in an increasingly decarbonized global automotive market. However, it is noteworthy that if South Africa's automobile market were compelled to transition to new energy vehicle (NEV) consumption without any supportive incentives and consumers are forced to absorb the full cost differential, the domestic vehicle market would likely contract significantly. This would have severe repercussions for the national fiscus and for an automotive industry that remains a cornerstone of the country's manufacturing sector [33]. To prevent economic disruption, environmental stagnation, and deepening inequality, South Africa must adopt a just and inclusive approach to vehicle electrification that supports local industry, protects vulnerable consumers, and aligns with global climate commitments. A transition without strategic incentives risks not only undermining a key economic sector, but also missing a critical opportunity to build a more sustainable and equitable transport future.

### 3.2 Evaluation of South Africa's EV policy feasibility, timeline, and enforcement challenges

South Africa has taken notable steps in articulating a policy vision for electric vehicle (EV) transition, including through the Automotive Production and Development Programme (APDP 2), the Green Transport Strategy (2018-2050), and the draft Electric Vehicle Transition Framework [34]. However, a closer critical analysis reveals that these policy instruments, while strategically aligned with global decarbonization trends, face considerable feasibility, timeline, and enforcement challenges.

#### 3.2.1 Feasibility analysis

It is noteworthy that while EV policy intent is commendable, the actual feasibility of these frameworks remains questionable. Specifically, the proposed fiscal incentives to support EV imports and local assembly have yet to be finalized or implemented. According to GreenCape [35], South Africa's EV market share is still under 0.05%, indicating that policy instruments have not significantly impacted market behaviour. Moreover, the country's reliance on coal-based energy and ongoing energy supply instability creates systemic barriers to the effective implementation of a clean transport agenda [36]. Institutional fragmentation between national, provincial, and municipal governments also complicates coordinated policy execution [37].

#### 3.2.2 Timeline realism

Many of the policy targets set forth for 2030 or 2035 appear overly optimistic when contrasted with the country's infrastructural and fiscal realities. For instance, the Department of Trade, Industry and Competition's Automotive Masterplan 2035 outlined goals for expanding local vehicle manufacturing, including EVs [38]. However, progress on establishing a local EV supply chain, most especially for batteries and semiconductors, remains slow due to lack of investment, skills shortages, and limited research and development R&D capacity [39]. Without clear short- and medium-term milestones and deliverables, the likelihood of meeting these long-term targets is significantly diminished.

#### 3.2.3 Enforcement challenges

The biggest gap in South Africa's EV policy framework is the weak enforcement mechanism. Presently, most of the outlined policies lack binding regulations or enforceable mandates. Particularly, there are no penalties or incentives linked to original equipment manufacturer (OEM) compliance with EV localization thresholds. Similarly, the draft EV transition framework lacks statutory authority and is yet to be enacted into law [34]. This creates uncertainty for industry stakeholders and weakens the credibility of the state's EV transition plans. As noted by McKinsey and Company [40], consistent regulatory frameworks are essential to attract investment and drive industrial transformation. In the absence of such mechanisms, the policy risk remains aspirational rather than operational. The summary of major policy instruments and implementation risk is presented in Table 1.

**Table 1.** Summary of key policy instruments and implementation risks

| Policy Instrument | Feasibility | Timeline Realism | Enforcement Challenges | Sources |
|---|---|---|---|---|
| **EV Import Duty Reform (planned)** | Medium | Delayed / Uncertain | Requires inter-ministerial coordination | [34, 37] |
| **Draft EV Transition Framework** | Low | Pending finalization | Not yet legally binding; lacks regulatory grip | [34, 37] |
| **Charging Infrastructure Investment Framework** | Low–Medium | Unrealistic (given loadshedding) | No national rollout strategy or financing | [35, 36] |
| **Automotive Masterplan (APDP 2)** | Medium–High | Realistic by 2035 | Weak compliance tracking for OEMs | [38, 41] |
| **EV Skills Development (DHET/PCC)** | Medium | Slow implementation | Lack of industry-accredited curriculum | [42, 43] |

### 3.3 Strategic industrial planning for EVs transition

The transition to electric vehicle production marks a transformative phase for the automotive industry. Manufacturers will need to reconfigure production lines, invest in advanced technologies, and upskill their workforce to meet the present demands of electric mobility. This shift aligns with global sustainability trends and presents opportunities for innovation, job creation, and broader economic diversification within the country. South Africa is steering its automotive industry toward electric vehicles through the 2023 Electric Vehicles White Paper, aiming to retain its manufacturing leadership withing African continent while aligning with global sustainable development goals SDGs. Key policy measures include R1 billion in government funding and tax incentives to boost local EV and battery production, expected to attract R30 billion in private investment. The strategy is expected to promote public-private partnerships, as seen in Volkswagen's R4 billion plant upgrades, an indicator of ongoing industry confidence. It also prioritizes infrastructure development, particularly expanding EV charging networks [44]. However, to support the transition, extensive capacity training programs should be introduced for the purpose of equipping automobile workforce and the youth with the skills needed for jobs in EV manufacturing and related sectors.

Government Industrial Policy Action Plan (IPAP) acknowledges the growing significance of green industries. Nevertheless, a targeted focus on EVs is only beginning to take shape. To capitalize on this emerging sector, strategic initiatives should prioritize investment in EV component manufacturing such as; batteries and drivetrains, along with support for local research and development, startups, and innovation hubs [45]. To ensure successful implementation of proposed action plan, the South African government must focus on holistic execution of planned incentives, fostering collaboration with industry, investing in education, and periodic evaluation of progress made. With decisive actions, South Africa can become a key player and leader in the African EV landscape, balancing industrial growth with environmental responsibility.

### 3.4 Skills for the just transition and manufacturing job roles

The transition to electric vehicles demands significant skills development across five key areas. First, upskilling current workers is important for EV-specific tasks such as installing batteries, inverters, and electric motors, along with specialized aluminium welding. Second, tertiary education programmes must evolve to combine mechanical and electrical engineering, creating a new demand for electro-mechanical engineers. Third, ecosystem-wide training is essential, particularly for emergency responders who must safely manage EV accidents involving high-voltage components and intense battery fires [46]. Fourth, testing and certification infrastructure must be developed, especially for EV battery exports, which currently lack certification pathways for markets like the EU, UK, and US. Lastly, reskilling is necessary as BEV production is less labour-intensive than internal combustion engine (ICE) manufacturing, potentially reducing traditional assembly jobs. Notably, the shift to EVs will not only change the automobile landscape but it will also reshape the workforce requirements across the value chain [47].

According to IForest [47], a sub-assembly analysis of job roles in the manufacturing sector indicates that the total number of roles is expected to increase slightly with the shift to electric vehicles (EVs). New employment opportunities are expected to emerge in areas such as battery production and electric motor manufacturing. However, roles related to ICE components such as engine, fuel system, and exhaust assembly will decline as these parts are phased out in EV production, as indicated in Table 2.

**Table 2.** Comparative evaluation of job roles in ICE and EV ecosystem and impacts [47]

| Job Roles | ICE | EVs |
|---|---|---|
| Batteries | - | 37 |
| Body and Chassis | 89 | 88 |
| Design | 9 | 11 |
| Drive Line | 11 | 11 |
| Electronics and Control System | 5 | 8 |
| EV Motor | - | 7 |
| Engine | 31 | - |
| Fuel System and Exhaust | 9 | - |
| General Purpose Components and Assembly Line Jobs Roles | 33 | 32 |
| Machining Job Roles | 34 | 34 |
| Plant and Equipment Maintenance | 10 | 11 |
| Transmission | 12 | 12 |
| Total | 243 | 251 |

Sequel to the five key areas highlighted, a shift to EV production and maintenance requires a significant re-skilling of the workforce. Core competencies will include high-voltage electrical engineering, battery technology, embedded systems, software development, and sustainable manufacturing practices [48]. Universities and colleges must adapt their curricula to meet these needs. Moreover, skills in renewable energy integration and smart grid management will be vital, considering South Africa's power supply constraints.

Though the shift in skills required for the electric vehicle (EV) transition is expected to be gradual, however, immediate action is essential to avoid relying on imported skills, given South Africa's high unemployment rates. Proactive skills development will ensure that local workforce is equipped with relevant knowledge and are ready to meet future EV manufacturing and service demands. Similarly, strategic collaboration among industry, labour organization, government, and training institutions will be key to building the much needed, capable and future-ready workforce.

### 3.5 South African EV adoption challenges

As a result of global shift toward EVs, several developed nations are actively pursuing the transition from ICE vehicles to EVs as part of their climate strategies.

South Africa's EV adoption remains unexpectedly low. Several key barriers contribute to this: imported EVs face a 7% higher import tax than ICE Vehicles, high upfront costs make EVs unaffordable for most citizens [49], and the country's vast geography, combined with limited public fast-charging infrastructure, amplifies range anxiety [50]. Additionally, many existing fast chargers are underpowered within the range of 60–80 kW, compared to over 270kW charging capacity of newer EVs [51, 52]. This has further worsened concerns around charging convenience and efficiency [53]. Public charging infrastructure is crucial for expanding electric vehicle adoption anywhere in the world, particularly for users without access to private residential chargers [54]. Studies have shown a positive correlation between EV adoption and the density of public charging networks [55]. Beyond functionality, more visible charging infrastructure can also enhance public perception of EV viability. However, simply increasing the number of chargers is not enough [56]. The availability of fast chargers plays a critical role in reducing charging time and range anxiety which many prospective EV users have expressed, and this is one of the key barriers to EV uptake [57]. Addressing these issues is fundamental to improving EV adoption in South Africa and positioning the country in meeting up with anticipated EU ban on the importation of ICE vehicles. Fast chargers will effectively expand EVs usable range, making it more practical for longer trips. Therefore, expanding charging infrastructure, availability and accessibility of slow and fast charging locations is seen as part of strategies that governments and auto manufacturers could implement to boost the populace confidence, thus advancing EVs adoption.

### 3.6 SWOT–policy impact matrix for EV adoption in South Africa

A SWOT–policy impact matrix provides a structured approach to analysing South Africa's potential and preparedness for electric vehicle (EV) adoption. It highlights the country's internal capabilities and constraints while identifying external conditions that influence the effectiveness of outlined national policy frameworks. Among South Africa's most prominent strengths is its historically robust automotive manufacturing sector, which contributes over 5% to GDP and is supported by programs such as the Automotive Production and Development Programme (APDP 2) [38]. Based on available records, the country also holds significant reserves of critical minerals, such as manganese, vanadium, and platinum, that are essential for EV batteries and catalytic systems [39]. However, systemic weaknesses present substantial barriers. South Africa's power grid is unreliable, plagued by ceaseless loadshedding, which compromises efforts to build charging infrastructure and support EV operations [36]. Furthermore, technical skills required for EV component production, battery management, and high-voltage maintenance are lacking, with insufficient alignment between training institutions and industry needs [42, 43]. Many EV-related policies remain in draft form or lack enforcement mechanisms, limiting their practical impact [34, 37].

In spite of these challenges, significant opportunities exist. Green industrialisation linked to EV manufacturing could boost job creation and stimulate upstream value chains, most especially in the area of battery production and recycling [35]. Additionally, regional integration under the African Continental Free Trade Area (AfCFTA) also presents export potential for locally manufactured EVs [58]. Aligning EV adoption with renewable energy expansion offers long-term environmental and economic benefits for the world at large. Nonetheless, threats such as high upfront EV costs, limited consumer demand, fragmented governance, and slow policy rollout persist [40, 41]. A SWOT-informed policy approach can help prioritise interventions, allowing South Africa to balance industrial ambitions with socio-economic realities.

The structured SWOT analysis presented in Table 3 offers a data-informed foundation for identifying leverage points and guiding more coherent policy and industrial strategies. The SWOT-policy impact matrix is based on synthesis of sources including [35, 55, 59], and other relevant sources as listed.

**Table 3.** Swot-policy impact matrix for EV adoption in South Africa

| Factor / Policy Area | SWOT Category | Impact on EV Adoption | Impact on Local Jobs | Impact on Investment Attraction | Impact on Grid Readiness | Reference |
|---|---|---|---|---|---|---|
| Abundant renewable energy (solar & wind) | Strength | High | Medium | High | High | [55, 59] |
| Existing automotive industrial base | Strength | Medium | High | High | Low | [38, 41] |
| Weak charging infrastructure | Weakness | Low | Low | Medium | Medium | [35] |
| Skills gap in EV manufacturing & services | Weakness | Medium | Low | Medium | Low | [58, 59] |
| High upfront EV costs | Weakness | Low | Low | Low | Low | [55, 60] |
| Import duty relief for EVs | Opportunity | High | Medium | Medium | Low | [34, 61] |
| Charging infrastructure investment policy | Opportunity | High | Medium | High | High | [35, 55] |
| Youth-targeted skills development programs | Opportunity | Medium | High | Medium | Medium | [42, 43] |
| Local battery production incentives | Opportunity | Medium | High | High | Low | [39] |
| Load-shedding & unreliable grid | Threat | Low | Medium | Low | Very Low | [36, 59] |
| Global EV competition (e.g., China, EU) | Threat | Medium | Medium | Medium | Low | [40] |
| Policy delays or inconsistency | Threat | Low | Low | Low | Medium | [34, 37] |

### 3.7 Investment opportunities in South African EV value chain

South Africa's automotive industry plays a vital role in the country's economy. It contributes 30% to the country's total manufacturing output and 14% to overall exports. Valued at over R500 billion, the industry supports nearly one million jobs across skilled, semi-skilled, and unskilled categories. Its significance extends beyond employment, also making substantial contributions to GDP and the balance of payments

[62]. The EV manufacturing value chain presents several high-potential investment opportunities for South Africa, as outlined in Table 4. According to market intelligence report of GreenCape [62], each opportunity is aligned with a specific implementation timeline, reflecting current market readiness and projected consumer demand. Additionally, each job category associated with these opportunities has been rated for required skill levels on a scale from 1 (low skill) to 5 (high skill). Similarly, the level of industrial investment needed to establish or scale each opportunity is rated from 1 (low investment) to 5 (high investment). This structured approach helps to identify and prioritize feasible and high-impact interventions for developing a local EV industry.

Based on electric vehicle intelligence market report of GreenCape [62], investment opportunities in South Africa's electric vehicle (EV) value chain can be identified across several segments. These include: electric passenger vehicles with a projected market size of 21,900 units by 2030, valued at approximately R13.9 billion; electric buses, estimated at 420 units worth R2.9 billion; electrification of freight and logistics, with 828 vehicles valued at R1.18 billion; and totaling R1.2 billion. These opportunities are being driven by factors such as innovative financing models, improved cost competitiveness amid rising fuel prices, the introduction of more affordable EV models, reduced range anxiety, and national decarbonisation targets.

Despite the promising investment prospects within South Africa's EV value chain, several critical barriers may impede the attainment of projected targets. Key challenges include policy and regulatory uncertainty, the limited availability of affordable and context-appropriate EV models, and persistent electricity supply constraints. Addressing these issues require coordinated action by government, industry stakeholders, and policymakers to create an enabling environment that supports the widespread adoption and sustainability of electric mobility to enable the successful development of the EV value chain.

**Table 4.** Investment opportunities in the South African EV value chain [62]

| EV Market Segment | EV Value-Chain | Timeline | Skill-Level Required | Industrial Investment Level Required |
|---|---|---|---|---|
| Electric Passenger Vehicle | Assembly | Medium to long term | 4 | 4 |
| Electric kick-scooter | Assembly | Short term | 3 | 3 |
| Electric bicycle | Assembly | Short term | 3 | 3 |
| Electric moped | Assembly | Short term | 3 | 3 |
| Electric 3- wheeler | Assembly | Medium term | 4 | 4 |
| Electric mini-bus taxi | Assembly | Medium term | 4 | 4 |
| Electric bus | Assembly | Medium term | 4 | 4 |
| Electric truck | Assembly | Medium to long term | 4 | 4 |
| Battery pack | Component manufacturing | Short term | 4 | 4 |
| Battery cell | Component manufacturing | Long term | 5 | 5 |
| EV skateboard platform | Component manufacturing | Medium to long term | 5 | 5 |
| Automotive glass | Component manufacturing | Short term | 2 | 2 |
| Automotive plastic and composite materials | Component manufacturing | Short term | 2 | 2 |
| Semi-conductors | Component manufacturing | Medium to long term | 5 | 5 |

## 4. CONCLUSION

This study has examined the current state and policy landscape of electric vehicle (EV) adoption in South Africa, highlighting key enablers and limitations within the national industrial, infrastructural, and legislative context. While the country possesses notable strengths such as abundant renewable energy potential and a well-established automotive industry, however, the transition to EVs is hindered by weak legal frameworks, limited charging infrastructure, and high upfront costs. Policy implications point to the need for urgent legally binding frameworks, targeted fiscal incentives, and coherent industrial strategies that align with the South African Automotive Masterplan (SAAM 2035). Investment in skills development and localized manufacturing will be critical to ensuring a just transition that safeguards and creates employment.

Future studies should focus on developing and simulating a localized EV policy frameworks tailored to South Africa's energy, industrial, and transport sectors. Furthermore, empirical studies should be conducted to assess the specific technical and vocational skill deficits for EV manufacturing, maintenance, and infrastructure support. Conclusively, the economic impacts of various EV incentives, infrastructure investments, and public-private partnerships across different adoption scenarios should be evaluated.

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