Challenges, Opportunities, and Strategic Pathways for a Resilient Electric Vehicle Charging Infrastructure Development in South Africa

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Abstract: - South Africa's shift to electric vehicles (EVs) remains slow due to high vehicle costs, limited charging infrastructure, and weak policy support. The country has fewer than 400 public charging stations, mostly concentrated in urban areas. With coal still dominating electricity generation, the environmental benefits of EVs are limited. This paper reviews the current state of EV adoption in South Africa and compares it with countries such as Norway, China, and the United States. It identifies policy, infrastructure, and energy integration gaps and calls for a unified national strategy. The study proposes expanding fast-charging networks, encouraging renewable-powered charging, strengthening public–private partnerships, and introducing incentives to promote wider EV use across the country. The goal is to reduce range anxiety, cut emissions, and make EVs practical under local conditions.

Key-Words: - Electric vehicles, charging infrastructure, Renewable energy integration, Public charging network, Policy incentives, Grid resilience.

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1 Introduction

The global transport industry is undergoing a steady transition towards electric vehicles (EVs). This transition is not incidental, but it is largely driven by targeted climate policies, continuous technology innovations, and proactive government support, [1], [2]. Many countries now view EVs as a critical component of their effort to reduce dependence on fossil fuels and lower greenhouse gas emissions. In leading markets such as China, the European Union and the United States (US), measures including financial incentives for EV buyers, stricter emissions regulations, and the expansion of EV charging infrastructure have significantly increased EV adoption, [1], [3]. This has changed the way that households, firms, and public authorities plan for mobility, [1], [3].

A highly reliable dense EV charging infrastructure is critical for wider EV adoption, [4], [5], [6]. Potential EV buyers who want to transition from internal combustion engines (ICEs) consider the ease of finding an EV charger, the time required to charge their EVs, and the convenience of EV charging location as the fundamental factors in their decision, [6]. This is evident in countries that invested in dense EV charging infrastructure with well-located EV charging stations; they have experienced a significant increase in EV sales. This dense charging infrastructure creates an environment that reduces the range anxiety that many EV drivers fear, [7]. It makes EVs suitable for daily travel routines as EV user can either charge their EVs at home and/or top up at public EV charging stations [4]. Along the highways and in cities, installation of fast EV charging stations would enable smooth, longer road trips while home EV charging stations enable short daily trips to be hassle-free, [7], [8], [9]. In addition, expanding EV charging infrastructure cuts local air pollution, brings down total emissions, and makes it easier to use more renewable energy on the power grid, [1], [3].

EV charging infrastructure in South Africa still lags far behind what you see in leading markets such as Europe or China. The number of public EV chargers is very low and is concentrated in large metropolitan areas such as Johannesburg, Cape Town and Durban, [10], [11], [12], [13]. Small towns and rural areas hardly have any, which makes it difficult for EVs to be considered as a realistic choice for most people outside major metros, [10], [12],, [14]. However, several development efforts have been initiated. Some auto and energy entities have started to build EV charging networks. Several proposed government initiatives are focusing on the installation of EV charging stations in strategic locations, [14]. Companies such as GridCars and Eskom have set up some pilot projects to test EV ownership feasibility. However, South Africa's electricity power generation is still dominated by coal. Coal accounts for about 10.8% of the country's total greenhouse gas emissions. This limits the immediate emissions benefits of EVs, [15].

Only 0.9% of the new car sales in 2022 were EVs. The low EV adoption was mainly a result of the high import duties imposed on EVs, lack of incentives, and the nonexistence of a reliable EV charging infrastructure, [12], [16]. For EVs to become a practical option for many potential EV users, there is a need for a well-coordinated strategy. This strategy must focus on expanding the EV charging infrastructure, reducing EV ownership costs, and increasing the use of renewable energy for EV charging. A clear EV policy with targeted investments and incentives would be able to accelerate the transition to a cleaner and more sustainable transport system. The contributions of this paper are as follows:

a. To explore the current state of the transport sector and EV charging infrastructure in South Africa.
b. To assess the challenges and opportunities of developing a resilient EV charging network in South Africa, using international experience as a reference.
c. To propose policy measures, technical options, and strategic priorities that can close the existing infrastructure gap and support broader EV adoption.

2 The Current State of the Transportation Market in South Africa

South Africa's transport system is the pivot of the country's economy. It interconnects the movement of people and goods and provides a network that connects South Africa with its neighbouring countries and the rest of the world, [17]. The transportation system network spans approximately 750,000 km of roads, as well as railways, ports, and airports. It faces a number of significant challenges, characterized by ageing infrastructure, rising vehicle ownership costs and increasing environmental pressures, [17], [18]. Road transport is the dominant mode. First-time road vehicle registrations accounted for 73% in 2022. The total registered vehicles were approximately 13.3 million vehicles and nearly 8 million were passenger cars, 300,000 minibus taxis, 60,000 buses, and 3 million trucks, [19], [20], [21]. This translates to approximately 182 vehicles for every 1,000 people, and thus shows a significant reliance of the South African population on road travel. Table 1 (Appendix) presents the registered vehicle population by class and province for September 2022, [22], [23]. The table shows that motor cars and station wagons make up 65.5% of all self-propelled vehicles, with Gauteng, KwaZulu-Natal and the Western Cape holding the largest shares. Light commercial vehicles under 3,500 kg (LDVs, panel vans and other light load vehicles) represent a further 23%, reflecting the importance of small freight and service fleets in both urban and regional economies. Minibuses, buses and midibuses form a relatively small share of the total fleet in percentage terms, but they carry a disproportionately high share of passengers in practice. Motorcycles, quadcycles and tricycles, heavy trucks above 3,500 kg and other self-propelled vehicles account for the remaining portion of the 12.96 million vehicles recorded nationally.

Public transport provision has not kept pace with growing demand. The dominant modes of transport for most people are buses, minibus taxis and passenger trains. Minibuses account for about 70% of daily commuter trips, [19], [24]. Many low- and middle-income households depend on these taxis for access to jobs and essential services.

However, the services are frequently overcrowded and lack adequate safety standards and regulatory oversight.

The passenger rail mode of transport, which is managed by Passenger Rail Agency of South Africa (PRASA), still remains an important segment of the transportation system network. However, negligence, operational problems and infrastructure vandalism have weakened its recovery path to become a significant contributor in the transport system network. There was a 21% increase in passenger journeys recorded in late 2024, hinting at some recovery, but frequent vandalism, delays, and service interruptions keep eroding people's trust, [24].

Major cities have attempted to modernise their local public transport through different initiatives. For example, the rolling out of Bus Rapid Transit (BRT) systems like Rea Vaya in Johannesburg and MyCiTi in Cape Town, [25], [26]. These systems aim to provide faster and more reliable services on dedicated corridors and ensure affordability and accessibility for their users. The impact of such systems is still geographically and/or locally limited. BRT only covers selected corridors, and it has not changed overall travel behaviour in the big cities. Large segments of the urban population continue to depend on informal taxis and conventional buses.

The freight and logistics sector forms a second key pillar of the transport market. This sector enables the movement of goods within South Africa and beyond its borders, [27], [28], [29]. Road freight is the most dominant mode. The location of South Africa and its infrastructure position it as the Southern Africa cargo hub. The major ports such as Cape Town and Durban facilitate substantial import and export volumes and link South Africa to the global world, [28], [30]. All this movement leaves a significant environmental footprint. Heavy reliance on fossil fuels and an aging vehicle fleet mean transport is responsible for about 10.8% of the country's greenhouse gas emissions. This highlights the need for cleaner technologies and more efficient logistics practices in future planning, [30].

3 State of Electric Vehicle (EV) Adoption in South Africa: 2022-2024 Overview

The transport policy in South Africa has gradually shifted towards cutting emissions and moving away from fossil fuels. Electric vehicles (EVs) are an important option in this transition, but the adoption rate has been modest. The main problems have been the high purchase prices, sparse EV charging network, and continued reliance on coal-based electricity generation, which limits short-term environmental gains, [1], [14], [16], [28], [31], [32], [33]. The use of targeted incentives for EV buyers and greater investment in renewable energy, particularly solar, could strengthen the business case and reduce the carbon footprint of electric kilometres travelled, [32].

In 2022, EVs made up to 0.9% of the new car sales, [1], [16]. Despite the presence of a broad group of EVs on the road, the plug-in hybrids are still the dominant model on the road. In the same year, Mercedes-Benz built 2,577 plug-in hybrids for export and Toyota manufactured 2,711 conventional hybrids for local sales, [11], [16]. In 2023, plug-in hybrid vehicle sales rose to 4,050 units. The plug-in hybrid vehicle adoption rose to 47.1% on a year-on-year increase. This jump is a clear sign that more vehicle buyers are now considering electrified vehicle options as practical. Toyota's Corolla Cross hybrid made up about two-thirds of the hybrid market. All this shows that the local auto industry can build EVs and hybrids, but homegrown demand still is not big enough to take in large numbers. As a result, a significant share of production is directed to markets with stronger green‑vehicle incentives. Figure 1 presents the EV sales for South Africa versus those of other African countries in 2023, [34]. The hatchback passenger vehicle accounts for 67% of the total vehicles in the passenger car segment. This shows their fit for urban travel. Multi-purpose vehicles grew the fastest because of their appeal to families and businesses. The strength of the hybrid market suggests that these vehicles are acting as a bridge between internal combustion engine (ICE) vehicles and fully electric cars.

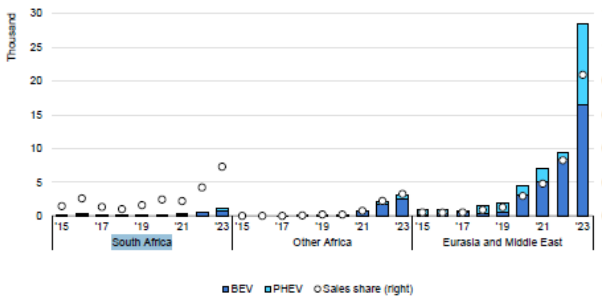

Fig. 1: Number of electric car sales in SA
Source: [32]

New energy vehicle (NEV) sales have started to grow more quickly. In the first quarter of 2024, the total number of NEV sales, including HEVs, PHEVs and battery electric vehicles (BEVs) were almost 40% higher than in the same period of 2023, [11], [35]. Hybrids led with 2,574 units sold. EVs reached 330 units while plug-in hybrids increased to 138 units, a commendable 452% year-on-year increase. The actual numbers are small; however, the pace of growth is strong and promising.

On the manufacturing side, BMW has proposed to build a plug-in hybrid X3 SUV for local distribution in the second half of 2024, [36]. This step signals a shift towards domestic production of electrified drivetrains. Supportive policies have also begun to be formulated and implemented. In 2023, the Department of Trade, Industry and Competition released a White Paper on local EV manufacturing and standardized charging infrastructure. It is backed by a reprioritised budget of R964 million for the automotive transition and a 150% investment allowance for qualifying EV investments from 2026, [14].

Model choice has also started to widen over time. In 2023, 18 EV brands and 31 hybrid models were available in the market. This constitutes premium brand cars like Mini Cooper SE, Volvo XC40 Recharge, Mercedes-Benz EQ series, Audi e-Tron, Jaguar I-Pace, BMW i Series and Porsche Taycan, [37]. This range has brought global EV technology into the local market, although mainly at higher prices. Figure 2 (Appendix) presents a 2023 EV sales breakdown by original equipment manufacturer [38]. The figure shows that EV models costing less than R1 million doubled in 2024. This development improved affordability and opened the market to a wider segment of middle-income buyers. On current projections, EV market share is expected to reach 5 – 7% by 2030. The main drivers are expanding model availability, gradual price reductions and growth in EV charging infrastructure, [10], [39].

Despite showing a gradual increase in adoption, key barriers still remain in place. Import duties of about 25% on fully built-up EVs, together with luxury taxes of 18 – 30% on vehicles priced above R600,000, still keep upfront prices high and limit broader adoption, [10], [39]. There is still a limited number of consumer incentives, and ongoing power supply problems affect the confidence of consumers in practical ownership of EVs, [10], [38], [39], [40]. Table 2 (Appendix) lists the main private passenger EVs available in South Africa in 2022, including driving range, retail price, and top speed, [37].

The table shows the presence of a range of varieties for EV users. EV users have options to choose from, the small compact city cars like Funky Electric and Eleska CityBug with a 100km range, to high-performance options like Porsche Taycan with a range of over 500km and a top speed of 260km/h. Several other models like Jaguar I-Pace and Volvo XC40 P6 Recharge also offer ranges well above 400 km. The short range of 100km is enough for most daily trips as well as short intercity trips on a single charge. The high range of above 400 km directly tackles EV driver range anxiety for long-distance trips, as many EV drivers fear running out of charge. The presented results show that the local market already delivers for short- and long-range, even though the overall EV sales are still relatively low.

4 Electric Vehicle Charging Infrastructure

The EV charging infrastructure is steadily growing, however, it is still the main constraint for broader EV adoption. The current layout works well for EV users in big cities. For long trips or large-scale use, it is still limited. The country has approximately 362 – 369 public charging stations, which is low when compared with the growing EV fleet and with international practice, [13]. In this context, access to charging is still viewed by many potential users as a risk factor rather than an enabler.

The EV-to-charger ratio underlines the scale of this constraint. The South Africa EV-to-charger ratio is still very high compared to the recommended International Energy Agency (IEA) ratio of 10 EVs per public charger [13], [40], [41], [42], [43], [44]. Leading markets like France, Germany, UK also struggle to achieve this recommended 10:1 guideline. In 2021, the European Union had an average of 14 EVs per public charger. China performed better and brought the figure down to 7:1, [43]. Public EV chargers in South Africa are still concentrated along main highways like N1 and N3 as well as in big main cities [13], [40], [41], [44], [45]. Smaller towns and rural areas still have little or no coverage, which limits the practical ownership of EVs outside the main cities.

However, there is a gradual improvement in the number of EV chargers being installed. The country now ranks in the global top tier for the proportion of EV fast chargers in its public EV charging network. This deliberate focus on fast EV chargers is aimed at reducing EV charging times. The EV charging network consists of both fast and slow EV chargers. For example, Rubicon manages 98 EV charging stations, which comprise 47 DC fast EV chargers and 51 AC slow EV chargers. Another entity, GridCars, has the largest number of EV chargers in South Africa, with approximately 280 EV charging stations. Approximately 85% of these include DC fast charging, with 150 kW ultra‑ fast chargers installed in partnership with Audi, [13], [40], [44]. Despite all these improvements, the total number of public EV charging stations remains low. The number of charging stations is approximately 362 – 369, which still gives the weakest ratio of public chargers to private passenger EVs among many advanced nations. The IEA's 2021 data, presented in Figure 3 show the contrast with the European Union and China.

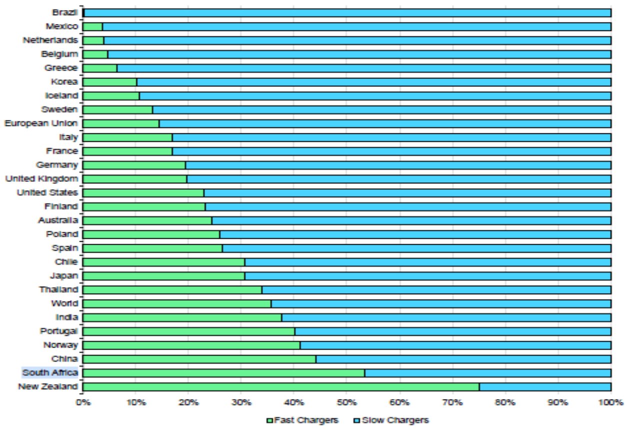

Fig. 2: Proportion of fast and slow public chargers in total public chargers
Source: [37]

Long-term planning currently taking place makes clear how much the EV charging network must grow. A joint report by Naamsa and the Department of Trade, Industry and Competition (DTIC) estimates that about 262,000 public EV charging stations will be needed by 2035 to provide complete national coverage, [14], [16]. Eskom has estimated the cost of replacing all conventional vehicles with EVs over 12 years at about R30 billion for EV charger installations. This figure could rise to around R90 billion if a strong emphasis is placed on solar-powered chargers. Figure 4 (Appendix) shows the forecasts of EV charging stations through 2030. The forecast assumes that both grid upgrade investments and smart charging technology are implemented concurrently.

A range of public, private and academic projects have been initiated and are all contributing to this expansion. These initiatives show a growing commitment to the adoption of EVs, renewable energy and transition to a more sustainable transport. Table 3 (Appendix) shows some of the different projects that are currently underway across these sectors.

South Africa is slowly diversifying its energy mix and making greater use of digital tools in the charging space. Apps such as ZimiCharge help drivers find EV charging stations and pay for their EV charging sessions. Some of these points are linked to solar PV systems at shopping malls and office parks. ZimiCharge plans to onboard 10,000 public EV chargers over three years, with a mix of AC and DC fast charging options, [57]. GridCars has incorporated its network with Google Maps to ensure that EV users can check the availability and location of EV chargers in real time. For many EV drivers, charging costs remain a big concern. Home charging usually costs about R3 – R4 per kWh. Public AC charging is around R5.88/kWh, while DC fast charging ranges from R7.00 to R8.12/kWh, [39], [46], [47]. Some providers offer reduced tariffs or free charging at selected sites. Installing a home charging unit typically costs between R9,000 and R24,000 for the equipment, with additional installation fees depending on the property, [39]. The presented figures and developments show both progress made and the size of the remaining gap in building a dense, reliable and user-friendly national charging network.

Despite all these activities to try to improve the EV adoption rate, there are still several challenges that need to be addressed. The EV charging network is still sparse in rural and semi‑ urban areas, so many potential buyers do not see EVs as a reliable option for their travel needs. High import costs for EVs, driven by taxes and tariffs, also weaken the case for EV adoption when compared with other developed markets, [10], [39]. In addition, South Africa's dependence on coal-based electricity raises valid questions about the net environmental benefits of EVs. The lack of tailpipe emissions is offset, at least in part, by emissions from a carbon-intensive grid.

5 Recommendations and Discussion

Different countries have varying rates of EV adoption. This variation is mainly driven by the different incentives available to EV users, government policy on EVs, the reliability of the charging infrastructure and the underlying market. Table 4 (Appendix) summarises the factors and challenges in selected countries and contrasts them with the situation in South Africa. Norway stands out as the most advanced case. It has adopted a variety of initiatives for its EV users. For example, EV users are exempted from VAT, import duties and road tolls, as well as access to free or discounted parking and bus lanes during traffic congestion. This has made the total cost of owning an EV much cheaper than owning a conventional ICE vehicle.

China leads the world in total EV sales. This position is supported by firm national mandates, generous subsidies and very large investments in EV charging networks. China's strength in battery manufacturing also lowers domestic EV costs, which reinforces demand. In the United States, there has been clear progress, but it is uneven. The state of California is at the forefront of other states and has adopted bold policies on EVs, which have resulted in significant investments in EV charging stations. The Federal tax credits have supported EV adoption across many US states. However, many of the developments are concentrated in big cities, while in rural and sparsely populated areas, there are still very few EV chargers available. On the other hand, Germany have focussed on reducing greenhouse gas emissions by ensuring that electricity for EV charging is generated using cleaner renewable energy sources. A range of EV buyer incentives and expansion of the fast EV charging network have also ensured a gradual, steady growth in EV adoption.

Within this framework, South Africa's EV adoption remains at an early stage. Economic constraints, high vehicle prices, limited EV charging infrastructure and relatively weak government support help to explain why EV adoption is much lower than in countries such as Norway and China. If South Africa is to close part of this gap, three elements will be essential. First, a stronger and more reliable EV charging network that serves both cities and key corridors. Second, implementation of financial incentives targeting the reduction of the cost of ownership of EVs for both households and fleet operators. Third, the introduction of a clear and stable policy framework that demonstrates a long-term commitment to faster and broader EV adoption. These measures can foster a more favourable environment necessary for an accelerated and equitable adoption of EVs. The following section looks at these elements in detail.

5.1 Expansion of EV Charging Stations

South Africa will not witness a substantial growth in EV adoption until a more extensive and intelligent EV charging network is developed. The current priority should focus on the installation of EV chargers in urban centres, along key transport corridors and in smaller towns and rural regions. While organisations such as Eskom, GridCars and other companies have initiated foundational efforts to establish the EV charging network, there is still no sufficiently large EV charging network to support broader EV adoption.

- ***Urban Focus:*** International experience shows the critical role that cities play in facilitating the early stages of EV adoption. In the Netherlands, urban cities such as Amsterdam, Rotterdam, and Utrecht have developed an extensive EV charging network that supports widespread EV use. EV charging stations are strategically located along residential as well as near commercial areas and public spaces, enabling residents without private parking to drive and charge their EVs. This approach has contributed to very high EV adoption rates. In the UK, especially in London, the big push has gone into curbside EV chargers and urban EV charging hubs. A combination of slow and fast EV chargers is deployed in these urban environment providing an effective solution for densely populated neighbourhoods where few people have garages or driveways. In comparison, Indian cities such as New Delhi, Bangalore and Mumbai are in the process of expanding their EV charging networks. However, the growth has been very slow, with most focus channelled to areas with the highest projected demand. Limited government support and planning capacity remain challenges. Japan's large cities, such as Tokyo and Osaka, place more emphasis on fast charging in residential buildings and public spaces. However, EV charging network growth has been slower than in Europe, mainly because incentives and public–private partnerships have been more modest.

  South Africa's urban EV charging network is still in its infancy compared with these examples. Companies such as GridCars are installing EV chargers at shopping centres, office parks and some residential developments, but there is no equivalent of the broad national or city-level support seen in Europe and the UK. Johannesburg, Cape Town, and Durban, in particular, need a lot more public EV chargers in shopping areas, business centres, and apartment complexes if they want to keep up with future demand. In practical terms, if people are going to see EVs as a realistic choice for daily life, the national and local governments need to team up with private companies and expand the EV charging networks.

- ***Rural and Highway Coverage:*** Long-distance trips and reaching smaller towns hinge on having EV charging stations on highways and in rural areas. This is another area where international practice offers valuable guidance. The Netherlands has many fast-charging sites along major routes. Operators such as Fastned and Shell Recharge have built high-power EV chargers at regular intervals so that drivers can move between cities without serious concerns about range. The UK has taken a similar approach. Networks like BP Pulse, Ionity, and Gridserve rolled out fast and ultra-fast EV chargers at motorway services, trying to keep EV drivers covered wherever they go.

  Japan’s highway charging network is also well served. CHAdeMO fast chargers are common at service areas and rest stops, enabling straightforward long‑ distance travel. South Africa is still far from this level. Several initiatives have been implemented, although the EV charging network remains fragmented compared to European or Japanese standards. Companies such as GridCars and other private operators have installed EV charging stations along main transport corridors. To enable the practical use of EVs for long-haul travel, tourism, or moving freight between cities or provinces, a significant expansion of fast EV chargers along highways and in rural regions is required. Ensuring reliable coverage across the national EV charging network is essential to build public confidence that EV drivers can travel long distances without having the risk of being stranded. Only through such assurance will EV be perceived as a practical option to ICE vehicles.

- ***Public and Private Partnerships:*** Public-private partnerships (PPPs) provide an effective way of distributing the financial risk and capital cost associated with the development of EV charging infrastructure. In the Netherlands, cooperation between the national and local governments and private sector entities such as Fastned, Allego and Shell has enabled the rapid extension of fast EV chargers along highways and within urban centres. Local governments also play a key role in planning, siting and management of EV chargers in residential neighbourhoods and public spaces. France has adopted a similar collaborative approach. The government partners with companies such as TotalEnergy and Ionity to increase the number of EV chargers in both cities and along highways. The government works with companies like TotalEnergies and Ionity to expand EV charging options, both in cities and along highways. This coordinated effort has resulted in broad national coverage and improved accessibility of EV charging stations throughout the country.

  In South Africa, PPP-type arrangements exist but are still emerging. Companies such as GridCars and Rubicon have partnered with automotive manufacturers such as Audi and Nissan to advance the deployment of EV charging infrastructure across South Africa. Companies such as GridCars and Rubicon have collaborated with automakers like Audi and Nissan. These companies also collaborate with property owners and government agencies to facilitate the installation of EV chargers nationwide. The government has shown real interest in working with renewable energy firms to bring off-grid solar EV charging stations to rural areas. For example, GridCars and Audi South Africa have already put fast EV chargers along major highways. Partnerships with companies like Zero Carbon Charge and retailers such as Woolworths also show how solar and wind power can become part of EV charging projects and tie into bigger green-energy goals.

  Compared to places like the Netherlands or France, South Africa’s PPP-based infrastructure is still at an early stage. The foundations exist, but the scale remains small. To achieve large-scale expansion of its EV charging infrastructure, South Africa needs more clearly defined policies and a standardised implementation framework that incorporates targeted financial and regulatory support mechanisms. Leveraging private sector investments and technical expertise will be essential. Integrating renewable energy solutions from the outset will further strengthen the sustainability and resilience of the EV charging infrastructure.

5.2 Renewable Energy-Powered Charging Solutions

The instability of South Africa's power grid, together with recurring load shedding, makes it difficult to support a large EV fleet using grid power alone. South Africa's EV charging strategy, therefore, needs to lean heavily on renewable energy, especially solar. Adding solar and, where possible, wind at EV charging sites will reduce reliance on Eskom and make EV charging more reliable, particularly in places far from major urban centres.

- ***Solar-Powered Charging:*** EV charging stations that are powered by solar energy sources have gained international acceptance as a sustainable component of modern transport infrastructure. In the Netherlands, for example, cities like Utrecht have installed solar canopies spanning over parking areas. The solar photovoltaic systems supply energy directly to the EV charging stations and any excess energy is stored in the battery storage units. The stored energy ensures continued operation during periods of limited sunlight and eases pressure on the power grid during peak hours. The approach aligns well with regional climate objectives and renewable energy targets.

  India offers another relevant point of comparison. In the National Solar Mission, solar EV charging stations are spreading fast, especially in rural or remote areas where power from the grid is scarce or simply not available. In these locations, solar-based systems provide a practical way to offer modern transport services without waiting for full grid reinforcement. South Africa is starting from a similar position in terms of resources. The country has abundant solar resources and faces persistent challenges with power grid reliability. Solar-powered EV charging stations, therefore presents an attractive practical solution. These systems can be implemented as off-grid and edge-of-grid locations where conventional infrastructure is limited or unreliable. This can boost local mobility, reduce greenhouse gas emissions and minimize the need for costly grid extension. Like India, South Africa is still at an early stage compared with European leaders such as the Netherlands, where solar EV charging is already well embedded in urban design. With its vast solar resource, South Africa has a real opportunity to lead in off-grid and hybrid solar EV charging, provided the right policies and business models take shape.

- ***Battery Storage Systems:*** Battery storage system is now an essential component of modern EV charging setups. These systems store extra energy from solar panels and release it when demand spikes or the power grid is constrained. They help flatten out local electricity loads, take pressure off the power grid, and increase the share of renewables in EV charging. In the US, battery storage with EV charging is increasing very quickly. Tesla's Powerwall and Powerpack, for example, are often installed alongside EV chargers to manage energy use, avoid big peak charges, and ensure supply reliability.

  The United Kingdom is following a similar path as EV numbers rise. Storage is used to protect local networks from overload and to support solar-powered EV charging stations that would otherwise impose large peaks on the power grid. Japan adopted a different approach to EV infrastructure development. It has deployed battery-backed EV charging stations that are able to maintain operations during emergencies. These systems ensure a continuous supply of energy for EV charging during critical situations. Similarly, India is piloting integrated solar and battery storage solutions in its rural areas where the power grid is weak or non-existent. The aim is to provide a continuous, steady EV charging service to a broader community.

  For South Africa, the integrated solar and battery storage solutions are not only beneficial but an essential requirement. Frequent blackouts and voltage fluctuations can undermine public confidence if EV charging stations shut down every time the power grid fails. Integrating solar-powered EV charging stations with battery storage systems enables continuous operation during loadshedding and other power supply disruptions. This strategy would enhance the practical EV ownership for daily use and mitigate concerns regarding power grid instability. Thus, integrating solar generation and battery storage in EV charging stations can help South Africa leverage its abundant renewable sources to develop a robust, clean and resilient EV charging network.

5.3 Standardization and Interoperability

A key challenge to the development of EV charging infrastructure is to ensure compatibility of all EV charging stations with the diverse range of EV models available in the market. To promote seamless operation across the EV charging network, South Africa must align its regulatory and technical frameworks with established international connector standards.

- ***Adherence to International Standards:*** One major requirement is that EV charging stations are compatible with the majority of the available EV models. South Africa needs to align with a clear set of EV charging standards, in particular those that are most common in leading markets such as CHAdeMO, CCS (Combined Charging System), and Type 2. This would ensure that manufacturers build EVs that can plug into almost all the available EV chargers without adapters, and also allow operators to invest with certainty. Most importantly, it will reduce the risk of EV drivers arriving at a charging station only to discover that their plug does not fit their EV – a frustration that kills trust in the technology. Countries that have standardized their EV charging systems early prove this approach works. Their EV charging networks serve all sorts of EVs right from the start, making the charging grid broader and more connected. South Africa can emulate what has worked in these leading markets as it finalizes its technical rules and codes.

- ***Interoperability Among Charging Networks:*** Another important element is the interoperability of EV charger stations. EV drivers should be able to use any public EV charging station, regardless of who owns it, without the need to use different cards, apps, or accounts. Other countries offer useful lessons. In the United States, the market developed with several competing networks, and only more recently have roaming agreements started to make it easier for users to move between them. The United Kingdom has adopted policy guidance to push networks towards app-based and card‑based solutions that work across providers. The Netherlands is a special example that can be used as a benchmark. The EV charging system operated by their company provides open access to public EV chargers through its extensive roaming network, which enables drivers to use any public EV charger with their app or card. South Africa needs to establish interoperability at present because the EV charging network infrastructure remains under development. The entry of new companies into the market will allow them to share platforms and establish roaming agreements, which will preserve system simplicity while stopping the entire EV charging system from becoming fragmented. The installation of EV charging facilities that allow EV drivers to pay for their use will increase their confidence in using EVs. South Africa can establish a complete EV charging system through the first stage by implementing the Netherlands' optimal practices.

5.4 Investment in Power Grid Resilience

The growing number of EV users will create increasing power requirements, which will become most pronounced during the evening hours. This makes power grid resilience absolutely central to any serious EV rollout.

- ***Smart Grid Implementation:*** Smart grid technology is one of the best tools for managing new loads in the power grid. Internationally, they are used to improve real‑time control, integrate renewables and keep power system networks stable as demand patterns change. In the United States, for example, utilities and private firms have used smart grid tools to run demand-response programmes, test vehicle-to-grid (V2G) schemes and apply dynamic tariffs that shift EV charging away from the most congested periods. Japan's smart grid agenda places more emphasis on efficiency and resilience. Its systems are designed to keep EV charging and other critical loads supplied even during emergencies.

  South Africa's smart grid activity has, up to now, focused mainly on stabilising a stressed power system network. Eskom is working to bring EV charging into its broader smart grid plans, with an emphasis on managing load growth and using more solar power where possible. Private operators such as GridCars are also exploring smart solutions, particularly for sites in remote or weak-grid areas. As EV adoption increases, there will be a stronger case for expanding these approaches. A more capable smart grid will allow better demand management, more flexible pricing and improved load balancing, all of which are essential to prevent local overloads at times of high EV charging demand.

- ***Energy Management Systems:*** Energy Management Systems (EMS) provide a complementary layer of control. Their role is to optimise *how*, *when* and *from where* EV chargers draw power. This often means encouraging or automating EV charging during off-peak hours or when solar and wind output is high. In the United States, advanced EMS are already in use at many grid-connected and off-grid EV charging sites. They provide real-time monitoring, adjust prices in response to system conditions and coordinate with smart grid platforms. In the European Union and the United Kingdom, EMS are used to integrate solar and wind into EV charging infrastructure and to limit peak demand. China uses EMS to manage large renewable capacities and to implement peak-shaving strategies at scale.

In South Africa, the push for EMS is closely tied to load shedding and the need to incorporate more solar energy. Eskom is developing EMS solutions that combine renewable generation, particularly solar PV, with EV charging, in order to spread load more evenly and keep EV chargers online under strained conditions. GridCars, as the largest public network operator, is also working on EMS-based approaches to optimise energy use at its EV charging stations and reduce pressure on the wider power grid. This focus on energy management is not optional; it is becoming a core requirement. South Africa will have to blend smart grids and energy management systems to keep both homes and EV chargers powered, even with existing strains on its power grid.

5.5 Focus on Fast-Charging Stations

Home and workplace AC chargers (Levels 1 and 2) are great for everyday EV charging, but they do not solve the issue of longer trips or reduce downtime. For EVs to really compete with conventional petrol and diesel cars, South Africa needs a visible EV charging network of DC fast chargers (Level 3) on main highways and in big cities.

- ***DC Fast Charging:*** The US and European markets have established extensive networks of DC Fast Charging stations, which China and India, along with other countries, are now implementing at a fast pace. Each region has chosen its own mix of locations and power levels exhibiting differences in urban form, income and EV penetration. The underlying logic is that drivers are far more likely to accept EVs if they can restore most of their range in a short stop. The message for South Africa is straightforward. The extended duration of EV charging operations, which occurs during long-distance travel between cities, makes some people hesitant to purchase electric vehicles. Major highways should have ultra-fast charging networks to solve the current problem of limited charging options. The installation of fast EV chargers, which provide complete battery recharge within 20 to 30 minutes, will reduce EV travel times to match the expectations of conventional petrol and diesel car drivers. The construction of this particular infrastructure will enhance the operational value of electric vehicles for South African motorists, while South Africa will reach the electric vehicle market standards of developed nations.

- ***Strategic Placement:*** The position of these EV chargers requires the same level of importance as their electrical output capacity. The countries that maintain the most effective EV charging systems develop their networks through strategic planning to establish EV charging stations that support efficient long-distance electric vehicle travel. Germany's "Deutschlandnetz" programme, for example, aims to install fast EV chargers roughly every 60 km along motorways, backed by city-level schemes that support urban sites. China has the world's largest EV charging network and ensures that fast EV chargers are available every 50 – 100 km on major expressways, with high densities in large cities. France's France Relance programme focuses on motorway service areas and large car parks, combining long-distance coverage with destination EV charging.

  South Africa should follow a similar corridor-based logic. The system needs to focus on essential transportation pathways, which include N1, N2 and N3 routes together with the essential routes that link Johannesburg to Cape Town and Durban and other essential urban centres. Fast EV chargers should be installed at highway rest stops, filling stations, busy shopping centres and other high-traffic nodes to ensure that EV drivers can incorporate EV charging in their travel patterns. The main focus for urban areas should concentrate on areas which attract both people who work and those who visit, such as shopping centres and business districts and crowded residential neighbourhoods. People can charge their EVs through this system, which operates without requiring them to modify their daily activities. The companies GridCars and Rubicon have started to install their fast EV charging stations throughout particular transportation routes and designated areas. The following step requires organizations to enhance their operations for EV charging network development, which should create a unified system instead of separate, disconnected elements. The installation of new fast EV charging stations at strategic locations will decrease driver anxiety about battery depletion while creating reliable transportation options for personal and business needs, which will promote EV ownership expansion.

5.6 Incentivizing Private Investment and Innovation

The pace of expansion of South Africa's EV charging network will largely depend on the level of private investment and the extent of technological innovation in the sector. Public resources alone will not be enough. The policy task is therefore to improve the economics of private projects and to create space for new business models in both hardware and payment systems.

- ***Tax Benefits:*** International experience shows that well-designed tax incentives can accelerate EV charger deployment. In the United States, the Alternative Fuel Infrastructure Tax Credit allows firms and individuals to claim up to 30% of the cost of an EV charging installation, capped at 100,000 US dollars per station, with the measure extended to 2032 under the Inflation Reduction Act. In addition, several states provide their own support. For example, the California Electric Vehicle Infrastructure Project (CALeVIP) provides rebates to California residents who want to purchase new EV charging stations. New York offers credits for workplace and apartment-building EV chargers. Germany allows businesses to deduct the cost of installing EV chargers and even gives subsidies covering up to 80% of installation costs. The UK's Workplace Charging Scheme pays up to 75% per EV charging socket (up to 350 British pounds). The "Super-Deduction" permits companies to deduct 130% of eligible installation expenses from taxable income and households can also access support under the EV Homecharge Scheme. Norway offers reduced VAT and rebates for both business and residential EV charging installations. It also does not treat free workplace EV charging as a taxable benefit, which encourages employers to provide this service.

  South Africa's EV market is still at an early stage, and current incentives are modest by comparison. Some provisions support solar-powered and other green EV charging infrastructure by allowing firms to claim tax deductions under existing renewable energy allowances. These measures help, but they do not yet match the scale or focus of incentives in high-adoption countries. South Africa needs improved fiscal instruments to achieve its target rate of development. The government should choose between two options, which offer businesses either tax credits or faster EV charging asset depreciation. The government should allocate more funds to support projects that link EV charging networks with renewable power systems and establish financial incentives for both residential and commercial EV charging installations. The international evidence suggests that such measures can make a material difference to investment decisions when designed with clear rules and predictable timelines.

- ***Innovation in Payment and Energy Systems***: Progress on payment and energy management systems is just as important as hardware rollout. In many advanced markets, EV charging has shifted from cash or card‑only models to integrated digital platforms. In the United States, networks such as ChargePoint and Electrify America use contactless cards, mobile apps, RFID tags and, increasingly, "Plug and Charge" technology based on ISO 15118, which allows vehicles to authenticate and pay automatically once plugged in. The United Kingdom now requires public EV chargers to support contactless payments, and services like Zap‑Map give users a single interface to locate EV chargers and manage billing across multiple networks. Germany is also rolling out Plug and Charge on major networks such as EnBW and Allego, reducing friction at the point of use. Norway combines a high density of EV chargers with user-friendly payment via apps and contactless systems across networks like Fortum and Grønn Kontakt. In China, mobile platforms such as Alipay and WeChat Pay are tightly integrated with public and private EV charging networks, while in India, digital wallets like Paytm and Google Pay, together with QR-code payments, are becoming standard at many sites.

  South Africa is still catching up in this area. The EV charging networks, such as the one owned by GridCars, already support app payments, RFID, and bank cards, but the system is still fragmented compared to those in leading markets. There is a real opportunity to build something simpler and more unified. Encouraging firms such as ZimiCharge to develop comprehensive applications that combine EV charger discovery, tariff information, booking and payment, which could simplify the experience for drivers and make public EV charging feel more reliable and predictable. The power grid, together with climate, will experience advantages from EV charging optimization because of future implementations that combine renewable energy with time-of-use pricing systems. The combination of better incentives with digital innovation support systems will decrease costs while enhancing operational efficiency, which will increase EV appeal to customers and obtain essential private funding for a successful transition.

5.7 Electrifying Public Transportation

Public transport electrification is the fastest way for South Africa to reduce emissions and clean up the city air. The climate benefits from electric drivetrain adoption become more significant when buses and taxis operate at high annual distances than when focusing on private car ownership.

- ***Electric Buses and Taxis:*** Electric buses and taxis operate as the primary clean transportation system, which multiple nations have adopted for their urban areas. China stands as the leading nation, as Shenzhen city has achieved a complete transition to electric buses for its public transportation system. It operates more than 16,000 electric buses supported by dense networks of fast-charging stations at depots and terminals. These depots use high‑capacity DC chargers, in some cases up to 250 kW, to turn vehicles around quickly between trips, and similar systems support large numbers of electric taxis in cities such as Beijing and Shanghai.

  South Africa is at a much earlier stage. There are promising initiatives such as Eskom's collaboration with Golden Arrow Bus Services and pilot electric minibus taxis from firms like Flx EV. However, the scale of deployment and the supporting EV charging infrastructure remain limited compared with China and leading European cities. Cape Town and Johannesburg have begun to test electric buses and taxis in regular service, yet dedicated fast-charging facilities for these fleets are still sparse. In contrast, Europe is already experimenting with on-route pantograph and inductive charging testing for its buses. Norway shows that these technologies can be integrated into day-to-day operations. South Africa needs to transition from its current pilot projects, which operate independently, to organized fleet programs that will provide EV charging facilities at both depot locations and throughout key transportation routes.

- ***Government Support for Fleet Electrification:*** The transition of international fleets depends heavily on government backing for their electrification process. The evaluation process uses Norway as its reference country for assessment purposes. Their electric buses and taxis benefit from exemptions from import taxes, cheaper tolls, free or discounted parking, grants, and low-interest loans for operators. The advantages of EVs are that it decreases both initial expenses and ongoing expenses, which makes them financially beneficial for electric vehicle fleets and enables Norway to achieve its position as a global leader in electric vehicle adoption.

  South Africa's policy framework is still in its infancy. The government talks more and more about the need for clean public transport and offers some incentives for renewables that support EV charging. However, there is little in the way of targeted subsidies or special financing for bus and taxi operators compared to what Norway or China offer. Funding EV charging infrastructure development and integration with existing operations remain major challenge. To accelerate progress, South Africa will need clearer and more substantial support for fleet electrification. This must cover vehicle acquisition, depot and on-route EV charging, and operational risk so that public transport companies and taxi organisations can plan long-term transitions with confidence.

6 Conclusion

Multiple national governments have started fast-paced programs to establish electric vehicles as their main transportation option. They are implementing this through three strategies include financial rewards and regulatory rules and substantial funding for electric vehicle charging facilities. The primary goals focus on lowering greenhouse gas emissions while they work to improve urban air quality standards. Leading markets such as Norway, Germany, China, the U.S and India are all building up their public and private EV charging networks, both in cities and along highways. This objective is achieved through working with business groups and dedication to establishing enduring policy stability. The countries now provide their EV systems with fast charging capabilities and interoperability, and electricity from low-carbon sources as their default features.

South Africa is moving in the same direction, but at a much slower pace. The current policy support and subsidy levels in our market remain significantly lower than what other major EV markets provide. The high prices of imported EVs, along with insufficient government funding and public doubts about power grid stability, make it difficult for people to purchase EVs. Most public EV charging stations are concentrated in a few big cities, with barely any on the major highways or out in rural areas. South Africa needs a national strategy that establishes particular goals to unite efforts between infrastructure development and regulatory frameworks and market development initiatives. The strategy demands fast EV charging facilities to start right away for building a network of EV charging stations, which will link major roads to extensive urban EV charging systems and rural town charging facilities through public-private sector partnerships. The implementation of renewable energy systems with storage capacity needs to become part of EV charging infrastructure while following international technical standards and developing smart grid and energy management systems. South Africa needs to implement these measures to manage increased electricity consumption while improving its power system, which depends heavily on coal generation. The implementation of electric public transportation and commercial fleet operations, together with information and skill development programs, will establish EVs as normal transportation options for society. South Africa will achieve three important goals by executing these measures, which is reduction in transportation emissions, improved urban air quality and enhance its energy stability. The establishment of a dependable policy framework that follows worldwide best practices yet fits the economic and power grid requirements of South Africa is a critical requirement. This would improve the country's position in the global EV value chain and help unlock wider social and economic benefits from the transition to electric mobility.

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Conflict of Interest

The authors have no conflicts of interest to declare.

APPENDIX

Table 1. The live registered vehicle population in SA by market segment

Vehicle Class	**GP**	**KZN**	**WC**	**EC**	**FS**	**MP**	**NW**	**L**	**NC**	**Total**	**% of Total Self-Propelled**
Motor cars and station wagons	3,247,469	1,077,438	1,343,611	493,119	331,445	464,210	351,222	380,406	137,532	7,826,452	65.5%
Minibuses	133,608	60,136	38,066	27,194	13,463	27,207	27,207	27,869	6,746	356,485	3%
Buses, bus trains, midibuses	20,608	8,190	4,746	3,447	4,746	4,090	7,105	1,994	1,994	65,329	0.6%
Motorcycles, quadcycles, tricycles	148,618	33,130	89,589	21,542	17,538	17,538	12,778	8,820	7,483	356,830	3%
LDVs, panel vans, other light load vehicles ≤3,500kg	892,302	387,386	349,563	213,082	137,280	232,462	164,512	252,574	84,223	2,713,384	23%
Trucks (heavy load vehicles >3,500kg)	147,582	53,518	47,593	24,014	24,561	43,976	18,176	28,001	9,461	395,372	3%
Other self-propelled vehicles	38,244	32,511	41,790	17,156	39,156	21,493	11,493	17,736	9,718	242,013	2%
Total self-propelled vehicles	4,628,431	1,652,309	1,917,188	799,853	563,220	821,369	594,467	722,511	257,157	12,956,465	100%
Provincial % of total	38.7%	13.8%	16.7%	6.7%	4.7%	6.9%	0,05	5.6%	0,02	100%	

Source: [22]

Table 2. Private passenger EVs currently available on the SA Market

OEM Brand	**Range**	**Price**	**Top Speed**
Funky Electric	100 km	R190,000	60 km/h
Eleksa CityBug	100 km	R230,000	55 km/h
MiniCooper SE	215 km	R694,600	150 km/h
Volvo XC40 P6 Recharge	423 km	R1,075,000	160 km/h
Mercedes-Benz EQA 250 Progressive	429 km	R1,169,500	160 km/h
BMW iX3 M Sport	460 km	R1,290,000	180 km/h
Audi e-tron 55 Quattro	440 km	R1,745,000	200 km/h
Jaguar I-Pace EV400 AWD S Black	470 km	R2,029,800	200 km/h
Porsche Taycan	573 km	R2,303,000	260 km/h

Source: [37]

Table 3. Pivotal projects across public, private and academic sectors

Project/Initiative	Description & Scope	References
Eskom's Pilot Charging Stations	Installation of 10 EV charging stations at five Eskom sites (Midrand, Brackenfell, Mkondeni, Tlhabane CNC, Marathon CNC) with DC fast chargers (60kW) and dual AC chargers (22kW). Part of the plan to electrify Eskom's fleet by 2040.	[46], [47]
Collaboration with Golden Arrow Bus Services	Partnership to convert 10% of Golden Arrow's bus fleet to electric by 2025. 120 BYD electric buses to be deployed, with 20 already operational and 100 more by the end of 2025. Annual procurement of 60 electric buses from 2023/2024.	[48]
Flx EV's Electric Minibus Taxi Field Testing	Introduction and field testing of South Africa's first electric minibus taxi (15-seater, 200+ km range) in partnership with local taxi associations. Includes charging hub solutions near taxi ranks for operational convenience.	[49]
MiPower's Electric Student Shuttle Bus	Launch of South Africa's first electric shuttle service in 2022, in partnership with the University of Johannesburg. Two electric buses were acquired for student transport, with plans to expand to 15 over five years.	[50]
ZimiCharge's App-Based Charging System	App-based payment and management system for EV charging, integrating with solar PV at malls and office parks to provide sustainable charging options. Plans to onboard 10,000 public chargers over three years.	[51]
GridCars' Charging Network Expansion	Largest private EV charging network in SA with 280 stations as of May 2023. Partnership with Audi SA to expand public charging infrastructure, focusing on DC fast charging.	[46], [47]
Rubicon's Charging Stations	Second-largest public EV charging network operator with 98 stations (47 DC fast, 51 AC slow, 4.7 MW total capacity). Distributor of Tesla Powerwall and other energy products.	[52]
Zero Carbon Charge's Renewable-Powered EV Network	Nationwide network of 120 off-grid, solar/wind-powered ultra-fast truck charging sites and 120 passenger vehicle charging stations. Modular battery packs for trucks enable charging in under 20 minutes.	[53]
Fleet Electrification by Woolworths, Takealot, and FedEx	Major companies are transitioning delivery fleets to EVs. FedEx introduced its first 10 EVs in June 2023; Uber targets a full EV driver fleet by 2030.	[35]
Volvo's Electric Trucks	Launch of Volvo's electric truck range in South Africa in July 2023, advancing heavy-duty EV adoption.	[54]
Shoprite's Electric Truck Pilot	Piloting a heavy-duty electric truck in a logistics fleet since 2022, in partnership with Scania Euro 5 trucks, as part of sustainability efforts.	[55]
Stellenbosch University & Rham Equipment's Electric Minibus Retrofit	Collaboration to retrofit a traditional minibus taxi with an electric drivetrain, demonstrating EV technology adaptation in diverse sectors.	[56]

Source: created by authors

Table 4. Key aspects of electric vehicle (EV) adoption in different countries compared to South Africa

Country	EV Adoption Rate	Focus Areas	Drivers of EV Adoption	Government Support & Policies	Key Challenges	References
South Africa	0.9% of local car market in 2022; ~1.45% in 2023; rapid growth in 2024	Public transportation electrification, renewable energy integration, and fast-charging networks	Environmental concerns, reducing oil dependence, mitigating power grid stress, and job creation in green sectors	Limited incentives, pilot projects by Eskom and private entities, support for charging infrastructure, and tax relief on electric buses	Grid reliability, high EV costs, and limited charging infrastructure	[12], [58], [59], [60]
Norway	>80% of new car sales are EVs (2024); BEVs ~90% of sales	Full EV transition, zero-emission vehicles by 2025	Strong environmental policies, consumer incentives, and low taxes for EVs	Tax exemptions, free toll roads, free parking for EVs, strong infrastructure investment, rebates	Limited availability of EVs due to high demand	[43], [59], [61], [62], [63]
China	~25% of new car sales in 2023; 50%+ in 2024; 66% of global EV	Mass EV production, battery technology, and urban pollution reduction	Government-driven industrial policy, massive EV production incentives, and	Subsidies for EV manufacturers and consumers, aggressive EV infrastructure	Managing grid load, battery recycling, and air quality concerns	[12], [58], [61], [62], [63]

Country	**EV Adoption Rate**	**Focus Areas**	**Drivers of EV Adoption**	**Government Support & Policies**	**Key Challenges**	**References**
	sales in 2024		technological leadership in battery manufacturing	rollout, and national EV mandates		
United States	~7% of new car sales (2023)	Growth in private sector-driven EV innovation, state-level initiatives	Tesla-driven innovation, reducing transportation emissions, and energy independence	Federal tax credits for EV buyers, state incentives (e.g., California's Zero Emission Vehicle program), and EV infrastructure grants	Inconsistent state policies, charging infrastructure gaps	[12], [58], [64]
Germany	14.6% of new car sales in 2023	EV production leadership, green energy transition	Strong automotive industry transitioning to EVs, European Green Deal commitments	Subsidies for EV buyers, stringent CO2 emission reduction targets, and investment in charging infrastructure	Dependency on fossil fuels, public acceptance, and high EV costs	[12], [58], [65]
Netherlands	30% of new car sales	Urban sustainability, cycling integration with EVs	Climate goals, focus on urban air quality, encouraging low-emission zones	Extensive EV incentives, free charging stations in urban areas, tax deductions for EV owners, and subsidies for EV infrastructure	Limited charging in rural areas, grid capacity concerns	[12], [58], [66]
United Kingdom	25% of new car sales	EV market growth, commitment to ban fossil fuel vehicles	Climate targets, reducing oil dependence, and air pollution in urban centers	Ban on sales of new petrol and diesel cars by 2035, subsidies for EV buyers, funding for charging networks, promotion of EV fleets	High EV purchase cost, charging infrastructure rollout pace	[12], [58], [67]
India	2% of new car sales	Focus on two-wheelers and public transportation	Reducing oil imports, pollution control in large cities, and promoting local manufacturing	National EV policies for public transport electrification, subsidies under the FAME (Faster Adoption and Manufacturing of Hybrid and EVs) program	Cost of EVs, charging infrastructure limitations, and battery supply	[12], [58], [68]
France	25% of new car sales	Urban EV adoption, transitioning from diesel vehicles	Carbon neutrality goals, European emissions targets, and promoting domestic EV production	Purchase incentives for EVs, tax breaks, diesel-to-electric vehicle transition plans, and investment in EV charging infrastructure	High cost of EVs, slow rural infrastructure deployment	[12], [58]
Japan	~2% of new car sales	Hybrid and EV development, hydrogen fuel cell vehicles	Technological innovation, reducing oil dependence, developing EV charging and hydrogen re-fuelling stations	Government incentives for EV buyers, strong support for hydrogen technology, and investment in both EV and hybrid technologies	High EV costs, limited fast-charging networks	[12], [58]

Source: created by authors

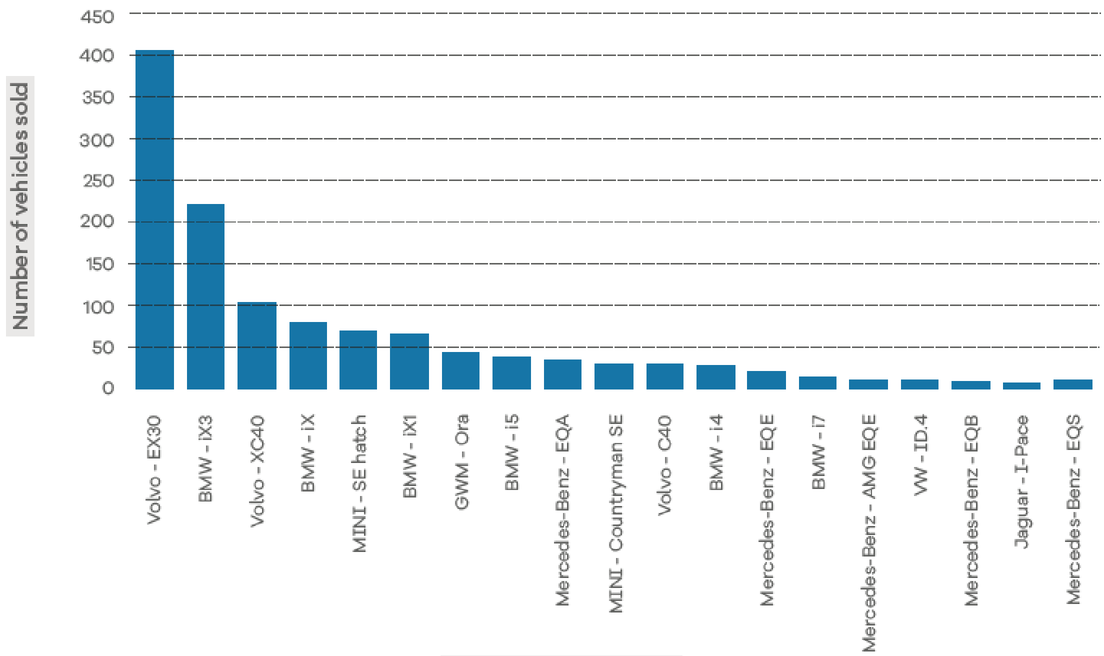

Fig. 3: EV sales in SA in 2023 by OEM brand
Source: [38]

Fig. 4: Number of charging stations in SA
Source: [38]