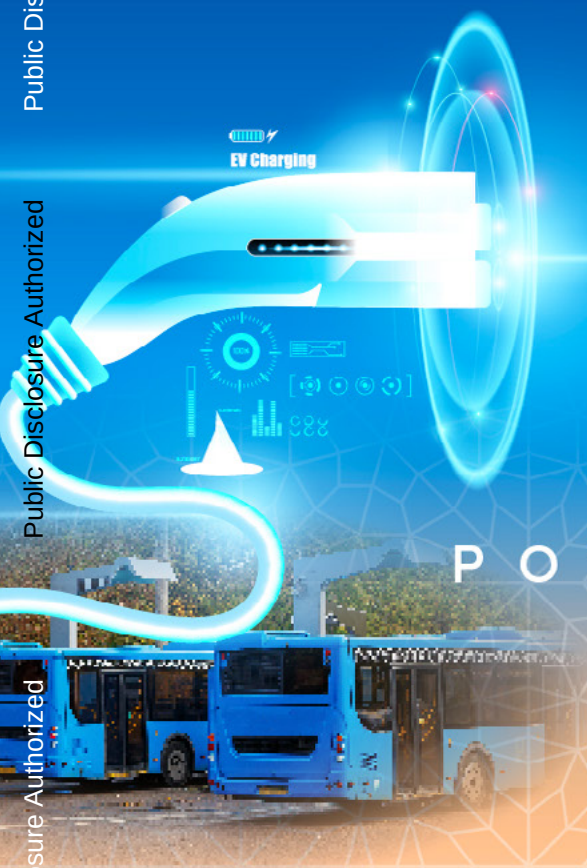

UNLOCKING ELECTRIC MOBILITY

POTENTIAL IN MENA

Executive Summary – Morocco

WORLD BANK GROUP
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Background and Motivation

The electrification of transport, popularly known as "electric mobility," is among the most promising emerging technologies at the nexus of the clean energy transition and sustainable transportation. Electric mobility (e-mobility) creates opportunities to mitigate climate change, enhance energy efficiency and the quality of transport services, and improve urban air quality while taking advantage of electricity grids across the Middle East and North Africa (MENA) region, which are evolving through the integration of greater shares of renewable resources, energy storage, and demand response technologies.

MENA countries are at different stages of deploying e-mobility across transport subsectors and the electrification of public transport remains particularly challenging, given the relatively high infrastructure investments needed. Supporting future e-mobility will require the large-scale deployment of infrastructure for charging electric vehicles (EVs) and potential upgrades to electricity generation, transport networks, and utility distribution grid infrastructure. This should include renewable energy where possible, along with addressing the need for new skills and jobs to cater to the growth of this industry. With appropriate interventions, e-mobility presents opportunities to transform both the energy and transport sectors, while also creating social, environmental, economic and employment opportunities.

The MENA region features a unique operational environment where dynamics related to the mobile cooling of vehicles also warrant sensible and strategic considerations. Experience in other regions suggests that meeting EVs' mobile cooling needs—which include mobile air-conditioning (MAC), transport refrigerated units (TRU), and cooling for batteries and power electronics—consumes considerable battery power. This consumption could result in the significant reduction of actual driving ranges, in comparison with designed driving ranges, particularly in summer seasons in warm-weather countries in the region. Thus, additional EV-charging infrastructure may be required, with considerable costs and other implications.

Electrification is one of the main ways to decarbonize the transport sector in Morocco, and e-mobility uptake could present opportunities to increase renewable energy-based electricity consumption. Morocco is the largest energy importer in the MENA region. In 2019, Morocco imported close to 90 percent of its total primary energy supply, according to the Moroccan Ministry of Energy. The new energy transition strategy (Conseil économique

2020) aims to limit Moroccan energy dependency by promoting renewable energy use and energy efficiency. Transport accounts for 38 percent of final energy consumption and contributes as much as 23 percent of greenhouse gas emissions in Morocco (AMEE 2021). Therefore, transport electrification is an important step to cut the reliance on fossil fuels within the Moroccan energy mix and curbing emissions. Morocco has ambitious goals, aiming to reduce its greenhouse gas emissions by 42 percent below business-as-usual levels by 2030. To do so, it plans to (1) provide 52 percent of the installed electric capacity from renewable energy sources (RES)—20 percent from solar energy, 20 percent from wind energy, and 12 percent from hydro energy by 2030; (2) develop combined cycle power plants running on imported natural gas in order to replace carbon-based (coal and oil) power plants by 2050; and (3) achieve 20 percent energy savings by 2030 compared to current trends. Figure ES.1 provides a snapshot of Morocco's energy sector.

FIGURE ES.1. • Snapshot of Morocco's Energy Sector

Source: Original compilation.

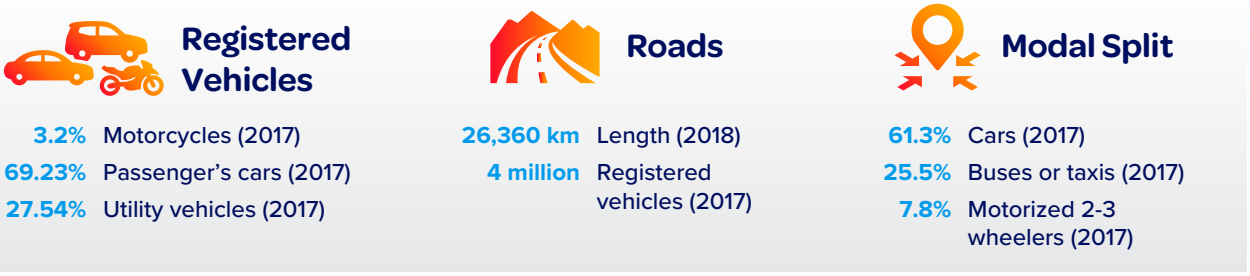
Country Overview

The Moroccan transport sector shows a high level of fragmentation. Figure ES.2 shows a summary of the available passenger transport services in Morocco. The focus of this report is on public buses, taxis, and to a more general extent private passenger transport. More than 4 million vehicles were driven on Moroccan roads in 2017 (over 1.5 million in Casablanca). Roughly 61.3 percent of all road trips are made by cars, 7.8 percent by motorbikes or bicycles, 25.5 percent by buses or taxis, and the remaining 5.4 percent on foot (Ministry of Transport, Bilan des activités). The modal share at the urban level is largely dominated by walking. The role of public transport remains insufficient, which leaves room for taxis and a rise in informal transport (regular vehicles transporting up to six passengers).

There are two main bus operators in Morocco:

- Alsa, a subsidiary of the UK's National Express Group and the largest private bus and coach operator in Spain, operates the bus networks in the cities of Marrakesh, Rabat, Casablanca, Khouribga, Tangier, and Agadir. At present, it has a total of 1,745 buses: 206 in Agadir; 257 in Marrakech; 192 in Tangier; 40 in Khouribga; 350 in Rabat; and 700 planned buses in Casablanca.
- Citybus Group is a national operator owned by

FIGURE ES.2. • Snapshot of Morocco's Transport Sector



Source: Original compilation.

Moroccan shareholders. It mainly operates the bus networks of Fes, Meknes, and Tetouan. It currently has a total of 511 buses: 252 in Fes; 169 in Meknes; and 90 in Tetouan.

In Morocco, taxis compensate for the insufficient supply of quality public transport. In Casablanca, for example, taxis represent a modal share of 10 percent, compared to 13 percent for public transport. There are two main types of taxis. The first group comprises taxi vans ("grands taxis") that transport up to six passengers, operate on fixed routes, and are essentially a substitute for public buses. Approximately 45,000 taxi vans were in circulation on Moroccan roads in 2020. The second group comprises smaller taxis ("petits taxis") carrying up to three passengers to their destination of choice within city limits.

Organization of Public Transport

At the strategic level, the Ministry of Interior, through the General Directorate for Local Authorities (Direction Générale des Collectivités Locales; DGCT) is responsible for the urban transport sector in Morocco. Through the recently created Directorate of Urban Transport and Mobility **(Direction de la Mobilité Urbaine et Transport; DMUT)**, it is responsible for: (1) defining the urban transport sector strategy as well as designing, implementing, and monitoring any specific central measures supporting the sector; and (2) providing support and overseeing the activities of the local authorities in the sector. Furthermore, it manages—jointly with the **Ministry of Economy, Finance and Administrative Reform (Ministère de l'Économie, des Finances et de la Réforme de l'Administration; MEFRA)**—the state's urban transport financing instrument through the Urban Transport Fund (FART), a specific committee existing within the Secretariat General of the Ministry of Interior, which is responsible for examining and approving financing demands submitted by local entities. FART finances mainly the initial investment in infrastructure and/or the rolling stock; the debt service of Sociétés de développement local (SDLs), and the operational deficit in the ramp-up period of a new service (generally for the first three years of operation). Recently, Bus Rapid Transit (BRT) preparation studies were also included in the financing offer of FART in order to enhance the quality of projects prepared by cities.

At the local level, two types of institutional setup for the provision of public transport are possible in the Moroccan context.

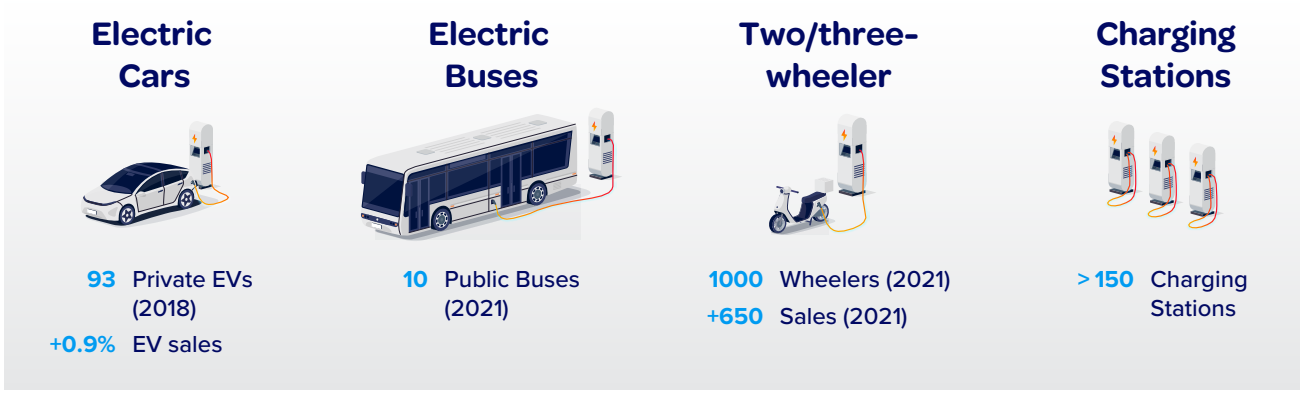
- With the first type, the SDL ensures public transport management functions (public service manager functions) that are contracted by local authorities (municipalities or intermunicipal entities) as well as the supervision of public transport operators. This type is implemented in Marrakesh and Agadir.
- With the second type, no SDL is created, and local authorities (municipalities or intermunicipal entities) directly ensure the management and supervision of public transport operators. This type is deployed in cities like Tangier and Fes.

Status Quo of E-Mobility in Morocco

Morocco is at a nascent stage of e-mobility deployment, with the majority of current stock being private consumer vehicles, mostly imported second-hand electric cars. Figure ES.3 shows key numbers related to e-mobility uptake. Ninety-three electric cars were listed in the market by late 2018. Since 2018, there were (and still are) 10 BRT e-buses in Morocco. There were more than 1,000 units for both hybrid vehicles and electric two-wheelers. And more than 150 charging points have been installed, 37 of which are located at gasoline stations on the Tangier–Agadir highway. The shift to EVs is driven by numerous interconnected forces, mainly government regulations and incentives as well as technological advances to overcome the challenges concerning availability of charging stations and related issues and ensure the number of EVs on the road continues to increase.

Sales of passenger EVs are still very low or nearly nonexistent. This low figure can be explained by various obstacles hindering market development, including political, economic, and technological factors, as highlighted in figure ES.4. Some of the major disadvantages of passenger EVs are (1) the price of e-vehicles, (2) the range, (3) the

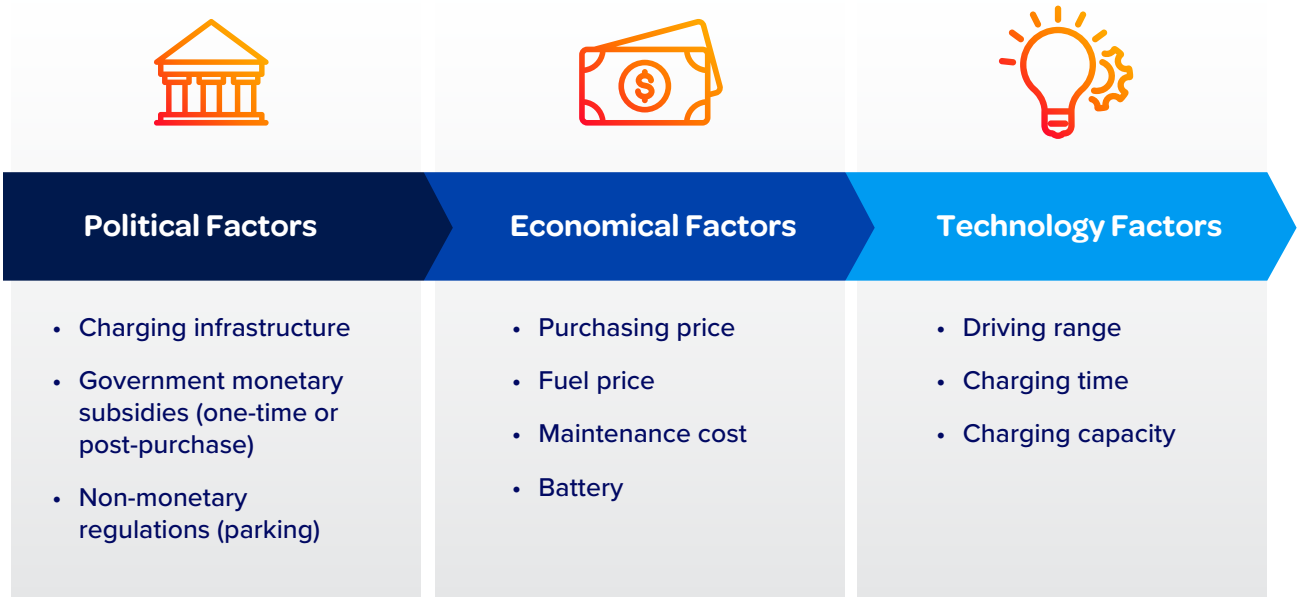
FIGURE ES.3. • Key Numbers Related to e-Mobility Uptake in Morocco



Source: Original compilation.

charging time, and (4) access to charging points. Currently, the rapid improvement witnessed in the development of the technologies may abate these disadvantages. In addition, policy incentives may be offered to compensate or eliminate some of these disadvantages.

FIGURE ES.4. • Factors affecting passenger electric vehicle market attractiveness



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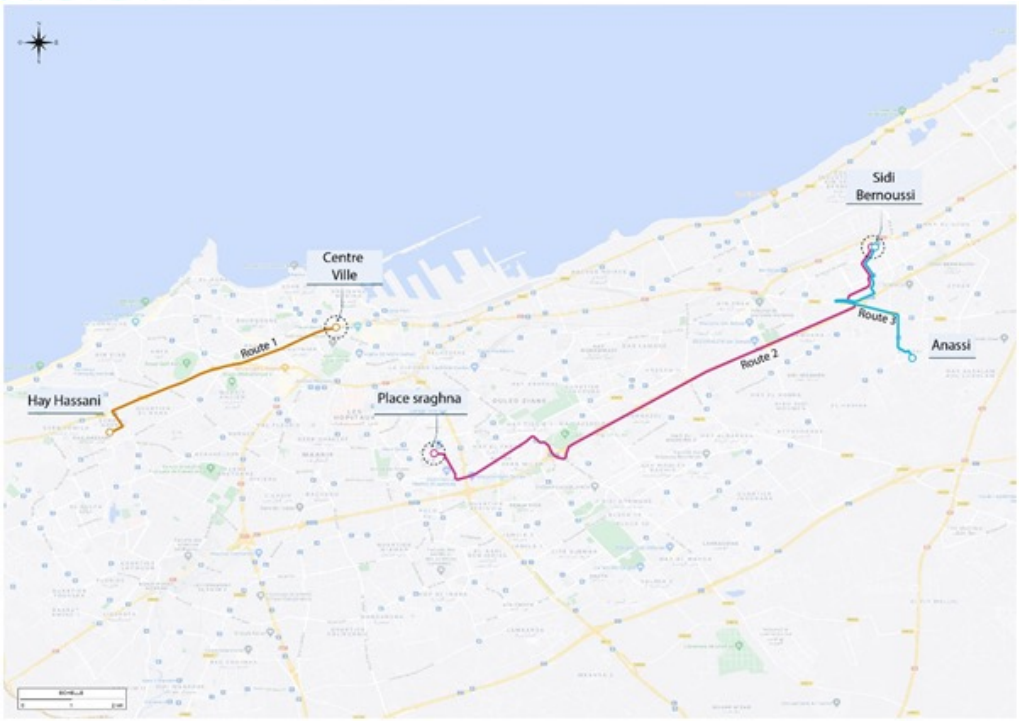
Technical Options for E-Mobility in Morocco

This assessment and scale-up analysis of Morocco focuses on regular buses (non-BRT in Rabat), taxi vans in Casablanca, and private passenger vehicles. The report takes advantage of several studies that are being conducted in parallel. Public buses in the capital, Rabat, and taxi vans represent a significant share of public transport and are understudied. Casablanca was chosen for the analysis of taxi vans, as it has the largest population, the biggest fleet, the greatest use of taxis, and a good stakeholder's organization and involvement in the decarbonization process. Figures ES.5 and ES.6 show the routes in Casablanca and Rabat that were studied.

FIGURE ES.5. • Selected Routes for Technical Analysis of E-Taxis in Casablanca



Source: Original compilation.

FIGURE ES.6. • Selected Routes for Technical Analysis of E-Buses in Rabat

Source: Original compilation.

Results from Energy and Charging Analysis

Public Buses

Based on the energy consumption of the buses on the selected routes, and information on their battery capacity, it can be seen which charging strategy is required (table ES.1).

Specifically:

- Routes 106/25/04 can be charged solely at the bus depot (overnight charging). The question that still remains is whether fast direct current (DC) charging is also required, since alternating current (AC) charging can be a candidate as well, if the total charging time is small.
- Route 33 requires a combination of overnight bus depot charging with opportunity charging (at end stops during operation). Our analysis concludes that this strategy is essential to cover the total energy demand of the entire bus trip on a daily basis, while accounting for cooling, auxiliary, and elevation energy requirements.

Depending on the total distance of the route, depot charging may be sufficient (as seen by analyzing route 106/25/04). But to serve longer routes (such as route 33), a combination of depot charging and opportunity charging is needed. In general, it is suggested that the maximum charging power possible for opportunity charging should be installed.

E-Taxis

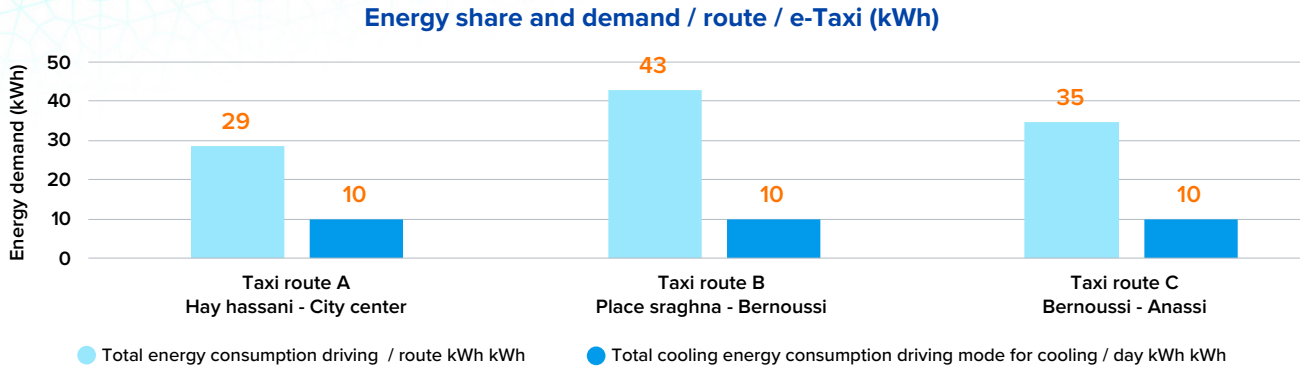
Since e-taxis are not parked in depots overnight, the necessary energy to charge the battery at the end of a day back to 100 percent SOC (state of charge) must be supplied (1) at the start/end of the day, (2) at private wall boxes overnight (to be installed at home), or (3) at public charging stations overnight. In general, it is suggested that the maximum charging power possible be installed at e-taxi charging locations. A minimum of 100 kilowatts (kW) is recommended. Less charging power (such as AC) will result in longer charging time and will thus significantly decrease the possible operational time (driving time) of the e-taxi. Figure ES.7 gives a sense of the energy consumed by e-taxis.

TABLE ES.1. • Share of Energy Demand Among E-Buses Along Different Routes

Route	Daily energy demand/bus (kWh)	Energy demand driving (kWh)	Energy demand cooling (kWh)	Energy demand auxiliary (kWh)
33	420	372	36	12
106	245	188	43	14
25	252	192	45	15
04	324	265	44	15

Source: Original compilation.

FIGURE ES.7. • E-Taxi Energy Consumption



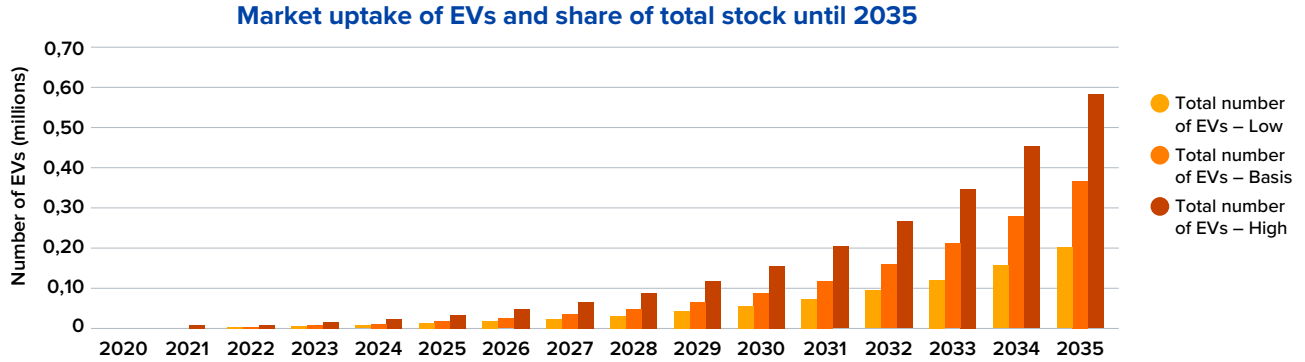
Source: Original compilation.

Smart (controlled) charging functionality (load shifting) implemented within the EV charging back-end application is necessary to be able to react to possible grid constraints (such as in transmission, distribution, or in the local grid) and energy demand and response commands (such as with integration in local energy management application). However, the chosen smart charging functionalities must be controlled and supported by the selected charging stations. In the initial phase, smart charging functionality is not required but needs to be foreseen in the longer term.

Ramp-up and Penetration Forecast of Private Passenger EVs

In Morocco, the total share of passenger EVs is expected to reach 7 percent of the total stock by 2035 (basis scenario), amounting to roughly 370,000 vehicles (figure ES.8). This figure is rather conservative, accounting for the current market dynamics and existing market share of EVs, which is less than 100 vehicles in total. For the high (aggressive expansion) scenario, the total share can reach 11.1 percent of the total stock (which is in line with the 10 percent strategic target set by the Research Institute for Solar Energy and New Energies (Institut de Recherche en Énergies Solaires Et Énergies Renouvelables; IRESEN) roadmap published in 2021).

FIGURE ES.8. • Forecasted Passenger EV Stock with Exponential Growth Expected starting 2030



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Results from Total Cost of Ownership Analysis

A switch to e-buses could be financially attractive for a Moroccan-based operator. By removing the dependence on imported fossil fuels, EVs logically appear to be a better-performing option, with total financial cost of ownership per kilometer estimated to be about 25 percent and 22 percent cheaper than diesel and diesel-hybrid vehicles, respectively. In economic terms, the case for e-buses is even stronger, with an economic total cost of ownership (TCO) reduced by 43 percent and 37 percent compared to internal combustion engine (ICE) alternatives.

However, there are additional non-quantified factors at play, such as the additional grid connection and reinforcement costs, the increased complexity of implementation, and the lower operational flexibility of e-buses (such as traveling where charging facilities are not available). In addition, operators in Morocco tend to have a short-term investment horizon and, given the fairly long operating period required for the expected savings from e-bus ownership to materialize, they may conservatively favor more traditional engine technologies unless additional incentives are offered.

From that perspective, an acceleration of the roll-out of e-buses may require government interventions, for instance, in the form of concessional financing being offered to operators, perhaps via support from development partners. These types of measures, if adopted, would help reduce the gap in financial costs in favor of e-buses for operators willing to experiment with newer technologies.

TABLE ES.2. • Morocco Financial TCO Comparison for E-Buses

Scenario	Diesel	Hybrid	Battery electric
Financial TCO per km results (USD/km)			
Base case fuel—Differential useful life	0.68	0.65	0.54
Base case fuel–Equal useful life	0.68	0.65	0.63
Higher fuel case–Differential useful life	0.76	0.71	0.54
Higher fuel case–Equal useful life	0.76	0.71	0.63

Source: Original compilation.

TABLE ES.3. • Morocco Economic TCO Comparison for E-Buses

Scenario	Diesel	Hybrid	Battery electric
Economic TCO per km results (USD/km)			
Base case fuel—Differential useful life	0.91	0.82	0.54
Base case fuel–Equal useful life	0.91	0.82	0.58
Higher fuel case–Differential useful life	1.03	0.92	0.54
Higher fuel case–Equal useful life	1.03	0.92	0.58

Source: Original compilation.

In the case of taxi vans (the grands taxis), the financial savings from the switch to electric are expected to be lower due to the unavailability of locally produced van-type EVs and the large difference in after-tax prices with locally manufactured ICE-powered vans. However, the fact that they operate on fixed routes, with established starting points and destinations and significant turnaround times during which they could recharge batteries, make them ideal candidates for pilot electrification projects.

The case for passenger taxis is slightly different. While the financial and economic numbers are much more compelling, the difficulty is that taxis operate all day and not on fixed routes. Therefore, a taxi business based on EVs is unlikely to be viable before a reliable fast-charging network is available. There may, however, be potential to start pilot e-taxi projects from specific locations like the airport, where taxis always come back to one single location where they wait for customers and where fast chargers could be installed.

Commercial Options for E-Mobility in Morocco

The general contractual structures of e-buses and e-taxis resulting from the analysis above are illustrated in figures ES.9 and ES.10.

Some cities in Morocco, like Rabat, for example, currently use the concessional model for bus operations. The roll-out of future e-buses can be done in the same manner. The government can launch tenders to recruit operators on a concession basis, while including the investment and public-private partnership (PPP) elements related to the financing and procurement of e-bus fleets and charging infrastructure assets.

This would be a PPP where the resulting asset function of the operator resembles, and may indeed be structured as, a private asset company or lease company. The concession or PPP contracts are recommended to include initial government subsidies refinanced on concessional terms so as to reduce the cost of capital applicable to the project.

The preferred option for accelerating an e-taxi transition in Morocco is to build on or extend the existing taxi renewal program through the FART fund supported by the creation of a charging network along taxi van routes through specific concession arrangements.

- Replicating the program that is already in place will likely produce a faster outcome.
- Charge points would be installed along the predefined routes through a concession on the basis of rate per kilowatt-hour (and may include a minimum revenue guarantee).
- To create the market or identify where the market is, the government could start an initiative to get taxi owners to express interest and intent to switch to e-taxis.

FIGURE ES.9. • Contractual Structures for E-Buses

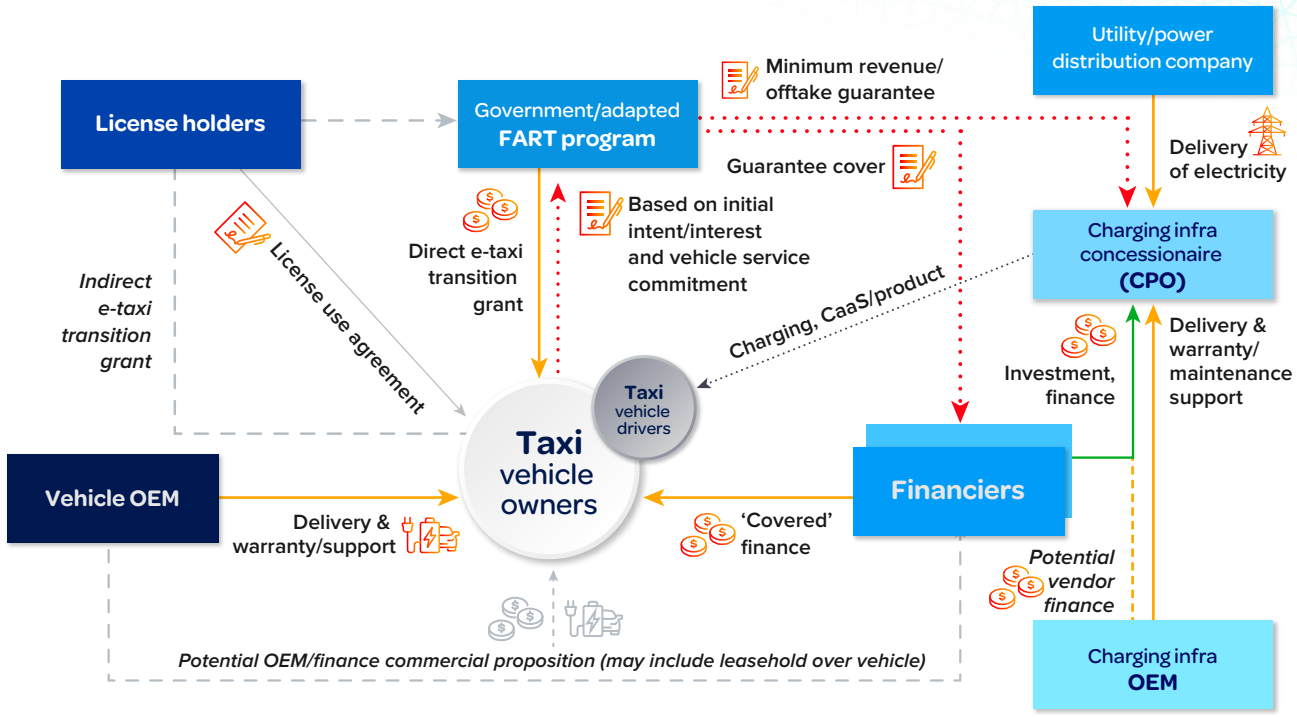

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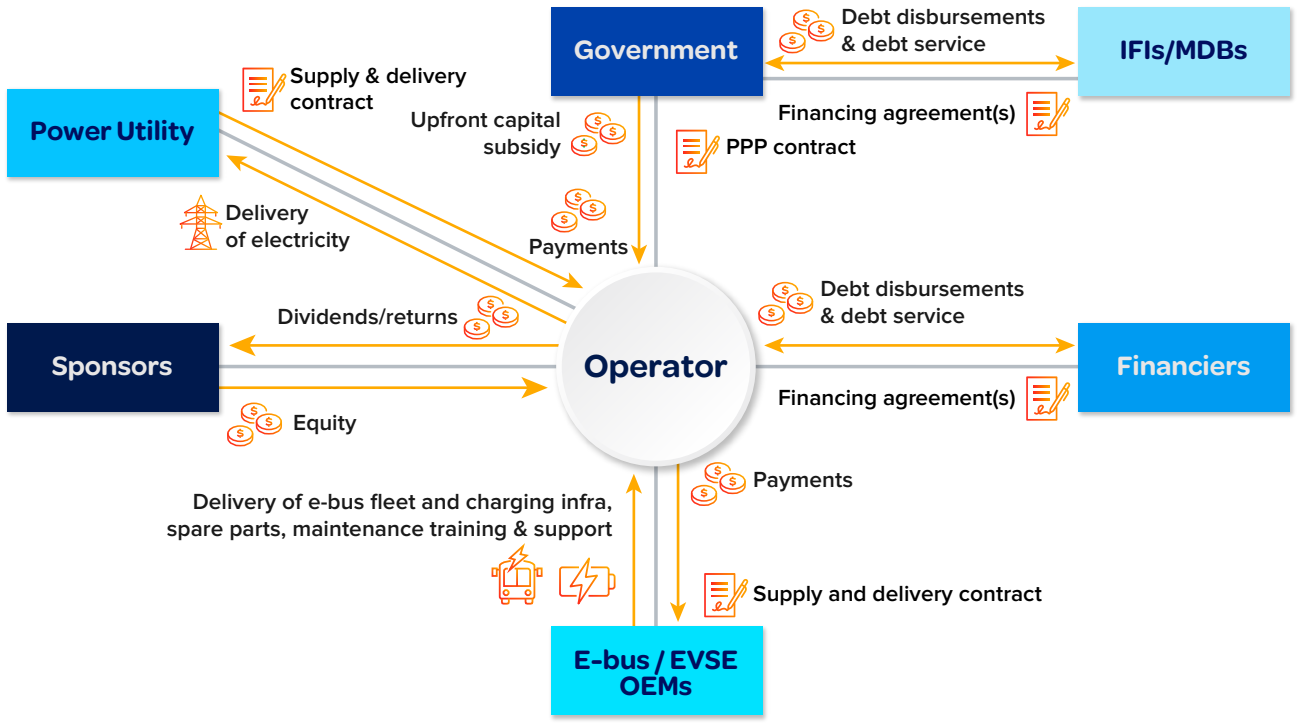
FIGURE ES.10 • Contractual Structures for E-Taxis



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Policy Takeaways

The following section and Annex 1 include a significant number of Moroccan government and organizational acronyms. They are defined in table ES.4.

TABLE ES.4 • Government and Organizational Acronyms

ANRE	National Electricity Regulatory Authority (Autorité Nationale de Régulation de l'Electricité)	METLE	Ministry of Equipment, Transport, Logistics and Water (Ministère de l'Équipement, du Transport, de la Logistique et de l'Eau)
DGCL	General Directorate for Local Authorities (Direction Générale des Collectivités Locales)	MoEnv	Ministry of Environment (Ministère de l'Environnement)
DGCT	General Directorate for Local Authorities (Direction Générale des Collectivités Territoriales)	MoETSD,	Ministry of Energy Transition and Sustainable Developement (Ministère de la Transition Énergétique et du Développement Durable)
DMUT	Directorate of Urban Transport and Mobility (Direction de la Mobilité Urbaine et Transport	MoETLW	Ministry of Equipment, Transport, Logistics and Water (Ministère de l'Équipement, du Transport, de la Logistique et de l'Eau)
FART	Urban Transport Fund	MoF	Ministry of Finance (Ministère des Finances)
IRESEN	Research Institute for Solar Energy and New Energies (Institut de Recherche en Énergies Solaires Et Énergies Renouvelables)	MoI	Ministry of Industry (Ministère de l'Industrie)
MEFRA	Ministry of Economy, Finance and Administrative Reform (Ministère de l'Économie, des Finances et de la Réforme de l'Administration)	ONEE	Office National de l'Eau et de l'Électricité (The National Office of Electricity and Water)

Four policy pillars are recommended for e-mobility adoption in Morocco.

Policy 1-1: Adopting a national e-mobility strategy—to be led by MoETSD, METLE, and DGCL.

- Currently, there are several strategy documents in Morocco that outline initiatives and projects related to the electrification of transport fleets. However, there is **no single coherent strategy** for scaling up e-mobility in Morocco.
- Like most countries that took a step forward toward e-mobility development, the government should establish **a clear, unique, and nationally adopted strategy**, with clear short-, medium-, and long-term action items and targets, covering the various segments, such as passenger EVs, public transport, and taxis.
- In addition, a clear **institutional champion** should be identified to lead the implementation of the strategy.

Policy 1-2: Cross-sectoral coordination framework—to be led by IRESEN and AMEE.

- Several stakeholders in government are (or will potentially be) involved in scaling up e-mobility in Morocco. Both the transport and energy sectors alone involve various public and private

institutions at the strategic, regulatory, and operational levels.

- To date, efforts related to e-mobility have been **mostly fragmented** among various national and municipal-level organizations.
- IRESEN and AMEE have taken the initiative to coordinate some of the different efforts through the "Roadmap for Electric Mobility" that is being developed and awaits being adopted officially by the government.
- Despite these efforts, a stronger coordination framework is necessary across the different stakeholders, including ONEE, AMEE, IRESEN, METLE, DGCT as well as private stakeholders such as car manufacturers and equipment suppliers represented by CGEM.
- As the entity overseeing the transport sector at the strategic level, METLE and DGCL (within the Ministry of Interior) should play a stronger role and even serve as a champion in scaling-up e-mobility in the country, especially when it comes to transport services, in general, and public transport and taxis, in particular.

Policy 2-2: Financial incentives for purchasing new e-buses and e-taxis—to be led by DGCL and FART.

- With the inevitable changes regarding transportation vehicles, especially taxi **renewal programs** and new buses standards set by FART, incentives should be allocated during the purchase of e-buses and e-taxis, to **encourage operators** to increase share of e-buses within their fleets.

Policy 2-3: Import tariffs on e-buses and e-taxis—to be led by the Ministry of Finance.

- Regulatory change regarding import taxation or interdiction requires extensive sector outreach as well as coordination between different ministries and legislative bodies. The nature of the import regulations could address **tax breaks, penalties, and high import duties.**
- Furthermore, import tariffs can be placed on new buses and taxis that produce **emissions above a predetermined** level to help prevent fleet operators from purchasing diesel- and gasoline-powered vehicles.
- Morocco's Nationally Determined Contributions in the transport sector include reductions in the percentage of fuel consumption and in overall emissions from the sector. The government can raise the import tariff placed on diesel or petrol engine vehicles, especially for buses and taxis, to discourage fleet operators away from purchasing those types of vehicles.

Policy 3-1: Capacity building in support of locally manufactured EVs and MAC systems—to be led by IRESEN.

- Adopting e-mobility at the national level requires building local capacity across the value chain—from maintenance of charging facilities, vehicles, and mobile cooling equipment to the operation of electric buses and cars. Existing organizations in Morocco, such as the IRESEN Institute, can play an important role in that respect.
- The capacity-building effort should be done in close coordination with the Ministry of Labor, which can facilitate the various programs and align them with local needs. Morocco should also **explore advancing and building capacity in EV manufacturing.**
- In addition to local manufacturing, local training and certification programs for **MAC technicians** should be introduced.

- A train-the-trainers (TtT) program would need to be supported and established at a central level, such as by Ministry of Energy, Mines and Environment (MEME) or an industry collaboration body, in order to provide basic training and ensure upskilling of air-conditioner technicians.
- The design of such a training program would involve selecting the eligible outreach organizations, defining the training syllabus in coordination with the vendors and suppliers of the technology, and defining the training program's details including levels and qualification criteria.

Policy 4-2: Government funding for depot charging demonstration project (Pilot) (e-buses)—to be led by MoETSD, MoETLW, DGCL, and the Ministry of Finance.

- Government funding should be provided for early adopters, such as e-bus purchasers with depot charging. This would further reduce the economic risk taken by the fleet operator for being an early adopter of electrified modes of transport.

Policy 4-5: Regulations and permits for charging points—to be led by MoETSD, ANRE, and municipalities.

- The international experience and lessons learned show that markets that have introduced EVs in other parts of the world have often experienced delays in installing charging infrastructure **due to lack of permitting and planning permission, particularly in brown fields.**
- MEME, ANRE, and municipalities should streamline relevant processes and coordinate more closely to reduce the time that it takes to install charging points.
- This also allows for capacity mapping of the medium- and low-voltage networks in ways to improve system utilization in areas where energy is not constrained; these hyperlocal capacity maps are common practice in other countries, essentially pinpointing the areas of the grid where little or no upgrades are necessary in order to carry additional loads in those areas.
- Planning should also include clear concise messaging on the applicable standards, procedures, approvals, and timelines to ensure stakeholders are well informed.


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