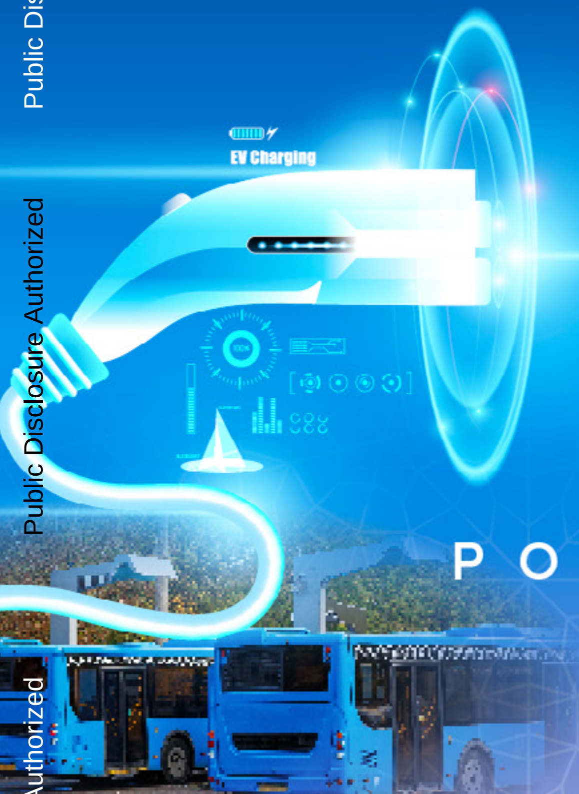


# UNLOCKING ELECTRIC MOBILITY POTENTIAL IN MENA

## Executive Summary – Jordan

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1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Internet: www.worldbank.org



The Jordan Study has been led by Yanchao Li, with contributions from Mira Morad, Muneeza Alam, Yang Chen, Mohamed Zakaria Kamh, Ashok Sarkar, Tarek Keskes, María Rodríguez de la Rubia and Yao Zhao. The analysis underpinning this Summary was commissioned by the World Bank and conducted by a consulting team comprising of Rebel Group, Siemens, Engicon, MRC and TRT.

# Background and Motivation

**The electrification of transport is one of the most promising and readily deployable solutions to speed up decarbonization and energy transition.** Known as electric mobility, or e-mobility, it could contribute to mitigate climate change, enhance energy efficiency and the quality of transport services, and improve urban air quality. This could be particularly powerful when taking advantage of electricity grids that are evolving through the integration of greater shares of renewable resources, energy storage, and demand response technologies. E-mobility also presents opportunities to increase renewable-energy-based electricity consumption, creating new value streams for utilities and operators.

**Countries of the Middle East and North Africa (MENA) region are at different stages of deploying e-mobility across transport subsectors, but the electrification of public transport remains particularly challenging, given the relatively large investments needed.** Ensuring that transport services are sustainable will require large-scale deployment of electric vehicle (EV) charging infrastructure and potential upgrades to the infrastructure underlying electricity generation, transport networks, and utility distribution grids. With appropriate interventions, e-mobility presents opportunities to transform both the energy and transport sectors, creating social, environmental, and economic opportunities, including jobs.

**This summary captures key findings from the full report "Electrification of Public Transport in Jordan,"** which is one of the reports produced under the Unlocking the Electric Mobility Development Potential in MENA activity funded by trust funds of the World Bank Energy Sector Management Assistance Program (ESMAP), the Mobility and Logistics (MOLO), and Public-Private Infrastructure Advisory Facility (PPIAF). The objective of the study is to provide a comprehensive overview and assessment of the technologies, policies, and business models that may support the electrification of Jordan's public transport sector. The activities undertaken draw upon global experiences and practices from both developing and developed countries.

# E-Mobility Situational Analysis — Outlining the Status Quo

**The Jordanian transport sector, characterized by a high level of fragmentation, consumes the most energy among all sectors in the country.** It is also the main culprit behind the nation's air pollution, contributing 28 percent of all greenhouse gas emissions in 2016, with a 49 percent energy share. This has adverse effects on the environment and on public health. Figure ES.1 shows a summary of the available passenger transport services in Jordan. This report focuses on public transport[1] (formally called "regular passenger transport services") and taxis. Large buses are operated by companies, whereas minibuses and white taxis generally run under an owner-operator model. Over 80 percent of the public transport fleet is owned by individuals. This fragmentation is seen as one of the key hindrances in developing public transport services.

**E-mobility has been gaining traction in Jordan since 2015, when the government first lowered import tariffs and eliminated taxes on EVs.** In the following years, the transition to EVs has been highlighted in various sectoral and cross-sectoral strategies. This increasing interest has been largely driven by the country's ambitious climate agenda. In late 2021, Jordan increased its GHG emissions reduction targets in its updated Nationally Determined Contributions (NDCs) from 14 percent to 31 percent. The country's National Green Growth Plan includes several interventions related to e-mobility in order to reduce emissions.

**Jordan is a leader in MENA in terms of EV uptake in the private sector but remains at a very early stage of deploying publicly accessible charging infrastructure and electric buses.** By early 2022, according to information provided by the government of Jordan, the total number of passenger cars in Jordan was 1.8 million, of which 235,816 were hybrid cars, and 31,816 were electric cars (figure ES.2). By contrast, there were only two e-buses operating in Petra that same year and there are plans for Amman to purchase 15 e-buses for its public transportation system.

**FIGURE ES.1. • Snapshot of Jordan's Transport and Energy Sectors**

**Vehicles**

72% Passenger's cars
69.23% Buses
27.54% Taxis and microbuses

**Roads**

8,000 km Length
~1.8 million Registered vehicles

**Modal Split**
Per day

14% Public Transport

**Electricity**

99.9% Electrification Rate
5.56 GW Transmission-connected installed capacity (2021)
26% RE share (2021)

**Demand**

3% Demand Growth (% per year)
3770 MW Peak Demand (2021)

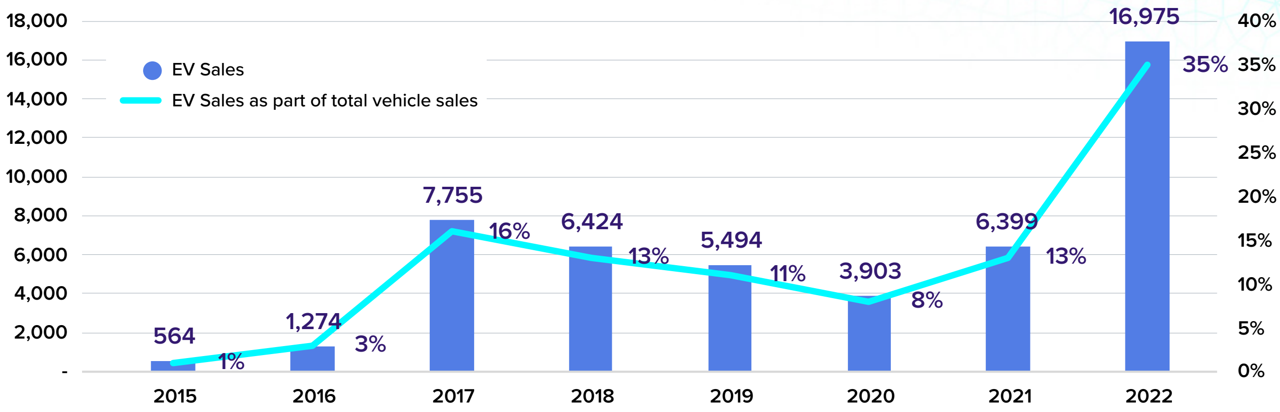
**RE Capacity**

1498.1MW Installed capacity
947.6 MW Net metering & wheeling

*Source:* Original compilation (energy data based on 2021 Annual Report of MEMR and NEPCO; transport data based on data collected from MoT and LTRC)

1 For a comprehensive diagnostic of Jordan's public transport sector, see World Bank, 2022. Jordan Public Transport Diagnostic and Recommendations.

**FIGURE ES.2. • E-Mobility Uptake in Jordan**

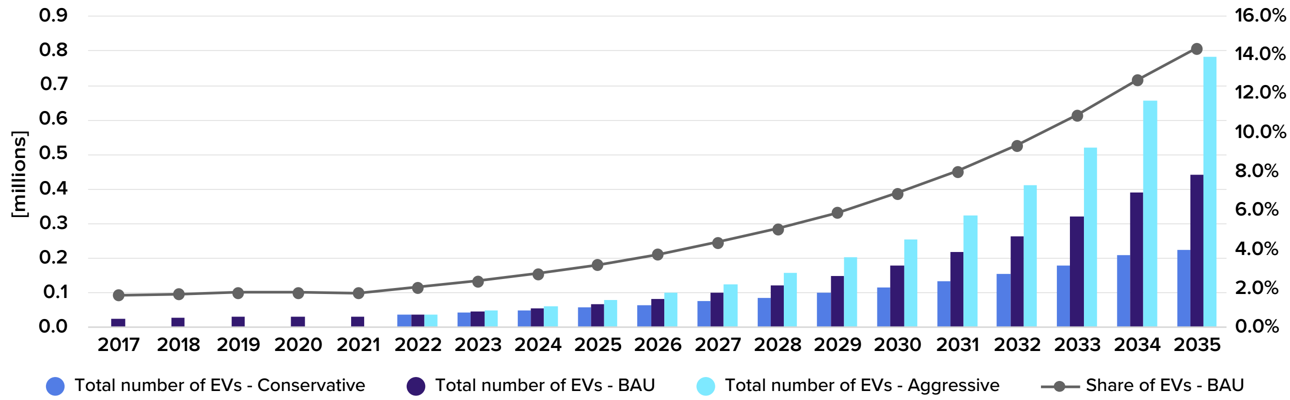



*Source:* Original compilation.

**Two main reasons account for the e-mobility gap between private and public modes of transport.** First, Jordan's roads are well developed, and cars have been the main mode of road transport. Second, the low price of imported second-hand EVs coupled with the lower costs associated with their operation (given the very low cost of electricity) and maintenance, have made EVs an appealing option for consumers with budget constraints. This influx of second-hand EVs poses a downstream challenge in terms of battery end-of-life management that will need to be addressed. Also, there are no explicit policy incentives to support the electrification of public transport in Jordan, and decision-making is mostly on an ad hoc basis.

**Based on forecasts, Jordan could have over 430,000 passenger EVs in its vehicle stock (an approximately 9 percent penetration rate) by 2035, even under a business-as-usual (BAU) scenario.** Figure ES.3 illustrates the projected growth of the country's EV stock based on several input parameters (including population growth and motorization rate). The projection indicates the number of passenger vehicles per 1,000 inhabitants, vehicle ownership, and the decommissioning of aging vehicles. Macroeconomic parameters, such as consumer price index and inflation rates, and microeconomic factors, such as product pricing and market attractiveness, will drive ramp-up rates.

**FIGURE ES.3. • Projected Market Stock of Electric Vehicles in Jordan, 2035**



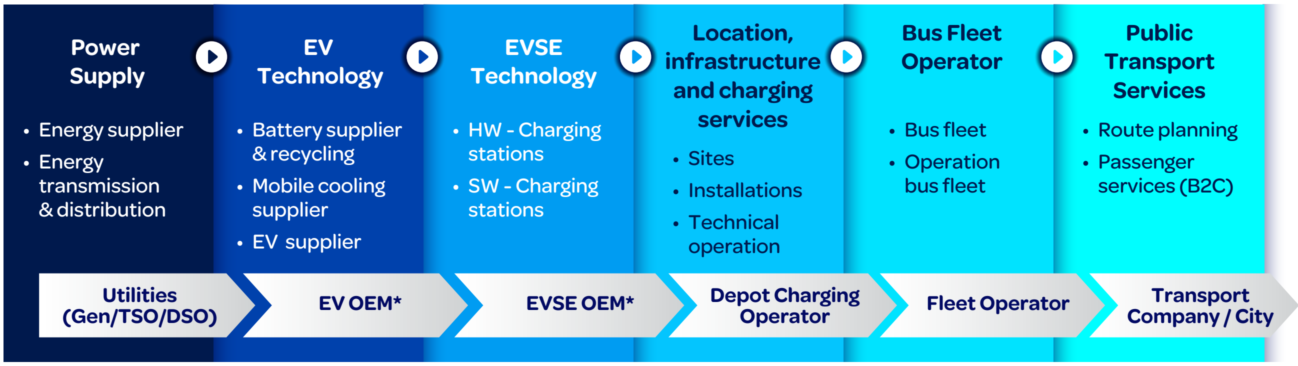

*Source:* Original compilation.

**Jordan has made limited progress in scaling up EV charging infrastructure.** By 2021, apart from the private charging stations that individuals with their own electric cars usually install at home, there were approximately 34 public charging stations owned by various entities (including the Manaseer Group, Gulf Jordan Power Company, Ion Energy, and others). The Jordan Energy and Mineral Regulatory Commission (EMRC) is only responsible for regulating site schematics, electricity connection, and the safety of public chargers. It exerts no control over the technical standards of charging stations but allows investors scope for technological innovation. Given that no regulations are in place, EVs are imported into Jordan with various charging standards. The downside of this approach is the limited compatibility of the current charging infrastructure with the different types of imported EVs. However, the EMRC has indicated that efforts are being made to amend the current regulations to allow new gas stations sufficient space to accommodate EV charging stations.

**Jordan's e-bus value chain remains underdeveloped, especially in the downstream segments.** As figure ES.4 indicates, there is a gap in the "Bus Fleet Operator" and "Public Transport Services" segments since there are only two e-buses operating in Jordan's public transport in Petra.

**In the past, at the policy level, there was no consistent promotion of EV uptake in Jordan; however, 2022 ushered in change at the strategic level.** Notably, in 2015, the government lowered the import tariffs and eliminated taxes on EVs and EV chargers. Regulations for the licensing of EV charging stations and the establishment of EV charging tariffs were also approved by the EMRC in May 2016. However, there was an apparent reversal of the policy signal when the customs duty on EVs was increased from zero to 25 percent in 2019, and weight and clearance taxes were subsequently imposed. With those policy decisions, the price of EVs increased, resulting in a 70 percent drop in sales. In 2020, the government lowered the taxes for batteries of less than 250 kilowatts (kW) from 25 percent to 10 percent and 15 percent for batteries of more than 250 kW. The weight tax was removed and replaced by a 4 percent tax on the original value of the vehicle. Strategically, in 2022, the Ministry of Energy and Mineral Resources (MEMR) initiated the coordination of all e-mobility stakeholders and the formulation of a national e-mobility strategy with the World Bank's support. At an even higher level, e-mobility has been positioned as a key enabler of growth toward the green economy in Jordan's Economic Modernization Vision, which is intended to be a comprehensive socioeconomic reform package.

**FIGURE ES.4. • The E-Bus Value Chain in Jordan**




*Source:* Original compilation.

# Analysis of Technical Options

Based on existing evidence, a range of key assumptions regarding EV deployment patterns were derived (summarized in figure ES.5) during the technical analysis of energy demand and charging strategies in Jordan.

**This assessment focuses on regular buses (excluding bus rapid transit (BRT), and including both large buses and minibuses) and conventional taxis in Jordan.** The justification for the assessment is that there have been numerous studies reviewing the feasibility of adopting e-buses for BRT, and new studies are being planned. However, regular buses and conventional taxi services, which represent a significant share of Jordan's public transport, are understudied. Specifically, the following routes were selected as a sample for the assessment of the electrification of public transport in Jordan (illustrated in figure ES.6).

- Route 15: Northern Terminal – W.I.S.E (World Islamic Sciences and Education) University route
- Route 19: Northern Terminal – Al Balqaa Applied University route
- Route 1: 33 Coasters (mini-buses) operating on the Al-Mohajereen-Wadi El-Seer route
- Route 2: 17 Coasters operating on the Ras Al-Ein-Jawa eastern district route

**Based on a review of route 19, the charging strategy analysis suggests that, depending on the total distance of the route, depot charging strategy**

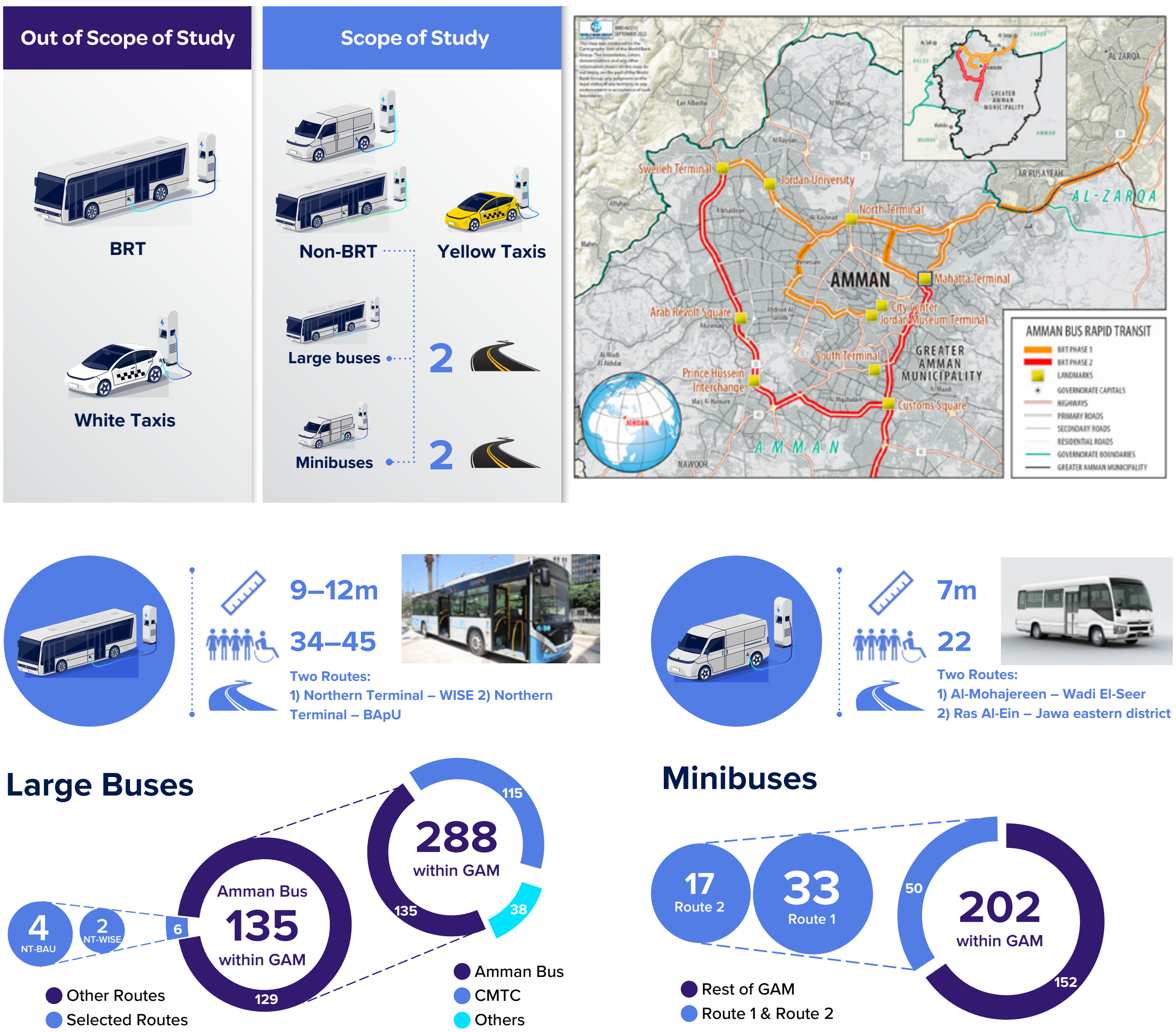
**FIGURE ES.5. • Summary of Key Assumptions Used for Technical Analysis**

| Private & Urban Mobility | Key Takeaways: Charging Landscape | Early-Stage & Growing Electrification |
|---|---|---|
| **High reliance on private transportation:** 95% of 1.8mn+ vehicles on road are privately owned with limited public transportation (bus, taxi, ride hailing, etc.) | **Amman & Other major cities** as early candidates for EV charging network setup with particular focus on electrification of transport fleets | **Early-stage EV adoption:** EV adoption is growing but in the early stages with EVs <2% vehicles on road. |
| **High urbanization & congestion:** 42% population & ~80% of vehicles are within Amman. High share of Jordan's population (90+%) live in urban areas | **New charging concepts** required in addition to traditional gas/electric charging stations | **Rising fuel costs & financial incentives accelerate EV adoption:** 10% tax exemption on EVs in comparison to ICEs & hybrids. Increasing fuel costs also accelerating adoption of EVs |
| **Mobility patterns:** Mainly consist of intra-city travel and inter-city travel between Amman and other key cities (<100 km). Mobility demand growing owing to young and growing population. | **Ecosystem approach & partnerships** across the EV charging value chain for public transport | **EVs integral to Jordan Energy Strategy:** Govt. energy strategy 2030 focuses on reducing reliance on imported crude with focus on increasing private & public EV adoption ad improving charging infrastructure |

*Source:* Original compilation.
Note: ICE = internal combustion engine; EV = electric vehicle.

**on its own (even with today's state-of-the-art e-bus battery technologies >400 kWh), might not be sufficient to meet the energy demand of e-buses.** To be able to serve longer routes, a combination of depot charging and opportunity charging at end-bus stops (a so-called hybrid charging strategy) will be needed to cover the total necessary energy demand of driving and cooling. For opportunity charging, it is suggested to install the maximum possible charging power. Figure ES.7a illustrates a typical load curve of e-buses in a hybrid charging mode, while figure ES.7b shows the energy consumption and remaining battery balance for selected routes under different charging strategies.

**FIGURE ES.6. • Selected Scope for Technical Analysis**




*Source:* Original compilation based on data from World Bank 2022 report Jordan Public Transport Diagnostic and Recommendations

# Total Cost of Ownership Analysis

A total cost of ownership (TCO) analysis was conducted to compare EV technology vis-à-vis traditional engine technologies being used in bus, minibus, and taxi vehicles (tables ES.1–3). The analysis looks at the TCO per kilometer driven as the main parameter of comparison across these technologies, and takes both a financial and an economic approach to cost calculations.

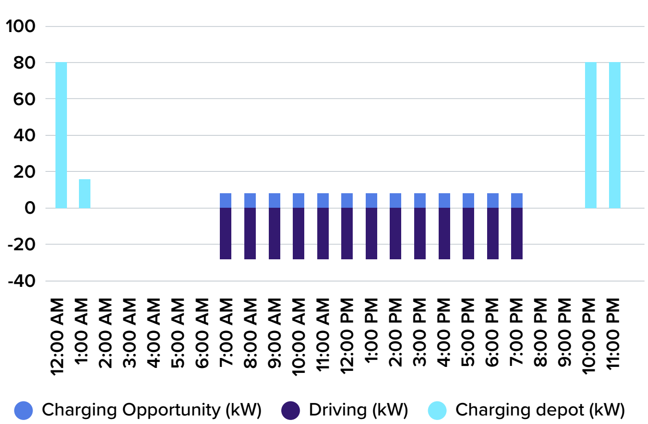
Two sensitivity analyses were run: (1) of useful life (in the base case, a usable life of 12 years was assumed for internal combustion engine (ICE) vehicles and 15 years for EVs, and this was compared against 12 years for all technologies), and (2) of fuel price changes. Given the recent (2022) hike in fuel prices, driven by global macroeconomic conditions, an increase of 20 percent in baseline fuel prices was assumed for the sensitivity analysis. The results of the TCO analysis under different scenarios (such as equal or differential useful lifetimes) highlight the role that enabling regulatory frameworks and policies could play in realizing the full TCO potential of EVs. It is also worth noting that in a scenario wherein the full useful life of EVs is not maximized, some residual value (not quantified in this analysis, and potentially coming from other uses of the vehicles, or from scrap value) may be expected to decrease the long-term TCO of EVs.

**These analyses indicate that a switch to e-buses could be financially attractive for a Jordan-based operator.** Given the country's dependence on imported fossil fuels, EVs could be a better-performing option especially when their expected useful life is assumed to be maximized, and considering rising fuel costs. In economic terms, the case for e-buses is even stronger: their TCO is at least 8 percent lower than that of ICE alternatives.

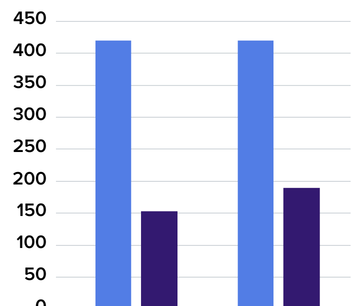
**A switch to e-minibuses, however, will unlikely be financially attractive for a Jordan-based operator given the current state of technology and pricing.** From an economic perspective, the case for a switch is also quite weak: investment costs of e-minibuses are generally not offset by their economic benefits.

**FIGURE ES.7. • Example Load Curve and Overview of Energy Demand**

**7a • Load Curve of E-Bus on Route 19**




**7b • Overview of Energy Demand /day**




| | Route 15 | Route 19 |
|---|---|---|
| Total E-bus battery size in kWh | 420 | 420 |
| Remaining energy balance when arriving at the depot (Opp. charging considered for only Route 19) | 154 | 190 |

*Source:* Original compilation.

This may change in the future as e-minibus technology and pricing evolve.

**The case for 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 airports, where taxis always come back to one single location where they wait for customers and where fast chargers could be installed.

**TABLE ES.1. • TCO and Sensitivity Analysis Results—Buses**

| Scenario | Diesel | Hybrid | Battery electric |
|---|---|---|---|
| Financial TCO results (US$/km) | | | |
| Base case fuel – Differential useful life | 0.50 | 0.49 | 0.48 |
| Base case fuel – Equal useful life | 0.50 | 0.49 | 0.55 |
| Higher fuel case – Differential useful life | 0.55 | 0.53 | 0.48 |
| Higher fuel case – Equal useful life | 0.55 | 0.53 | 0.55 |
| Economic TCO results (US$/km) | | | |
| Base case fuel – Differential useful life | 0.72 | 0.67 | 0.58 |
| Base case fuel – Equal useful life | 0.72 | 0.67 | 0.62 |
| Higher fuel case – Differential useful life | 0.80 | 0.73 | 0.58 |
| Higher fuel case – Equal useful life | 0.80 | 0.73 | 0.62 |

*Source:* Original compilation.
Note: TCO = total cost of ownership.

**TABLE ES.2. • TCO and Sensitivity Analysis Results—Minibuses**

| Scenario | Diesel | Battery electric |
|---|---|---|
| Financial TCO results (US$/km) | | |
| Base case fuel – Differential useful life | 0.26 | 0.34 |
| Base case fuel – Equal useful life | 0.26 | 0.40 |
| Higher fuel case – Differential useful life | 0.28 | 0.34 |
| Higher fuel case – Equal useful life | 0.28 | 0.40 |
| Economic TCO results (US$/km) | | |
| Base case fuel – Differential useful life | 0.32 | 0.34 |
| Base case fuel – Equal useful life | 0.32 | 0.39 |
| Higher fuel case – Differential useful life | 0.35 | 0.34 |
| Higher fuel case – Equal useful life | 0.35 | 0.39 |

*Source:* Original compilation.
Note: TCO = total cost of ownership.

**TABLE ES.3.** • **TCO and Sensitivity Analysis Results–Taxis**

| Scenario | Diesel | Battery electric |
|---|---|---|
| Financial TCO results (US$/km) | | |
| Base case fuel – Differential useful life | 0.19 | 0.16 |
| Base case fuel – Equal useful life | 0.19 | 0.18 |
| Higher fuel case – Differential useful life | 0.20 | 0.16 |
| Higher fuel case – Equal useful life | 0.20 | 0.18 |
| Economic TCO results (US$/km) | | |
| Base case fuel – Differential useful life | 0.24 | 0.19 |
| Base case fuel – Equal useful life | 0.24 | 0.20 |
| Higher fuel case – Differential useful life | 0.25 | 0.19 |
| Higher fuel case – Equal useful life | 0.25 | 0.20 |

*Source:* Original compilation.
Note: TCO = total cost of ownership.

# Business Model Analysis

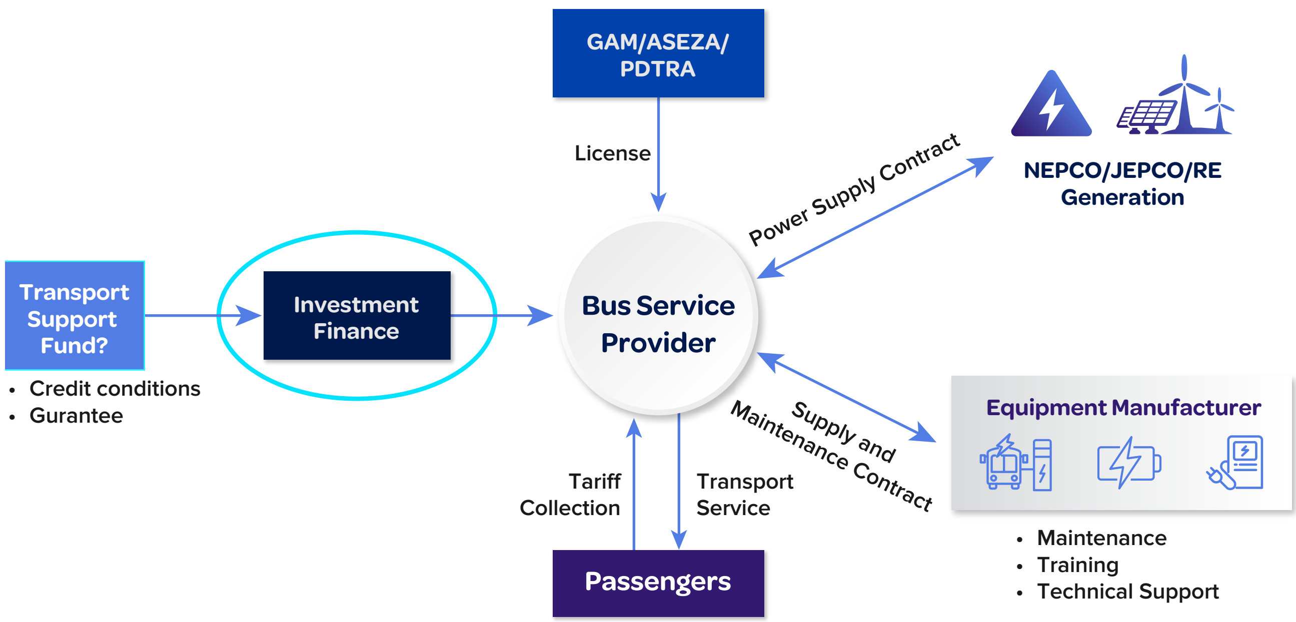
**Given that there are no operational e-buses in the country (except for a tourist area of Petra), the analysis has considered the current models being used for ICE buses and then proposed some improvements.** At present, there is no ownership separation. The bus service provider (BSP) receives a license from the municipal authority (GAM, ASEZA, PDTRA)[2] and must obtain the required financing to purchase the required equipment (including chassis, batteries, chargers). A transport support fund could provide financial guarantees or improved credit conditions. As the owner of the assets, the BSP needs to maintain service contracts with the manufacturer for the life of the assets. As in the case of AVT, it requires capacitation for the operation of the chargers. A power supply contract needs to be maintained with the distribution companies or renewable energy independent power producers. As for revenue, the BSP collects fares from the passengers it serves. Figure ES.8 summarizes this bundled model, while figure ES.9 considers an alternative.

The benefit of the unbundled model is that it enables both AssetCo (the owner of the vehicle titles) and electric vehicle charging infrastructure (EVCI) to enjoy economies of scale in the purchase of assets (achieved through better access to financing and increased bargaining power with respect to the manufacturer) and in the operation and maintenance of facilities (higher level of occupation and ability to close power purchase agreements in the case of chargers, and provision of operations and maintenance to several BSPs in both cases). The rest of the relationships in the model do not change. However, if a transport fund is created, it can be turned into a farebox trust fund, that centralizes revenue collection from travelers. If that is

2 GAM = Greater Amman Municipality; ASEZA = Aqaba Special Economic Zone Authority; PDTRA = Petra Development & Tourism Region Authority.

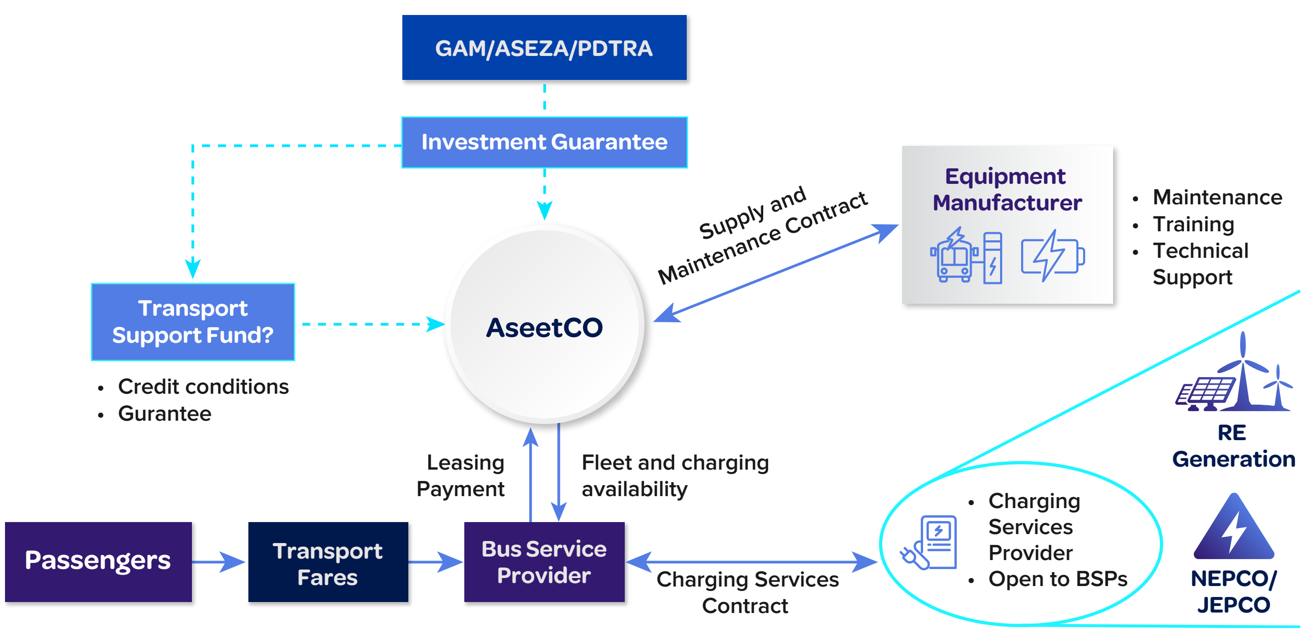
the case, the transport fund can directly pay AssetCo (increasing payment guarantees and reducing risks for third-party investors) and can also enforce quality of service regulation for BSPs (who don't have direct access to collected cash). This would need to be coupled with the deployment of electronic fare cards and with incentives (such as discounts) and penalties that push customers toward electronic methods.

**FIGURE ES.8. • Bundled Model of E-Bus Operation**




*Source:* Original compilation.

**FIGURE ES.9. • Unbundled Model of E-Bus Operation**




*Source:* Original compilation.

# Policy Takeaways

Key policy takeaways from this analysis[3] are grouped under three main categories, as shown in figure ES.10 and outlined below.

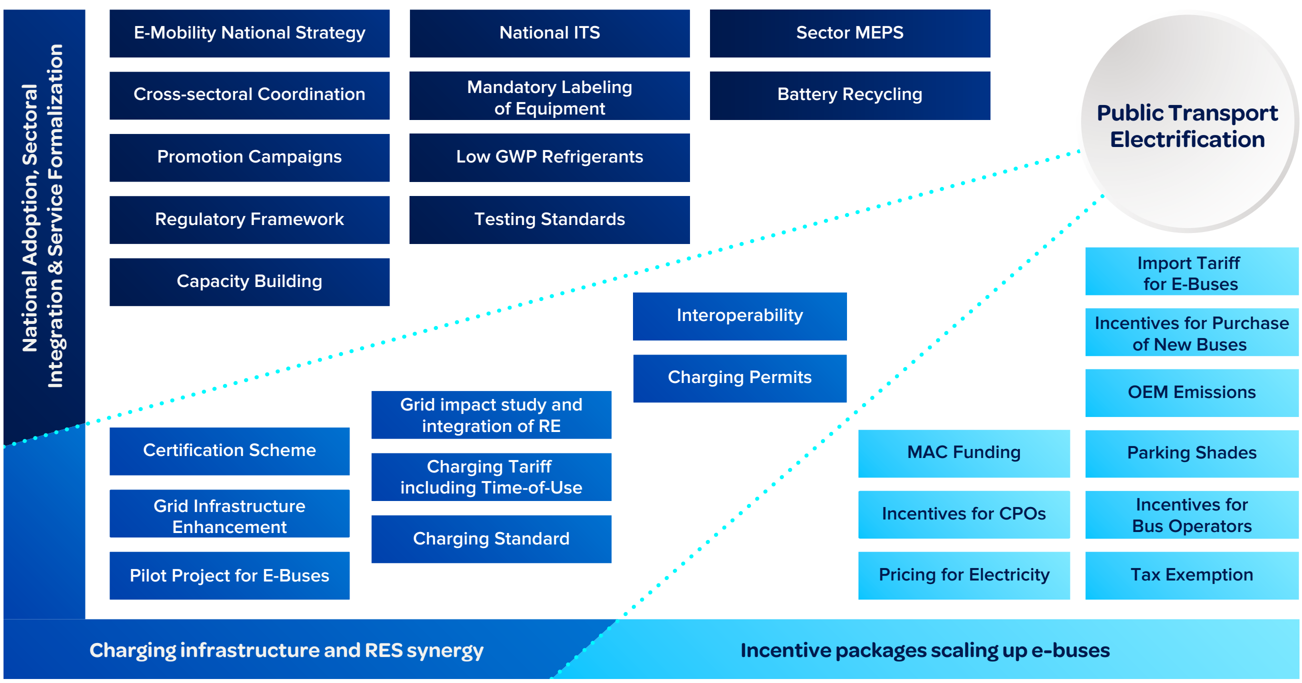
**The three main categories and priority actions are:**

1. **Adoption, sectoral integration, and service formalization:** Actions include both broader sector reforms such as formalizing public transport, and focused strategic actions such as developing a National E-Mobility Strategy (ongoing). Adoption of standards, testing practices, labeling, and awareness campaigns, is included in this category.

2. **Incentive packages for scaling-up e-buses:** These would center on financial and nonfinancial instruments, such as emissions reduction regulations, tax exemptions for e-buses, and pricing signals related to tariffs.[4]

3. **Enabling the charging infrastructure and synergizing with renewable energy:** Key steps include electricity-related certification procedures, standards, licensing, grid impact studies and planning, infrastructure enhancement, as well as piloting to test out different solutions.

**FIGURE ES.10. • Key Policy Takeaways**




*Source:* Original compilation

*Note: CPOs = charging point operators; MAC = mobile air conditioning; OEM = original equipment manufacturer; MEPS = minimum energy performance standards; GWP = global warming potential. ITS = Intelligent Transportation Systems; RES = renewable energy sources*

3 It is worth noting that analysis conducted under this study, including technical, financial and business model aspects, is exploratory and high-level. Concrete investments should be informed with more detailed, case-by-case feasibility studies.

4 EMRC has issued a new Time-of-Use tariff for EV charging stations (both residential and commercial scale) as a pilot for six months effective May 28, 2023, details available at: https://emrc.gov.jo/DetailsPage/NewsDetails?ID=12346