

Article

Electromobility in Kazakhstan: Current State, Legal Aspects, and Consumer Preferences

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Highlights

What are the main findings?

- The development of electric mobility in Kazakhstan is largely dependent on government support, the development of charging infrastructure and regulatory coherence.
- The main factors influencing the adoption of electric vehicles are economic and technological advantages, while insufficient infrastructure development and operational constraints remain key barriers to market growth.

What are the implications of the main findings?

- For the sustainable development of the electric vehicle market in Kazakhstan, a unified state policy, accelerated development of charging infrastructure and modernization of electric networks are needed.
- The results of the study show that institutional readiness and long-term infrastructure planning are essential conditions for a successful transition to electric mobility in emerging economies.

Abstract

The study provides an institutional strategic assessment of the development of electric mobility in the Republic of Kazakhstan, taking into account international trends and national characteristics. Market diagnostics are based on statistics, regulatory and legal analysis, surveys of electric vehicle owners, and interviews with stakeholders. This study represents one of the first integrated institutional and strategic assessments of the development of electric mobility in Kazakhstan, combining regulatory analysis, consumer survey data, stakeholder interviews and semi-quantitative structures of PESTEL and SWOT in the context of the emerging electric vehicle market in Central Asia. The market's high sensitivity to institutional policy is demonstrated: with state support, the strategic position becomes stable (SWOT index +1.65), and without it, critically vulnerable (−4.05). The conclusions of the study form a scientifically sound basis for the development of a comprehensive state program for the development of electric mobility, focused on regulatory unification, infrastructure modernization, and institutional coordination.



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Keywords: electric vehicles; charging infrastructure; sustainable development of transport infrastructure; legal regulation; consumer survey; SWOT analysis; PESTEL analysis

1. Introduction

Vehicles powered by internal combustion engines are a significant source of anthropogenic pollutants, contributing to increased toxicity in urban atmospheres [1–3] and intensifying global climate change processes [4–6]. The share of greenhouse gas (GHG) emissions in Kazakhstan from the “Transport” category during the observed period has been growing: in 1990, the share of transport was 7% of the “Energy” sector, while in 2021 the share of the Transport category was 10% [7]. At the same time, electric vehicles are seen as one of the ways to solve the problems of sustainable transport development.

Research [8] has established that the spread of battery electric vehicles and the growth in the share of renewable energy reduce CO₂ emissions. At the same time, the greatest effect of reducing emissions from battery electric vehicles is observed in countries with a high level of renewable energy sources (e.g., Norway), while in China and the United States, the positive effect is limited due to the “dirty” energy balance.

The number of electric vehicles is growing annually worldwide. According to forecasts by the International Energy Agency (IEA), by 2030, the global EV fleet will reach 250–400 million units, which will lead to a sharp increase in charging infrastructure [9,10]. Electric vehicles are concentrated in urban areas, where their spread is facilitated by the availability of infrastructure and socio-economic factors [11]. In densely populated cities, reducing exhaust emissions and traffic noise levels contributes significantly to improving public health and social well-being [12].

At the same time, governments around the world increasingly see electric mobility not only as an environmental and climate policy tool, but also as a strategic industrial priority related to technological competitiveness, energy security and participation in the global automotive value chain. The transition to electric transport is accompanied by increased competition in the production of batteries, charging infrastructure technologies, supply chains for critical raw materials, and localization of the production of electric vehicles. As a result, national electric vehicle policies increasingly combine environmental goals with broader industrial and economic development strategies.

Electric vehicles have a number of advantages over vehicles equipped with internal combustion engines. Among the advantages of electric vehicles are reduced CO₂ emissions, increased energy efficiency, reduced noise levels, and lower cost of ownership. The main disadvantages are high capital costs, concerns about the efficiency and durability of batteries, underdeveloped charging infrastructure, and limited electrical networks in certain regions [13,14].

Contemporary research covers a wide range of issues related to the introduction of electric vehicles in various countries [15–17], policy and incentives [18–24]. Review articles devoted to specific aspects of the introduction of electric vehicles have begun to appear [25,26].

Attention must be paid not only to the environmental benefits of electric transport, but also to ethical, social, and infrastructure issues that are often overlooked. They emphasize that without comprehensive socio-political measures, electric vehicles cannot be considered a complete solution to sustainable mobility challenges [27].

Without enhanced legal regulation (EPA standards, tax incentives, federal infrastructure programs), the US will not achieve carbon neutrality by 2050 [28].

The article examines how ambitious the national strategies of the EU and the UK countries are in terms of the transition to electric mobility compared to the pan-European goals [29].

China has created a dynamic and adaptive regulatory system that has evolved from financial subsidies and direct grants to market-based instruments (tax breaks, priority in transport quotas, access to lanes, urban restrictions on internal combustion engines) (Figure 1) [30].

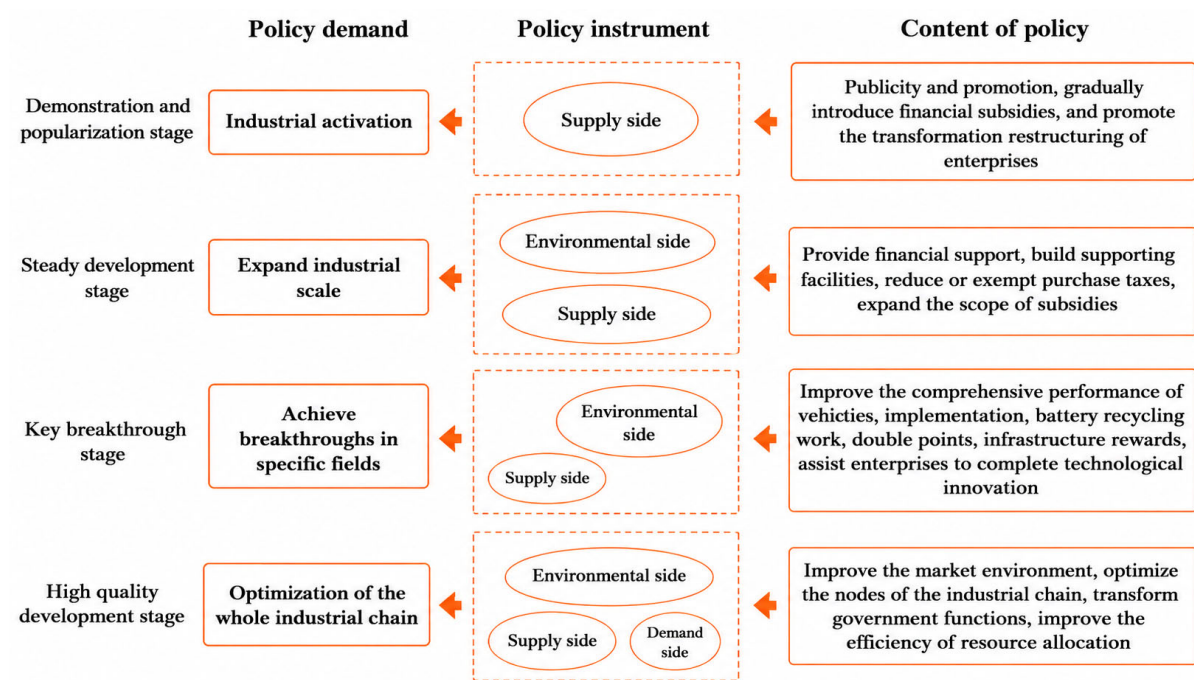


Figure 1. Analysis of the policy path of China's electric vehicle industry (Liu Z., Zhang Y., Li F., et al. [30]).

In Kazakhstan, where more than 19,000 electric vehicles were registered at the beginning of 2026, the development of electric mobility is at an early stage, but has shown high growth rates over the past three years. At the same time, infrastructure and regulatory support lag significantly behind market needs [10].

Kazakhstan is promoting the electric mobility initiatives of the International Electric Vehicle Initiative (EVI, 2010). In support of EVI initiatives, Kazakhstan adopted a strategy to achieve carbon neutrality by 2060 [31,32]. According to this strategy, greenhouse gas emissions are to be reduced by 15–25% by 2030 compared to 1990 levels. To achieve this goal, measures are planned to promote electric vehicles and provide state incentives for charging infrastructure.

The development of electric mobility will also help solve the problem of air pollution in large cities in Kazakhstan (Almaty, Astana, Shymkent) [33–35].

While extensive research has been devoted to the introduction of electric vehicles in developed economies, limited attention has been paid to developing and post-Soviet markets, especially in Central Asia [11,18,36]. Kazakhstan has unique structural features, manifested in a high concentration of pollutants in the urban atmosphere, the predominance of electricity generated from fossil fuels [37], an insufficiently integrated regulatory framework, and rapid growth in the number of electric vehicles in cities [10].

Among the most significant Kazakhstani studies are those devoted to forecasting the development of the electric vehicle market [10] and a systematic analysis of the legal aspects of the industry [38]. In particular, it is noted that the EAEU countries face significant

obstacles to the mass introduction of environmentally friendly transport due to problems in legislation, the lack of tax incentives, and an underdeveloped charging infrastructure. Measures to stimulate and support electric mobility are mainly implemented at the level of individual city administrations. An integrated approach is needed, combining public policy, infrastructure investment, innovation in business models, and active stakeholder engagement [39]. Existing research on electromobility in Kazakhstan primarily focuses on descriptive market analysis, legal regulation or technological forecasting. However, limited attention has been paid to a comprehensive institutional assessment combining regulatory readiness, infrastructure adequacy, consumer behavior and strategic scenario analysis within a single analytical framework. In particular, the interplay between institutional coordination, infrastructure modernization and policy support mechanisms remains understudied in the context of Kazakhstan and other emerging electric vehicle markets in Central Asia [40,41].

The development of electric transport in the Republic of Kazakhstan is a strategically important direction in the transition to a low-carbon economy, but the widespread use of electric vehicles in Kazakhstan is limited by a number of barriers [10,33–35,42]. Key obstacles include:

- Legal aspects: the absence of a single law on the development of electric transport, fragmented legislation, insufficient requirements for the design and operation of charging stations, and unclear distribution of responsibilities among market participants.
- Technical aspects: non-standardized conditions for connecting electric charging stations to power grids, poor adaptation of standards to climatic conditions, lack of standard design solutions, worn-out power grids, and power shortages in certain regions.
- Economic and institutional aspects: lack of tax and financial incentives, investor support mechanisms, and a leading agency responsible for the development and maintenance of electric mobility.

Thus, identifying the main drivers of electric mobility development that are relevant to Kazakhstan's conditions is an important scientific and practical task. The transition to EVs is not purely a technological process; institutional coordination determines the speed of implementation [43,44]. Thus, understanding the institutional readiness of emerging economies for large-scale adoption of electric vehicles presents an important research and policy challenge.

Existing studies on Kazakhstan mainly focus on descriptive market analysis and do not contain comprehensive institutional assessment tools. This study aims to provide a comprehensive institutional and infrastructural assessment of the state of electromobility in the Republic of Kazakhstan, developing a quantitatively formalized strategic model for the scenario-based development of the electric transport market until 2030.

Research objectives: to study the dynamics of electromobility, identify key factors and barriers with a quantitative assessment based on the PESTEL index for various scenarios, develop a SWOT model and calculate an integral SWOT index for institutional scenarios; assess the sensitivity of the market to changes in government policy. The results of the study formed the basis for strategic recommendations to accelerate the development of electric mobility.

2. Materials and Methods

2.1. Research Design

This study uses a mixed research method that combines quantitative and qualitative approaches to assess the current state and prospects for the development of electromobility in the Republic of Kazakhstan. The methodological framework integrates regulatory and

legal analysis, statistical market assessment, electric vehicle (EV) owner survey, expert interviews, and strategic analytical tools including PESTEL and SWOT analysis.

The study was conducted in several sequential stages [28,29]. First, the statistics of the Bureau of National Statistics of the Republic of Kazakhstan were analyzed. Second, a regulatory review was conducted to assess the institutional environment. Third, a survey of electric vehicle owners and stakeholder interviews were conducted to identify key factors influencing the adoption of electric vehicles. The empirical data collected were integrated into a semi-quantitative strategic evaluation framework based on the PESTEL and SWOT methodologies.

Rather than providing a deterministic forecast of the electric vehicle market, the study develops scenario-based strategic trajectories that reflect different levels of institutional support and infrastructure development. The proposed model should be interpreted as a research-based policy-oriented analytical framework for assessing the sensitivity of the Kazakhstan electromobility sector to changes in public policy, technological modernization and infrastructure expansion.

2.2. Survey of Electric Vehicle Owners

To identify key drivers of electric vehicles, in the period from 2025 to 2026, a structured survey of owners of electric vehicles was conducted in Almaty. A total of 356 valid questionnaires were collected and included in the analysis. The questionnaire was developed based on a preliminary review of the international literature on electric vehicle adoption, charging behavior, infrastructure availability and consumer preferences, as well as consultations with industry experts and electric vehicle users [45–50].

The survey included questions related to:

- socio-demographic characteristics of respondents;
- EV usage models;
- charging mode;
- motivation to purchase;
- satisfaction with the performance of the vehicle;
- perception of charging infrastructure;
- quality of service;
- barriers to EV operation in Kazakhstan.

Almaty currently serves as the most representative urban environment for exploring electric vehicle adoption patterns, use of charging infrastructure, and consumer behavior in the country. At the same time, the authors admit that the survey primarily reflects the conditions for the adoption of metropolitan electric vehicles and may not fully reflect the characteristics of rural regions or regions with limited charging infrastructure [47]. Consequently, the survey results were used primarily to identify dominant behavioral and institutional trends rather than to produce statistically representative national estimates [49,50].

2.3. Expert Group and Interviews with Stakeholders

Expert interviews and stakeholder consultations involving 63 participants were conducted to assess the institutional, technological and infrastructural factors influencing the development of electromobility. The expert group included representatives of government agencies, power grid companies, charging infrastructure operators, participants in the electric vehicle market, researchers and specialists in the field of transport and energy systems [48].

Participants were selected according to their direct involvement in areas related to electric mobility, including energy infrastructure, transportation regulation, charging station deployment, environmental policy, and electric vehicle market development.

The peer review process was conducted in two stages. During the first stage, experts participated in determining the most significant political, economic, social, technological, environmental and legal factors affecting electric mobility in Kazakhstan. At the second stage, the selected factors were evaluated using structured scoring scales reflecting the expected strength and the likelihood of their influence under alternative development scenarios [51–55].

To reduce subjectivity, the final scores used in the PESTEL and SWOT models were calculated as aggregated mean expert ratings. The use of aggregated peer reviews reduced the impact of individual subjective opinions and improved the coherence of the strategic assessment framework [53–55]. The algorithm for SWOT analysis is shown in Figure 2.

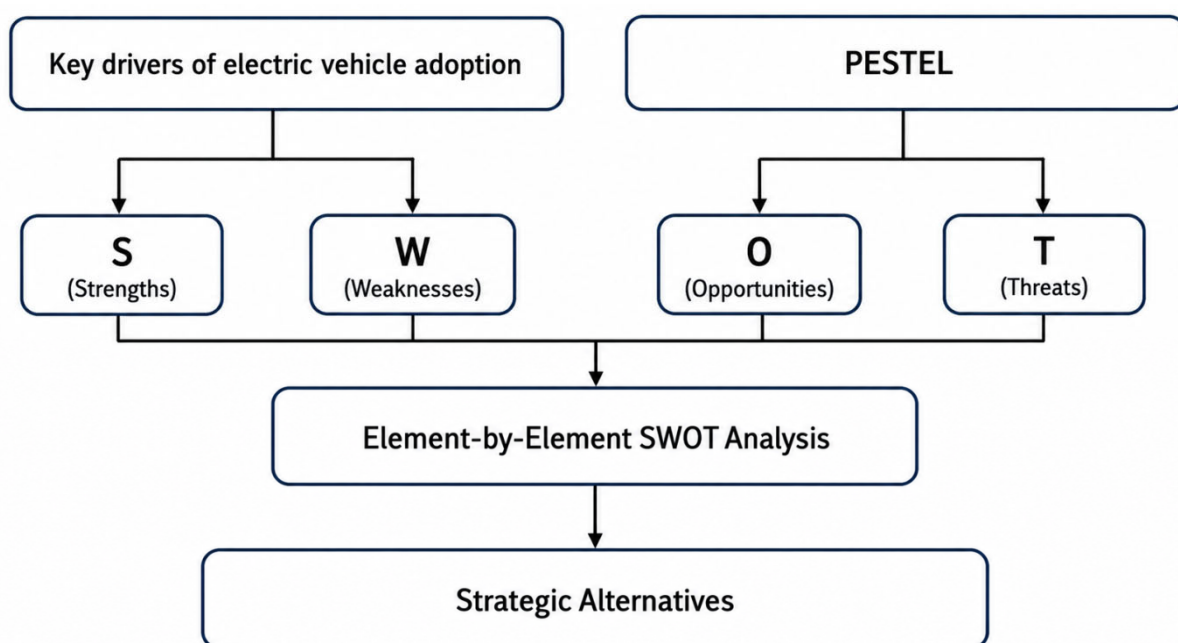


Figure 2. SWOT analysis algorithm.

The composition of the expert panel used in the study is consistent with methodological recommendations for strategic assessment, scenario planning and policy-oriented research. Previous research suggests that expert groups of 15–60 qualified professionals are generally sufficient to achieve stable and reliable assessments when the research topic requires highly specialized knowledge and stakeholder representation. In the present study, the panel comprised 63 participants representing government agencies, power grid companies, charging infrastructure operators, market participants, and academic experts. This diversity of expertise has ensured a broad coverage of institutional, technological, economic and regulatory aspects of the development of electromobility. The selected composition (number) of the group was considered sufficient to obtain reliable expert assessments and reduce the impact of individual bias on the final assessment results.

Previous methodological studies indicate that expert panels of 15–60 qualified professionals are generally sufficient to strategically assess and build consensus on complex policy and technology issues [56]. In the present study, the group consisted of 63 participants representing government agencies, energy companies, charging infrastructure operators, market participants, and academic experts, providing broad stakeholder representation and analytical reliability.

2.4. PESTEL Framework and Quantification Procedure

To assess the impact of the external macro-environment on the development of electromobility in Kazakhstan, the PESTEL structure was used. The analysis included six analytical aspects: political, economic, social, technological, environmental and legal factors influencing the development of the electric vehicle market and infrastructure readiness [57].

For further evaluation, the factors most frequently identified by respondents and experts as strategically significant were selected. As a result, 50 factors were included in the final analytical matrix with 10 factors assigned to each PESTEL block. The selection procedure was aimed at ensuring a balanced coverage of the institutional, infrastructure, technological and socio-economic aspects of the development of electromobility.

The method is widely used in strategic management, risk analysis and scenario planning, as it simultaneously reflects:

- expected direction and force of factor influence;
- probability of its occurrence within a specific development scenario.

The integral index for each factor was determined according to the formula:

$$I_{PESTEL} = \sum_{i=1}^n (S_i \times P_i) \quad (1)$$

where S (strength)—strength and direction of influence of the factor; P (probability)—the probability of this influence occurring in a specific scenario.

The obtained integral values should not be interpreted as absolute predictive indicators. Instead, they are relative comparative measures designed to assess the favorability or limitations of the macro-environment in different institutional settings. Negative aggregate values indicate the prevalence of structural barriers and institutional constraints, while positive values reflect increasingly favorable conditions for the development of the electric vehicle market and the scaling of infrastructure.

The total macro-environment index was calculated as the cumulative sum of all indicators of the PESTEL block. Given the transitional nature of Kazakhstan's electric vehicle market and the uncertainty associated with technological and regulatory transformation, the PESTEL model in this study should be interpreted as a structured expert-based strategic assessment tool rather than a deterministic forecasting tool.

2.5. SWOT Analysis and SWOT Index Calculation

Following the PESTEL assessment, a SWOT analysis was conducted to identify internal strengths and weaknesses in the development of electric mobility in Kazakhstan, as well as external opportunities and threats associated with alternative institutional and infrastructural conditions.

The SWOT matrix was developed from the integration of several data sources:

- statistical analysis of the electric vehicle market;
- regulatory review;
- results of a survey of EV owners;
- expert interviews and consultations with stakeholders;
- PESTEL results.

To improve analytical consistency and ensure scenario comparison, the traditional qualitative SWOT framework was supplemented with a semi-quantitative SWOT index. The purpose of the index was not to provide an accurate assessment of the market, but to assess the relative strategic position of the electric vehicle sector in different institutional support settings [58–60].

The impact assessment represented the expected impact of the factor on the development of electromobility and was assessed on a five-point scale:

- 5—very strong influence;
- 4—strong influence;
- 3—moderate impact;
- 2—low impact;
- 1—minor impact.

For each factor, a weight (W_i) and a score (B_i) were established, after which the aggregated indicators were calculated for each group of factors.

The integral summary index, the SWOT index, was determined using the formula:

$$SWOT = (S + O) - (W + T) \quad (2)$$

where $S = \sum \omega_i S_i$ —Strengths group index (S); $W = \sum \omega_i W_i$ —Weaknesses group index (W); $O = \sum \omega_i O_i$ —Opportunities group index (O); $T = \sum \omega_i T_i$ —Threats group index (T).

The SWOT index should be interpreted as a scenario-based strategic assessment tool rather than an objective predictive assessment of market performance. Since the values of opportunities, threats and institutional conditions vary depending on political assumptions, the resulting index reflects the relative sensitivity of the electric mobility sector to changes in government support, infrastructure modernization and regulatory development.

2.6. Development of Alternative Scenarios for the Development of Electromobility

To assess the potential development trajectories of electric vehicles in Kazakhstan, three alternative scenarios were developed for the period up to 2030: inertial, realistic and accelerated development scenarios. The scenario framework was designed to assess the sensitivity of the electric vehicle market to various levels of institutional support, infrastructure expansion, and regulatory transformation.

Scripting was based on:

- current statistical trends in Kazakhstan's electric vehicle market;
- international practices of electric mobility development;
- comparative analysis of the policy of transition to electric vehicles in the EAEU countries and emerging markets;
- expert assessments of infrastructure readiness and institutional capacity;
- forecasted growth rates of the fleet in Kazakhstan.

Three scenarios were considered:

Scenario A—Inertial Development (STEPS). This scenario assumes the absence of major additional policy measures aimed at accelerating the development of electric vehicles. Existing tax incentives and limited infrastructure expansion remain, but no systemic institutional reforms are underway.

Scenario B—Realistic Development (APS). This scenario assumes moderate institutional support and partial implementation of strategic electrification measures. It includes accelerated deployment of charging infrastructure, additional regulatory support, expansion of concessional financing mechanisms, and gradual modernization of electrical networks.

Scenario C—Accelerated Development (NZE). This scenario assumes active and systemic government support for electric mobility in accordance with the long-term goals of carbon neutrality. It includes large-scale infrastructure investments and rapid deployment of ultrafast charging stations.

The numerical parameters of the scenarios were adapted to the conditions of Kazakhstan using comparative benchmarks from the EAEU countries and international routes to transition to electric vehicles. However, due to differences in institutional structure, energy

systems, infrastructure density, and consumer purchasing power, the resulting trajectories should be interpreted as analytical approximations rather than direct cross-country projections. Table 1 shows the main assumptions of alternative scenarios for the development of electric vehicles.

Table 1. Key assumptions underlying alternative electromobility development scenarios in Kazakhstan.

Assumption	Scenario A (Inertial)	Scenario B (Realistic)	Scenario C (Accelerated)
Government support	Existing measures only	Moderate expansion of support programs	Comprehensive long-term support policy
Charging infrastructure	Slow growth	Steady expansion in urban areas and highways	Rapid nationwide deployment including ultra-fast chargers
Grid modernization	Limited investments	Partial modernization of distribution networks	Large-scale modernization and capacity expansion
Financial incentives	Existing tax benefits only	Additional financing mechanisms and incentives	Broad subsidies and preferential financing
Regulatory development	Fragmented regulation remains	Partial harmonization of regulations	Comprehensive regulatory framework and dedicated EV legislation
Consumer awareness	Gradual growth	Moderate increase through market expansion	Rapid increase supported by public campaigns
Private sector participation	Limited	Moderate	High
EV market share by 2030	~3%	~7%	~15%

The scenario assumptions reflect different levels of institutional commitment, infrastructure readiness, and market support. Rather than representing precise forecasts, the scenarios were designed to evaluate the sensitivity of Kazakhstan’s electromobility sector to alternative policy and investment conditions. The resulting trajectories provide a structured basis for subsequent PESTEL and SWOT assessments.

3. Results

3.1. Analysis of the State of Electric Mobility in Kazakhstan

The meta-analysis of electric mobility in Kazakhstan was based on data from the National Statistics Bureau of the Republic of Kazakhstan and open sources (EV operator websites, media publications, analytical reports, etc.). Analysis of statistical data showed that the Kazakh market is centered on passenger cars, but the first orders for commercial vehicles are starting to appear. The share of EVs in sales grew from 0.92% (2023) to 1.26% (2024), then declined slightly (1.04% in 2025). Consequently, EV penetration is less than 1%, but there is a steady upward trend. At this stage of development, the electric vehicle market is very sensitive to macroeconomics and government support.

Electric mobility indicators in Kazakhstan are presented in Figures 3–9. The localization of the electric vehicle fleet is characterized by a high concentration in large metropolitan areas—Almaty (60%) and Astana (13%)—while in the regions the level of electric mobility development remains low.

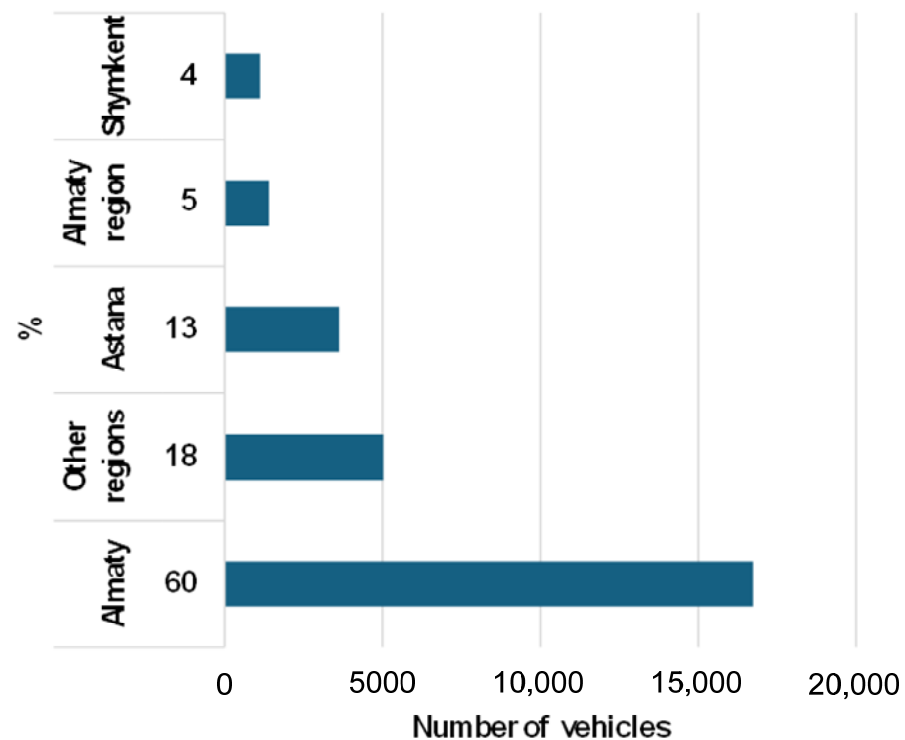


Figure 3. Distribution of electric vehicles by region in the Republic of Kazakhstan.

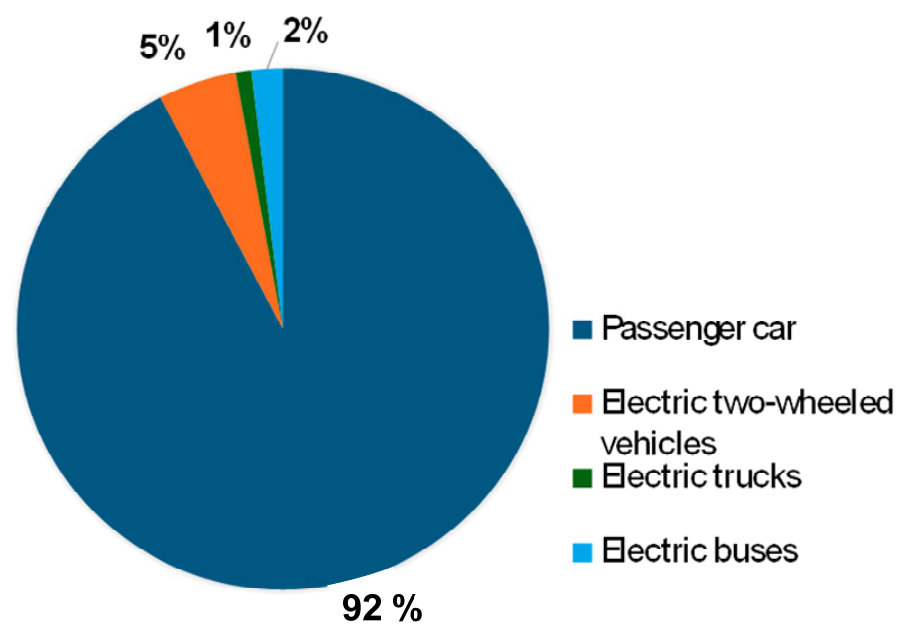


Figure 4. Distribution of electric vehicle fleet by purpose.

Passenger cars account for 97% of the total number of electric vehicles, with more than 70% of this segment represented by Chinese-made models. The most popular brands among users are ZEEKR and TESLA (Figures 3–5).

The technical profile of the electric passenger car fleet in Kazakhstan is determined by the predominance of NCA and NMC lithium-ion batteries, the dominance of models with electric motor power in the range of 100–300 kW, as well as a relatively even distribution of cars by range, with an average value of 450–500 km (Figures 6–8).

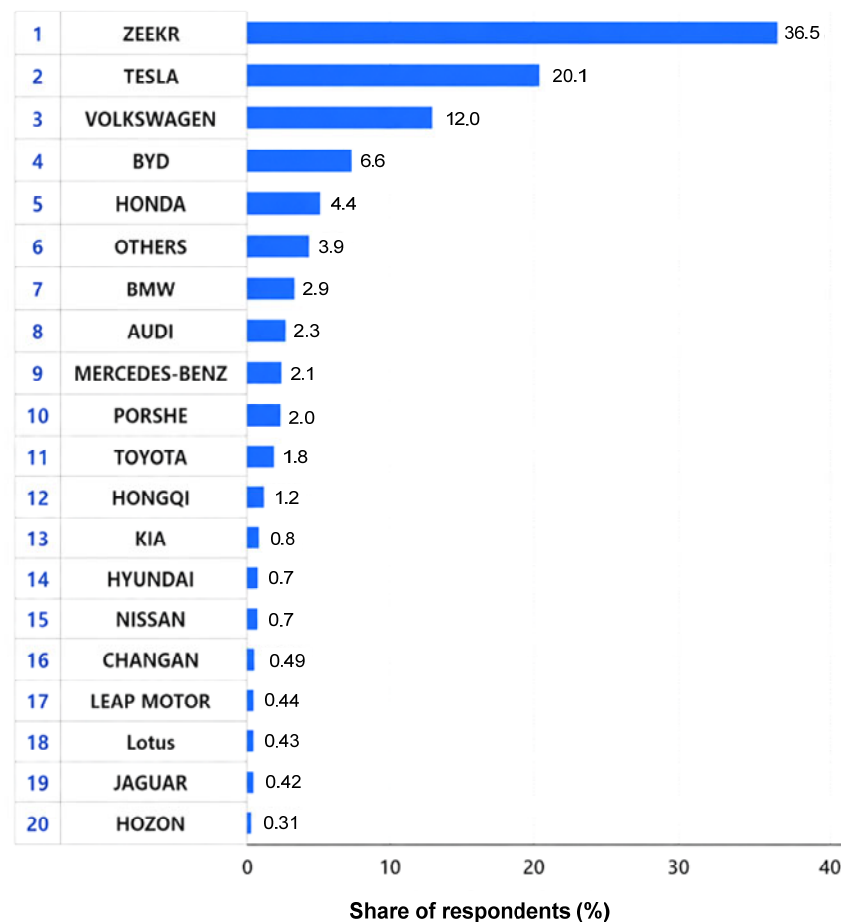


Figure 5. Rating of popular electric vehicle brands (in %).

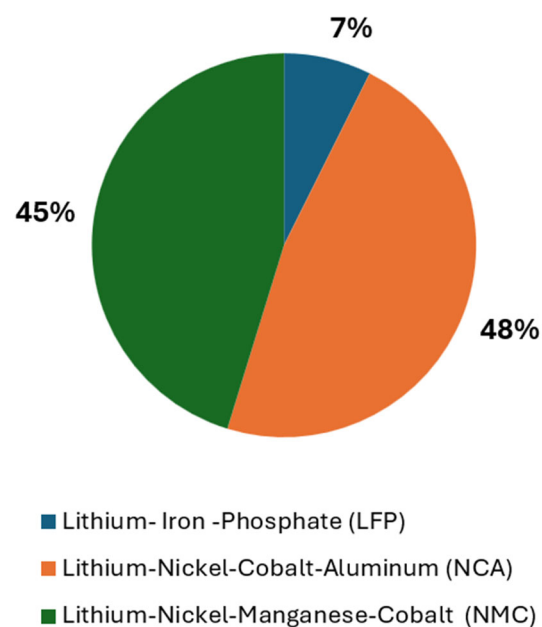


Figure 6. Distribution of the fleet by battery type.

The total number of charging stations in Kazakhstan does not exceed 1000, with an average of about 20 electric vehicles per charging station (in metropolitan areas). The density of the charging infrastructure is uneven: most charging stations are located in the city of Almaty. There are only 23 charging stations operating on highways, which is a significant barrier to the development of electric mobility. Depending on the power and

type of current, about 57% of all charging stations are fast DC charging stations with a capacity of up to 120 kW, while the share of ultra-fast charging stations is extremely small, which increases the charging time of the vehicle.

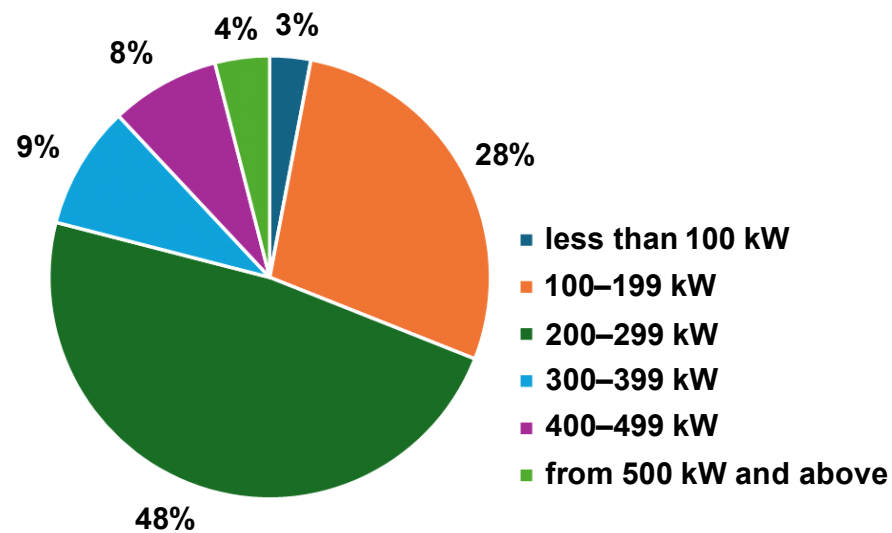


Figure 7. Distribution of electric vehicles by engine power.

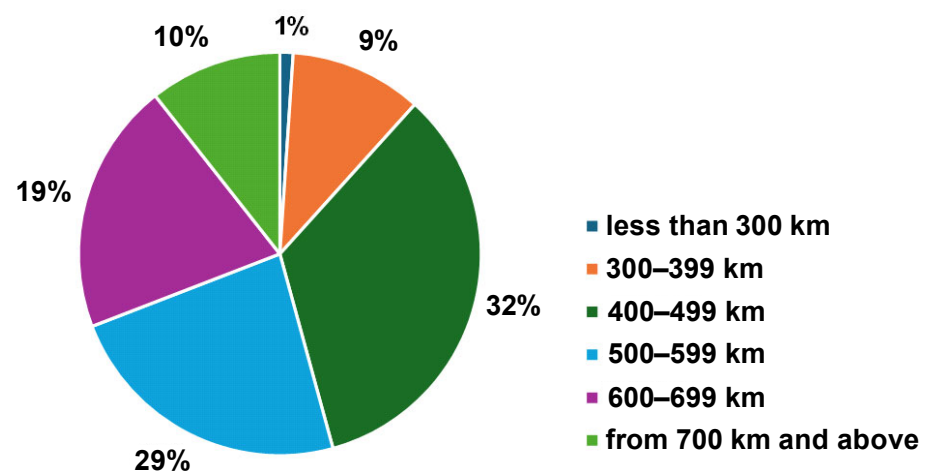


Figure 8. Distribution of electric vehicle fleet by range.

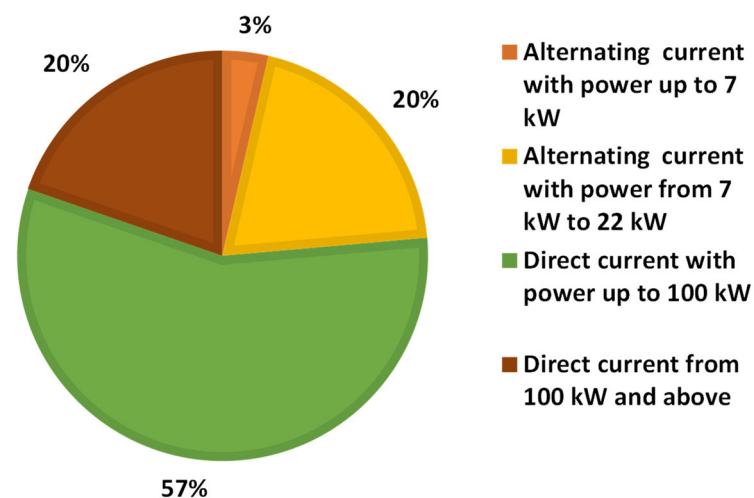


Figure 9. Distribution of electric charging stations by power.

The cost of one kilowatt-hour of electricity for charging electric vehicles in Kazakhstan varies depending on the location and power of the charging station and ranges from \$0.18 to \$0.5/kWh. In the city of Almaty, local authorities have set a maximum tariff of 0.2\$/kWh, which is one of the lowest tariffs in the world.

Overall, Kazakhstan is only beginning to develop its charging infrastructure network, relying on long-term planning and cooperation with private businesses in this area. Currently, there are no direct government incentives for the development of charging infrastructure.

3.2. Factors Influencing Electric Vehicle Adoption

To identify the main key drivers of electric vehicle adoption, a survey of 356 electric vehicle owners was conducted. The survey was carried out using a structured questionnaire developed on the basis of a preliminary analysis of literature and expert opinions.

Based on the research, the following key characteristics and trends can be identified:

1. Socio-demographic profile of electric vehicle owners:

Men predominate (77%), the main age group is 20–40 years old (75%), and most users operate their electric vehicles daily (87%). The most popular brands are Zeekr (36%), Tesla (20%), and Volkswagen (14%). More than 70% of owners charge their vehicles mainly at public stations.

2. Motivational factors for purchase:

The main motives are technological innovation, fuel economy, and the availability of benefits and subsidies. Environmental reasons are of secondary importance.

3. Assessment of performance characteristics:

Most owners rate the range of electric vehicles positively (94%), with most having a range of 320–480 km or more. A total of 42% of respondents are completely satisfied with their purchase.

4. Problematic aspects of operation:

A total of 42% of respondents express dissatisfaction with the charging station infrastructure (queues, lack of stations, inconvenient locations), and 38% are dissatisfied with the service and support provided by manufacturers/dealers. The main complaints are related to the lack of spare parts, software problems, poor adaptation to winter conditions, and high repair costs. High dependence on public stations with insufficient availability is also a significant barrier.

5. Operating features:

The peak charging time is in the evening (35%) and at night (28%), with a quarter of owners reporting queues of more than 30 min for charging, and half of owners keeping a backup car with an internal combustion engine.

An analysis of the socio-economic profile of electric vehicle owners in the Republic of Kazakhstan shows that new electric vehicles are mainly purchased by people with above-average incomes. For this category of private owners, price and various incentives, with the exception of preferential parking, are not decisive factors in the purchase decision; prestige and fashion are significant motivating factors. At the same time, consumer perceptions of electric vehicles are gradually changing thanks to the emergence of more affordable brands and the implementation of government policies aimed at developing charging infrastructure.

Based on the survey results, the key drivers of electric vehicle adoption have been formulated (Table 2).

Table 2. Key drivers of electric vehicle adoption.

Growth Drivers	Barriers to Development
Existing tax and customs incentives for EVs	High cost of electric vehicles
Improved air quality in metropolitan areas	Insufficient number of ultra-fast chargers
Relatively low cost of electricity compared to fuel	Insufficient development of charging infrastructure
Growing environmental awareness in metropolitan areas	Fragmented regulatory framework
Corporate demand (taxis, logistics, car sharing)	Rapid battery degradation in cold climates
Relatively low cost of ownership compared to cars equipped with internal combustion engines	Lack of a state program for the development of electric mobility
Technological appeal	Lack of model projects and transparent regulations for connecting EV charging stations to distribution networks, lack of capacity in some regions
Relatively high level of purchase satisfaction, including the factor of fashion and prestige	Carbon dependence of the energy sector
Improved comfort and operation	Low quality of maintenance and service
Improvements in the regulatory framework	Low localization of production and dependence on imports

Overall, the results demonstrate significant room for improvement in charging station infrastructure and services, and confirm the high level of technological and economic motivation among electric vehicle owners.

3.3. Analysis of Electric Mobility Development Scenarios in Kazakhstan

The dynamic growth of the electric vehicle market is driven by three main forces that interact and influence each other:

- (1) government policy aimed at tightening requirements for harmful emissions and, at the same time, subsidizing the transition to electric vehicles, including the development of charging infrastructure;
- (2) automotive companies that are already investing heavily in the development of electrified transport in order not to lose their share of this promising market;
- (3) consumers who are becoming increasingly demanding in terms of the environmental friendliness and economy of cars, with many of them willing to “switch” to electric vehicles.

An analysis of global practices shows that the development of electric vehicle markets in different countries follows a fairly typical pattern, with three distinct stages [61]:

- (1) The subsidy paradigm: Electric vehicles account for up to 2–3% of new car sales, electric vehicles are expensive, and subsidies are needed for consumers.
- (2) Transition to the mass market paradigm: Electric vehicle sales grow sharply to tens of percent, electric vehicles successfully compete with traditional vehicles in terms of price, and subsidies to consumers become an additional factor.
- (3) Free market paradigm and reaping the benefits of transport electrification.

The third stage has not yet been implemented anywhere in the world and is still in its infancy. However, the completion of the first two stages by a number of countries has provided insight into the algorithms of the processes involved and the most effective mechanisms that the state can use to support them.

According to E. Rogers’ theory of diffusion of innovations, for a new technology to transition to mass consumption, it is important to ensure demand at the level of 2.5% of

the total market volume—the first consumers act as “innovators.” If the “innovators” have a positive experience with the new technology, another 13% of consumers, who can be conditionally called “early followers”, will be ready to try it [62].

At the beginning of 2026, the share of electric vehicles in Kazakhstan relative to the total number of motor vehicles in the country was less than 1%, which corresponds to the “subsidy paradigm” stage. For electric vehicles to enter the mass market, institutional support for initiatives to develop the necessary infrastructure and additional measures to stimulate consumers are needed. The dynamics of the development of the electric vehicle fleet in Kazakhstan are shown in Figure 10.

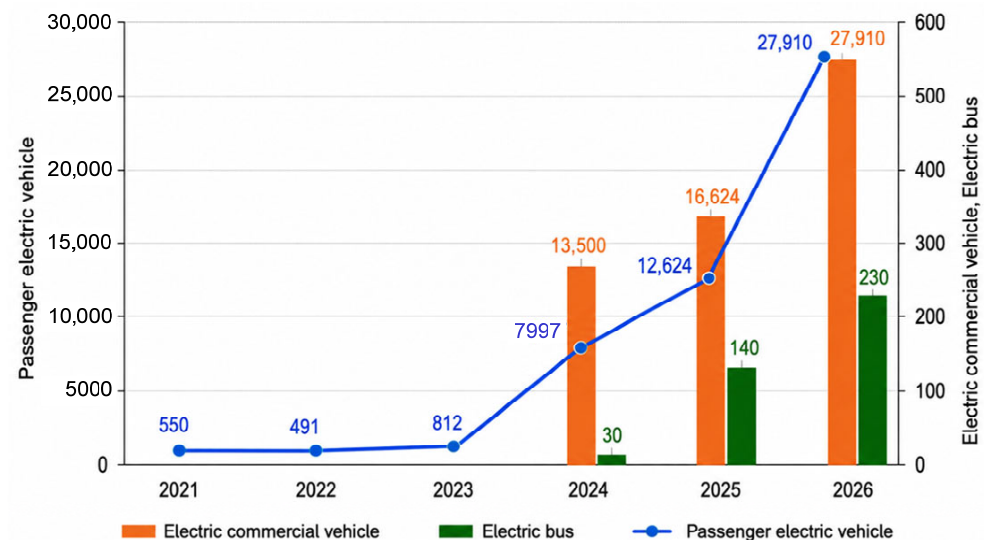


Figure 10. Dynamics of electric vehicle development in Kazakhstan, number of units (as of 1 January of the year under review).

In order to establish policy priorities in the field of electromobility, it is necessary to forecast the growth of electric vehicles in the total vehicle fleet. When forecasting the growth of electric vehicles, in the EAEU countries that are most similar to Kazakhstan, I most often consider three scenarios [63,64]: inertial, realistic, and accelerated development scenarios. The growth rate of electric vehicles in the total vehicle fleet in this study is determined as an average indicator calculated based on forecast scenarios for the development of the electric vehicle market in the Russian Federation and the Kyrgyz Republic:

- Inertial scenario (scenario A)—complete absence of new measures to stimulate electric mobility. In this case, in 2030, the share of electric passenger cars in Kazakhstan will be no more than 3% of the total car market.
- Realistic scenario (scenario B)—a scenario in which the share of electric passenger cars in 2030 will be 7% of the total motor vehicle market. This scenario is based on the state supporting infrastructure development and consumer demand.
- Accelerated development scenario (scenario C)—proactive support for infrastructure, stimulation of demand, and restrictions on the use of internal combustion engine vehicles (Western European countries, the US, and China are moving towards this scenario). This approach would allow the electric vehicle fleet to grow to 15% of the total motor vehicle market by 2030.

Based on statistical data, we will determine the annual growth rate of passenger cars and build trends for the development of the electric vehicle market in the period up to 2030 for scenarios A, B, and C.

As of 1 January 2026, there were more than 5.42 million passenger cars registered in Kazakhstan. The average growth rate of the passenger car fleet is about 3% per year

(according to data from the National Statistics Bureau of the Republic of Kazakhstan for 2023–2025).

Figure 11 shows the growth trends for the electric vehicle fleet until 2030 based on the scenarios presented and taking into account the growth rates of the total number of motor vehicles.

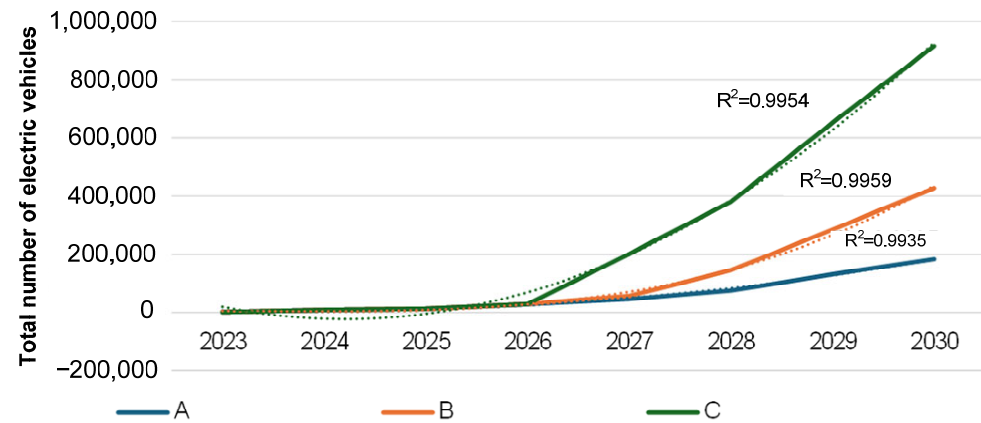


Figure 11. Growth trends in the electric vehicle fleet based on possible scenarios for the development of electric mobility in Kazakhstan (A, B, C).

Figure 11 shows three growth trajectories for electric vehicles, each characterized by exponential acceleration. All models demonstrate high approximation (coefficient of determination $R^2 > 0.99$), which indicates the statistical stability of the trends.

Table 3 shows the main characteristics of possible scenarios for the development of electric mobility.

Table 3. Scenarios for the development of electric mobility in Kazakhstan.

№	Indicator	Scenarios		
		A	B	C
1	Growth rate of electric vehicle fleet	Low (3% of total vehicle fleet)	Medium (7% of total vehicle fleet)	High (15% of total vehicle fleet)
2	Institutional support	Minimal	Moderate	Systemic
3	Infrastructure	Limited	Developing	Large-scale
4	Environmental impact	Limited	Significant	Transformational
5	Total number of electric vehicles in 2030	180,000	420,000	910,000
6	Consistency with international programs	Stated Policies Scenario (STEPS) [65,66]	Announced Pledges Scenario (APS) [65,67]	Net Zero Emissions by 2050 Scenario (NZE) [67,68]
7	Scenario features	The growth of the electric vehicle fleet continues, but without a sharp acceleration, dependence on existing subsidies remains, infrastructure is developing gradually, and EV penetration is limited by budget constraints.	EV growth accelerates after 2026–2030, additional incentives are introduced.	Rapid acceleration of electric vehicle adoption.

These development scenarios serve as a basis for assessing the impact of the macro-environment on the scaling of electric mobility.

3.4. Assessment of the Impact of External Factors in the Context of Electric Mobility Development Scenarios

To study the impact of external factors on the development of electromobility in Kazakhstan, a PESTEL analysis of the external environment was conducted. At the first stage, based on the results of a survey (356 questionnaires), a list of factors affecting electromobility was compiled. Based on the analysis of the frequency of responses, 50 factors were selected, at a rate of 10 factors for each PESTEL block (Table 4), for further analysis.

Table 4. Main external factors affecting electromobility in the Republic of Kazakhstan.

1. Political	2. Economic
1.1. Existence of a long-term national electric mobility strategy (until 2030/2060).	2.1. Cost of an electric vehicle
1.2. Adoption of a separate law “On the Development of Electric Transport.”	2.2. Cost of ownership of an electric vehicle compared to a vehicle with an internal combustion engine.
1.3. Integration of EV policy with the carbon neutrality program.	2.3. Direct subsidies for the purchase of electric vehicles.
1.4. Interagency coordination (ministries—local executive bodies).	2.4. Tax and customs incentives.
1.5. Political stability and continuity of support programs.	2.5. Availability of preferential financing.
1.6. Government investment in the modernization of electrical networks.	2.6. Electricity tariff policy (night tariffs).
1.7. Support for the development of charging infrastructure at the national level.	2.7. Investment attractiveness of the EV infrastructure sector.
1.8. Installation of ultra-fast charging stations (at least 60% of the total number)	2.8. Level of household income.
1.9. Kazakhstan’s participation in international climate agreements.	2.9. Carbon regulation (introduction of carbon pricing).
1.10. Regional differentiation of policy (southern regions with a shortage of electrical grid capacity).	2.10. Import dependence on foreign EV manufacturers.
3. Social	4. Technological
3.1. Development of green finance.	4.1. Localization of production.
3.2. Environmental awareness of the population.	4.2. High level of technical maintenance, opening of specialized service centers.
3.3. High level of trust in innovative technological solutions.	4.3. Developed charging infrastructure in populated areas (1 charging station per 20 electric vehicles).
3.4. Perception of electric vehicles as a symbol of social status or as a means of saving money.	4.4. Well-developed charging infrastructure on highways (1 charging station per 100 km).

Table 4. Cont.

3.5. Readiness of corporate fleets for electrification.	4.5. Availability of ultra-fast charging stations with a capacity of over 150 kW (at least 60% of the total number).
3.6. Availability of service.	4.6. Wear and tear of distribution electrical networks, lack of free capacity.
3.7. Availability of educational and retraining programs.	4.7. Introduction of smart charging systems.
3.8. Compliance of EV economic and operational parameters with consumer expectations.	4.8. Expansion and introduction of Vehicle-to-Grid (V2G) technologies.
3.9. Social inequality in access to EVs.	4.9. Adapting EV equipment and batteries to cold climates.
3.10. Readiness of the population to change behavioral patterns.	4.10. Standardization of technical requirements for electronic data storage systems.
5. Legal	
5.1. Unification of procedures for connecting EV charging stations to electrical networks.	
5.2. Introduction of standards for the construction of charging infrastructure in residential complexes and public places.	
5.3. Introduction of safety standards for rechargeable batteries.	
5.4. Introduction of standards for the recycling of rechargeable batteries (EPR).	
5.5. Introduction of dynamic tariff regulation.	
5.6. Development of a regulatory framework for Vehicle-to-Grid (V2G) technologies.	
5.7. Introduction of environmental standards for internal combustion engine emissions, ban/restriction on motor vehicles with internal combustion engines.	
5.8. Tightening of requirements for the certification of electric vehicles: software, language interface, electromagnetic radiation.	
5.9. Establishment of regulatory requirements for data processing and the operation of digital platforms related to the operation and infrastructure of electric mobility.	
5.10. Introduction of the law “On Electric Transport.”	

In the second stage, experts (63 people) assessed the selected factors in terms of their degree of influence and the likelihood of their manifestation in the implementation of the above development scenarios.

The integral indicator for the PESTEL block is determined by Formula (1), and the overall macro-environment index is calculated by the formula:

$$I_{total} = \sum I_{block} \quad (3)$$

The use of a general index allows for the assessment of various development scenarios, the identification of dominant blocks, and the performance of sensitivity analysis.

The model uses the following rating scales (Tables 5 and 6).

Table 5. Influence strength scale (S: $-3 \dots +3$).

Meaning	Interpretation
+3	Transformational driver
+2	Strong positive factor
+1	Moderate positive impact
0	Neutral impact
−1	Moderate constraint
−2	Strong structural barrier
−3	Critical systemic risk

Table 6. Probability scale (P: $0 \dots 3$).

Meaning	Interpretation
0	The factor will have virtually no impact
1	Low probability
2	Medium probability
3	High probability/structural inevitability

Quantitative transformation of qualitative macro-environmental factors is recognized as an effective tool for strategic analysis. Recent studies confirm that integrating expert assessments with scoring scales improves the reproducibility and analytical rigor of SWOT and PESTEL models. The use of a symmetrical scale S ($-3 \dots +3$) is justified by the need for a balanced assessment of opportunities and threats, ensuring sufficient differentiation without pseudo-accuracy, as well as compatibility with the risk-oriented logic of “impact $\times$ probability.” This approach allows for consideration of the direction of the effect and the degree of its feasibility, which is widely used in risk management and strategic planning [69,70].

The use of a discrete scale P ($0 \dots 3$) is due to the scenario nature of the analysis, the difficulties of accurate probability assessment in a transition economy, and the use of ranking scales in expert methods. This approach avoids the illusion of accuracy and adequately reflects the degree of institutional consolidation. Thus, the probability scale reflects the degree of institutional and structural consolidation of the factor within the scenario.

Table 7 summarizes the results of the quantitative PESTEL analysis, and Figure 12 shows its visualization.

Table 7. Results of the quantitative PESTEL analysis of the impact of the macro-environment on electromobility.

№	Integral Indicator for the Block	Scenarios		
		A (STEPS)	B (APS)	C (NZE)
1	Political	+3	+42	+48
2	Economic	−7	+24	+36
3	Social	−3	+18	+28
4	Technological	−39	+15	+42
5	Legal	−11	+26	+52
6	Overall indicator	−57	+125	+206

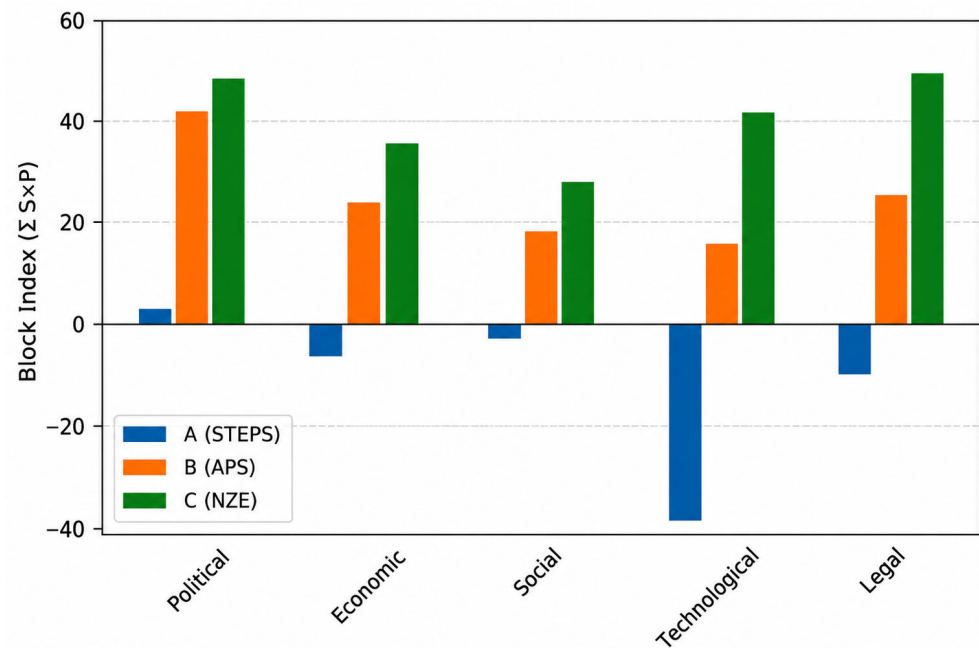


Figure 12. Comparative PESTEL block distribution A-B-C scenarios.

Under scenario A (STEPS), Kazakhstan's macro-environment is characterized by a predominance of infrastructure and network constraints, fragmented regulatory and legal frameworks, limited economic support in the form of individual incentives, and a lack of systemic technological transformation. In this case, the growth of the electric vehicle market is possible, but its scale is significantly limited by infrastructure costs and institutional barriers. Scenario A (STEPS) demonstrates a negative integral value—the prevalence of barriers.

In scenario B (APS), the macro-environment in Kazakhstan acquires a favorable character: legal policy provides systemic support, economic incentives, and contributes to growth in demand, while infrastructure develops at an accelerated pace. Despite continuing constraints related to network capacity and import dependence, these do not have a decisive impact on market dynamics. This scenario is characterized by a phase of accelerated but controlled growth.

In scenario C (NZE), the legal block is the main driver of institutional transformation, while the technological block has significant potential but retains systemic risks related to the wear and tear of the electrical grid infrastructure. The economic effect is positive but sensitive to import substitution and implementation costs. The social block is characterized by reduced sustainability due to unequal access to electric vehicles. The political block provides support for the transition but requires significant budgetary resources. Thus, scenario C (NZE) is structurally favorable for the development of electric mobility, but its implementation requires a thorough modernization of the energy system and ensuring the financial stability of the state.

3.5. SWOT Analysis

Based on Tables 1 and 3, an itemized SWOT analysis matrix is formed and a SWOT index is determined. To assess the market's sensitivity to changes in government policy, the SWOT index is calculated for three alternative scenarios (baseline, increased government support, no government support) (Table 8).

Table 8. Element-by-element SWOT analysis matrix for electric mobility in Kazakhstan.

Strengths		Opportunities	
S1	Low cost of ownership	O1	Integration of electric mobility policy with carbon neutrality program
S2	No local emissions	O2	Expansion of government support
S3	Reduced noise levels	O3	High level of trust in innovative technological solutions
S4	Technological appeal	O4	Reduction in the cost of electric vehicles
S5	Economic incentives (tax breaks, free parking)	O5	Development of charging infrastructure
S6	Corporate demand (taxis, logistics, car sharing)	O6	Modernization of electrical networks, development of renewable energy sources
S7	High level of purchase satisfaction, fashion and prestige factors	O7	Localization of production
S8	Improvement of the regulatory framework	O8	Adaptation of equipment and batteries to cold climates
		O9	Introduction of smart charging systems and V2G technology
Weaknesses		Threats and Risks	
W1	High cost of electric vehicles	T1	Cancellation of subsidies
W2	Insufficient development of charging infrastructure	T2	Increase in electricity tariffs
W3	Weak service base	T3	Decline in service quality
W4	Climatic limitations	T4	Competition with other types of vehicles
W5	Low localization of production and dependence on imports	T5	Tighter certification requirements for electric vehicles and charging stations
W6	Fragmented regulatory framework	T6	Lack of spare parts and their high cost
W7	Lack of a state program for the development of electric mobility	T7	Lack of interagency coordination
W8	Carbon dependence of the energy sector		

The baseline scenario corresponds to scenario A (STEPS).

The “Increased government support” scenario corresponds to scenario B (APS): introduction of direct subsidies for the purchase of EVs; accelerated construction of charging stations; adoption of the law “On Electric Transport”; tariff incentives for night charging; adoption of the necessary regulatory and legal acts.

The “No government support” scenario: cancellation of tax breaks and duties; no direct subsidies; slowdown in the construction of charging stations; lack of regulatory unification; tariff increases without compensatory measures.

When determining the SWOT index, an influence scale (B: 0–5) was used: 5—very strong influence; 4—strong; 3—moderate; 2—weak; 1—insignificant. The weight (ω_i) reflects the relative importance of the factor within the group, with each weight for each group = 1. These indicators were determined based on expert assessments. The results of the SWOT index calculation for alternative scenarios are shown in Table 9.

Table 9. Calculation of the SWOT index for alternative scenarios for the development of electromobility.

Block	Indicator	Alternative Scenarios								
		Basic			Strengthening Government Support			Lack of Government Support		
		ω_i	B_i	$\omega_i B_i$	ω_i	B_i	$\omega_i B_i$	ω_i	B_i	$\omega_i B_i$
Strengths	S1	0.2	4	0.8	0.2	4	0.8	0.2	4	0.8
	S2	0.15	3	0.45	0.15	3	0.45	0.15	3	0.45
	S3	0.05	2	0.1	0.05	2	0.1	0.05	2	0.1
	S4	0.15	2	0.3	0.15	2	0.3	0.15	2	0.3
	S5	0.1	2	0.2	0.1	5	0.5	0.1	1	0.1
	S6	0.1	2	0.2	0.1	4	0.4	0.1	1	0.1
	S7	0.1	2	0.2	0.1	1	0.1	0.1	2	0.2
	S8	0.15	4	0.6	0.15	5	0.75	0.15	1	0.15
	$\sum \omega_i S_i$		2.85			3.4			2.2	
Opportunities	O1	0.2	5	1	0.1	3	0.3	0.1	1	0.1
	O2	0.1	3	0.3	0.1	5	0.5	0.1	1	0.1
	O3	0.1	4	0.4	0.1	4	0.4	0.1	4	0.4
	O4	0.1	4	0.4	0.15	4	0.6	0.15	4	0.6
	O5	0.15	4	0.6	0.15	5	0.75	0.15	1	0.15
	O6	0.15	3	0.45	0.1	4	0.4	0.1	1	0.1
	O7	0.1	3	0.3	0.1	4	0.4	0.1	3	0.3
	O8	0.1	3	0.3	0.1	3	0.3	0.1	3	0.3
	O9	0.1	3	0.3	0.1	3	0.3	0.1	3	0.3
	$\sum \omega_i O_i$		3.35			3.95			2.35	
Weaknesses	W1	0.2	5	1	0.2	3	0.6	0.2	5	1
	W2	0.2	5	1	0.2	3	0.6	0.2	5	1
	W3	0.1	3	0.3	0.1	2	0.2	0.1	3	0.3
	W4	0.05	3	0.15	0.05	3	0.15	0.05	3	0.15
	W5	0.05	3	0.15	0.05	2	0.1	0.05	3	0.15
	W6	0.1	4	0.4	0.1	2	0.2	0.1	5	0.5
	W7	0.15	4	0.6	0.15	2	0.3	0.15	5	0.75
	W8	0.15	4	0.6	0.15	3	0.45	0.15	5	0.75
	$\sum \omega_i W_i$		4.2			2.6			4.6	
Threats and Risks	T1	0.2	5	1	0.2	3	0.6	0.2	5	1
	T2	0.15	5	0.75	0.15	3	0.45	0.15	5	0.75
	T3	0.1	4	0.4	0.1	4	0.4	0.1	4	0.4
	T4	0.1	5	0.5	0.1	5	0.5	0.1	5	0.5
	T5	0.15	5	0.75	0.15	5	0.75	0.15	5	0.75
	T6	0.1	3	0.3	0.1	3	0.3	0.1	3	0.3
	T7	0.1	3	0.3	0.1	1	0.1	0.1	3	0.3
	$\sum \omega_i T_i$		4			3.1			4	
SWOT index			−2			1.65			−4.05	

The SWOT index values are interpreted as follows:

- A value greater than +2 corresponds to a strong strategic position;
- Values in the range from 0 to +2 reflect a moderately stable position;
- Values from 0 to −2 characterize a vulnerable position;
- A value of less than −2 indicates a critically weak market position.

In the baseline scenario, the electric vehicle market in Kazakhstan is characterized by a vulnerable but developing position: despite significant potential (S + O), institutional and infrastructure constraints (W + T) continue to dominate.

In the scenario of increased government support, the market moves from the vulnerable zone (−2) to the area of sustainable growth (+1.65), which is due to the reduction in the influence of infrastructure and institutional weaknesses, which are key drivers of positive change.

In the scenario of no government support, the critical role of institutional policy is confirmed: government support is a systemic factor, and the difference between the extreme scenarios ($\Delta = +5.7$) demonstrates the high sensitivity of the electric mobility market to changes in the institutional environment.

4. Discussion

4.1. Institutional Sensitivity of Electromobility Development

The results of the study show that the development of electromobility in Kazakhstan is highly dependent on the institutional environment and the scale of state support. PESTEL and SWOT analyses show that the strategic position of the EV sector is changing significantly in different regulatory and infrastructure settings.

In contrast to mature electric vehicle markets, where consumer demand is increasingly evolving regardless of direct government intervention, Kazakhstan still corresponds to an early transition stage where infrastructure expansion and institutional regulation play a critical role in market scaling.

The quantitative assessment of PESTEL showed that technological and legal factors have the greatest impact on the future development of electromobility in Kazakhstan. In the inertial scenario, technological limitations associated with insufficient charging infrastructure, limitations of electrical networks and low localization of production form the largest group of structural barriers. However, in scenarios involving stronger institutional support, legal and policy aspects become the main drivers of transformation through the introduction of coordinated regulatory measures, infrastructure standards and incentive mechanisms.

An important finding of the study is that consumer environmental motivation currently plays a secondary role to economic and technological considerations. The survey results show that the introduction of electric vehicles in Kazakhstan is primarily due to technological attractiveness, reduced operating costs and prestige-related factors, while dissatisfaction with charging availability and quality of service remains high. This finding confirms that infrastructure readiness and operability are now more influential determinants of EM acceptance than environmental awareness alone.

The findings should be interpreted in the context of scenario-based strategic evaluation rather than deterministic forecasting. Since the SWOT and PESTEL indices are derived in part from institutional assumptions included in alternative scenarios, the analysis primarily demonstrates the relative sensitivity of the electric vehicle sector to changes in public policy and infrastructure conditions.

4.2. Comparison with Emerging and Post-Soviet Electric Vehicle Markets

The trajectory of development of electric mobility in Kazakhstan generally corresponds to the transition scheme at an early stage observed in the developing and post-Soviet markets of electric vehicles. As in other countries with an evolving institutional framework, the adoption of electric vehicles in Kazakhstan remains highly dependent on government incentives, the availability of paid infrastructure, and regulatory coordination.

One of the defining features of the Kazakhstan electric vehicle market is the extremely high concentration of electric vehicles in large metropolitan areas, especially in Almaty and Astana. This model is consistent with the results of international studies showing that the spread of electric vehicles in developing countries initially occurs in urban regions with higher incomes and better infrastructure availability. Similar city-focused adoption patterns were seen in Russia, China and several Eastern European countries in the early stages of electric vehicle development.

Compared to Western European countries and China, Kazakhstan currently lacks a single institutional framework governing electromobility. In mature electric vehicle markets, the rapid expansion of electric transportation has been largely supported by coordinated national policies, including direct subsidies, infrastructure deployment programs, preferential taxation, stringent emissions standards, and long-term industrial strategies.

The analysis shows that Kazakhstan remains particularly vulnerable to infrastructure-related constraints due to large geographical distances between regions, uneven population density and limited development of motorway toll networks.

Although electric vehicles contribute to reducing local urban emissions and improving air quality, the overall environmental effect remains partially limited by the carbon intensity of electricity generation. Similar problems have also been identified in a number of transition economies, where decarbonization of transport is simultaneously dependent on modernization of the energy sector.

The country is reminiscent of the early stages of development previously seen in China and some Eastern European markets, where the deployment of state-backed infrastructure and regulatory coordination have been critical in overcoming initial barriers to electric vehicle adoption.

The findings suggest that in countries with economies in transition, the success of EV policies depends not only on consumer demand or technological affordability, but also on the government's ability to coordinate long-term infrastructure and regulatory changes.

4.3. Infrastructure Constraints and Consequences for Consumer Behavior

The survey results show that infrastructure availability and usability now represent the most significant practical barriers to wider adoption of electric vehicles in Kazakhstan. More than 70% of respondents reported regular use of public charging stations, while a significant proportion experienced charging queues exceeding 30 min during peak periods. This situation reflects the insufficient density of charging infrastructure compared to the rapidly growing fleet of electric vehicles, especially in metropolitan areas.

An additional factor affecting consumer behavior is the persistence of "range anxiety," especially for intercity travel. The findings suggest that the current charging infrastructure remains largely adapted to urban day-to-day mobility rather than nationwide transport integration.

The findings have important implications for infrastructure planning and public policy:

- accelerated deployment of charging infrastructure, especially ultrafast charging stations and motorway charging corridors;
- modernization of electric distribution networks is becoming more important as the use of electric vehicles expands;

- improvement of maintenance services, technical support and adaptation of electric vehicle technologies to cold climatic conditions.

The results show that the transition to electric mobility in Kazakhstan depends not only on the availability of electric vehicles themselves, but also on the creation of an integrated infrastructure and institutional ecosystem capable of supporting large-scale operation of electric vehicles, taking into account geographical and climatic conditions.

4.4. Policy Implications for EV Development

Further expansion of electric mobility in Kazakhstan requires a coordinated institutional approach combining regulatory reform, infrastructure modernization, economic incentives and long-term strategic planning. Analyses conducted by PESTEL and SWOT show that isolated measures are unlikely to ensure sustainable growth of the electric vehicle market without systemic coordination between transport, energy, environmental and industrial policies.

The policy recommendations proposed in the study directly stem from empirical findings from the electric vehicle owner survey, expert consultations and assessments.

First, the survey results showed that a significant proportion of electric vehicle users experience dissatisfaction with the availability of charging infrastructure, including insufficient station density, long waiting times and limited highway coverage. These findings indicate that accelerated deployment of fast and ultrafast charging stations should be a national infrastructure priority, particularly in major urban areas and along long-distance transport corridors.

Second, the PESTEL analysis identified technological and legal factors as the most influential determinants of the future development of electromobility. Establishing a single regulatory framework for electric mobility, including technical standards for charging infrastructure, grid connectivity procedures, and operational requirements, could significantly improve institutional coordination and reduce barriers for investors.

Third, the SWOT assessment demonstrated the high sensitivity of the electric vehicle sector to changes in government support measures. Under scenarios with stronger institutional support, the sector's strategic position has improved significantly. Consequently, maintaining stable tax incentives, concessional financing mechanisms and public-private partnership instruments remains important in the early stages of market development.

Fourth, the study found significant dependence on imported vehicles, technology and equipment. In the longer term, industrial policy measures aimed at supporting the domestic assembly, maintenance, production of charging equipment and related technological industries can increase the sustainability of the national electromobility ecosystem and reduce external dependence.

Finally, the results suggest that successful large-scale EV deployment requires close coordination between transport policy, energy planning and carbon neutrality goals. Accordingly, future EV strategies should be integrated into broader national programs for energy transition, infrastructure modernization, and sustainable economic development.

The analysis also shows that the modernization of electric distribution networks should become an integral component of the policy in the field of electromobility. Therefore, the development of charging infrastructure must be coordinated with the long-term planning of the power system.

Another policy consequence is the importance of maintaining stable and predictable economic support mechanisms in the early stages of market development. SWOT analysis shows that the removal of incentives and the lack of coordinated institutional support significantly weaken the strategic position of the electric vehicle sector.

The study shows that the successful transition to electromobility in Kazakhstan depends on the ability of the state to ensure long-term institutional coherence and infrastructural coordination. E-mobility policies should be integrated into broader energy transition and carbon neutrality strategies.

4.5. Limitations and Directions of Future Research

Several limitations of this study should be recognized when interpreting the findings.

First, the survey of electric vehicle owners was primarily conducted in the city of Almaty, which currently represents the largest concentration of electric vehicle users in Kazakhstan. This made it possible to analyze the most active segment of the national electric vehicle market, where the availability of charging infrastructure and socio-economic conditions differ significantly. Future research should therefore include broader regional coverage to increase the representativeness of consumer behavior analysis at the national level.

Second, PESTEL and SWOT quantitative scores are based in part on expert evaluations, which inherently involve a degree of subjectivity. In countries with economies in transition, characterized by rapidly changing institutional and technological conditions, expert-based strategic assessment remains one of the most practical approaches to assessing long-term development scenarios in conditions of uncertainty.

Third, the scenario framework developed in this study represents exploratory strategic trajectories rather than deterministic projections of the development of the electric vehicle market. The dynamics of electric mobility in Kazakhstan may be influenced by additional external factors that were not fully included in the analysis, including technological breakthroughs, geopolitical risks, changes in energy markets and changes in international environmental policy.

Fourth, the study primarily focuses on the institutional, infrastructure, and consumer aspects of EV development and does not include detailed techno-economic modeling of electric grid loads, environmental life cycle assessment of EVs, or economic cost-benefit analysis of infrastructure deployment. These aspects require separate specialized research.

Despite these limitations, the study represents one of the first comprehensive institutional and strategic assessments of the development of electromobility in Kazakhstan and contributes to understanding the dynamics of the transition to electric vehicles in emerging and transition economies.

5. Conclusions

This study provides a comprehensive institutional and strategic assessment of the development of electric mobility in the Republic of Kazakhstan by integrating statistical market analysis, regulatory review, stakeholder consultation, surveys of electric vehicle owners and semi-quantitative structures of PESTEL and SWOT. The results show that the Kazakhstan electric vehicle market remains at an early stage of development and is characterized by high sensitivity to institutional support, infrastructure readiness and regulatory coordination.

The analysis showed that the current development of electromobility in Kazakhstan is concentrated primarily in large megacities, especially in Almaty and Astana, where charging infrastructure and consumer demand are relatively more developed. At the same time, regional differences, insufficient motorway charging infrastructure, limited service support, and reliance on imported technologies remain significant barriers to wider expansion of the electric vehicle market.

A survey of electric vehicle owners found that economic and technological factors now play a more important role in electric vehicle adoption than environmental considera-

tions. The most significant barriers identified by respondents include insufficient charging infrastructure, limited quality of service, winter operating restrictions and issues around long-distance travel and charging availability.

Scenario analysis of PESTEL and SWOT showed that institutional and legal factors have the greatest impact on the future trajectory of electric mobility in Kazakhstan. In scenarios involving increased government support, regulatory coordination and accelerated infrastructure deployment, the strategic position of the electric vehicle sector becomes significantly more stable. Conversely, with limited institutional support, infrastructural and technological constraints continue to dominate market conditions.

The study confirms that the transition to electric mobility in emerging economies depends not only on consumer demand or technological accessibility, but also on the ability of the state to provide coordinated long-term infrastructure modernization, regulatory coherence and integration of transport electrification into broader energy transition policies.

Based on the results obtained, the following strategic priorities for Kazakhstan can be distinguished:

- development of a unified legal framework for electric mobility;
- accelerated deployment of urban and road charging infrastructure;
- modernization of electrical distribution networks;
- introduction of sustainable economic incentive mechanisms;
- support of maintenance services and technical adaptation of electric vehicle technologies to local climatic conditions;
- integrating e-mobility policies into national carbon neutrality and sustainable transport strategies.

Overall, the study contributes to understanding the processes of transition to electromobility in emerging and post-Soviet economies and demonstrates the critical role of institutional readiness and infrastructure coordination in the sustainable development of electric vehicle markets.

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