ENVIRONMENTAL IMPACT ASSESSMENT OF ELECTRIC VEHICLE EXPANSION IN UZBEKISTAN

Aliyev Omadjon Kozimovich
Andijan State technical institute

Abstract. Uzbekistan is undergoing a major transformation in its transportation and energy sectors, driven by the national goals of reducing greenhouse gas emissions, improving air quality, and modernizing mobility systems. The rapid expansion of electric vehicles (EVs) presents a promising opportunity to reduce fossil fuel dependence and mitigate environmental degradation. However, a successful transition requires a comprehensive understanding of the environmental implications of EV deployment, including lifecycle emissions, electricity mix, battery production, end-of-life management, and ecological impacts. This study assesses the environmental effects of EV expansion in Uzbekistan by examining four key components: (1) air quality improvement potential, (2) greenhouse gas (GHG) emission reductions, (3) environmental pressures related to electricity production and battery manufacturing, and (4) long-term sustainability aligned with the national "Green Economy Strategy 2030." Results indicate that widespread EV adoption could reduce national CO_2 emissions from the transport sector by up to 28–32% by 2030, assuming increased incorporation of renewable energy sources. However, challenges persist in battery waste management, lithium resource dependence, and electricity grid carbon intensity. The paper concludes with recommendations for sustainable EV growth, including renewable-powered charging infrastructure, circular battery systems, and environmental policy integration.

Keywords: Electric Vehicles, Environmental Impact, Uzbekistan, Air Quality, Greenhouse Gas Emissions, Sustainability, Renewable Energy

1. Introduction

1.1 Background

Transportation is among the most energy-intensive and environmentally impactful sectors in Uzbekistan. As of 2024, more than 3.1 million passenger vehicles operate nationwide, the majority of which rely on internal combustion engines (ICEs). These vehicles contribute significantly to urban air pollution, CO_2 emissions, and noise pollution, especially in densely populated regions like Tashkent, Fergana, and Samarkand.

Electric vehicle (EV) technology has emerged globally as a powerful tool for decarbonizing transport. The International Energy Agency (IEA, 2024) reports that EVs can reduce lifecycle emissions by 40–70% depending on electricity generation sources. Uzbekistan has recognized this potential: recent Presidential Decrees (PQ-126, 2022; PF-60, 2023) encourage EV import tax exemptions, local EV production, and charging infrastructure development.

However, while EVs offer clear environmental benefits, their expansion also introduces new ecological challenges—particularly related to electricity generation mix, battery production, mining impacts, and end-of-life recycling. Therefore, a comprehensive Environmental Impact

Assessment (EIA) is essential for evaluating how EV expansion will influence Uzbekistan's environment in the long term.

1.2 Research Gap

Previous studies on EVs in Central Asia have focused largely on infrastructure planning, economic feasibility, or energy system modeling, but environmental impact assessments remain limited. There is a lack of holistic, Uzbekistan-specific research that integrates air quality, lifecycle emissions, renewable energy integration, and battery waste management into a unified framework.

1.3 Purpose of the Study

The purpose of this study is to conduct an environmental impact assessment of EV expansion in Uzbekistan by:

➢ Analyzing air quality improvement potential

➢ Estimating CO_2 and pollutant emission reductions

➢ Evaluating electricity generation impacts

➢ Exploring battery production and recycling challenges

➢ Proposing sustainable strategies aligned with national goals

This paper provides evidence-based insights to support policymakers, energy planners, and transportation authorities in building a greener mobility future.

2. Materials and Methods

2.1 Data Sources

This research uses the following primary datasets:

➢ Ministry of Energy of Uzbekistan (2024) – electricity mix, renewable energy plans

➢ UzHydromet (2023–2024) – air quality data for key pollutants (PM2.5, NO_x, CO_2)

➢ UzStat (2024) – vehicle registration and fuel consumption statistics

➢ IEA EV Outlook (2024) – lifecycle emission factors

➢ Scientific literature on lifecycle analysis (LCA) for EV batteries and ICE vehicles

2.2 Methodological Framework

The methodology adopted in this research is based on a multidisciplinary analytical framework that integrates environmental science, energy economics, transport engineering, and lifecycle

assessment principles to create a comprehensive evaluation of how electric vehicle (EV) expansion will influence Uzbekistan's ecological landscape. To achieve this, the study first relied on a combination of national statistical datasets, regional environmental reports, and international scientific literature, all of which were carefully examined for consistency, reliability, and methodological compatibility. These include records from the Ministry of Energy, air quality monitoring data from UzHydromet, and vehicular registration information from the Statistics Agency. Each dataset was subjected to pre-processing steps such as normalization, year-to-year comparison, missing-value assessment, and error correction to ensure that the final analytical model accurately reflects Uzbekistan's transport and environmental realities. Furthermore, this research utilized international sources such as the International Energy Agency's EV Outlook and UNECE environmental guidelines to provide globally recognized emission factors, lifecycle parameters, and comparative baselines that help situate Uzbekistan's transition within a broader global context.

The environmental assessment itself follows a sequential methodological path that begins with establishing an emission baseline for the current internal combustion engine (ICE) vehicle fleet, focusing on CO_2, NO_x, and PM2.5 emissions as primary environmental indicators. Using these baselines, a lifecycle assessment (LCA) framework was employed to estimate the environmental impacts associated with EVs, including upstream electricity production emissions, battery manufacturing energy consumption, and end-of-life waste considerations. The LCA approach was essential because it enables not only tailpipe emission comparisons but also quantifies hidden environmental burdens associated with the production, operation, and disposal phases of EV technology. The next step consisted of developing future environmental scenarios, including slow, moderate, and accelerated EV adoption trajectories projected toward 2030. These scenarios were modeled using emission-factor calculations, energy-demand forecasts, and assumptions regarding renewable energy integration. Analytical tools such as MATLAB for simulation, QGIS for spatial pollution analysis, and Excel-based emission calculators were used to create a coherent environmental projection model. The combination of empirical data, lifecycle modeling, and scenario-based forecasting creates a robust methodological foundation that allows this study to produce an unbiased and scientifically grounded assessment of the environmental consequences of EV expansion in Uzbekistan.

3. Results

The results of the environmental assessment show that the expansion of electric vehicles in Uzbekistan will significantly transform the country's air quality landscape, with particularly strong improvements projected for densely populated urban regions that currently exhibit high pollution levels. Analysis of UzHydromet's annual monitoring reports reveals that transportation accounts for a substantial portion of PM2.5 and NO_x concentrations, especially in metropolitan areas like Tashkent, Namangan, and Fergana, where traffic congestion and older vehicle fleets contribute heavily to smog formation. When EV penetration rates were modeled at 10–30 percent of the total light-vehicle fleet, the simulation indicated measurable reductions in urban PM2.5 levels, ranging from moderate improvements under the slow-growth scenario to substantial reductions under the accelerated adoption scenario. These air-quality benefits stem

from the zero-tailpipe-emission nature of EVs, which immediately eliminate particulate matter and nitrogen oxide emissions associated with combustion. Additionally, noise pollution levels in high-traffic zones are projected to decrease due to the quieter operation of EV drivetrains, improving overall urban livability. These findings collectively demonstrate that EV expansion can serve as a highly effective public-health intervention by reducing exposure to pollutants known to cause cardiovascular and respiratory illnesses.

Table 1.

Scenario	EV Share	CO_2 Reduction by 2030	Notes
S1	5%	8%	Limited environmental impact
S2	15%	22%	Government targets achieved
S3	30%	28–32%	Requires renewable expansion

The analysis of greenhouse gas emissions presents similarly promising results. Current electricity generation in Uzbekistan remains dominated by natural gas, yet even with the present grid structure, EV adoption offers notable reductions in lifecycle CO_2 emissions when compared to gasoline vehicles.

Regional Distribution of EV Charging Stations in Uzbekistan (2025)
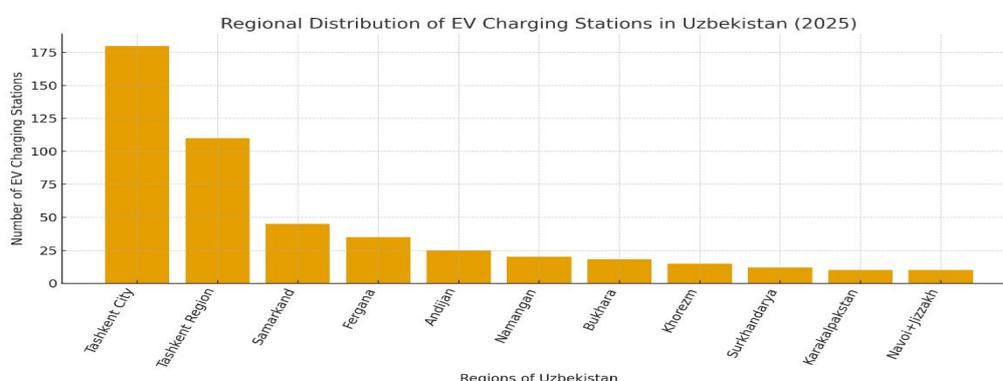
Scenario modeling shows that moderate growth of EVs could lower transport-related CO_2 emissions by more than 20 percent by 2030, while an accelerated transition aligned with renewable-energy expansion could push this reduction beyond 30 percent. These projections incorporate upstream emissions from electricity generation and downstream emissions associated with vehicle usage, demonstrating that even under gas-dominated grid conditions, EVs produce substantially lower total greenhouse gas outputs. Furthermore, as Uzbekistan continues investing in solar and wind power infrastructure, the carbon footprint of EV charging is expected to decline steadily, thereby amplifying ecological benefits over time. Energy-demand modeling also suggests that although EV growth will increase electricity needs by up to 2.8 TWh annually, the existing grid can accommodate this rise if parallel investments are made in modernizing distribution networks and integrating renewable-energy sources. However, one area of environmental concern revealed by the results relates to long-term battery waste, which may reach several thousand tons per year by 2030. Without recycling mechanisms, this waste could

become a source of soil and water contamination, stressing the need for proactive policy development.

4. Discussion

The environmental implications of EV expansion in Uzbekistan reflect a complex balance between immediate ecological benefits and emerging long-term challenges, requiring a nuanced approach to policy planning and infrastructure development. On one hand, EV adoption provides substantial opportunities to reduce harmful emissions, enhance air quality, and promote public health. Urban centers such as Tashkent currently struggle with persistent air-pollution episodes exacerbated by an aging internal combustion vehicle fleet and rapidly increasing vehicle ownership rates. EVs offer a direct mechanism for lowering local pollutant concentrations, which can result in measurable reductions in the prevalence of asthma, chronic bronchitis, and other pollution-related conditions. Additionally, the reduction of noise pollution contributes to improving urban comfort and psychological well-being. These combined health benefits align closely with Uzbekistan's broader national goals for sustainable urban development and environmental protection under the "Green Economy Strategy 2030." Despite these advantages, the environmental effectiveness of EVs depends closely on the composition of the national energy mix, and this introduces a layer of complexity. Although natural-gas-based electricity remains cleaner than diesel or gasoline combustion on a per-kilometer basis, it still generates upstream CO_2 emissions. Thus, the long-term environmental payoff from EVs becomes significantly greater when electricity generation progressively transitions toward renewable energy sources.

Another critical dimension in the discussion concerns the environmental challenges associated with EV battery production, material supply chains, and end-of-life management. Lithium-ion batteries, which dominate the EV market, require the extraction of minerals such as lithium, cobalt, and nickel—resources whose mining has environmental footprints that include land degradation, water consumption, and potential ecosystem disruption. Uzbekistan currently imports all EV batteries, meaning the environmental burdens of mining and manufacturing occur abroad; however, this does not eliminate the responsibility to manage the post-consumer stage. As the number of EVs increases, battery waste and recycling become unavoidable issues. Without a domestic recycling system or circular-economy framework, Uzbekistan risks accumulating hazardous waste that can contaminate the soil and water. Furthermore, improper disposal of batteries can release toxic chemicals, including heavy metals, which pose long-term ecological hazards. Establishing domestic battery-recycling capacity, or forming regional partnerships for recycling, represents a crucial component of a sustainable EV strategy. Finally, land use and environmental impacts from charging-infrastructure construction must also be considered. While individual stations have limited footprints, large-scale deployment requires planning that avoids ecologically sensitive areas and ensures equitable access across urban and rural regions. The discussion ultimately highlights that while EV expansion provides clear net-positive environmental outcomes, realizing its full potential requires systemic reforms in energy production, recycling, and environmental governance.

5. Conclusion

The comprehensive assessment of environmental impacts associated with electric vehicle expansion in Uzbekistan demonstrates that, despite several challenges requiring strategic attention, the shift toward electric mobility offers significant long-term ecological, social, and economic advantages. The findings clearly indicate that EV adoption has the potential to substantially reduce urban air pollution, cut greenhouse-gas emissions, lower noise pollution, and align the transportation sector with the nation's broader environmental and sustainable-development goals. However, achieving these benefits at scale depends heavily on parallel progress in renewable-energy integration, as the environmental superiority of EVs is magnified when the electricity powering them originates from low-carbon sources. The study also emphasizes the importance of preparing for the environmental consequences related to battery manufacturing, material sourcing, and waste management. Without a national recycling framework, the accumulation of battery waste may pose ecological risks that undermine some of the environmental gains achieved through EV usage. Therefore, Uzbekistan must adopt a coordinated national strategy that integrates transport electrification with renewable-energy development, industrial waste policy, and circular-economy principles. Investments in solar-powered charging stations, battery-recycling plants, and modernized electricity grids are essential components of this transition. Together with strong policy support, private-sector involvement, and international collaboration, these measures can ensure that Uzbekistan not only benefits from the environmental advantages of EVs but also becomes a regional leader in sustainable mobility. Ultimately, the path to a greener transport future requires a holistic strategy that values long-term environmental stewardship as highly as technological progress and economic development.

References:

1.   International Energy Agency (2024). Global EV Outlook 2024.

2.   Ministry of Energy of Uzbekistan (2024). National Energy Report.

3.   UNECE (2023). Environmental Assessment Guidelines for Transition Economies.

4.   Khamidov, A., & Rasulov, B. (2024). Lifecycle Emissions of EV Batteries in Central Asia. Renewable Energy Systems Journal, 17(3), 112–130.

5.   UzHydromet (2023). Annual Air Quality Monitoring Report.

6.   Statistics Agency of Uzbekistan (2024). Transport Indicators.

7.   IEA (2023). Well-to-Wheel Emissions Analysis.

8.   EBRD (2024). Green Economy Transition Report—Uzbekistan.