The Application of Electromobility in Azerbaijan and the Problems Arising in the Network as a Result

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Abstract— **Promoting environmentally friendly vehicles is crucial for accelerating the shift to cleaner, sustainable transportation by reducing carbon emissions, enhancing energy efficiency, and driving innovation.In this regard, it is necessary to form a normative legal framework that ensures the expansion of the use of electric vehicles, the development of the necessary infrastructure, as well as the integration into the general transport system. Preparation of proposals for optimizing the number of electric energy charging points (ECP) in the country (including for vehicles that will be used on regular city bus routes) and expanding the scope, assessment of the possibilities of electrification for the vehicle transport zone of Azerbaijan and demand based on the results. A review of the current state of the electromobility market in Azerbaijan, as well as the identification of obstacles related to the expansion of electric vehicles and charging stations across the country and the preparation of proposals for their elimination, the economic benefits of the electromobility strategy and its recommended implementation mechanisms assessment can create new opportunities for more detailed application of electromobility in the country. This article provides an overview of these opportunities and strategic proposals.**

Keywords—electromobility, green energy, charging stations, electric vehicles, ecology

I. INTRODUCTION

The 29th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP29) in Azerbaijan, the definition of one of Azerbaijan's national priorities for socio-economic development by 2030 as "Country with a clean environment and green growth", and the declaration of 2024 as the "Year of Solidarity for a Green World" are manifestations of the purposeful and consistent state policy pursued in this area. Stimulating the circulation of environmentally friendly and safe vehicles (cars, buses, etc.) and creating the necessary infrastructure at the same time create numerous problems [1]. A brief overview of these problems and difficulties is given below.

- Electromagnetic waves generated by an electrical device connected to the network negatively affect the operation of other devices powered by the same network.
- There is no common charging standard used by electric vehicle manufacturers, as a result, each type (model) of ECS has a different impact on the network.
- Connecting different ECSs to the networks negatively affects the unified scheme of the Power Grid, leading to a decrease in the stability of the power supply.
- Connecting EDMs to distribution networks in a fragmented manner has a negative impact on the power and consumption balance (Frequency Constant) in the power supply system.
- 5. EVs are usually charged in residential areas, and since the charging operation is most often plugged in in the evening and morning, it coincides with peak times of electricity consumption, which leads to additional loading of the distribution networks.
- 6. On weekends, EVs are charged in different places, for example, in holiday areas, creating additional power requirements in the power distribution networks in those areas [2]. For this reason, an electricity distribution infrastructure must be created in all areas to meet the increased power requirements.

II. DIFFICULTIES THAT HAVE OCCURRED AND MAY OCCUR AS A RESULT OF THE IMPLEMENTATION OF ELECTRIC VEHICLES AND ENERGY CHARGING STATIONS

The necessary tasks of the distribution networks for the implementation of the Electromobility Program can be specified as follows.

1. Determination of the financial required resources and implementation deadlines for the application of the above tasks;

2. Creation of substations, networks, power centers and infrastructure in general for feeding the ECS;

3. Assessment of the power potential of existing networks in accordance with the dynamics of the increase in the number of electric vehicles;

4. Determination of a strategy for increasing the load capacity of local networks (by informing relevant agencies);

5. Implementation of pilot projects in priority areas with the potential for increasing electromobility indicators;

6. Taking appropriate measures to expand renewable energy sources and install ECS in Power Centers;

7. Preparation of a draft Action Plan in this direction for the implementation of the State Program on Electromobility without violating the rights of existing consumers, without harming energy quality and efficiency indicators (SAİDI/SAİFI, Service Level, etc.), and without disrupting the operation of Distribution Networks;

Considering the expected ECS energy demand, the amount of financial resources required for the maintenance of distribution networks will increase further [3]. Since the energy supply of Energy Charging Stations is carried out

through technological connection to 0.4 kV networks, it is important to implement the following necessary technical measures:

- Increasing the cross-section of existing cable lines by at least 2 steps or replacing copper-core lines with cable lines 1 step higher;

- Providing 3-phase networks for power supply of fast EDM;

- Replacing the Subscriber's Metering Device;

- Increasing the power of distribution transformers (to maintain the voltage drop within the regulatory limits) by at least 2 times;

- Reconstruction of the HV power transmission lines feeding transformer points with lines with a larger cross-section;

- Replacing the Power Transformer at 110/35 and 35/10-6 kV Substations, installing additional sockets, rebuilding Relay Protection and Automation circuits, installing Reactive Energy Compensators (since ECS devices have converter inverters).

According to statistical information provided by the State Statistics Committee, the total number of vehicles in the country in 2023 was 1,738,940 units. According to the analysis, the average growth rate of vehicles in 2019-2023 is 5.23%. If we predict an annual growth rate of 5.23% in vehicles, the total number of vehicles in 2030 will be 2,483,838.

TABLE 1. NUMBER OF ELECTRIC VEHICLES IN THE COUNTRY ACCORDING TO THE STATE STATISTICS COMMITTEE

Years	Total number of vehicles (actual)	Growth rate, %
2019	1418404	2.5
2020	1473563	3.9
2021	1566743	6.3
2022	1645253	5.0
2023	1738940	5.7

Given the statistical growth rate of electric vehicles in the country, by 2030, 16% of the car fleet will be electric vehicles, at which time there are expected to be 397,000 electric vehicles in the country.

TABLE II. SCENARIO OF INCREASE OF VEHICLES IN THE NUMBER

Years	Estimated number of vehicles	Growth rate, %
2024	1829876	5.2
2025	1925568	5.2
2026	2026264	5.2
2027	2132226	5.2
2028	2243729	5.2
2029	2361063	5.2
2030	2483838	5.2

III. FACTORS AFFECTING THE GROWTH RATE OF ELECTRIC VEHICLES ACROSS THE COUNTRY

The following steps are included in the state's incentives for electric vehicles in the country [4].

- VAT exemption for the import and sale of electric vehicles;

- VAT exemption for the import of second and third level electric chargers for electric vehicles for a period of 3 years from January 1, 2022.

- 5.2.5 of the Action Plan of the "Socio-Economic Development Strategy for 2022-2026". Action line: Expanding the use of environmentally friendly vehicles and other green technologies to combat climate change; Increasing the number and scope of electric charging stations in the country

- Implementing measures envisaged in the roadmap for 2024 to stimulate the circulation of environmentally friendly and safe vehicles and improve their infrastructure.

- Creating a "green energy" zone in the liberated territories and using electric vehicles within the framework of the measures.

-Increasing the availability of electric vehicles worldwide (compared to previous years, the price of electric vehicles has decreased and the intensity of the decline dynamics will continue in the coming years).

-Lower operating costs of electric vehicles (low electricity tariffs in Azerbaijan).

-Implementation of other stimulating measures by the state in the coming years (preferential use of bus lanes, parking lots, toll roads for electric vehicles, expansion of the possibilities of organizing "zero emission" zones that restrict the entry of internal combustion engine vehicles, etc.)

The consumption power required by the Energy Charging Stations to be installed in Baku and surrounding areas by 2026 is given in the table below.

TABLE III. THE TOTAL CONSUMPTION POWER REQUIRED FOR THE INSTALLATION OF CHARGING POINTS FOR ELECTRIC VEHICLES IN BAKU AND SURROUNDING AREAS, HIGHWAYS AND REGIONAL AREAS

№	ECS	Power required by ECSs	Number of ECSs
1	Baku and surrounding areas	47.28	93
2	Regions	29.04	121
3	Additional ECSs suggested	4.40	27
4	Individual nstallations by people	120	-
5	ECSs to be installed for electric buses	260	9
Total		460.72	250

IV. CONCLUSION

According to the information provided by the Ministry of Digital Development and Transport, 2,600 electric buses are expected to be delivered by 2026. In order to meet the power requirements of ECSs, it is necessary to strengthen the existing 110 kV substations and construct new 110 kV substations. Work carried out by the supply network towards electromobility [5]:

During 2021-2023, visits were organized to Germany, Turkey, the Russian Federation, the United Kingdom,

Belarus, Kazakhstan, South Korea and China, and experience was exchanged with representatives of the distribution network and local experts in this field;

In 2022, an extensive analysis was conducted based on international experience on the “Electromobility Concept and the Increase in Power Required in Distribution Networks”.In 2023, the implementation of the Energy Charging Device Management and Power Balancing system was launched together with the specialists of the “Setevaya Kompaniya” company of the Republic of Tatarstan and the “Energorazvitie” Engineering Center (tested on ECSs installed at Shusha, Hadrut, Jabrayil and Fuzuli substations) [6];

In 2023, a special “ECS - Automatic Management” software was tested at the Main Control Center of Digital Networks to monitor the power demand of ECSs. From 2021 to the present, the integration of ECSs, initially in the liberated territories, and later in other territories, into the dispatch control system of SK-11 - 0.4 kV networks is being carried out [7]. In addition to ECSs, the issues of power supply of NFC - Energy Charging Stations intended for Drones in the future are also being analyzed.Small-power solar power plants have been installed and integrated into networks to power ECSs in the liberated areas.

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