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Assessment of Emissions Reduction Through the Transition of Azerbaijan's Transport Sector to Electric and Hybrid Vehicles

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Abstract: ***This article investigates the impact of transitioning Azerbaijan's road transport fleet to electric and hybrid vehicles. The motor transport sector accounts for more than 80% of the country's toxic waste emissions into the atmosphere and ranks second after the energy sector in terms of greenhouse gas (GHG) emissions. The article examines the potential growth of the electric vehicle (EV) market in Azerbaijan until 2030. The reduction in GHG emissions is assessed by analysing the increase in the number of battery electric vehicles (BEVs) within Azerbaijan's road transport fleet. The implementation of smart charging systems and the potential of grid technology are also explored. Forecasts indicate that the adoption of electric vehicles is expected to increase by 20% compared to conventional motor vehicles by 2030. The primary drivers of this trend are the growing interest in electric cars and the national objective of transitioning to cleaner transportation. Analysis suggests that with a significant share of hybrid and electric vehicles, particularly BEVs, CO_2 emissions could be reduced by up to 32–35%.***

Keywords: motor transport, emissions, greenhouse gases, PHEVs, EVs, ecology, environment, charging stations.

1. Introduction

The history of electric vehicle (EV) production dates back to 1834. However, only in the late 19th century were some units produced in North America, Great Britain, and France. EVs were largely withdrawn from the market in the 1930s due to high initial costs and local regulatory restrictions. Interest in EV technology re-emerged in the 1970s [1]. Today, efforts to limit fossil fuel consumption (oil, gas, coal) and decarbonize energy use have significantly influenced the technological advancement of EVs. This development is shaped by legislative frameworks, charging infrastructure, the global car market, energy prices, climate policies, and the energy sector. Over the past decade, EV adoption has been supported by European and U.S. initiatives aimed at developing clean technologies to reduce CO_2 emissions and promote strategic diversification in the automobile industry [2].

The **Paris Agreement (2015)** was signed by 196 countries, collectively responsible for 99.75% of global GHG emissions Azerbaijan joined the Paris Agreement in 2016. The signatory countries committed to limiting the long-term average global temperature increase to below 2°C above pre-industrial levels, ideally capping it at 1.5°C, while also reducing GHG emissions. According to Azerbaijan's 4th National Report under the UN Framework Convention on Climate Change [4], the total GHG emissions from the transport sector amounted to 5,7 Gg CO_2 equivalent (10.4% of total emissions). Reducing carbon dioxide emissions from motor transport can be achieved through the use of purely electric vehicles, including Battery Electric Vehicles (BEVs), Plug-in Hybrid Electric Vehicles (PHEVs), and Hydrogen Internal Combustion Engine Vehicles (ICEVs) utilizing hydrogen fuel cells [3],

To estimate vehicle emissions, the **IPCC methodology** has been applied. Azerbaijan is committed under international conventions to reducing its GHG emissions by 35% by 2030 compared to 1990 levels. The diagram below presents EV development forecasts worldwide up to 2035 [5].

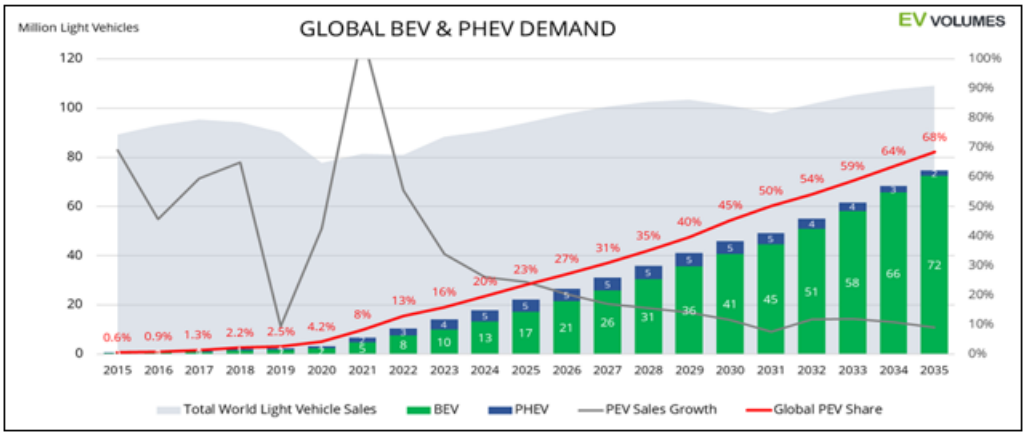

Diagram 1: Actual Development of BEVs and PHEVs Worldwide (2015–2023) and Forecast Indicators Until 2035

In recent years, there has been strong growth in electric vehicle (EV) sales, accompanied by improved range, a wider variety of models, and increased performance. By the estimate data that more than one in five new cars sold in 2024 is electric. A total of 17 million new Battery Electric Vehicles (BEVs) have been sold in 2024, marking a 25 % increase. Sales in China jumped 36.5% to 1.3 million vehicles in December, and totalled 11 million for the whole of 2024 [6].

According to the forecast data from Diagram 1, global BEV sales are projected to reach 18 million in 2025, 35 million in 2030, and 64 million in 2035. Meanwhile, Plug-in Hybrid Electric Vehicles (PHEVs) are expected to account for 7% of total vehicle sales. This growth trend is anticipated to continue, with EVs projected to comprise 23.5% of the global light-vehicle market by 2025 and 45.3% by 2030 [7].

Under the Public Policy Scenario (STEPS), the number of BEVs and PHEVs worldwide is expected to reach approximately 145 million by 2030, with an annual growth rate of around 30%. Specifically, forecasts indicate that 18 million electric cars will be sold in 2025, and more than 25 million in 2030 [8]. According to estimates from the U.S. Environmental Protection Agency (EPA), gasoline-powered vehicles produce nearly three times more emissions than BEVs. Assessment data show that all-electric vehicles still generate 1,783.8 kg (3,932 pounds) of emissions per year due to electricity consumption. Emissions from PHEVs amount to 2,621.3 kg (5,778 pounds), while hybrid vehicles (which use both gasoline and electricity) emit about 2,838.5 kg (6,228 pounds). In contrast, gasoline-powered vehicles produce 5,186.8 kg (11,435 pounds) of CO_2 emissions annually. While BEVs do generate emissions through electricity use, their direct mobile activity does not contribute to emissions [9].

2. Discussions

According to official data by State Committee of Azerbaijan in 2024, Azerbaijan had a total of 1,8 million vehicles, including 1,6 million are private passenger cars (86.4% of the total fleet). Azerbaijan recorded 6,13 thousand (409 number in 2021) EVs (190 of is electric bus) and 66,3 thousand PHEVs including 9,7 thousand is plug in hybrid. An analysis of the total vehicle fleet in 2024 revealed that 4,5 % in 2024 (4.2% in 2023) consisted of EVs and hybrid vehicles, while 75.2% were gasoline-powered, 18.0% were diesel-powered, and only 0.8% used natural gas [9].

The emission data presented below is based on Azerbaijan's 4th National Report [10].

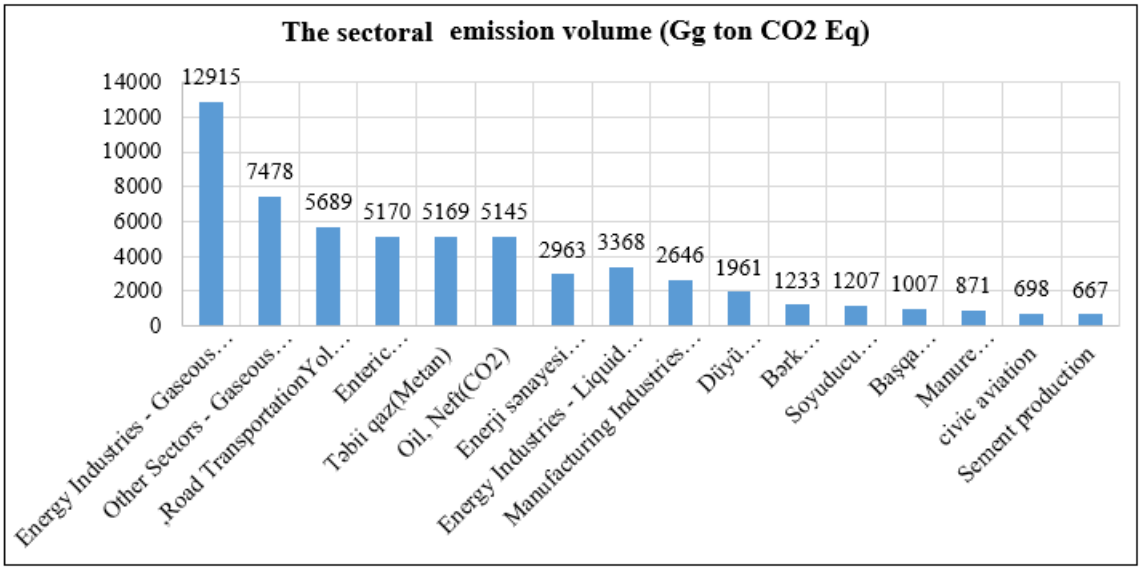

Diagram 2: Greenhouse Gas (GHG) Emissions by Sector in Azerbaijan

Diagram 2 illustrates total GHG emissions in Azerbaijan so that the road transport sector is the second-largest contributor to CO_2 emissions after the energy sector. In total, Azerbaijan emitted 53 million tons of GHG emissions in 2023. With a population of 10.2 million, Azerbaijan contributes only 0.15% of the world's total greenhouse gas (GHG) emissions, amounting to 6.2 t CO_2eq per capita (2019) without land use and forestry (LULUCF) activities and 5.4 t CO_2eq per capita with LULUCF. The energy and agriculture sectors are the largest sources of greenhouse gas emissions in Azerbaijan. The country's GHG emissions decreased by 37% between 1990 and 1995, reaching approximately 52 million t CO_2eq, a level that remained unchanged in 2010. Since then, GHG emissions have increased by 19% to 61 million tons. In 2016, the t CO_2eq GDP decreased by 14% due to falling oil prices. No significant differences were observed in the data on GHG emissions and GDP during the reviewed period, which can be attributed to the country's hydrocarbon-based economy. Azerbaijan has committed to achieving a 35% reduction in greenhouse gas emissions by 2030 compared to 1990, as stated in its first Nationally Determined Contribution (NDC). Additionally, Azerbaijan has announced a target of a 40% reduction in greenhouse gas emissions by 2050 [4]. The country is actively implementing sectoral measures to reduce emissions, including policies targeting the road transport sector.

As part of the **"Azerbaijan 2030: National Priorities for Socio-Economic Development"**, approved by the President's decree, Azerbaijan has set goals to achieve a clean environment and promote "green growth." The document outlines measures to encourage the adoption of environmentally friendly vehicles. On March 7, 2024, the head of state signed a decree titled **"On Promoting the Use of Electric Motor Vehicles,"** emphasizing the need to establish a regulatory framework for expanding EV adoption, developing the necessary infrastructure, and integrating EVs into the national transportation system.

Hosting the **29th Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP29)** in Azerbaijan, along with defining **"clean environment and green growth"** as a national priority until 2030, and declaring 2024 the **"Year of Solidarity for the Green World,"** highlights the country's commitment to environmental sustainability. Greenhouse gas emissions, nitrogen oxides, and particulate matter from vehicles contribute to poor air quality, increased health risks, and economic losses.

Recognizing the role of electric vehicles in reducing carbon emissions and improving energy efficiency, Azerbaijan has taken steps to promote the use of environmentally friendly transportation [11]. By transitioning to electric vehicles, Azerbaijan has the potential to significantly reduce harmful emissions from internal combustion engine vehicles and create a more sustainable ecological environment. The measures implemented by the Supreme Executive Power of the country mark a turning point in the development of BEVs. This research was prepared based on development forecasts, taking into account annual trends in transportation growth, population expansion, GDP increases, and per capita income.

General vehicles (GV) in Figure 2; including the actual requirements and prognoses for ICEVs

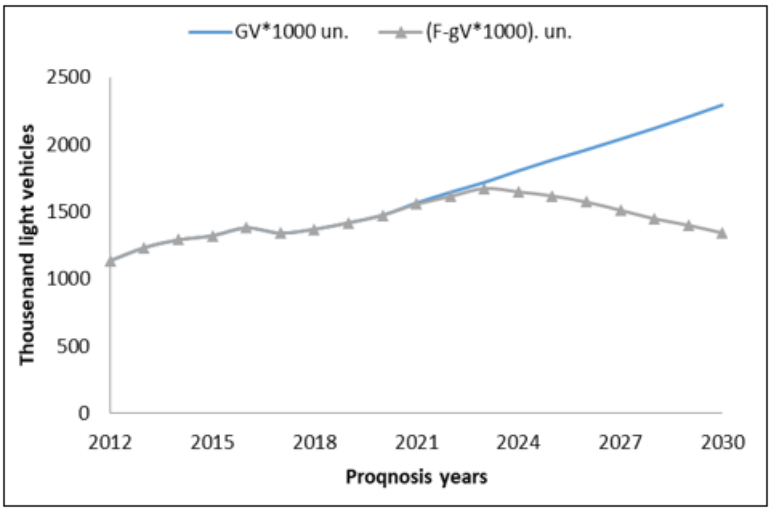

Figure 1: Prospects for the Development of Vehicles up to 2030

Figure 1 shows the forecasted development of the transport fleet up to 2030. The blue line in the figure represents the total number of vehicles (GV), including Internal Combustion Engine (ICE) vehicles, hybrid plug-in electric vehicles (HPEVs), and battery electric vehicles (BEVs). The brown line represents the number of vehicles running solely on fossil fuels.

As seen in Figure 1, during the forecast period, the number of ICE vehicles is expected to decrease by approximately 20%. Additionally, between 2025 and 2030, the demand for general ICE vehicles is projected to increase by 1.27 times and then decline to 0.81 times its previous value. Forecasts indicate that as the total number of vehicles and vehicles per capita steadily increase, the demand for ICE vehicles will ultimately decline by about 20% until 2030 year.

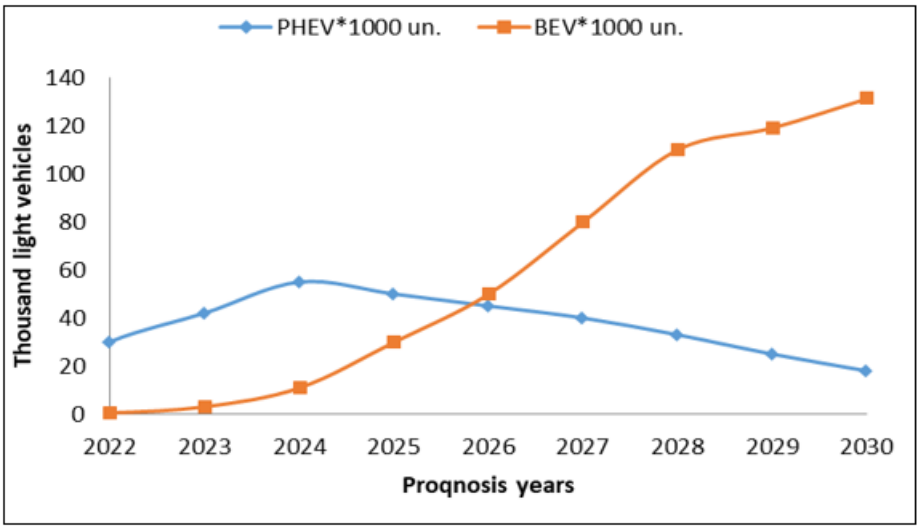

Figure 2: Actual and Forecasted Demand for Electric and Hybrid Vehicles

Figure 2 presents the actual and projected demand for battery electric vehicles (BEVs) and hybrid plug-in electric vehicles (HPEVs).

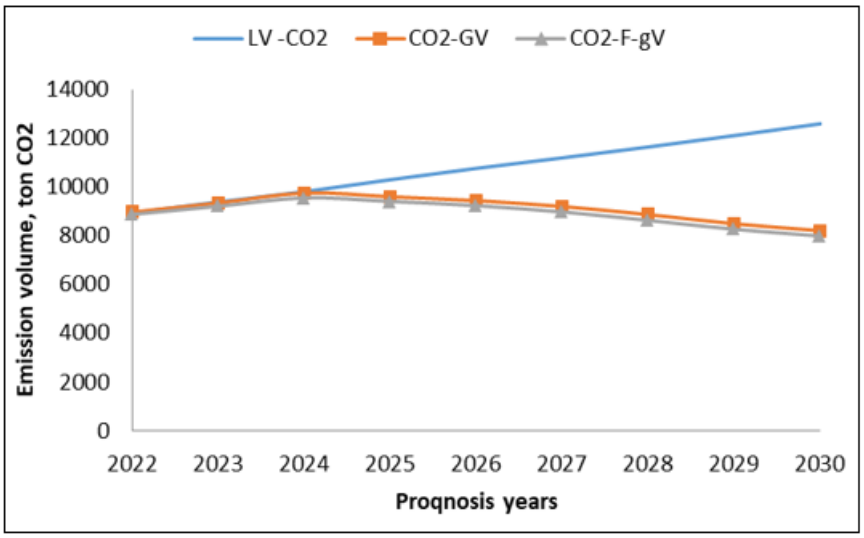

Figure 3: Carbon Dioxide (CO_2) Emission Trends up to 2030

Figure 3 illustrates the projected trend of carbon dioxide (CO_2) emissions from vehicles through 2030. The blue line represents total vehicle emissions (GV), including ICEVs, HPEVs, and BEVs. The brown-white shaded area shows emissions from vehicles running on compressed natural gas (CNG). The reduction in total vehicle emissions demonstrates the impact of transitioning to green vehicles. By 2030, the increasing share of BEVs and HPEVs in the vehicle fleet is expected to reduce emissions in this sector by up to 35%. Overall, total emissions are forecasted to decrease by 37-40%.

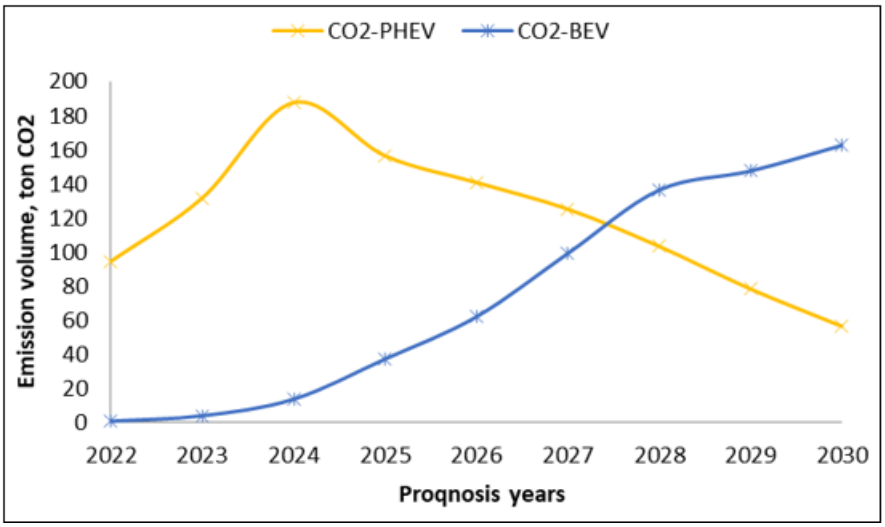

Figure 4: Projected Carbon Dioxide Emission Trends for BEVs and PHEVs up to 2030

Figure 4 displays projected CO_2 emissions trends for battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs). The blue line represents emissions from BEVs, while the yellow line represents emissions from HPEVs.

As shown in Figure 4, emissions levels fluctuate based on the increasing number of electric and hybrid vehicles. By 2030, emissions from HPEVs are projected to increase from 14 tons in 2025 to 163 tons, whereas emissions from ICE vehicles are expected to decline from 188 tons in 2025 to 56 tons.

These forecasts are based on current targets as the share of hybrid and electric vehicles increases significantly, total CO_2 emissions could decrease by 32-35%. Additionally, considering the rapid development of green energy and the expansion of renewable energy production in Azerbaijan's energy sector, the development of fast-charging infrastructure for BEVs will contribute to achieving zero emissions for these vehicles. In this case, total emission reductions could exceed 35%.

Prospective Development of BEVs and Charging Infrastructure in Azerbaijan

The development of BEV charging infrastructure in Azerbaijan is currently at a low level. However, trends between 2023 and 2030 indicate strong incentives for its growth. Tax benefits aimed at accelerating the adoption of electric vehicles and the expansion of charging infrastructure have been effective. The map below illustrates the existing charging locations in Azerbaijan.

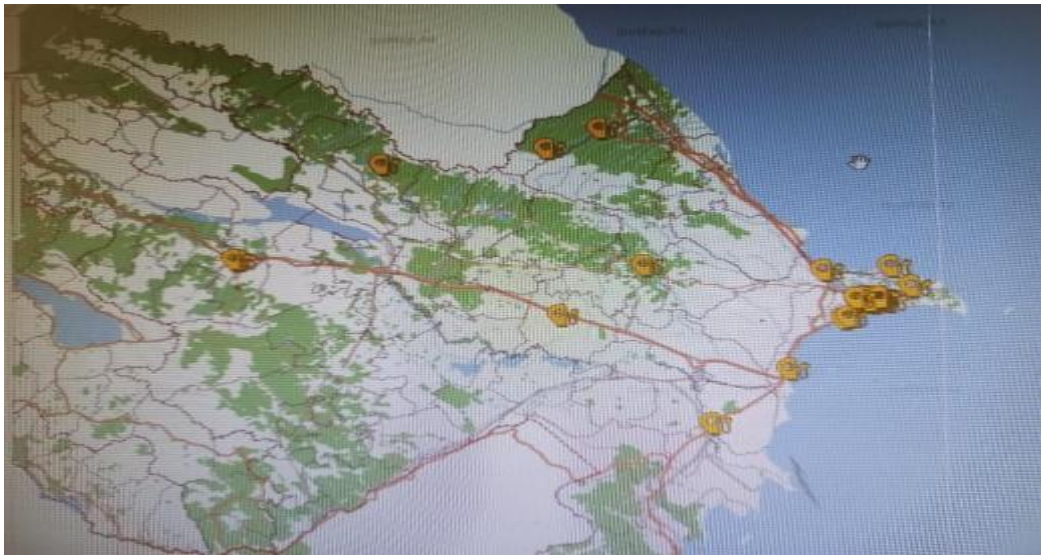

Figure 5: Map of BEV Charging Stations in Azerbaijan (2024).

Figure 5 is an interactive map showing the locations of electric vehicle (EV) charging stations across Azerbaijan, based on information from the official website of the Azerbaijan Land Transport Agency under the Ministry of Digital Development and Transport [11]. The map displays the charging locations available in 2024.

With the positive outlook for battery electric vehicles (BEVs) in the near future, projections indicate that by 2030, Azerbaijan will have more than 200,000 electric and hybrid vehicles, with approximately 120,000 BEVs and more than 80,000 hybrid electric vehicles, including PHEVs. Currently, 15 charging points have been installed near fuel stations across the country to support EVs. The government plans to

increase the number of charging points, including the potential installation of BEV charging points in residential areas and near buildings [12].

Electric cars, which are developing rapidly, can serve as a solution to traffic congestion, mobility challenges, and emissions reduction in cities. However, current challenges include limited mileage and long charging times at charging stations. Ongoing research and innovation worldwide are expected to resolve these issues, leading to further advancements in the sector [13].

3. Results

Based on research and assessments, the following opportunities for the development of BEVs and emission reduction have been identified:

1) Assessment data indicate that the demand for general transport vehicles is expected to increase by 1.27 times and for internal combustion engine (ICE) vehicles by 0.81 times by 2030. This is due to the growing demand for BEVs and PHEVs in the transport sector. Forecasts, considering Azerbaijan's government policies, suggest that interest in electric cars is high, with BEVs expected to comprise more than 30% of the car fleet.
2) CO_2 emissions are expected to decrease by 27-30% as hybrid and electric vehicles gain a significant share of the car fleet. The prospects for green energy development in Azerbaijan, along with increasing renewable energy production (solar and wind energy), will contribute to reducing CO2 emissions. The expansion of fast-charging infrastructure and the increase in the number of charging stations will further boost BEV adoption.

4. Recommendations

1) Although incentives for the import of electric vehicles and charging equipment have stimulated the market, they have not significantly increased sales. The high cost of electric vehicles, lack of full consumer confidence, and insufficient charging infrastructure remain major obstacles.
2) Expanding the charging network in residential areas, administrative buildings, and newly constructed developments, along with providing certain incentives and subsidies for buyers, could further stimulate the market.
3) Newly built residential buildings with more than 10 parking spaces should include provisions for electrical ducts and cables in their design to facilitate outdoor charging points in all parking spaces. In buildings with more than 20 parking spaces, at least one charging station should be installed, with electrical conduits, wires, and cables covering at least 20% of the parking spaces inside or outside the adjacent building. For new non-residential buildings, 20% of parking spaces (1 in 5) should be equipped with charging facilities, whether inside or outside the building.
4) Encouraging the installation of BEV charging points in homes, both inside and outside buildings, will accelerate public interest in EVs and the growth of charging station availability each year.

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