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Integrated Policy Strategies and Regional Policy Coordination for Resilient, Green and Transformative Development: Supporting Selected Asian BRI Partner Countries to Achieve 2030 Sustainable Development Agenda

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Kazakhstan's transport sector: opportunities for decarbonization

Abstract

This policy paper examines Kazakhstan's transport sector, a key economic driver contributing 5.6% to GDP but also a major source of greenhouse gas (GHG) emissions, accounting for 7.4% of total emissions in 2021. Road transport is the largest contributor (81%), with an aging vehicle fleet and minimal electric vehicle (EV) adoption (less than 0.2%). The paper highlights the urgent need for decarbonization through infrastructure development, policy reforms, and public awareness. Key recommendations include creating a unified decarbonization strategy, establishing a coordinating body, incentivizing green transport, and expanding EV and hydrogen infrastructure. By adopting a holistic approach, Kazakhstan can achieve carbon neutrality by 2060, ensuring economic growth, energy security, and environmental sustainability.

Contents

KEYWORDS: Sustainable Transport, Electric Vehicles, Infrastructure Development, Hydrogen Fuel, Policy Reforms

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Introduction

This policy paper analyzes Kazakhstan's transport sector, its contribution to greenhouse gas (GHG) emissions, and opportunities for decarbonization. The transport sector is vital to Kazakhstan's economy, contributing 5.6% to GDP and employing 7.3% of the workforce. However, it is also a major source of GHG emissions, accounting for 7.4% of total emissions, with road transport being the largest contributor (81%). The paper emphasizes the need for a holistic approach to decarbonization, integrating infrastructure development, policy reforms, and public awareness campaigns to achieve carbon neutrality by 2060.

Key Sections and Findings

Analysis of the Transport Sector
Kazakhstan has invested $35 billion in transport infrastructure over 15 years, with railways dominating freight transport. However, the sector relies heavily on fossil fuels (83.8% of energy consumption), and the vehicle fleet is aging, with 45% of cars over 20 years old. Electric vehicles (EVs) make up less than 0.2% of the fleet. The sector also faces challenges of import dependency in transport equipment. Modernization and electrification are urgently needed to reduce emissions and improve efficiency.

Integrating Decarbonization into Government Planning
Current strategies, such as the *Strategy for Achieving Carbon Neutrality*, focus on the "Avoid-Shift-Improve" framework. However, gaps remain, including the lack of a unified decarbonization strategy, unclear targets, and insufficient government support. More concrete actions and coordination are required to achieve meaningful progress.

Institutional and Legislative Framework
Responsibilities for decarbonization are fragmented across ministries, leading to inefficiencies. Establishing a single coordinating body is essential for setting priorities, allocating resources, and monitoring progress. Existing measures, such as tax exemptions and subsidies for EVs, are insufficient to drive large-scale transition. A clear regulatory framework is needed.

Infrastructure for Green Transport
Kazakhstan has only 269 EV charging stations, far below international standards. The government’s roadmap aims to develop EV infrastructure by 2029, but challenges remain, including an unstable electricity grid and lack of technical expertise. A phased approach to infrastructure development is recommended, starting in urban centers and expanding to highways.

International Best Practices
Lessons from the EU, US, China highlight the importance of financial incentives, infrastructure development, and regulatory measures. China leads in EV adoption and infrastructure, while the EU integrates alternative fuels comprehensively. Kazakhstan can adopt similar measures tailored to its context.

Forecasting Decarbonization
By 2060, electricity is expected to account for 58.6% of transport energy demand, with biofuels (24.4%) and hydrogen (17.0%) playing significant roles. Investments in renewable energy, grid modernization, and advanced technologies (e.g., solid-state

batteries, hydrogen fuel cells) are critical. Decarbonization will also bring economic and health benefits, including job creation and reduced air pollution.

Policy Recommendations

Key recommendations include:

- Developing a unified decarbonization strategy with clear targets.
- Establishing a single coordinating body for decarbonization.
- Implementing financial incentives for green vehicles and infrastructure.
- Prioritizing EV and hydrogen infrastructure development.
- Strengthening public awareness and R&D initiatives.
- Adapting transport infrastructure to climate change impacts.

Decarbonizing Kazakhstan's transport sector is both an environmental necessity and an economic opportunity. A coordinated approach, supported by investments, technological innovation, and behavioral change, can reduce emissions, enhance energy security, and position Kazakhstan as a regional leader in sustainable transport. The long-term benefits for the economy, environment, and public health are substantial.

1. Analysis of the Transport Sector of Kazakhstan

1.1 Global context

The economies of the main players in the Eurasian continent – the EU, China, India, Russia and Central Asia - are projected to grow and, consequently, investment and trade turnover are expected to increase.

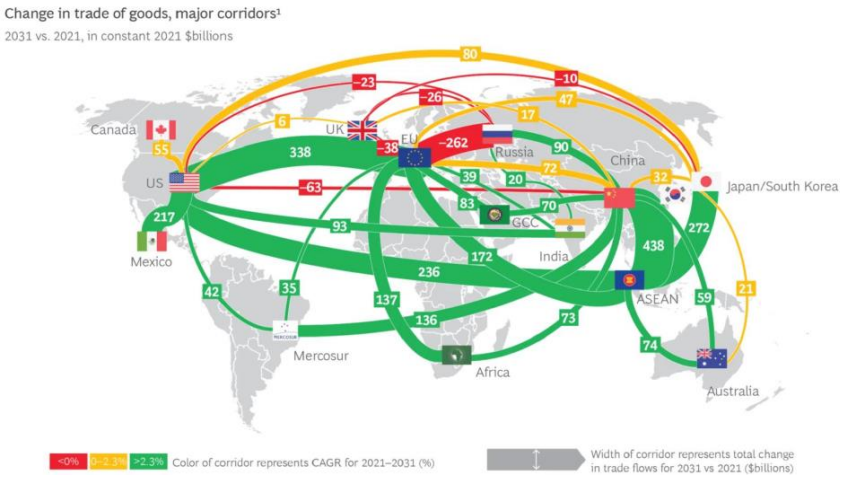
These countries account for 40% of the world economy and 43% of the world population. All of them are projected to show economic growth until 2028. The Indian and Central Asian economies will show the highest growth in percentage terms, the EU and Chinese economies will show the highest economic growth in absolute terms. India and Central Asia are expected to show the largest population growth. While the EU population will remain stable, the populations of China and Russia are expected to decline.

Although most of the trade between Asia and Europe is carried out by sea, there are several land routes that can diversify the risks associated with geopolitical tensions around the Red and South China Seas on the one hand, and technical constraints to expanding port infrastructure capacity (land, berths, environment) on the other.

This diversification of logistics opportunities could redirect some cargo turnover to land routes, as international trade is expected to grow between different regions of the Eurasian continent, especially between Europe and East Asia, the Middle East and East Asia, and Europe and Southeast Asia.

According to BCG, global trade will grow 2.3% per year through 2031, less than the projected annual growth rate of 2.5% for the global economy. Trade between the EU and China will grow, but at a slower rate than the global average as companies focuses on improving their resilience. Southeast Asia will have significantly more trade with China, the US, Japan and the EU. Companies will be attracted to the region by its lower costs and the growing breadth and depth of its manufacturing capabilities.

Figure 1. *Change in trade of goods*



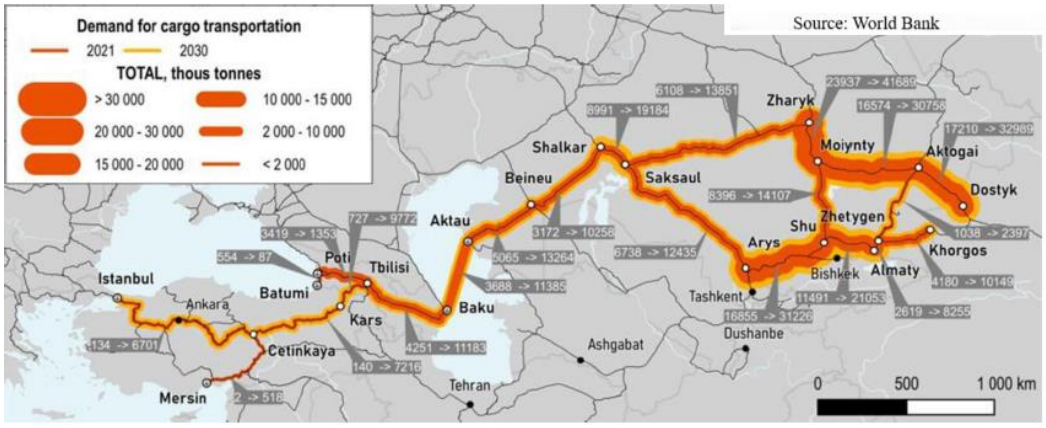
Source: https://www.bcg.com/publications/2025/great-powers-geopolitics-global-trade

The middle corridor shows growth in cargo volumes, and expansion of transport infrastructure is critical.

The Middle Corridor is a strategically important multimodal corridor with a length of 6,180 km and a capacity of 6 million tons, including 80,000 TEU. Transport time along the Middle Corridor has been reduced from 38-53 days to 19-23 days, including 5 days through Kazakhstan.

The World Bank forecasts that volumes along the Middle Corridor could triple by 2030 to 11 million tons per year, mainly due to economic growth in Central Asia and the Caucasus rather than growth in transit cargoes. The WB expects the Middle Corridor to remain largely a regional route, with intercontinental trade accounting for less than 40 percent of its volumes by 2030.

Figure 2. *The Middle Corridor*



Source: https://thedocs.worldbank.org/en/doc/6248f697aed4be0f770d319dcaa4ca52-0080062023/original/Middle-Trade-and-Transport-Corridor-World-Bank-FINAL.pdf

Kazakhstan, as a key player in the Middle Corridor and North-South Corridor, is making significant efforts to develop its own transport capacity, including railroads, roads and ports.

The EBRD estimates that the total investment needed to significantly improve Central Asia's transport infrastructure and ensure sustainable connectivity is €5.5 billion for Kazakhstan and €18.5 billion for Central Asia as a whole, which includes 33 infrastructure projects and 7 soft connectivity measures. When considering the decarbonization of the transport sector, the amount of investment needed increases manifold.

To meet these needs, investment attraction, proper structuring of transactions, improvement of PPP and tariff setting mechanisms, digitalization, and international cooperation are necessary.

1.2 Transport and logistics infrastructure in Kazakhstan

Kazakhstan has invested $35 billion in transportation and logistics over the past 15 years. The share of transportation and logistics in the country's GDP will grow from 6.2% in 2022 to 9% by 2025.

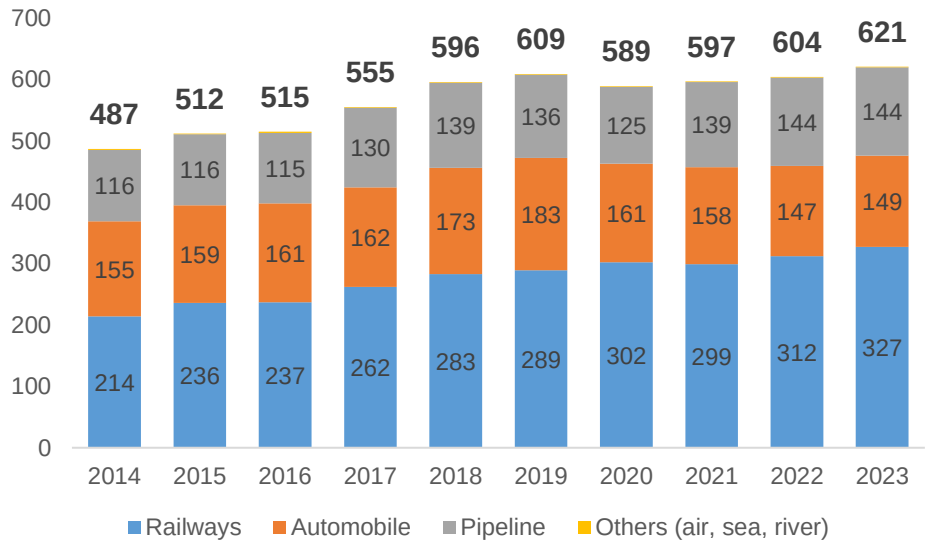
- Railways: 16,000 km;
- Roads: 94,800 km (including 24,900 km of international and national importance);
- Airports: 25 (18 international and 7 internal);

– Pipelines: 29,000 km (including 3,200 km of oil pipelines and 16,500 km of gas pipelines);
– Inland water routes: 2,170 km/

The total traffic volume shows a positive trend, increasing from 487 in 2014 to 621 in 2023, which may indicate infrastructure development and freight growth.

In terms of freight load[1], railway transportation is the most used mode of transportation in Kazakhstan, followed by road and pipelines. In real terms, the volume of cargo by other modes of transportation remains insignificant. Rivers in Kazakhstan have limited capacity for freight transportation, unlike rivers in North America or Europe.

Figure 3. *Volume of freight transportation by mode of transportation, 2014-2023 (billion tons-km)*



Source: Bureau of National Statistics

In 2023, according to the Logistics Performance Index of the World Bank, Kazakhstan is ranked 79th out of 139 countries with a total index of 2.7 out of 5.0. Kazakhstan's performance (score/place) by index components:

– Customs - 2.6/74;
– Infrastructure - 2.5/80;
– International transportation - 2.6/91;
– Logistics Competence - 2.7/81;
– Timeliness - 2.9/93;
– Freight Tracking - 2.8/80.

Railroads of Kazakhstan

[1] Freight load refers to the total quantity or volume of goods and cargo being transported by a specific mode of transportation (such as railway, road, pipelines, or waterways) over a given period of time. It is typically measured in metric tons, tonnes, or other units of weight, and reflects the capacity and utilization of the transportation system for moving goods.

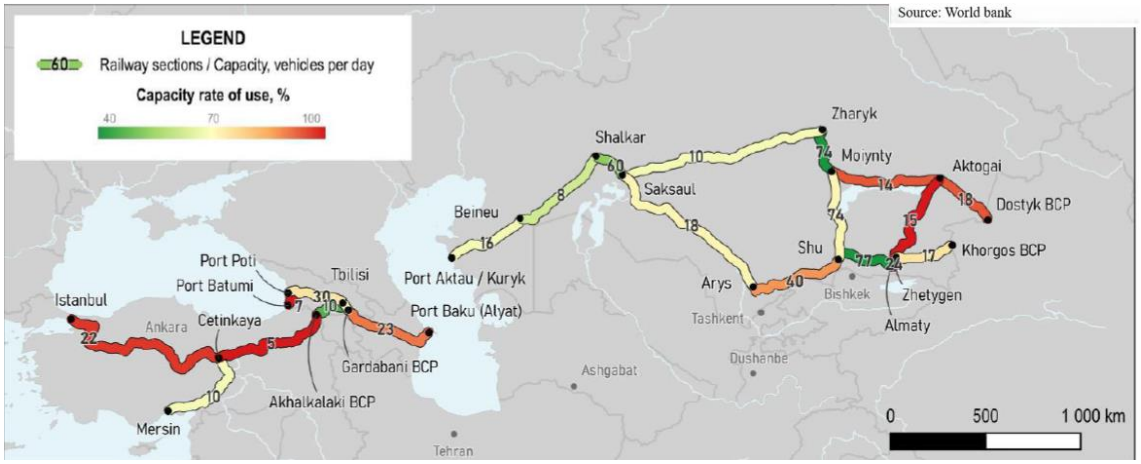
Railroads are the key mode of freight transportation in Kazakhstan. In 1991, Kazakhstan had a relatively developed but segmented rail network: West Kazakhstan, North Kazakhstan and East Kazakhstan were connected to South Kazakhstan, but not to each other. Major cities and all oblasts had rail connections; however, there were many connections through other countries, making transportation within the country difficult.

In recent years, Kazakhstan has worked on the integrity of its own rail network by building in-country connections such as Pavlodar-Ust-Kamenogorsk, Aktobe-Kostanai, Zhezkazgan-Aktau, and others. Kazakhstan also worked on new international connections for foreign trade, such as railroads to Turkmenistan and Iran, as well as China.

Electrification of railroads determines what types of locomotives and at what speeds can use them. Kazakhstan's electrified railroads operate at 25 kV AC voltage and are capable of handling high-speed trains. However, of the 16,000 km of railroads, only 4,200 km are electrified, thus the share of electrified tracks is 25%.

In Kazakhstan, the busiest railroad sections are Dostyk-Moyinty and Shu-Shymkent. Kazakhstan is currently expanding the capacity of Dostyk-Moyinty by building a second railroad track and has started construction of a new line that will connect Bakhty (the border point between Kazakhstan and China) to the national railroad system.

Figure 3. *Railroad Capacity and Congestion in the Middle Corridor*



Source: https://thedocs.worldbank.org/en/doc/6248f697aed4be0f770d319dcaa4ca52-0080062023/original/Middle-Trade-and-Transport-Corridor-World-Bank-FINAL.pdf

From 2012 to 2022, the number of locomotives decreased from 1,865 to 1,730, a decrease of 7.2%. The number of electric locomotives increased from 552 to 583. Over the same period, the number of freight cars increased from 127,695 to 137,189, an increase of 7.4%. The number of freight cars in state ownership decreased from 66,503 to 53,873. Flat wagons have the largest share among freight wagons in state ownership.

Kazakhstan's highway network

The length of the road network is about 94,800 km, including 24,900 km of international and republican importance and 31,800 km of regional level. Kazakhstan has about 230 cars per thousand people, which is comparable to Albania or China and half as many as in Hungary, Romania, Brazil and Bahrain.

Road transport in Kazakhstan accounts for a significant share of freight transportation, 24% in 2022, and more than 90% of passenger transportation. After reaching a peak in 2019, road freight transportation began to decline.

Between 2003 and 2008, the number of trucks nearly doubled, from 223,000 to 414,000. After that, the number of trucks was volatile, but the overall trend was upward. At the end of 2022, the number of trucks was 447,000.

Maritime transportation

The volume of cargo transportation by sea has been falling since reaching its peak in 2011. This was mainly due to the substitution of oil export volumes through Caspian Sea ports by other modes of transportation.

In 2022, the volume of cargo transshipment through the seaports of Kazakhstan reached 6.5 million tons, which is 19% higher than in 2021. In 2022, the number of vessel calls at seaports of Kazakhstan reached 2,237, which is 23% more than in 2021.

By vessel type, the largest share is accounted for by tugs, barges, sea boats and support vessels.

Most of the vessels are older than 10 years.

The Caspian Sea connects Kazakhstan via Aktau and Kuryk to Azerbaijan, Iran, Russia and Turkmenistan. The Caspian Sea is capable of receiving cargo ships and is connected to the world ocean through the Volga-Don River Canal, which runs entirely through Russia.

In 2018, Kazakhstan, Russia, Azerbaijan, Turkmenistan and Iran agreed on the legal status of the Caspian Sea, defining sovereignty over the seabed, subsoil and airspace.

Aktau has two “sub-ports”: a state-owned port in the south and a new public-private terminal north of the city.

The Kuryk port is under development, with only a ferry terminal currently operating.

Air transportation and international airports

Kazakhstan's aviation industry is recovering from a three-year slump caused by the Covid-19 pandemic. As industry recovers, air traffic is being restored, flights are resuming and new flight destinations are being opened.

Progress has been made in recent years in modernizing and expanding the country's international airports.

Now the development and expansion of cargo terminals is a priority for the country and is being carried out at the two largest airports: Almaty International Airport (Almaty) and Nursultan Nazarbayev International Airport (Astana).

Transit flight routes changed in 2022, making Kazakhstan's airspace more important.

In 2022, the number of serviced flights of foreign companies through Kazakhstan's airspace increased almost 2.5 times compared to 2021. In 2023, it exceeded 308 thousand (transit and landing). The number of air traffic service (ATS) routes through Kazakhstan in 2016-2019 was stable and began to grow after the adoption of the fifth degree of freedom on November 1, 2019.

Nursultan Nazarbayev International Airport in Astana could become a transit hub for cargo airlines flying from China to Europe. Its main competitive advantage is comparatively lower prices for ground handling and jet fuel.

Astana Airport currently handles more than 2,000 transit cargo flights per year, compared to less than 50 transit cargo flights before the Covid-19 pandemic.

Trade operations through Astana Airport:

- Asia-Europe transit cargo;
- Import of goods from East and Southeast Asia, Europe;
- Export of goods to neighboring countries.

Thus, the transport sector plays a key role in the economy of the Republic of Kazakhstan, providing connectivity between regions of the country and integration into international transport corridors.

The development of transport infrastructure, including railroads, roads and ports, contributes to economic growth, increases transit flows and strengthens Kazakhstan's position as a key player in international transport corridors such as the Middle Corridor and the North-South Corridor.

The transport sector makes a significant contribution to Kazakhstan's GDP. According to the Bureau of National Statistics of the Agency for Strategic Planning and Development of the Republic of Kazakhstan, in 2023 the transport sector accounted for 5.6% of countries' total GDP. This includes not only direct revenues from transportation, but also indirect effects associated with infrastructure development and job creation.
The transport sector, including the warehousing sector, employs about 7.3% of the country's economically active population.

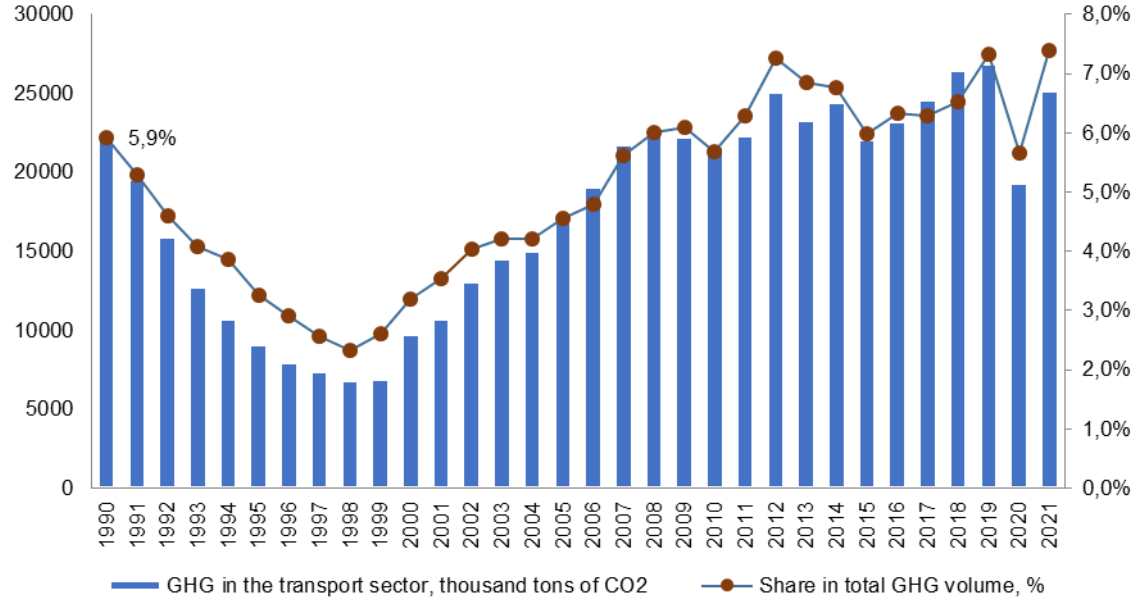
1.3 Overview of GHG emissions from the transport sector in Kazakhstan

Economic development in recent decades has stimulated activity in the transport sector and, as a result, increased the amount of transport used and the corresponding greenhouse gas emissions.

Thus, greenhouse gas emissions from the transport sector of Kazakhstan exceeded the base period of 1990 by 11.6%, and the previous year 2020 by 30.1%. The sector's share in total emissions increased from 5.9% in 1990 to 7.4% at the end of 2021[2] (Figure 5).
Due to measures taken to contain the COVID 19 pandemic, 2021 is still an unusual year in terms of emissions volumes. It is worth noting that the reduction in emissions occurred due to a decrease in passenger traffic by all national operators such as Kazakhstan Temir Zholy (rail transportation), Air Kazakhstan (air carrier), internal movements and others.

[2] National report of the Republic of Kazakhstan on the inventory of anthropogenic emissions from sources and absorption by sinks of greenhouse gases not regulated by the Montreal Protocol on the inventory of greenhouse gases of Zhasyl Damu JSC.

Figure 4. *Dynamics of greenhouse gas emissions from the transport category for the period 1990-2021*



Source: Kazakhstan National inventory report 2023

Over the 30 years since 1990, the structure has changed significantly. The main source of greenhouse gas emissions in this category is motor transport. Its share continues to remain at 81% of all emissions in this category. The share of the contribution of railway transport decreased from 23% to 4%, water transport decreased from 0.9% to 0.7%, and pipeline transport increased from 2% to 7%. Aviation, despite the small annual growth dynamics, occupies an almost stable share of 4%, with the exception of the last two years.

The transport sector runs largely on fossil fuels. Thus, motor gasoline and diesel fuel account for 83.8% of course fuel consumption in transport (Table 1).

Table 1. Final consumption by fuel type in the Transport sector at the end of 2022, thousand tons of oil equivalent, 1000 toe

		Final energy consumption	Transport sector	Domestic air transport	Road transport	Railway transport	Inland water transport	Pipeline transport	Other consumption (transport)
Energy coal		7,254.4	19.6	-	-	19.6	-	-	-
Lignite (brown coal)		1,230.0	0.7	-	-	-	-	-	0.7
Gas		6,638.5	49.3	-	3.2	-	-	46.2	-
Oil and petroleum products	Liquefied propane and butane	1,287.3	605.8	-	605.5	-	0.2	0.0	-
	Aviation gasoline	34.0	34.0	34.0	-	-	-	-	-
	Motor gasoline	4,964.6	4,886.7	-	4,886.7	-	-	-	-
	Jet fuel type gasoline	2.0	2.0	2.0	-	-	-	-	-
	Jet fuel type kerosene	348.5	334.6	334.6	-	-	-	-	-
	Kerosene	2.6	2.4	2.4	0.0	-	-	-	-
	Diesel fuel (distillation temperature 180-380 degrees Celsius) for road transport	2,321.8	2,321.8	-	1,557.3	756.5	8.1	-	-
	Heating and other gas oils	3,131.2	4.4	-	-	-	-	4.4	0.0
	Petroleum fuel (fuel oil), with sulfur content less than 1%	46.1	46.1	-	-	45.9	-	0.3	-
RES		2.2	0.0	-	-	-	-	-	-
Electricity		7 150.7	301.1	-	3.7	232.5	-	64.9	-
Total		42,248.0	8,608.9	373.0	7,056.5	1,054.5	8.3	115.8	0.9

Source: Fuel and Energy Balance of the Republic of Kazakhstan (2023)

As a result, at the end of 2021, 93.5% of greenhouse gas emissions in transport came from liquid fuel and 6.5% from gas.

In terms of modes of transport, the following situation has developed.

Motor transport (81% of greenhouse gas emissions)

Since 1990, when there was a total of 1278.8 thousand cars in the republic, their number has increased 4 times, and in 2021 reached 4386.8 thousand units. As of May 1, 2024, the number of registered vehicles was 5,442.9 thousand units[3].

The internal structure of the vehicle fleet in Kazakhstan consists mainly of passenger cars, which make up 88% of the total number of vehicles. Trucks occupy 10%, and buses only 2% of the vehicle fleet.

One should pay attention to the fuel structure of the vehicle fleet. 82.1% of vehicles in Kazakhstan run on gasoline, 7.6% on diesel fuel, 7.1% on gas equipment, 2.7% use mixed fuel, and only 0.2% are electric. These data show the dominance of petrol vehicles and minimal presence of electric vehicles, indicating significant potential for the development of the electric vehicle market in the country. As of May 1, 2024, 9,833 electric vehicles were registered[4].

According to the Bureau of National Statistics a total of 5.5 million cars are registered in Kazakhstan, of which 2.49 million are older than 20 years. In the breakdown by year of manufacture, the number of cars is as follows:

- less than 3 years old - 345,367 cars (6.2%);
- 3 to 7 years old - 733,421 cars (13.17%);
- 7 to 10 years old - 662,185 cars (11.89%);
- 10 to 20 years old - 1,328,606 cars (23.86%);
- 20 years and above - 2,499,463 cars (44.88%).

In Kazakhstan, there is a lower level of awareness about energy efficiency among the population and consumers compared to other countries. This is reflected in the common transportation habits, especially in large cities, where large SUVs like the Toyota Land Cruiser and Nissan Patrol are very popular. European experience demonstrates that improving consumer awareness and introducing labeling systems can help reduce fuel consumption by 4–5%[5].

These statistics indicate a high level of wear and tear on vehicles and potential risks associated with safety and environmental friendliness. The predominance of old cars also indicates the need to update the vehicle fleet. The small share of clean cars is mainly concentrated in cities, but given the average age of the vehicle fleet, they do not have a significant impact on reducing greenhouse gas emissions.

There is no effective system for monitoring technical condition and fuel efficiency. The technical inspection procedure in most cases is a formality.

[3] Ministry of Internal Affairs of the Republic of Kazakhstan
[4] Ministry of Internal Affairs of the Republic of Kazakhstan
[5] Technical analysis of measures to improve consumer awareness of emissions and fuel consumption of vehicles, European commission, May 2021
https://climate.ec.europa.eu/document/download/06ed3d87-64d8-43c2-9e4b-39514dfa42e8_en?filename=2019_0008_report_en.pdf

Rail transport (4% of greenhouse gas emissions)

The main sources of greenhouse gas emissions in the railway transport category include emissions from locomotives pulling trains. The inventory of diesel locomotives as of 2023 is 1,697 units locomotives, where 1089 units diesel locomotives and 608 electric locomotives. The share of electrified railway lines in Kazakhstan is 32.1%.

In terms of rolling stock[6] age: 419 units have been in operation for more than 5 years, 450 for more than 10 years, 827 units have been in operation for more than 25 years[7]. These data indicate a significant proportion of rolling stock that is aging, highlighting the need for modernization and renewal to improve the efficiency and safety of rail transport.

The orientation of railway transport towards the primary consumption of electricity has led to the fact that it is completely dependent on the production of energy resources by the country's fuel and energy complex in relation to both energy supply for transportation and making strategic decisions on the prospects of types of traction and energy sources for them.

Moreover, railway transport is not only a consumer of fuel and energy products, but at the same time a technological link in the energy production chain, since it ensures the transportation of primary energy resources from the place of their extraction to sources that reproduce energy for consumers, including railways. In the annual volumes of cargo transportation by railways, primary energy carriers account for 35%, including: coal 27%, hydrocarbons 8%.

Aviation transport (2% of greenhouse gas emissions)

Greenhouse gas emissions from aviation are mainly due to the combustion of jet fuel and, in small quantities, aviation gasoline.

The total number of civil aircraft at the end of 2023 was 941 units. In 2023, airlines carried 13.3 million passengers, served 26.1 million passengers at airports, and transported 23.8 thousand tons of cargo[8]. Air transport, especially domestic flights, has a smaller impact on overall emissions, but emissions at high altitudes have a significant impact on the climate[9].

Water transport (0.7% of greenhouse gas emissions)

Since Kazakhstan is landlocked, water transportation plays a less significant role than other types of transportation.

There are 263 sea vessels registered in Kazakhstan. Vessels under 10 years old make up a significant proportion (53%), indicating a relatively young fleet. However, there is

[6] Rolling stock refers to all the vehicles that move on a railway track, including locomotives, passenger coaches, freight cars, wagons, and other specialized rail vehicles used for transportation.
[7] https://rail-news.kz/ru/news/16673-ktz-vedet-poetapnuiu-rabotu-po-obnovleniiu-podviznogo-sostava.html#:~:text=%D0%9F%D0%B0%D1%81%D1%81%D0%B0%D0%B6%D0%B8%D1%80%D1%81%D0%BA%D0%B8%D0%B5%20%D0%B2%D0%B0%D0%B3%D0%BE%D0%BD%D1%8B&text=%D0%91%D1%8B%D0%BB%D0%BE%20%D0%B7%D0%B0%D0%BA%D1%83%D0%BF%D0%BB%D0%B5%D0%BD%D0%BE%201326%20%D0%BF%D0%B0%D1%81%D1%81%D0%B0%D0%B6%D0%B8%D1%80%D1%81%D0%BA%D0%B8%D1%85%20%D0%B2%D0%B0%D0%B3%D0%BE%D0%BD%D0%BE%D0%B2,%D0%B2%D0%B0%D0%B3%D0%BE%D0%BD%D0%B0%D0%BC%D0%B8%20%D0%BD%D0%BE%D0%B2%D0%BE%D0%B3%D0%BE%20%D0%BF%D0%BE%D0%BA%D0%BE%D0%BB%D0%B5%D0%BD%D0%B8%D1%8F%20%D0%BF%D1%80%D0%BE%D0%B8%D0%B7%D0%B2%D0%BE%D0%B4%D1%81%D1%82%D0%B2%D0%B0%20Stadler.
[8] https :// www . gov . kz / memleket / entities / aviation / documents / details /618713? lang = ru
[9] https://www.eesi.org/papers/view/fact-sheet-the-growth-in-greenhouse-gas-emissions-from-commercial-aviation

also a significant number of ships over 15 years old (47%), highlighting the aging portion of the fleet that requires special attention to maintenance and replacement.

Inland waterways are public routes and are subject to government maintenance and upkeep. As of 2023, the inland water transport fleet amounts to 231 units, most of which are the tug fleet (106 units) and non-self-propelled vessels - barges (91 units). At the same time, 70% of ships are operated beyond the standard period of 10 years.

Due to the insignificant share of water transport in transportation volumes and greenhouse gas emissions in Kazakhstan, it is not advisable to introduce market mechanisms for regulating greenhouse gas emissions by this type of transport in the medium term.

Pipeline transport (7% of greenhouse gas emissions)

The pipeline infrastructure of Kazakhstan is owned by the national operator for the main oil pipeline, JSC KazTransOil, its two joint ventures (Kazakhstan-China Pipeline LLP and MunaiTas North-West Pipeline Company LLP), as well as the Caspian Pipeline Consortium (CPC). The existing pipeline infrastructure in Kazakhstan has sufficient potential to increase oil transportation volumes from prospective projects.

JSC KazTransOil (KTO) is the national operator for the main oil pipeline in the Republic of Kazakhstan. The company owns an extensive network of main oil pipelines with a total length of 5,372 km, connecting nearly all oil fields in Kazakhstan. The company ensures the transportation of oil to the four largest oil refineries in Kazakhstan, as well as exports oil through the Atyrau-Samara pipeline, transships oil to the export pipelines of CPC and Atasu-Alashankou, and loads oil onto tankers at the port of Aktau and onto railway transport. Oil transportation through the main pipelines is supported by 36 oil pumping stations, 67 oil heating furnaces, and a tank farm with a total storage capacity of 1.4 million m^3. KTO also provides operation and maintenance services for the main oil pipelines of Kazakhstan-China Pipeline LLP, MunaiTas North-West Pipeline Company LLP, and Caspian Pipeline Consortium-K JSC.

Kazakhstan-China Pipeline LLP (KCP) is the owner of the Atasu-Alashankou pipeline (965 km) and the Kenkiyak-Kumkol pipeline (794 km). KCP transports Kazakhstani and transit Russian oil to the People's Republic of China (PRC), as well as to the domestic market of Kazakhstan.

MunaiTas North-West Pipeline Company LLP (MT) owns the Kenkiyak-Atyrau main oil pipeline, which is 449 km long. In 2018, the company initiated a project to reverse the Kenkiyak-Atyrau pipeline to ensure the supply of Western Kazakhstan oil to the refineries of the Republic of Kazakhstan and mitigate the effects of declining oil production in the Aktobe and Kyzylorda regions, as well as to export up to 6 million tons of oil annually to the PRC. The project cost is 28.6 billion tenge. As part of the project, the facilities of the first startup complex were commissioned, and the construction of the second startup complex was completed.

The Caspian Pipeline Consortium (CPC) is an international oil transportation project involving Russia, Kazakhstan, and leading industry players, established for the construction and operation of a main pipeline with a length of 1,510 km (of which 452 km is the Kazakhstani section). The CPC pipeline is one of the priority routes for the export of Kazakhstani oil, connecting the Tengiz oil field in Kazakhstan with the Yuzhnaya Ozereevka oil terminal on the Black Sea (near the port of Novorossiysk). Oil transportation through the CPC pipeline is supported by 15 oil pumping stations, a tank farm with a total storage capacity of 1.3 million m^3, and three offshore loading facilities.

Total emissions in the Pipeline Transport sector have been quite stable over the past four years. In 2021, CO_2 emissions eq. exceed emissions in 1990 by 37.6%.

Challenges and Opportunities for Development of the Transport sector

Kazakhstan's transport sector, particularly its railway network, plays a crucial role in the transportation of intermediate goods essential for industrial production. As the primary mode of freight transport in the country, railways facilitate the movement of key resources such as coal, oil, and metals. These commodities serve as the backbone of various industries, including energy, metallurgy, and chemical production.

For instance, coal, which accounts for 27% of the total freight transported by rail, is primarily used for electricity generation in the energy sector and steel production in metallurgy. Oil and gas, making up 8% of total freight volumes, are transported via pipelines and railways for further processing at refineries and for export. These resources are crucial for sustaining the petrochemical industry and ensuring the country's energy security.

Rail transport also plays a vital role in moving metals and ores used in machinery manufacturing and construction. For example, iron ore and steel are transported from mining regions to metallurgical plants, where they are processed into finished products such as pipes, construction materials, and machinery. These goods are then utilized across various industries, including construction, automotive manufacturing, and equipment production.

Dependence on Imported Transport Equipment

Despite significant investments in transport infrastructure, Kazakhstan remains heavily reliant on imported transport equipment and machinery across multiple sectors, including automotive, rail, aviation, and maritime transport.

Automotive Sector

Kazakhstan is highly dependent on imported vehicles and spare parts. Most vehicles used in the country are imported, with the primary suppliers being Russia, Japan, South Korea, and Europe. According to the Committee of State Revenues, from January to December 2023, Kazakhstan imported 156,000 passenger cars worth $2.9 billion.

Although Kazakhstan has several assembly plants for various car brands, these facilities primarily assemble vehicles from imported components rather than engaging in full-cycle production. According to the Bureau of National Statistics, 148,885 transport units of all types were manufactured in Kazakhstan in 2023.

- Allur (Kostanay) led the market with 90,230 vehicles produced;
- Hyundai Trans Kazakhstan (Almaty) increased production to 48,857 cars;
- SemAZ (Semipalatinsk) produced 3,788 commercial vehicles;
- QazTehna (Saran, Karaganda region) manufactured 1,801 commercial vehicles;
- KAMAZ Engineering (Kokshetau) produced 1,352 trucks;
- Hyundai Trans Almaty (Almaty) manufactured 981 commercial vehicles;
- Daewoo Bus Kazakhstan (Semey) produced 609 units.

Moreover, Kazakhstan has almost no production of electric vehicles (EVs), making the country dependent on imports in this segment. As of May 2024, only 9,833 electric vehicles were registered in Kazakhstan, accounting for less than 0.2% of the total number of cars. This indicates a significant potential for developing local EV manufacturing and reducing import dependency.

Railway Transport

Kazakhstan's railway sector also depends heavily on imported equipment. Although the country has an extensive railway network, a large share of its rolling stock, including locomotives and railcars, is imported. In 2023, there were 1,697 registered locomotives in Kazakhstan, of which:

- 1,089 were diesel-powered
- 608 were electric

Most of these locomotives were produced outside Kazakhstan, primarily in Russia and Europe.

A significant portion of the freight railcars in use is also imported. While Kazakhstan has several enterprises engaged in railcar production and repair, they do not fully meet the sector's needs, making the country reliant on foreign suppliers. This dependency could pose challenges in times of global crises or trade restrictions.

Aviation and Maritime Transport

The aviation sector is also highly dependent on imports. Most aircraft operated by Kazakh airlines are sourced from the United States, Europe, and Russia. In 2023, Kazakhstan had 941 registered civil aircraft, the majority of which were produced abroad. This reliance makes the aviation sector vulnerable to global market fluctuations and currency exchange rate changes.

Although maritime transport plays a less significant role in Kazakhstan's economy, it too depends on imported vessels. Most ships registered in Kazakhstan were built abroad, and a large share of the fleet is over 10 years old, indicating a need for fleet renewal and reduced import dependence.

Potential for Domestic Transport Equipment Production

Despite its reliance on imports, Kazakhstan has significant potential to develop domestic transport equipment manufacturing. The country already has enterprises engaged in railcar production and repair, as well as vehicle assembly plants. However, achieving full-cycle production requires investments in local technological development and research.

For example, Kazakhstan could expand its production of locomotives and railcars, reducing reliance on imports and creating new jobs. In the automotive sector, the development of electric and hybrid vehicle production could be a key step toward reducing import dependency while also improving environmental sustainability.

Additionally, strengthening domestic pipeline equipment manufacturing could reduce reliance on imported materials. Given the strategic role of pipelines in Kazakhstan's oil and gas exports, increasing local production of pipes and related infrastructure could enhance the country's competitiveness in global markets.

To establish a strong foundation for economic growth, reduce import dependence, and accelerate industrialization, Kazakhstan must prioritize the development of domestic transport equipment manufacturing, including:

- Locomotives and railcars
- Automobiles and electric vehicles
- Pipelines and transport-related infrastructure

This approach would not only decrease reliance on foreign imports but also create new jobs, stimulate technological advancements, and contribute to Kazakhstan's long-term economic growth and sustainability.

2. Integrating transport decarbonization issues into government planning

Currently, the State Planning System of the Republic of Kazakhstan has a number of documents that contain important strategies and measures for decarbonization of the transport sector.

The Strategy for Achieving Carbon Neutrality, which is the top-level document of the state planning system, states that the priority of transport decarbonization will be the transition from the predominance of petroleum products to electricity, hydrogen and biofuels .

The main concept for the development of the transport sector will be "avoidance - shift - improvement":

- Eliminating or reducing the need for travel (avoidance). Avoidance refers to a drop in energy demand from passenger cars, optimization of passenger and freight flows, development of a public transport system, optimal planning of cities, which will reduce the need for car travel as such.
- Transition to more environmentally friendly modes of transport (shift). The shift includes the active use of alternative fuels and large-scale electrification of transport.
- Increasing energy efficiency and reducing vehicle emissions (improvement). Improvement refers to the renewal of the vehicle fleet and the modernization of existing vehicles. This step will be combined with avoidance and shift.

The Concept for the Transition to a Green Economy, updated in July 2024, defines approaches to the implementation of energy saving and energy efficiency measures in the transport sector, namely:

- Ensure infrastructure development for clean fuel transport and bicycles.
- Improving the traffic flow management system (smart traffic control system).
- Transportation management (transport infrastructure that allows the efficient use of all types of transport, increasing the availability and quality of group passenger transportation).

The main technical measures to save energy and improve energy efficiency in the transport sector are:

- development of energy efficient transport infrastructure;
- increasing the efficiency of railway transport;
- increasing the energy efficiency of local public transport by switching it to clean fuel (gas and electricity);
- expanding public transport networks, making them more convenient for people and potentially moving from individual means of transport (cars) to public transport.

In total, US$162 billion will be required to implement energy efficiency measures in transport by 2050.

The approved Action Plan for the implementation of this Concept specifies only generalized measures: the development of alternative modes of transport and the corresponding infrastructure for electric vehicles and gas-fueled vehicles, improvement of the traffic flow management system..

In the new Action Plan, which is at the discussion stage, there are already more targeted measures regarding the decarbonization of transport:

- development of alternative modes of transport and corresponding infrastructure for electric vehicles (;
- improvement of the traffic flow management system (completion form - commissioning);
- increasing the energy efficiency of local public transport by switching it to clean fuel (gas and electricity); expanding public transport networks, ensuring their convenience for people and the potential transition from individual means of transportation (cars) to public transport;
- transfer of urban civil transport to electricity (priority cities – Almaty (2 mln 292 thousand people – 11.4% of total population), Astana (1 mln 528 thousand people – 7.6% of total population), Karaganda (518 thousand people – 2.3% of total population), Shymkent (1 mln 253 thousand people – 6.3% of total population), in which the conversion should cover at least 70% of the entire vehicle fleet until 2040). ;
- improving and expanding cycling and public transport infrastructure, sidewalks and walking distances, and integrating these modes of transport and walking into land use and other road transport planning to encourage a shift from private motorized transport to public transport, cycling or walking; ensure comfort, continuity and safety of bicycle transport and pedestrian infrastructure, reduce traffic congestion and accidents (completion form - commissioning).

The Concept for the Development of the Fuel and Energy Complex of the Republic of Kazakhstan for 2023–2029 indicates the role of the gas industry in the country's economy, including due to the increase in the number of vehicles using gas as raw material and energy.

The main document for long-term planning for the development of the transport system of the Republic of Kazakhstan is *the Concept for the development of transport and logistics potential of the Republic of Kazakhstan until 2030,* approved by Decree of the Government of the Republic of Kazakhstan No. 1116 dated December 30, 2022. This Concept outlines the transition to a low-carbon transport.

- large-scale deployment of charging infrastructure for electric vehicles along the busiest road transport corridors, as well as in cities, including for electric buses with the simultaneous development of industry standards for the construction and operation of charging infrastructure facilities;
- priority provision of energy capacity for the installation of high-power charging stations along international highway corridors and sections of highways connecting urban agglomerations with tourist and recreational facilities;
- creating conditions and infrastructure for increased use of bicycles, as well as electric and other non-motorized personal mobility devices.
- introduction of measures to stimulate the transition of the population to the use of public passenger transport, as well as the organization of designated zones for the movement of environmentally friendly vehicles;
- introduction of alternative and renewable energy sources, including installation of solar panels on the roofs of cargo and passenger terminals and public transport stops,

introduction of traffic control systems with autonomous power elements and other innovative technological solutions;

- introduction of measures of a regulatory legal and financial-economic nature that stimulate the active transition of enterprises and the population to the use of vehicles with a high environmental class, as well as electric traction, including subsidizing the cost of purchasing vehicles with electric engines with the exemption of this category of vehicles from payment for travel on toll sections of roads;
- development of a set of measures to stimulate the phased cessation of operation of vehicles that do not comply with current and future environmental standards;

Thus, the state planning system contains ideas and concepts for decarbonization of the transport sector, which is certainly a positive step. The State is aware of the need to switch to environmentally friendly transport and is taking steps in this direction. However, there are currently a number of challenges that needs to be addressed to effectively achieve decarbonization goals.

Firstly, there is no single document presenting a holistic vision of the transport decarbonization strategy. Such a document should contain clear directions for development and specific measures that will be taken to reduce emissions in the transport sector. Without a unified vision, it is difficult to coordinate the actions of various government agencies, businesses and other stakeholders.

Secondly, the relationship between different types of environmentally friendly transport is unclear. For example, at what stage of development are electric cars compared to hydrogen cars, and what is the role of biofuels in the overall plan.

It is important for Kazakhstan to define the design of long-term development of clean fuel sources and determine clear proportions of electrification of transport and hydrogen use. An analysis[10] of the priorities of national hydrogen strategies shows that they tend to focus on the application of hydrogen in the heavy and long-distance transport segments:

- heavy trucks;
- buses (especially long-distance buses);
- rail transportation;
- aviation and shipping.

The focus for hydrogen on the heavy and long-haul segments is because competitive battery-based solutions - BEVs (battery electric vehicles, battery/battery electric vehicles) - are already being developed for short-haul passenger cars. In terms of cost of ownership in Europe, battery electric vehicles are already on par with gasoline and diesel vehicles[11]. In the heavier vehicle segments, battery solutions are not yet attractive due to the large weight and size of the batteries required to keep the engines of heavy vehicles running for long periods of time, the long charging times of these batteries and the significant costs of developing the appropriate charging infrastructure.

In the heavy-duty truck segment, several countries and key automakers are considering the use of hydrogen - e.g. Daimler Truck, Dongfeng, Iveco, Hyundai, Sinotruck, Toyota, Volvo Group, Kenworth. The first truck models are already undergoing comprehensive tests and are being prepared for commercialization, but have not yet been widely distributed. There are only about 15 thousand hydrogen trucks and buses registered in the world, the overwhelming number of which is in China[12].

[10] Green hydrogen strategy:A guide to design, IRENA 2024. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Jul/IRENA_Green_hydrogen_strategy_design_2024.pdf

[11] DNV GL. Energy Transition Outlook 2023: Transport in Transition. https://www.dnv.com/Publications/transport-in-transition-242808

[12] IEA Global EV Outlook 2023. https://www.iea.org/reports/global-ev-outlook-2023

There is a widespread view that FCEVs have more advantages in this segment than BEVs[13]. Heavy hydrogen trucks are several times lighter than battery-powered trucks, are at about the same level of technological readiness (and have great potential for cost reduction), and are much faster (and easier for the driver) to refuel. The infrastructure to refuel them will be cheaper, especially for significant sized fleets. Clean energy in the form of hydrogen will be more readily available (in space and time) for FCEV refueling than electricity from RES for BEV charging - especially if the charging infrastructure is located far from where the electricity or hydrogen is produced.

In the vision of decarbonizing a sizable fleet, it is important to envision FCEV-based solutions by locating pilot charging infrastructure close to hydrogen production sites (including “gray” hydrogen, which is produced with significant greenhouse gas emissions), major cities, and along highways used for international freight transit. For each hydrogen refueling station there are from 10 to 200 hydrogen cars - depending on the country[14].

In climatic conditions of Kazakhstan another advantage of FCEV over BEV will be important - less loss of efficiency and driving range of hydrogen trucks and buses when outside air temperature decreases. The average annual temperature in Astana and Almaty (about 4-10 °C) and the average minimum (-1...+5 °C) are about 1.5-2 times lower than in Shanghai, Inchon, Rotterdam or California. According to Deloitte, when the temperature drops from +15 °C to -15 °C, the driving range of a passenger car BEV is reduced from 283 to 207 km[15]. An analysis of the performance of eight hydrogen and battery electric bus fleets in the United States shows that when the temperature changes from 10-15°C to -5-0°C, the range loss of BEVs is more significant than that of FCEVs (37.8% vs. 23.1%).

Thirdly, there are no specific yearly targets. For example, what proportion of green transport modes should be achieved by 2035 or other key periods. Clear targets are necessary so that progress can be measured and the strategy can be adjusted if necessary.

Fourthly, there is no specific understanding of what government support measures will be in place to stimulate supply and demand for environmentally friendly transport. The duration of these measures has not been determined, which creates uncertainty for businesses and consumers. For example, what tax breaks, subsidies or other incentives will be provided for the purchase and use of environmentally friendly vehicles, and how long they will last.

All these issues require careful consideration and coordination to achieve effective decarbonization of the transport sector.

[13] BEV or FCEV? The complementary roles of Battery and Fuel Cell Electric Trucks / Quatron AG, 2022. https://www.quantron.net/wp-content/uploads/2023/01/Quantron-AG_Whitepaper-BEV-or-FCEV.pdf
[14] IEA Global EV Outlook 2023. https://www.iea.org/reports/global-ev-outlook-2023
[15] Deloitte China & Ballard. Fueling the Future of Mobility. Hydrogen and fuel cell solutions for transportation. March 2020.

3. Institutional and legislative framework for decarbonization of the transport sector

Another important issue is institutional responsibility for decarbonizing the transport sector. In particular, at present there is no single coordinating government body responsible for the development and popularization of environmentally friendly modes of transport.

The Ministry of Transport of the Republic of Kazakhstan forms and implements state policy in the areas of railway, road, and inland water transport; coordinates and implements a unified state policy in the field of highways and road activities on the territory of the Republic of Kazakhstan and carries out other similar functions. However, the Regulations on this Ministry do not specify responsibility for the development of green modes of transport.

The Ministry of Ecology and Natural Resources of the Republic of Kazakhstan only approves, together with the authorized body in the field of state stimulation of industry, the rules for stimulating the production in the Republic of Kazakhstan of environmentally friendly automobile vehicles (corresponding to the environmental class established by the technical regulations of the Eurasian Economic Union; with electric motors) and their components, as well as self-propelled agricultural machinery that meets environmental requirements defined by technical regulations.

Ministry of Internal Affairs of the Republic of Kazakhstan carries out registration of vehicles by identification number and their accounting.

The Ministry of Industry and Construction of the Republic of Kazakhstan establishes requirements for energy efficiency of transport; develops and approves rules for the technical operation of vehicles; develops and approves rules for stimulating the production in the Republic of Kazakhstan of environmentally friendly automobile vehicles (corresponding to the environmental class established by the technical regulations of the Eurasian Economic Union; with electric motors) and their components, as well as self-propelled agricultural machinery that meets the environmental requirements determined by the technical regulations, together with the authorized authority in the field of environmental protection.

Ministry of Energy of the Republic of Kazakhstan including is responsible for the development of the electric power industry, its sufficiency for internal needs, incl. for transition to green modes of transport.

Local executive bodies decide on the location of electric charging stations and organize the engineering infrastructure for their operation.

Thus, in Kazakhstan there is no specific central government body that would be fully responsible for the decarbonization of the transport sector. This poses several challenges to the coordination and effective implementation of measures to reduce greenhouse gas emissions.

Firstly, the lack of centralized management leads to fragmentation of the efforts of various government bodies. As a result, each structure can work in its own direction, which leads to duplication of functions and insufficient coordination.

Secondly, this situation makes it difficult to make decisions and implement them. Without a single body responsible for decarbonizing transport, it is more difficult to set

priorities, allocate resources and monitor implementation of plans. This can slow down the progress towards carbon neutrality and lead to inefficient use of resources.

Thirdly, the absence of a central authority reduces responsibility and accountability for the results achieved. When responsibility for decarbonizing transport is distributed among several departments, it is difficult to determine who exactly is responsible for specific results and indicators. This can lead to insufficient motivation to achieve your goals.

The lack of a common vision, specific targets and a responsible central government body leads to the development of weak measures in the field of decarbonization of the transport sector in Kazakhstan.

Thus, measures are currently being taken to stimulate the transition to environmentally friendly modes of transport, including:

- exemption from customs duties until 2025;
- exemption from paying the recycling fee from June 2021;
- exemption from payment of transport tax;
- transition to the EURO-5 environmental standard[16] from 2016, within the framework of which the registration in Kazakhstan of vehicles below the specified standard is prohibited;
- annual financing under the preferential leasing program. Every year, funds from the republican budget are allocated under the preferential leasing program through the Industrial Development Fund JSC in order to transfer urban passenger transport to environmentally friendly fuels until 2030. As of March 2024, 386 buses have been updated.

Some (very rarely) mechanisms are implemented in the private sector. For example, green lending for the purchase of electric vehicles from Halyk Bank, which include reduced interest rates and the possibility of purchasing without a down payment. Various companies offer a Trade - in program under which owners can exchange their old car for a new one, which helps renew the country's vehicle fleet.

The first attempts to produce electric vehicles in Kazakhstan began at the end of 2014. The Ust-Kamenogorsk Asia Auto plant produced the first KIA Soul EV. In July 2016, the SaryarkaAvtoProm plant in Kostanay produced a pilot batch of electric vehicles of the Chinese JAC brand. Finally, in July 2017, Asia Auto presented the LADA Vesta EV at the EXPO-2017 exhibition. However, the above models did not become widespread and their production was suspended due to economic inexpediency.

Last year, the import quota within the EAEU for the number of electric cars for Kazakhstan was 15 thousand, but only half of this quota was used during the year.

The above measures are insufficient for a massive transition to “green” vehicles. It is necessary to understand that until cost of green vehicles becomes comparable to those fueled by fossils with an internal combustion engine, people will not be able to afford hence transition to green vehicles This requires significant changes in government support measures aimed at reducing the cost of environmentally friendly transport and creating incentives for its use. Car purchasing decisions typically involve consideration of the retail price and available subsidies, as well as life-cycle operating costs such as

[16] EURO-5 is an environmental standard that regulates the permissible level of harmful emissions from vehicles (such as nitrogen oxides, carbon monoxide, and particulate matter), aimed at reducing their negative impact on the environment and human health. It was introduced by the European Union (EU) as part of a series of regulations to improve air quality and reduce pollution from vehicles. The standards are developed and enforced by the EU, but they are widely adopted or referenced by other countries, including Kazakhstan, to align with global environmental goals.

fuel , insurance, maintenance and depreciation, which together add up to total cost of ownership. The cost of ownership between electric vehicles and ICE vehicles creates important financial incentives for the switch.

One of the key aspects to consider when discussing the cost of transitioning to environmentally friendly transport is the issue of externalities. Traditional vehicles powered by fossil fuels create significant negative consequences for the environment and public health, such as air pollution, greenhouse gas emissions, and noise pollution. However, these costs are not reflected in the market price of internal combustion engine vehicles, making them artificially cheaper compared to electric vehicles and other "green" alternatives.

The state plays a crucial role in addressing this imbalance. Through socially acceptable policies, such as carbon taxes, subsidies for manufacturers and buyers of electric vehicles, and investments in infrastructure, it can shift some of these costs to the current generation rather than leaving them for future generations. This not only promotes a fair distribution of costs but also encourages the transition to more sustainable transport models.

Furthermore, it is important to recognize that economic calculations based solely on market prices ignore the long-term environmental and health impacts. For example, reducing air pollution through the adoption of electric vehicles could lead to significant savings on healthcare costs and improve the quality of life for the population. These "hidden" benefits should be included in the overall assessment of the total cost of ownership of vehicles.

Thus, government policy should aim not only to reduce the cost of "green" transport but also to account for the externalities associated with the use of fossil fuels. This requires a comprehensive approach, including both economic incentives and regulatory measures, to make environmentally friendly transport more accessible and attractive to the population.

However, the main limitation of electric vehicle development not only in Kazakhstan but also in the world is the so-called “EV range anxiety” phenomenon, i.e. the fear of electric vehicle drivers that the battery charge may not be enough for the planned route and there will be no charging station networks along the way[17]. Accelerated development of charging station infrastructure can solve the problem of range anxiety. Regardless of their destination, electric vehicle drivers need the confidence that they can easily find charging points along their route and have confidence in the reliability of these chargers. In Norway, the most “electric vehicle populous” country, there are still reliability issues and a lack of standardization of chargers, associated payment systems and apps - each company has its own apps and payment methods[18].

Currently, there are 269 charging stations across Kazakhstan[19], which is really not enough. The main problem is the small number of charging stations for electric cars outside major cities such as Almaty, Astana, Shymkent, as well as their absence on highways, which does not allow traveling by car between cities and countries.

In major cities of Kazakhstan there are chargers that charge cars in garages, parking lots, charging stations and private homes. However, at the moment there is a ban on installing charging stations in residential buildings, which creates a number of inconveniences for those who drive electric cars.

[17] Wang et at, Range Anxiety among Battery Electric Vehicle Users: Both Distance and Waiting Time Matter, Sage Journals, Volume 67, Issue 1, September 2023, Pages 1309-1315
[18] https://pditechnologies.com/blog/norways-ev-growing-pains-convenience-industry/
[19] National Bureau of Statistics

So, to overcome the anxiety of electric car drivers who are planning long distance trips, an appropriate and efficient charging infrastructure for electric cars should be set up. This will help establish drivers' trust and convince them that they can easily find charging stations on their route and rely on their reliability, which will ultimately help accelerate the development of electric vehicle adoption infrastructure.

In the current situation, the key to the development of this area is the adoption of laws and regulations that promote electric vehicle popularization and infrastructure development, including safety standards, environmental requirements, and economic incentives. To encourage the purchase of electric vehicles, additions and amendments to current legislation may be required, as well as the development of regulations aimed at:

- additional measures to support the purchase of electric vehicles;
- regulations to standardize charging station networks;
- acts to integrate charging infrastructure into new construction of roads and building

4. Infrastructure for green modes of transport

One of the main limiting factors in the development of “green” transport is the insufficient development of electric vehicle infrastructure.

According to the latest data, the number of charging stations for electric vehicles in Kazakhstan is only 269 units, with an average of 42 cars per charging station. For comparison: in the world there are on average 10 electric vehicles per charging station, in the USA - 24, in the EU - 13, and in China - only 8 cars.

The development of infrastructure for electric vehicles (EVs) in Kazakhstan is still in its early stages, yet it is a critical component of the country’s future transition to green transportation. While the popularity of electric cars is gradually increasing, the current infrastructure – such as charging stations and grid capacity – is not keeping pace with this growing demand. This gap poses a significant barrier to widespread EV adoption, as potential buyers are often deterred by concerns about charging accessibility and range limitations. Despite the early phase of development, it is essential for Kazakhstan to proactively invest in and stimulate the expansion of EV infrastructure. Doing so will not only address existing challenges but also position the country to meet future environmental and economic goals. By fostering a supportive ecosystem for electric vehicles now, Kazakhstan can avoid falling behind in the global shift toward sustainable transportation and ensure a smoother transition as EV adoption accelerates. This proactive approach will also align with international trends, where countries with well-developed EV infrastructure have seen significant reductions in greenhouse gas emissions and improved air quality.

In July 2023, the government approved a roadmap for creating the necessary infrastructure for electric vehicles in all major cities of the republic by 2029. From open sources it becomes clear that the document provides for regulatory and technical requirements in terms of the design and arrangement of the necessary infrastructure, the production of domestic equipment for charging electric vehicles, as well as determining the need for charging stations for electric vehicles and their installation locations. However, there is no access to the government roadmap , the document to create the necessary regulatory and physical infrastructure for EVs.

In May 2024, Kazakhstan adopted the law “On amendments and additions to certain legislative acts of the Republic of Kazakhstan on the issues of popularizing environmentally friendly transport and developing infrastructure for electric vehicles.”

The purpose of the Law is to popularize environmentally friendly transport and develop electric vehicle infrastructure:

- provision of land plots from public lands for the placement of electric charging stations;
- granting permission to place electric charging stations in parking lots for vehicles in specially protected natural areas, subject to access to electrical networks;
- introducing the competence of local executive bodies with the authority to make decisions on the placement of electric charging stations;
- inclusion of electric charging stations in mandatory requirements when designing roads, as well as ensuring the reservation of territory for their placement in residential and public-business areas along with social, cultural and public services for the population;
- inclusion of electric charging stations in the list of roadside service facilities;
- introducing amendments to reduce the age and length of service requirements for bus and trolleybus drivers, as well as to organize engineering infrastructure for electric charging stations at taxi stands;
- introducing the definition of an electric charging station as an electrical installation for charging motor vehicles with electric motors;
- introduction of requirements for the safe connection, operation and consumption of electrical energy by electric charging stations;
- introducing a ban on unauthorized connection to electrical networks in violation of the established procedure;
- introduction of the concept of an electric car as a vehicle driven by an electric motor and charged using an external source of electrical energy;
- exemption from parking fees;

The law is supplemented by Article 42-2, which regulates parking in places equipped with electric charging stations. In accordance with the new regulations, parking in such places will be allowed only for charging electric vehicles, and local executive bodies are required to organize and mark parking areas with road signs and road markings. Amendments are also being made regarding allowing parking of electric vehicles with a running engine in a residential area.

Another issue with infrastructure is its adaptation. It is important to note that the current state of roads does not meet the requirements for adaptation to climate change. Rising temperatures and long periods of heat negatively affect the condition of roads, causing softening of the asphalt surface.

A panel of experts calculated, based on 24 case studies in the United States, that for every degree Celsius increase in temperature, road life cycle costs increase by 0.08% and 0.1%, while road maintenance costs for highway agencies increase by 0.45% and 0.41% for international and national roads, respectively. Increases in road life cycle costs and agency costs due to rising temperatures have an almost constant positive relationship.

An analysis of adaptation measures carried out using the e3.kz macroeconomic model by experts from the Institute of Economic Research showed that increasing the resilience of roads to climate change (drainage structures or a new pavement structure) increases costs by 7-9% of conventional investments in roads, which amounts to 64 to 82.5 billion tenge per year. Investment in climate-resilient roads is expected to reduce damage by 50%. Then the overall economic effect of adaptation will lead to GDP growth by 0.46%, or 389 billion tenge per year, respectively. Thanks to improved roads, travel times and therefore transport costs are reduced by 1%.

Thus, the current state of road infrastructure does not create the required conditions for increased use of public transport, electric vehicles, cycling and walking.

To stimulate the development of electric vehicle (EV) infrastructure, "Operator EZS" (Electric Charging Station Operator) was established as the first charging infrastructure operator in Kazakhstan. The company was created under "Operator ROP" (Operator of Extended Producer Responsibility), in accordance with the Environmental Code of Kazakhstan (Article 285-2 in the old version and Article 388 in the new version of the Code). The Code stipulates that the development of the EV charging network is to be funded through targeted resources during the market preparation phase, with Operator EZS authorized to oversee this process. Over the past few years, Operator EZS has installed 109 charging stations in the cities of Almaty, Astana, and Shchuchinsk, including 9 fast chargers and 100 slow chargers.

Subsequently, JSC "Institute for the Development of Electric Power and Energy Saving" (IDEEE), under the jurisdiction of the Ministry of Industry and Construction, was appointed as the key agency responsible for developing EV infrastructure and related policies and regulations in Kazakhstan. As a result, the charging stations owned by Operator EZS in Astana and Almaty were transferred to IDEEE.

Given the early stage of EV development in Kazakhstan, the optimal path forward remains unclear. Therefore, it is particularly important to first develop a structured plan for the deployment of charging infrastructure, which should be continuously aligned with the growth of EV adoption at each stage of development.

Since the greatest potential for EV adoption is concentrated in the cities of Astana, Almaty, and Shymkent, it makes sense to begin by deploying charging infrastructure in these urban centers and then expanding the network to surrounding areas. At the next stage, it will be necessary to equip highways with fast-charging stations and establish infrastructure for charging electric trucks along major freight routes, such as the Europe-Western China corridor and the Astana-Almaty route.

When deploying charging infrastructure, it is also essential to consider the integration of charging stations into the power grid. Kazakhstan's electricity grid is unstable and weak, particularly in remote areas, and may not be able to meet the additional demand generated by charging stations.

Based on these considerations, it is crucial to develop a phased and well-structured policy for EV infrastructure development, which could include:

- Developing a phased plan to align the growth of EV adoption with the deployment of charging infrastructure, ensuring that charging infrastructure is installed several years ahead of projected EV adoption rates;
- Conducting further demand analysis for charging infrastructure and identifying clear priorities for the installation of charging stations in optimal locations;
- Testing the integration of charging points into the grid through pilot projects, which could also promote broader EV adoption across the country;
- Monitoring the use of pilot charging infrastructure and comparing progress with developments in neighboring countries, such as Uzbekistan, which share similar energy grid characteristics and purchasing power but have already initiated EV pilot projects and adopted EV policies.

The first regulatory measures regarding requirements for shopping malls and residential complexes to install charging infrastructure were introduced in the Law on Architectural, Urban Planning, and Construction Activities. This law defined the concept of a charging station and established requirements for the mandatory installation of such stations during the construction of shopping malls and residential

complexes, as well as the division of responsibilities between local and central government authorities. However, there are still many uncertainties and a lack of technical expertise regarding the integration of charging stations into the grid.

Due to limitations related to grid development, it remains unclear whether the additional demand caused by charging stations could lead to further disruptions and breakdowns, even in urban areas. Additionally, the northern part of the country's power grid is synchronized with the Russian system but offers limited balancing capabilities. Furthermore, Kazakhstan's power grid struggles to handle the variable energy output from renewable energy sources. The widespread use of battery storage could be a solution, but there is currently no comprehensive framework for integrating EV infrastructure into the energy system.

Moreover, the roles and responsibilities of stakeholders in the charging infrastructure market remain unclear, and the existing regulatory framework is complex and ambiguous. The electricity sector needs to be prepared and incentivized to deploy charging infrastructure. Kazakhstan's Electric Grid Operating Company (KEGOC) and regional energy companies (RECs) must define the obligations to be included in the technical specifications provided to potential charging point operators. Additionally, RECs should be allowed to act as charging point operators to benefit from business models related to charging infrastructure.

The regulatory framework should also include a standardized process for connecting charging stations to the power grid, as well as legal obligations for each party involved (distribution network operators, charging point operators, KEGOC, and local executive bodies). This requires further cross-sectoral discussions and the alignment of all industry strategies with the integration of charging infrastructure.

Finally, the regulatory framework for charging infrastructure must define market conditions for charging point operators. Some companies, such as KazParkingSystems, have already begun implementing charging infrastructure in their parking facilities at hotels and shopping malls. However, for many stakeholders, such as housing associations or shopping mall owners, selling electricity is currently not permitted, and there are no clear standards for developers regarding the installation of charging infrastructure.

In conclusion, while Kazakhstan is taking initial steps toward developing EV infrastructure, significant challenges remain. A coordinated and phased approach, supported by clear regulations, stakeholder collaboration, and strategic investments, will be essential to ensure the successful integration of electric vehicles into the country's transportation and energy systems.

5. Comparative Analysis of International Best Practices for Decarbonization of the Transport Sector

Globally, electric vehicle (EV) sales in 2023 approached 14 million units, up 3.5 million from 2022 and up 35% year over year. This is more than six times more than in 2018, just 5 years ago.

60% of new EV registrations were in China, about 25% in Europe and 10% in the United States, corresponding to almost 95% of global EV sales combined.

Electric vehicles made up about 18% of all cars sold in 2023, up from 14% in 2022 and just 2% 5 years earlier in 2018.

These trends indicate that growth remains robust as EV markets mature. Battery electric vehicles made up 70% of the electric vehicle fleet in 2023 [20].

The automotive industry, aligning with global sustainability goals, has been actively working to reduce its environmental footprint by adopting greener technologies and practices. One of the most significant shifts has been the transition from internal combustion engine (ICE) vehicles, which rely on fossil fuels and emit greenhouse gases, to more sustainable alternatives. For instance, hybrid vehicles, which combine ICEs with electric motors, have gained popularity as a transitional solution, offering improved fuel efficiency and reduced emissions. However, the industry's ultimate focus has increasingly shifted toward fully electric vehicles (EVs), which produce zero tailpipe emissions and are seen as a key solution to combating climate change. Major automakers like Tesla, Volkswagen, and General Motors have committed to electrification, with many pledging to phase out ICE vehicles entirely by 2035 or earlier. Additionally, advancements in battery technology, such as solid-state batteries, promise to further enhance EV range, charging speed, and sustainability by reducing reliance on rare materials like cobalt. Governments worldwide are also incentivizing this shift through subsidies, tax breaks, and investments in charging infrastructure. For example, the European Union's "Fit for 55" package aims to reduce CO2 emissions by 55% by 2030, with a strong emphasis on EV adoption. While challenges such as battery recycling, energy grid capacity, and the environmental impact of battery production remain, the automotive industry's pivot to EVs represents a critical step toward a more sustainable future. As renewable energy sources like solar and wind power become more prevalent, the overall carbon footprint of EVs is expected to decrease even further, solidifying their role as a cornerstone of environmentally friendly transportation.

Yet, production of EV s are not the most efficient environmentally according to a study by the Argonne Laboratory in Chicago[21], the production of a conventional mid-range gasoline car emits more than 5.5 kg of CO2 , while the production of a similar electric car produces more than 8.1 kg of CO2 .

This is mainly due to the use of more critical metals (particularly for battery assembly). Thus, the production of electric cars consumes 6.2 times more critical metals than conventional cars (206.1 kg/vehicle and 33.5 kg/vehicle, respectively).

Compensation of emissions from electric cars is achieved during their operation. For example, when comparing Tesla Model 3 and petrol Toyota Corolla in the USA, the leveling of electric car emissions is achieved at 21,725 km, since a quarter of the US electricity is generated by burning coal, in Norway - after 13 440 km (due to renewable energy sources), in China and Poland – after 125 920 (due to predominantly coal generation).

For the analysis of support measures for the transition to environmentally friendly transport, examples were selected from the European Union, the United States, China.. These regions demonstrate different approaches to promoting the use of "green" transport, allowing for the identification of effective mechanisms and successful initiatives. The EU and the US have well-developed markets and strict environmental regulations, China is a global leader in the number of electric vehicles and charging infrastructure, while Uzbekistan represents an example of a developing economy that is also implementing support measures for environmentally friendly transport. This

[20] https :// www . iea . org / reports / global - ev - outlook -2024/ trends - in - electric - cars
[21] https://publications.anl.gov/anlpubs/2023/11/179337.pdf

selection makes it possible to trace which mechanisms work under different economic and political conditions.

Financial incentives

Some countries are actively encouraging the transition to environmentally friendly modes of transport by providing subsidies and tax incentives.

Germany provides individual subsidies of up to €9,000 for the purchase of an electric vehicle, France offers €5,000 and Italy provides €3,000 for the purchase of electric vehicles. In addition, citizens are exempt from import tax and transport tax, and compensation is also provided for the installation of home and public charging installations.

In the US, the Inflation Relief Act offers individual subsidies for electric vehicles of up to $7,500.

China has been driving the transition to electric vehicles for 13 years. As of January 1, 2023, China suspended subsidies for new energy vehicles. Starting January 1, 2024, electric cars purchased in 2024 and 2025 will be exempt from purchase tax up to RMB 30,000 ($4,170).

In Uzbekistan, citizens can count on compensation when purchasing a domestically produced electric car. Also, on January 1, 2019, Uzbekistan applied a zero customs rate on the import of electric vehicles. Additionally citizens are released from payment of excise tax (Table 2).

Table 2. Incentive measures for the transition to environmentally friendly modes of transport

Countries	Tax privileges	Subsidies
European Union	import tax exemption exemption from transport tax	up to 9,000 euros for the purchase of a new electric car up to 5,000 euros for the purchase of a used electric car on installation chargers stations
United States of America		up to $7,500 towards the purchase of a new electric vehicle up to $4,000 towards the purchase of a used electric vehicle on installation chargers stations
China	exemption of electric vehicles from VAT up to 30,000 yuan (approximately 4170 US dollars)	up to 12,600 yuan (approximately 1,745 US dollars) for the purchase of a new electric vehicle (until 12/31/2022)
Uzbekistan	import tax exemption excise tax exemption	30 million soums (approximately 2,300 US dollars) for the purchase of an electric car manufactured in Uzbekistan

Infrastructure development

The transition to “green” transport requires the creation of the necessary conditions and infrastructure for development. Important components of the infrastructure are electric charging stations and hydrogen filling stations. Countries actively support the development of infrastructure and direct investments to the construction of this infrastructure so that drivers can easily move both within the city and between cities without fear of recharging.

European Union within the framework of the “Fit” program for 55 adopted Regulation 2023/180/ EU on the deployment of alternative fuel infrastructure, which came into force on April 13, 2024. The regulation aims to support the use of alternative fuels and sets requirements for the creation of EZS, VZS and other types of fuel[22]. A key EU funding instrument in the implementation of the European strategy Green Deal is the Connecting program Europe Facility. The program allocates €1 billion to finance the roll-out of alternative fuels infrastructure across the EU.

The program establishes clear, binding targets for the deployment of charging stations across member states, ensuring that infrastructure keeps pace with the rapid growth of electric vehicles. The regulation mandates that fast-charging stations be installed at regular intervals along major highways and urban areas, addressing range anxiety and accessibility concerns. Additionally, it integrates public and private sector investments, encouraging market-driven expansion while securing government support. By aligning infrastructure development with the EU's broader climate and transport decarbonization goals, the regulation creates a stable and predictable policy framework that fosters investor confidence and accelerates EV adoption across Europe.

China is a leader in green vehicle infrastructure development. In 2020, more than 800,000 public charging stations were installed across the country. By 2023, China already had about 1.8 million public charging stations throughout the country. According to China's 14th Five-Year Economic and Social Development Plan, it is planned to create a modern charging infrastructure system by 2025 to meet the demand for more than 20 million electric vehicles. In terms of hydrogen transport infrastructure, the number of hydrogen refueling stations in China reached 351 in the first half of 2023, accounting for 32% of the global share. The plan also provides for the construction of 400 hydrogen filling stations. by 2035[23].

Bipartisan for infrastructure development in 2021 Infrastructure Law, which includes an investment of up to $7.5 billion in electric vehicle charging to help create a national network of 500,000 electric vehicle chargers across the United States by 2030[24].

The Charging and Fuelling Infrastructure Discretionary Grant Program in the U.S. can be considered as successful because it takes a strategic, nationwide approach to infrastructure deployment, ensuring equitable access to charging and refuelling stations for all vehicle types, including electric, hydrogen, and gas-powered vehicles. By allocating $2.5 billion over five years, the program provides sustained funding that supports both urban and rural areas, bridging infrastructure gaps and promoting widespread adoption of clean transportation. A key factor in its success is the clear and measurable targets set by the government, such as the construction of 200 hydrogen stations by 2025 and 1,000 by 2030, which provide certainty to investors and industry stakeholders. Additionally, the program leverages public-private partnerships, encouraging private sector investment while maintaining federal oversight to ensure efficiency and alignment with broader sustainability goals. This comprehensive and

[22] https :// eur - lex . europa . eu / legal - content / EN / TXT /? uri = CELEX %3 A 32023 R 1804
[23] China's 14th Five-Year Economic and Social Development Plan
[24] https://www.whitehouse.gov/wp-content/uploads/2022/05/BUILDING-A-BETTER-AMERICA-V2.pdf#page=138

coordinated approach has accelerated the development of a robust alternative fuel infrastructure, fostered consumer confidence and driving the transition toward cleaner transportation solutions.

Closest neighbor to Kazakhstan Uzbekistan has seen an increase in charging stations for electric vehicles. In 2022, the Resolution “On measures to expand the infrastructure for the operation of electric vehicles” was adopted within the framework of which it is planned to increase the number of charging stations for electric vehicles to 2,500 units. In 2023, there were approximately 450 electric charging stations in Uzbekistan 1.5 times more than in Kazakhstan[25].

R&D support programs

Many countries are implementing programs to support research activities in the field of green transport development. These initiatives aim to stimulate innovation, reduce GHG emissions and promote sustainable development in the transport industry.:

The National Key R&D Program of China has been successful due to its strategic focus on addressing major technological challenges and fostering innovation in critical industries, including electric vehicles, battery technologies, and alternative fuels. With a substantial investment of 20 billion yuan ($2.4 billion), the program ensures long-term financial support for cutting-edge research, enabling breakthroughs in battery efficiency, energy density, and cost reduction – key factors driving the mass adoption of electric vehicles. A major strength of the program is its alignment with China's broader industrial and environmental policies, such as its commitment to carbon neutrality by 2060 and its dominance in the global EV supply chain. By integrating government funding, private sector participation, and collaboration between top research institutions, the program accelerates the commercialization of new technologies, strengthening China’s leadership in the global clean energy and transportation sectors. This comprehensive and well-coordinated approach has positioned China as a key player in the future of sustainable mobility.

Regulation and Standards

The first automobile emissions standards were enacted in 1963 in the United States, mainly as a response to Los Angeles' smog problems. Three years later Japan enacted their first emissions rules, followed between 1970 and 1972 by Canada, Australia, and several European nations.. In 2015, the EU adopted the EURO-6 environmental standard, which sets strict requirements for the content of harmful substances in the exhaust. In 2023, the EU adopted Regulation 2023/851, tightening CO_2 emission standards for new passenger cars in response to climate challenges.

The European Parliament has approved a ban on the production of new cars with internal combustion engines from 2035. According to this decision, only zero-emission vehicles should be produced in the EU from 2035. This measure is part of the program "Fit for 55", aimed at reducing emissions by 55% by 2030.

China 6 standard in 2016, which tightens the requirements for vehicle emissions. China also plans to ban the sale of new cars with internal combustion engines by 2035. From now on, all new cars sold in China must be green energy vehicles (electric, hybrid, etc.).

[25] https://www.lex.uz/uz/docs/6316595

The United States is also taking measures to regulate emissions from motor vehicles and, starting in 2024, the Environmental Protection Agency (Environmental Protection Agency) have introduced national GHG emission standards for heavy-duty vehicles, which set stringent requirements for vehicle emissions.

In addition, the United States plans to introduce a ban on the production of new cars with internal combustion engines from 2035. A number of states such as California, Colorado, Massachusetts, New Jersey, New York, District of Columbia, etc. are planning to adopt an official ban.

A number of countries are taking action and setting strict requirements for pollutants in vehicle emissions. These measures encourage automakers to introduce newer and cleaner technologies and also help reduce pollutants, improving air quality, thereby reducing the number of diseases associated with air pollution.

Exchange and recycling program

In addition to the above measures, countries are introducing exchange and recycling programs for vehicles with internal combustion engines, supporting citizens to upgrade high-emitting vehicles to more environmentally friendly models.

For example, the "Umweltprämie" program in Germany was successful because it provided a strong financial incentive for individuals to transition from older, high-emission vehicles to cleaner alternatives, including electric vehicles. By offering subsidies of up to €4,500, the program made the purchase of electric cars significantly more affordable for consumers, reducing the cost barrier that often hinders adoption. Additionally, by requiring participants to scrap their old vehicles, the initiative actively removed high-emission cars from the roads, directly contributing to the reduction of air pollution and greenhouse gas emissions. This dual approach – encouraging new EV purchases while phasing out polluting vehicles – helped accelerate Germany’s transition to sustainable mobility.

Another key factor behind the program’s success was its alignment with Germany’s broader environmental and industrial policies. As part of the country's commitment to the European Green Deal and its goal of carbon neutrality by 2045, "Umweltprämie" played a crucial role in driving consumer behavior toward low-emission vehicles. The program also benefited the domestic automotive industry by stimulating demand for electric and hybrid models, encouraging manufacturers to expand production and innovate in battery technology. This synergy between policy incentives and industrial strategy ensured that the program had a lasting impact beyond just short-term EV sales.

Furthermore, the structure and accessibility of the program contributed to its effectiveness. The straightforward application process and the clear financial benefit made it widely popular among German drivers. The program’s duration – spanning seven years until December 2023 – allowed for a sustained and gradual increase in EV adoption, rather than a temporary spike followed by stagnation. Its success also served as a model for other European countries, such as France’s “Prime à la Conversion”, which similarly incentivizes the retirement of old vehicles with a subsidy of up to €2,500. By making clean transportation more accessible and attractive to consumers, these programs have played a significant role in the broader shift toward greener mobility in Europe.

International experience shows that countries have taken and are taking various incentive measures to ensure the transition from vehicles with internal combustion engines to more environmentally friendly modes of transport. Taking such measures

helps countries increase production and demand for green transport, which allows them to renew their outdated vehicle fleet.

6. Forecasting decarbonization of the transport sector

The development of the transport sector must align with the Avoid-Shift-Improve concept, a framework for sustainable transport planning. In the context of decarbonization, measures in the transport sector will focus on three main areas. First, reducing or eliminating the need for travel through better urban planning, digitalization, and remote work solutions. Second, transitioning to more environmentally friendly modes of transport, such as public transit, cycling, and walking. Third, enhancing energy efficiency and reducing emissions from vehicles through technological advancements and the adoption of low-carbon fuels.

Energy Consumption by Transport Mode and Fuel Type

The following table provides a detailed breakdown of energy consumption by transport mode and fuel type, both current and projected under a carbon neutrality scenario *(modelled by author for Carbon neutrality strategy Roadmap)*. The data is presented in thousand tons of oil equivalent (ktoe).

Table 3. Energy consumption by transport mode and fuel type, in thousand tons of oil equivalent

Fuel Type	2022 (Fact)	2030	2040	2050	2060
Oil Products	8,238.1	9,056.3	8,667.4	4,260.0	0.0
Natural Gas	49.3	545.0	801.0	850.0	0.0
Electricity	301.1	277.0	945.0	1,488.0	3,043.0
Biofuels	0.0	0.0	132.0	532.0	1,269.0
Hydrogen	0.0	0.0	33.0	127.0	883.0
Total	8,589	9,878	10,578	7,257	5,195

Under the decarbonization scenario, energy and carbon intensity in the transport sector are expected to decline, leading to a reduction in final energy demand and GHG emissions. By 2060, final energy demand in the transport sector is projected to decrease by 40% compared to current levels. This reduction will be achieved primarily through reduced demand for fossil fuels, optimization of passenger and freight flows, and a shift to alternative fuels.

The decline in oil product consumption will be driven by the electrification of passenger vehicles and the modernization of the vehicle fleet. It is expected that 2-5% of the vehicle fleet will be renewed annually, with a focus on electric and hybrid vehicles. Improved logistics and transport planning will reduce unnecessary travel and increase the efficiency of freight transport. The use of oil products, liquefied petroleum gas (LPG), and

natural gas will be phased out entirely by 2060, replaced by electricity, biofuels, and hydrogen.

By 2060, electricity is expected to account for 58.6% of total energy demand in the transport sector. This will be driven by the widespread adoption of electric vehicles (EVs) in both passenger and freight transport. The government's focus on developing EV infrastructure, such as charging stations, will play a critical role in supporting this transition. Biofuels are projected to cover 24.4% of total energy demand by 2060, particularly in sectors that are difficult to electrify, such as aviation and maritime transport. Hydrogen, accounting for 17.0%, will also play a significant role, especially in heavy-duty freight transport and long-distance travel.

To reduce private car usage, Kazakhstan will need to invest in efficient and affordable public transport systems, including electric buses and trains. Shared mobility solutions, such as car-sharing and ride-hailing services, will also contribute to reducing the number of vehicles on the road. The transport sector's decarbonization will be closely linked to the development of renewable energy sources, such as wind and solar power. This will ensure that the electricity used for EVs and other low-carbon transport solutions is generated sustainably.

Achieving carbon neutrality will require significant changes in consumer behavior, including a shift away from private car use and high-carbon transport modes like aviation. Investments in pedestrian-friendly infrastructure, cycling lanes, and smart urban planning will be essential to support this transition.

Challenges and Opportunities

While the transition to low-carbon transport presents significant opportunities, it also comes with challenges. Kazakhstan's electricity grid is currently unstable, particularly in remote areas. The integration of EV charging stations and other low-carbon infrastructure will require substantial upgrades to the grid, including the deployment of energy storage systems to balance supply and demand. A comprehensive regulatory framework is needed to define the obligations of distribution network operators, charging point operators, and other key players.

The adoption of advanced technologies, such as solid-state batteries and hydrogen fuel cells, will be critical to achieving the goals of the decarbonization scenario. Kazakhstan will need to invest in research and development (R&D) to support these innovations. International collaboration will also be essential, as Kazakhstan can benefit from international best practices and partnerships, particularly with neighboring countries like Uzbekistan, which have already initiated pilot projects and adopted policies to promote EV adoption.

The transition to low-carbon transport is not just an environmental imperative but also an economic opportunity. By investing in EV infrastructure, Kazakhstan can stimulate job creation in the manufacturing, installation, and maintenance of charging stations, as well as in the production of electric vehicles and components. Furthermore, reducing dependence on imported fossil fuels will enhance energy security and reduce vulnerability to global oil price fluctuations.

The shift to electric and hydrogen-powered transport will also align Kazakhstan with global trends, making the country more attractive to international investors and partners. For instance, multinational corporations increasingly prioritize sustainability in their supply chains, and a robust low-carbon transport system could position Kazakhstan as a regional logistics hub.

Moreover, the health benefits of reduced air pollution cannot be overstated. Lower emissions from transport will lead to fewer respiratory and cardiovascular diseases, reducing healthcare costs and improving overall quality of life. This aligns with the global Sustainable Development Goals (SDGs), particularly SDG 3 (Good Health and Well-being) and SDG 11 (Sustainable Cities and Communities).

In conclusion, the decarbonization of Kazakhstan's transport sector is a multifaceted challenge that requires a holistic approach. By addressing infrastructure gaps, fostering innovation, and promoting behavioral change, Kazakhstan can achieve a sustainable and resilient transport system that benefits both the environment and the economy.

7. Policy Recommendations

The development of a single document containing clear goals, support measures and time frames for their implementation will be an important step towards sustainable and environmentally friendly transport. This document must contain calculations of the required amount of energy/hydrogen/biofuel.

It is necessary to create a single coordinating body or designate an existing body to be responsible for the decarbonization of the transport sector. Such a body should have the authority to coordinate the actions of various ministries and departments, set priorities, allocate resources and monitor the implementation of emission reduction measures. This will allow us to effectively and purposefully move towards achieving carbon neutrality in the transport sector of Kazakhstan.

Regarding motor transport**,** it is important to recognize that a large-scale transition to "green" vehicles is unlikely to occur until their cost becomes comparable to that of traditional internal combustion engine (ICE) vehicles. This necessitates significant changes in government support measures aimed at reducing the price of environmentally friendly transport and creating incentives for its adoption. However, relying solely on cost as a measure for decision-making in this transition may be problematic, as it does not fully capture the broader societal and environmental impacts of fossil fuel-based vehicles.

An alternative approach could involve ensuring a green transition despite the higher upfront costs by implementing policies that reflect the true societal costs of using ICE vehicles. For example, governments could introduce carbon pricing, higher fuel taxes, or congestion charges to make fossil fuel-based transport less economically attractive. These measures would not only incentivize the adoption of green vehicles but also generate revenue that could be reinvested in sustainable transport infrastructure, such as charging stations and public transit systems.

Additionally, the total cost of ownership (TCO) of green vehicles, which includes lower operating and maintenance costs compared to ICE vehicles, should be emphasized in public awareness campaigns. By shifting the focus from upfront costs to long-term savings, consumers may be more willing to invest in environmentally friendly options. Furthermore, innovative financing mechanisms, such as green loans or leasing programs with lower interest rates for electric vehicles, could make green transport more accessible to a wider population.

Regarding aviation transport, opportunities for the production and use of sustainable aviation fuel (SAF) need to be explored.

Regarding railway transport, when developing and implementing state support mechanisms for updating rolling stock, the priority should be the acquisition of vehicles with a high environmental class, primarily on electric traction, as well as on alternative

fuels. The use of more energy efficient vehicles and hybrid energy generation and storage technologies. Further electrification of railways and optimization of freight transport should be strengthened.

Infrastructure development should be an important area.

In particular, it is recommended to define the development of a detailed plan for a charging network along highways, and a detailed charging plan for residential areas.

To decarbonize the sector, urban planning and transport infrastructure systems must be improved. Sustainable urban mobility and public transport systems will be actively developed by optimizing passenger transportation, large-scale electrification and gasification.

It is important to note the need to build strategies to adapt transport infrastructure to climate change*.* It is necessary to use forecasts and calculations in trends in the influence of climate on the state of transport infrastructure, to develop documents that will reflect measures to adapt the transport system to climate change, it is necessary to revise the standards for construction and repair of roads taking into account the impact of climate change. New infrastructure must be both energy efficient and climate resilient to avoid/reduce vulnerability to the impacts of climate change.

The development of domestic transport production using alternative and renewable energy sources will play a significant role in the decarbonization of transport.

To effectively reduce greenhouse gas emissions, a paradigm shift in mobility demand is required. This includes reducing private car use in favor of public transport and other environmentally friendly travel options.

It is also important to strengthen efforts to raise public awareness of the benefits of clean transport and support research and development in this area.

Developing programs to raise public awareness of the benefits of clean transport and supporting educational initiatives are important elements of the decarbonization strategy. Information campaigns, educational programs and media participation will help raise public awareness and encourage the use of environmentally friendly transport.

References

Technical analysis of measures to improve consumer awareness of emissions and fuel consumption of vehicles, European commission, May 2021 https://climate.ec.europa.eu/document/download/06ed3d87-64d8-43c2-9e4b-39514dfa42e8_en?filename=2019_0008_report_en.pdf

https :// www . gov . kz / memleket / entities / aviation / documents / details /618713? lang = ru

https://www.eesi.org/papers/view/fact-sheet-the-growth-in-greenhouse-gas-emissions-from-commercial-aviation

Green hydrogen strategy: A guide to design, IRENA 2024. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2024/Jul/IRENA_Green_hydrogen_strategy_design_2024.pdf

DNV GL. Energy Transition Outlook 2023: Transport in Transition. https://www.dnv.com/Publications/transport-in-transition-242808

IEA Global EV Outlook 2023. https://www.iea.org/reports/global-ev-outlook-2023

BEV or FCEV? The complementary roles of Battery and Fuel Cell Electric Trucks / Quatron AG, 2022. https://www.quantron.net/wp-content/uploads/2023/01/Quantron-AG_Whitepaper-BEV-or-FCEV.pdf

IEA Global EV Outlook 2023. https://www.iea.org/reports/global-ev-outlook-2023

Deloitte China & Ballard. Fueling the Future of Mobility. Hydrogen and fuel cell solutions for transportation. March 2020.

Wang et at, Range Anxiety among Battery Electric Vehicle Users: Both Distance and Waiting Time Matter, Sage Journals, Volume 67, Issue 1, September 2023, Pages 1309-1315

https://pditechnologies.com/blog/norways-ev-growing-pains-convenience-industry/

https :// www . iea . org / reports / global - ev - outlook -2024/ trends - in - electric - cars

https://publications.anl.gov/anlpubs/2023/11/179337.pdf

https :// eur - lex . europa . eu / legal - content / EN / TXT /? uri = CELEX %3 A 32023 R 1804

https://www.whitehouse.gov/wp-content/uploads/2022/05/BUILDING-A-BETTER-AMERICA-V2.pdf#page=138