HISTORY OF THE DEVELOPMENT OF ELECTRIC CARS AND DEVELOPMENT PROSPECTS IN UZBEKISTAN

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Annotation. An electric car is a type of vehicle that uses electricity as an energy source and is driven by a traction electric motor.

The energy that drives the vehicle can be obtained from several sources, including: from the chemical energy of on-board batteries and accumulators (electric car, electric bus, etc.);

An electric vehicle is a vehicle driven by one or more electric motors that work with an independent source of electrical energy (batteries, fuel cells, capacitors, etc.) rather than an internal combustion engine.

Keywords. electric car, battery, batteries, BYD automobile company, hybrid car.

Currently, in developed countries, a targeted policy for the popularization of electric transport, in particular, electric cars, is being carried out. This is because internal combustion engine vehicles (hereinafter referred to as ICE) run on liquid fuel and their supply is already limited. Against the background of these problems, alternative sources of fuel, first of all, the possibilities of electric transport with an electric car are revealed. Its disadvantages are also known. However, the competition and demand in the field of electric transport are increasingly creating new technologies, which further stimulate the development of electric vehicles and allow a systematic approach that satisfies the manufacturer, the user, and also meets environmental protection standards.

In the late nineteenth and early twentieth centuries, interest in electric vehicles was high, and at times their production and sales exceeded that of the automobile industry. Electric cars have attracted attention due to their noiselessness, ease of operation and absence of exhaust gases.

A small power reserve, the need for frequent battery charging or the need to completely replace heavy batteries did not bother buyers at that time. These were mostly representatives of the aristocracy, and in their eyes, the electric car was a clean and convenient toy - in contrast to the smell of gasoline and oil, smoking and noisy gasoline cars. By the end of the nineteenth century, the number of electric vehicles exceeded the number of cars with internal combustion engines several times. At the time, their speed and range were insignificant compared to the convenience and simple maintenance and upkeep, as well as the lack of noise and ride comfort and the speed of starting an electric motor. There are dozens of companies producing electric cars in many European and American countries. Famous inventors such as the Russian engineer Ippolit Romanov, as well as large companies were involved in electric machines: the French "Django", the English "Bersey", the Austrian "Lorner" and others. Electric cars were the most popular in America.

The first electric cars were assembled in the 1830s and 1840s. The British Robert Anderson, Robert Davidson and the American Thomas Davenport are the discoverers in this matter. It is known that Englishman Davidson assembled the first electric car in 1838 only six years after Faraday discovered electromagnetic induction. The first examples were awkward structures whose speed was less than walking speed.

Inventor Walter Baker (1868-1955) is considered the founder of the electric car business in America and a pioneer of American motorization in general. Baker's first invention was not much different in appearance from the Henry Ford, Oldea or Packard cars of those years. It was a light and tall 2-seater cart mounted on 4 bicycle wheels. Due to the presence of batteries, the electric car was very heavy, and Baker equipped it with a soft suspension on elliptical springs. Electric headlights and an electric horn were new in those years. The battery allowed to use the electric vehicle for 6-8 hours without recharging.

The speed of electric vehicles has increased rapidly. The first significant speed record among self-propelled crews was set in 1898 by an electric motor car. Count Gaston de Chaslus-Lobas, driven by Jeantaud Duc, then reached a speed of 63.15 km/h. In 1899, he already passed the milestone of one hundred kilometers. The record was set by the Belgian Camille Genatsy in Asher, France (near Paris) in the electric car "La Jamais Contente". The electric car had a simplified body made of aluminum and tungsten alloy, and had two engines with a total power of 67 horsepower. In 1901, this electric car was modernized. It began to look more solid - it was equipped with a canopy, a steering wheel and a two-seater seat with a backrest and armrests. The batteries were located under the seat, and a 0.75 hp electric motor drove the rear axle using a chain drive. The car developed a speed of only 30 km/h and could cover a distance of 80 km on a single charge. The increase in driving speed was achieved with the help of electric sports cars - races that attracted many spectators (Figure 1).

Figure 1. 1901 electric car

In 1900, Ferdinand Porsche's front-wheel drive electric car was presented at the Paris Motor Show. Later, the inventor added two gasoline internal combustion engines in the middle of the electric car chassis, which served as a driving force for electric generators. The electricity produced by the dynamos went to the motors on the wheels, and the excess energy went to the batteries. In 1901, F. Porsche's hybrid car again achieved great success at the

Paris Motor Show. Famous in the history of the development of electric vehicles is the speed competition involving the two-seater Torpedo on a public street in New York. May 31, 1902. In 47 seconds, the car reached a speed of about 120 km per hour and soon reached about 170 km per hour, which was 55 km per hour higher than the current speed record. Suddenly, the electric car ran into an obstacle - the tramway. Advances in automotive technology, the growth of the oil infrastructure, mass production and the expansion of the range of gasoline cars, as well as a significant drop in the price of gasoline, led to the almost complete displacement of electric motors from the market by the 1930s.

In the 20th century, electric cars gave way to cars with internal combustion engines. The main reason was the batteries, which were not perfect. Thanks to them, the power reserve was not large, and car production expanded, they became more widespread. The dynamics of the driving and speed parameters of the electric vehicle increased.

The development of automotive technology, the growth of the oil infrastructure, the mass production and the expansion of the range of gasoline cars, as well as a significant decrease in the price of gasoline, led to the fact that by the 1930s electric motors were almost completely displaced from the market.

After World War II, almost all cars produced had internal combustion engines. Only some types of city public transport were electrified. The period of stagnation in the development of electric transport continued until 1960. During this period, electric cars gave way to cars with internal combustion engines. Thus, from 1830 to the present, the development of the design and dynamic capabilities of the electric car, taking into account the rise and fall of interest, has a history of almost 200 years. This is probably the longest development process and has recently gained interest.

Due to global warming and requirements to reduce environmental pollution from exhaust gases from automobile engines, as well as limited reserves of hydrocarbon fuels, interest in electric vehicles has increased dramatically.

The main advantages of electric vehicles are:

- environmental cleanliness;
- noiselessness;
- high level of reliability and durability with simplicity of design;
- the possibility of using ecologically clean and renewable energy sources;
- regenerative use of energy during braking.

Disadvantages of electric vehicles include:

- short distance compared to cars with internal combustion engine;
- the need to create infrastructure for powering electric vehicles and battery safety;
- long charging time;
- development of methods to reduce electromagnetic influence.

The need to develop electric vehicles is understood in all countries of the world. An analysis of the development of electric vehicles shows that the global sales of electric and plug-in hybrid vehicles in 2023 will increase by 31% compared to 2022. In 2024, according to forecasts, the global sales of electric cars will increase from 25 to 30 percent. Almost all major automakers have announced plans to develop new electric vehicle models and increase their share of overall sales. Toyota plans to sell 1 million electric cars by 2030. Volkswagen aims to increase the number of electric cars sold to 1 million by 2025. BMW will present 12 new electric car models by 2027. According to analysts' forecasts, by 2030 the global sales of

electric vehicles will exceed 30 million per year. This will be helped by: strengthening environmental regulations and standards in many countries; introduction of incentives and subsidies for electric car manufacturers and buyers; the growth of environmental consciousness among the population.

Table 1.2 shows the production schedule of electric cars in the forecast until 2030.

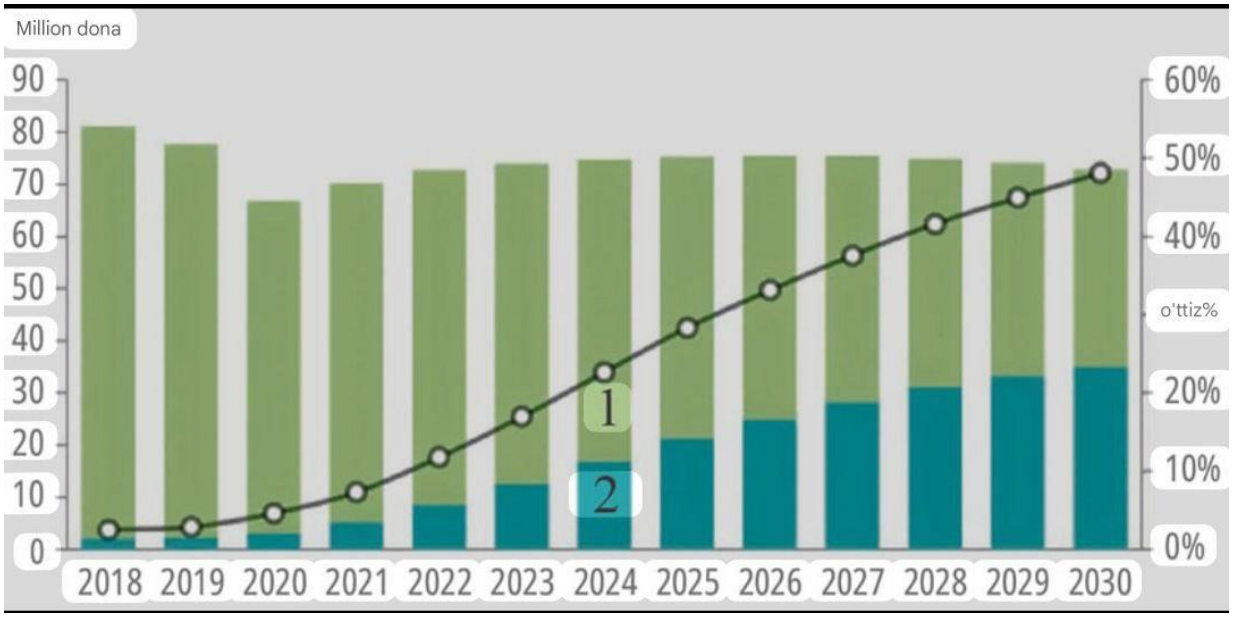


Figure 2. Forecast of production of electric cars until 2030

1 - hybrid car; 2 - electric cars. The graph above shows that the development of electric vehicles has a progressive growth trend, while the number of traditional hybrid vehicles is decreasing.

Table 1.1 shows the main characteristics of electric vehicles. According to the data, electric cars are not inferior to conventional cars in terms of dynamic qualities and are significantly superior to them in terms of energy efficiency. A range of 150-180 km is quite satisfactory for urban operating conditions when using fast charging stations.

ELECTRIC CARS	MACCA FULL, KG	Engine power, N, KBT (MK, HM)	100 KM/H	MAXIMUM SPEED, U, KM/H	BATTERIES, POWER	CHA...
Tesla Model X (production from 2016)	-	567	3.8	250	90	400
Jaguar Land Rover «I-Pace»	2100-	294	4.8	200	90 (Li-Ion)	480
Damaha Tau (presentation 2019)	-	660 (1050)	2.5	260	93.4 (Li-Ion)	412
Nissan Leaf E (production from 2010)	1525-1965 years	80 (280)	11.9	144	24 (Li-Ion), 250 kg	175
Volvo Polestar 2 (presentation 2020)	-	300	5	-	78 (Li-Ion)	500
Danauli ClanA (production since 2012)	1605-2025	70 (220) AS Synchronous	13	135	22 (Li-Ion), 398 V	185
Renault 7 (production since 2012)	1 390 -	80 (222) AS Synchronous	-	135	(Li-Ion), 400 V	160
Dali Daura 109EY (presentation 2012)	-	290 (800)	8	165	Li-NMC, 810 ng	200
Chauralat Rait (production from 2017)	-	147 (360)	7.0	160	60 (Li-Ion) Swad 435 kg	380
RMW 12 (production since 2013)	-	125 (250)	-	-	42 (Li-on 36085230 kg	-
Mazda MY.10 presentation 2020)	-	107 (265)	-	-	35.5	200
Audi e-tron presentation 2015)	-	265	6	200	65 (Li-Ion), DC/DC Inverter	400
Lada presentation 2012)	1250-1610	60 (279)	14	130	17.3 (Li-Ion), DC/DC Inverter	150

Table 1.1.
Comparative characteristics of electric vehicles

Many other countries support the production of electric vehicles. Programs for the development and use of electric transport have been developed, including in the Republic of Belarus.

Forecasts for the development of electric transport in the Republic of Uzbekistan

As in all developed countries of the world, in Uzbekistan, not only the use of electric cars produced in other countries is rapidly developing, but further expansion of the production of electric cars has begun and is planned.

According to the Center for Economic Research and Reforms, the sale of passenger electric cars in Uzbekistan has increased 19 times over the past two years, reaching 3,600.

In 2022, 2,180 electric cars with a total value of 69.8 million dollars were imported into Uzbekistan, and in April of the same year, a monthly record was set for the import of electric cars - 279 cars, of which almost 90 percent of all deliveries were made. or about 2 thousand. Electric cars have arrived in China. The second place was taken by the United Arab Emirates with 111 electric cars, and the third place by Germany with 58 cars. In 2023, the import of electric cars to Uzbekistan continued to grow. In the first seven months, 7,139 electric cars were imported to our country worth 217 million dollars (Table 1.2). In July, monthly imports of electric vehicles set a record for the sixth time this year, approaching almost 2,000 vehicles. In addition, China's share increased compared to the previous two years - 93.2%. Hong Kong took the second place with 376 electric cars, and Germany took the third place with 64 cars.

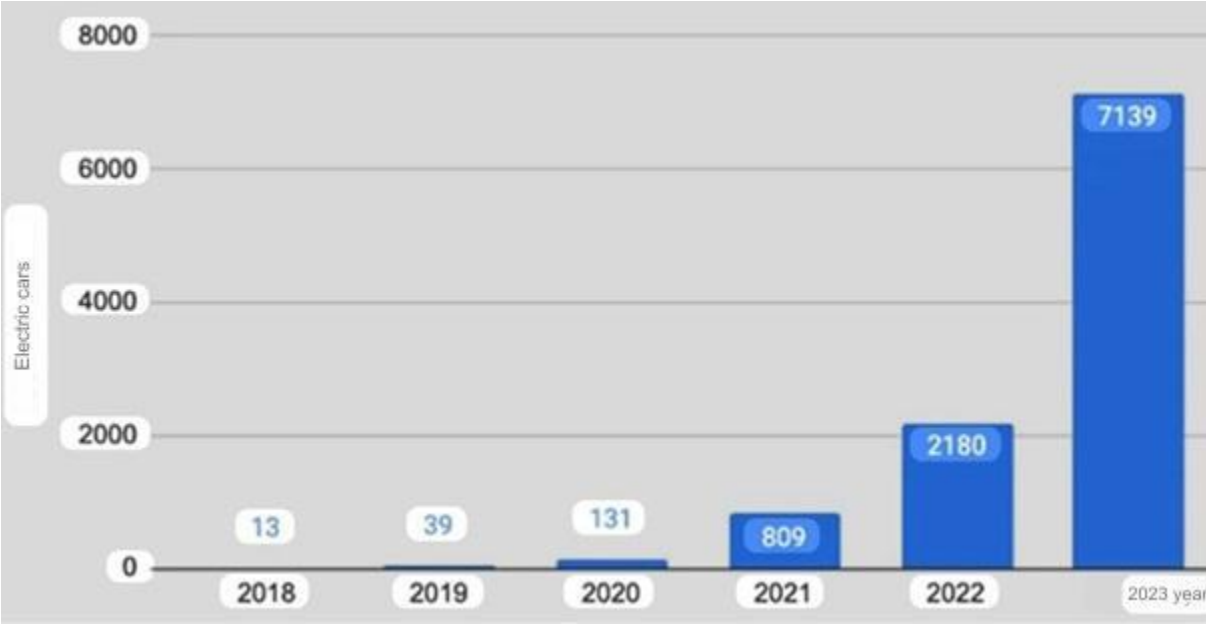


Table. 1.2 Import of electric cars to Uzbekistan

Electric cars imported into the country are exempted from customs duties, excise tax and motor vehicle taxes.

In March 2022, the Ministry of Economic Development and Poverty Alleviation developed a draft of the Presidential Decree "On Measures to Support the Organization of Electric Vehicle Production" and published it for discussion. According to the project, by 2030 it is planned to increase the share of electric cars in the total sales of cars by at least 15%. To achieve this, it is planned to create a full cycle of production of electric cars and components based on available natural resources (lithium, graphite and copper). Uzbekistan is moving to the production of electric cars in its own country. An enterprise producing four models of electric cars with the capacity to produce up to 10,000 units of electric cars per year has started working on the basis of a mechanical plant in Fergana. Spare parts for electric cars are also produced there.

Uzbekistan is starting cooperation with China's major electric car manufacturers as part of the production of electric cars. The production of electric cars is being launched by China's BYD automobile company in Jizzakh region. At the first stage, 50,000 electric cars will be produced, and it is planned to increase production to 300,000 in the future. It is planned to launch the production of electric buses in Andijan. As a result of the agreements reached with China, production can be launched. It is planned to produce about 2,000 electric buses per year. The Asian Development Bank (ADB) will allocate 170 million dollars to the electric transport development program in Uzbekistan. Funds will be allocated to the deployment of a fleet of electric buses and auxiliary infrastructure, improvement of the public transport system and development of electric cars.

In the development strategy of New Uzbekistan in 2022-2026, special attention is paid to hydrogen energy in our country. The government has approved a research and development program for the development of technologies for the production, storage and transportation of hydrogen in the field of hydrogen energy. Starting from November 2021, the State Traffic Safety Inspectorate began to issue green license plates for electric vehicles - in the future, they will give benefits to their owners.

In the early stages of electric vehicle development, electric vehicles did not have the proper infrastructure, which hindered their sales. In October 2020, the first electric car charging station in Tashkent was installed in the parking lot of the Makro Ekopark branch. By May 2021, Tashkent will have nine power stations, four of which were built by Makro, and the rest were installed by TokBor. By June, the number of electric gas stations increased to 20, and by the end of September it reached 33, located in Tashkent, Tashkent, Fergana, Namangan and Samarkand regions. By early 2022, there were 36 power plants across the country built by the private sector, mainly represented by Makro, TokBor and Megawatt Motors. At the end of December 2022, President Shavkat Mirziyoyev signed the decision "On the development of electric transport infrastructure in Uzbekistan". In particular, it is planned to increase the number of electric gas stations to 2500 by the end of 2024. In Uzbekistan, from January 1, 2023, business entities were given the right to sell electricity through gas stations, as well as to independently set the prices for charging electric vehicles, regardless of the current electricity tariffs regulated by the state. In addition, gas stations were exempted from property and land taxes, and their equipment was exempted from customs duties. In addition, revenues from charging electric vehicles are no longer subject to turnover tax, and businesses that specialize in this have the right to avoid paying income tax.

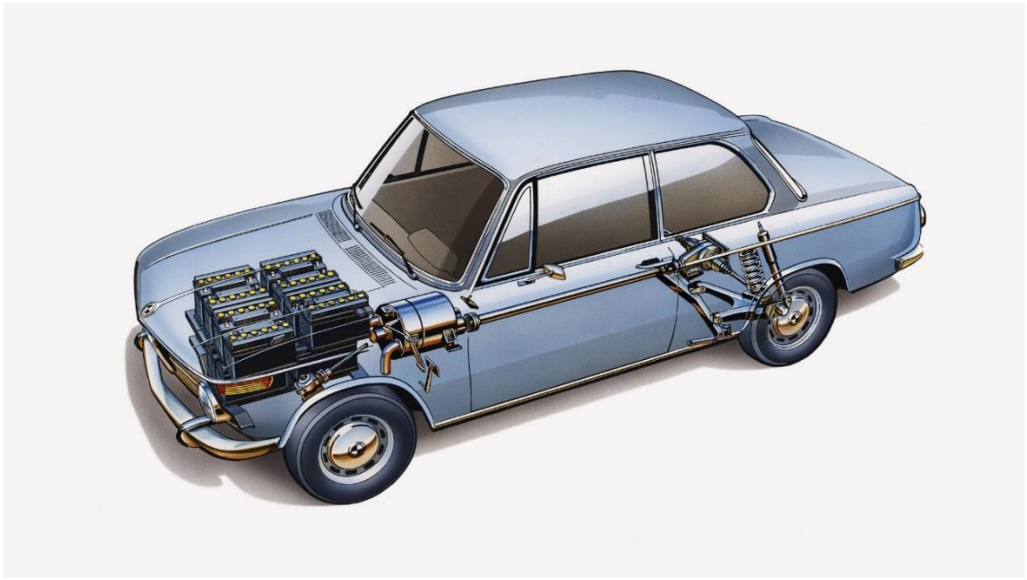
From January 1, 2024, the installation of electric gas stations will become a mandatory requirement for new commercial and entertainment complexes, hotels, gas stations, business centers and infrastructure facilities located along highways.

At the end of May 2023, it became known that the Environmental Protection Fund will allocate subsidies in the amount of 100 million sums for the construction of the first 50 power plants powered by photoelectric plants in the desert and steppe parts of the Tourist Highway. According to the data of the PlugShare service, there are currently 200 electric gas stations in all regional centers and major cities in Uzbekistan. Most of the power plants are located in Tashkent city and Tashkent region, and the rest are mainly located in Uzbekistan. Samarkand, Namangan, Andijan and Fergana. Analyzing the planned events, it can be noted that Uzbekistan is taking a leading place in the world in terms of the use of electric transport.

The evolution of the development of electric vehicles

The evolution of the development of electric vehicles can be divided into several generations.

The first generation includes electric passenger cars created from ordinary cars (Fig. 3). Their internal combustion engine under the hood was replaced with an inverter electric motor, and the batteries were placed in the trunk instead of the fuel tank, which significantly reduced its size. The first generation of electric cars did not have a large range, because such vehicles did not consume energy at an optimal level, because they kept the usual transmission and other characteristics of the car. Movement speed was also low. And this design had only one plus - relative cheapness. The first generation includes not only many prototypes from previous years or the RAV4 EV series from 1997, but also the all-new "E-Hunter".



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The second stage of evolution is partially integrated cars with models with internal combustion engines, the design of which has been specially modified for the use of a power plant (Fig. 4). They no longer had a conventional transmission, but the same "empty" spaces left over from the abandonment of the internal combustion engine were used to house electrical components. This design has improved the characteristics of an electric car, but it has not yet made it equal to a regular car. Typical examples are the 2014 Kia Soul EV or the 2015 VW E-Golf with batteries under the front seats and in the center tunnel, which were able to travel just over 100 kilometers without a charge. The first electric Nissan Leaf, the "Car of the Year", turned out to be the most suitable for everyday use in this generation. It no longer had any analogues with internal combustion engines, but many of its components were still combined with other models of the Japanese brand.

Figure 4. Second generation electric car

The third generation can be started with the Tesla Model S sedan - the first production electric car with a flat battery under a hollow interior and an engine mounted in the back, where the gas tank is usually located in regular cars (Figure 5). Due to the size of the power unit, such an arrangement is almost impossible in an internal combustion engine, but in an

electric car it provides a number of advantages: electric charging does not pile up passengers and cargo, and the weight distribution of the car with a heavy battery under the floor and has a positive effect on management. But the main thing is that the battery itself can have a large volume and, accordingly, a large capacity.

Tesla also implemented a dual-motor design, with each electric motor driving its own axis. In addition to the obvious advantages of all-wheel drive, this makes each electric motor more compact and lighter. Also, increase the total power of the power plant, which increases not only the dynamics, but also the efficiency - that is, the range on one charge. There is no paradox here, because powerful motors are also powerful generators that generate additional electricity during braking. The British Jaguar I-Pace is designed in a similar way, combining an in-floor battery with good off-road capabilities.

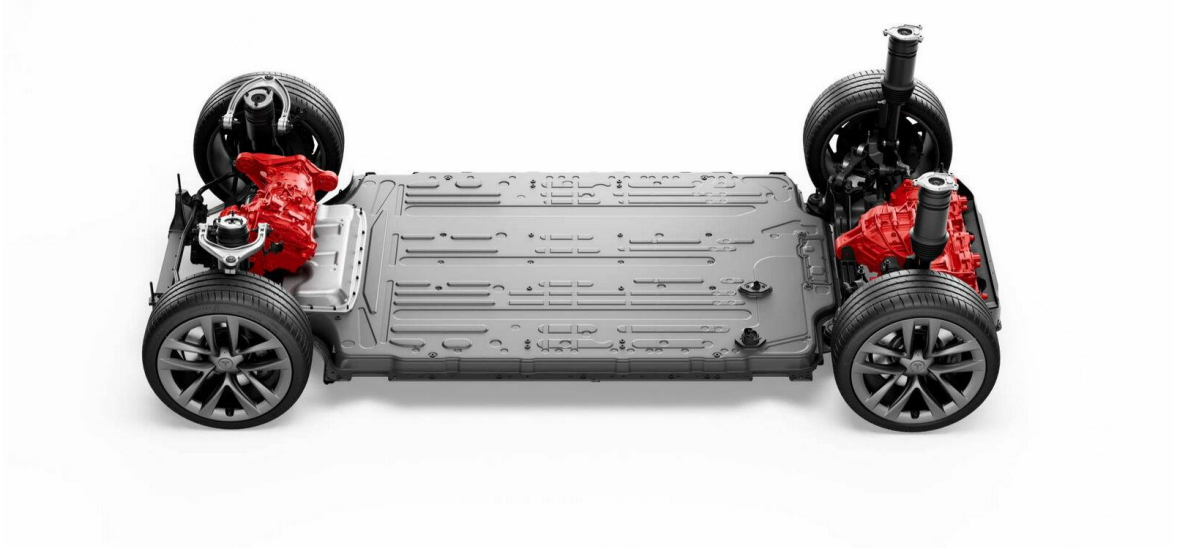

Figure 5. Third generation electric car

Other developers have pushed the multi-engine idea. For example, the modern Audi e-tron S already has three engines - each rear wheel is driven by its own motor, and the third engine is used to provide traction on the front axle. And the Pininfarina Battista hypercar has four electric motors with a total power of 1900 horsepower! Electric cars are fourth-generation models (Porsche Taycan, new Hyundai and KIA E-GMP electric cars) that use more efficient 800-volt batteries instead of 380-450-volt batteries. For now, they barely surpass Tesla's achievements in terms of the sum of their features, but they could potentially offer greater autonomy and even faster charging.

Prospects for the development of electric cars

Most car manufacturers have already prioritized the development of electric vehicles, and they are not working alone, but in collaboration with chemists and electrical engineers. Every year, companies increase the capacity of batteries, reduce their cost, increase the speed of charging from high-capacity electric charging stations, expand the networks of electric charging stations, and improve electric motors. The further we go, the more electric cars we'll see with the best combination of price and capabilities. Modern hybrid vehicles have an autonomy or driving range of 750 km or more. In the near future, it may reach 1000 kilometers. Production fully electric cars usually have a range of 250-300 km. The declared autonomy of the top modification of the Tesla Model 3 is about 500 km, the maximum autonomy of the Tesla Model S exceeds 600 km, according to the EPA (US Environmental Protection Agency). Such high autonomy of Tesla electric cars is achieved, first of all, by using

high-capacity batteries, as well as by optimizing the battery management system. However, it should be noted that the American company Tesla has been caught repeatedly exaggerating the technical characteristics of its cars.

In 2015, the Institute for Transportation Research at the University of California (ITS-Davis) conducted a comparative study of hybrid (PHEV) and electric vehicle (EV) autonomy (Figure 6).

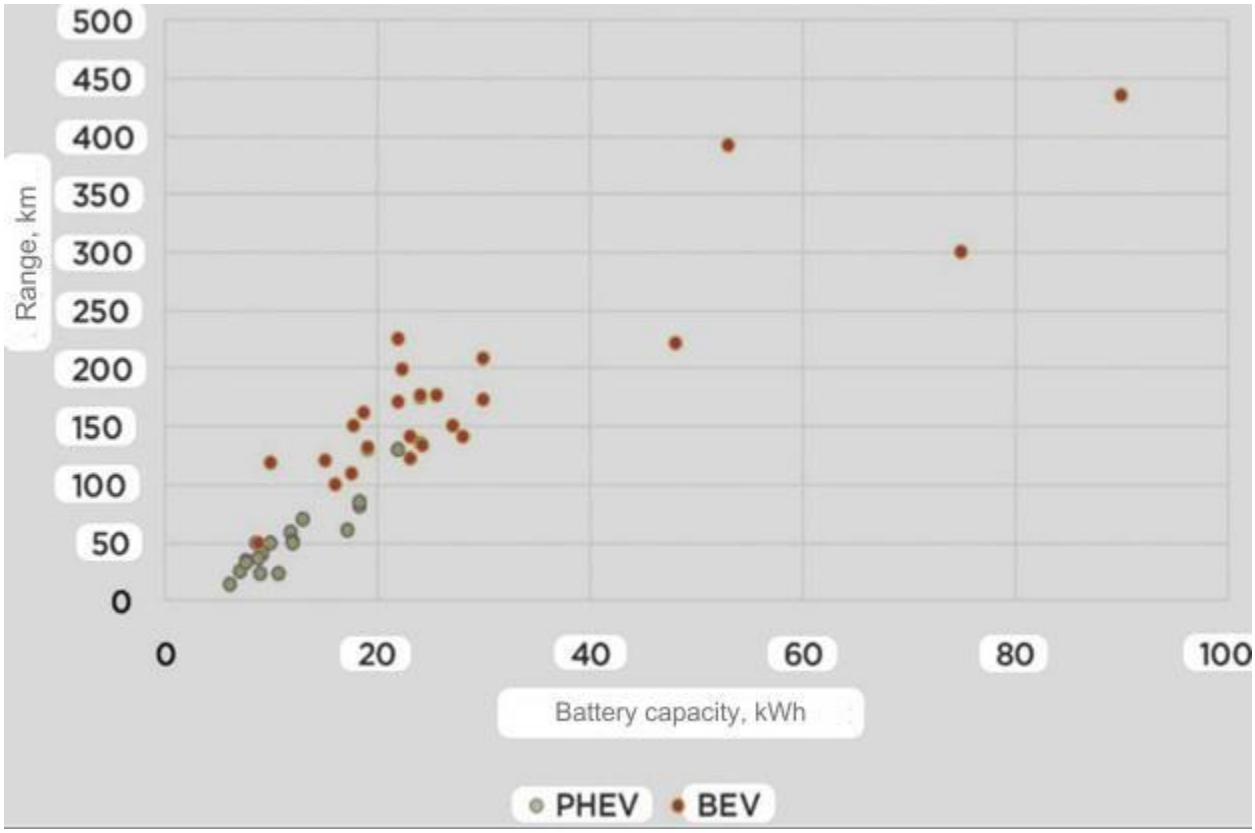

Figure 6. A comparison of the autonomy of hybrid (PHEV) and fully electric vehicles (EV).

If we compare these numbers with the data we have by 2022, we can safely say that the main disadvantage of electric vehicles, which is related to low autonomy, has not yet been overcome. Thus, insufficient power, long charging times, and low specific energy of batteries have limited the efforts of EV designers for many years. In addition, the increasing popularity of electric vehicles requires an increase in the number of batteries, which are components of complex systems that must work optimally to ensure safe and efficient use of energy. At the same time, another major disadvantage of electric vehicles, related to the cost of batteries, is slowly becoming a thing of the past (see Figure 7). If in 2005 the price of batteries averaged $1,300-$1,500 per kWh, by 2015 its price had almost tripled to $500. According to optimistic forecasts, the price may approach $100 per kWh in 2025.

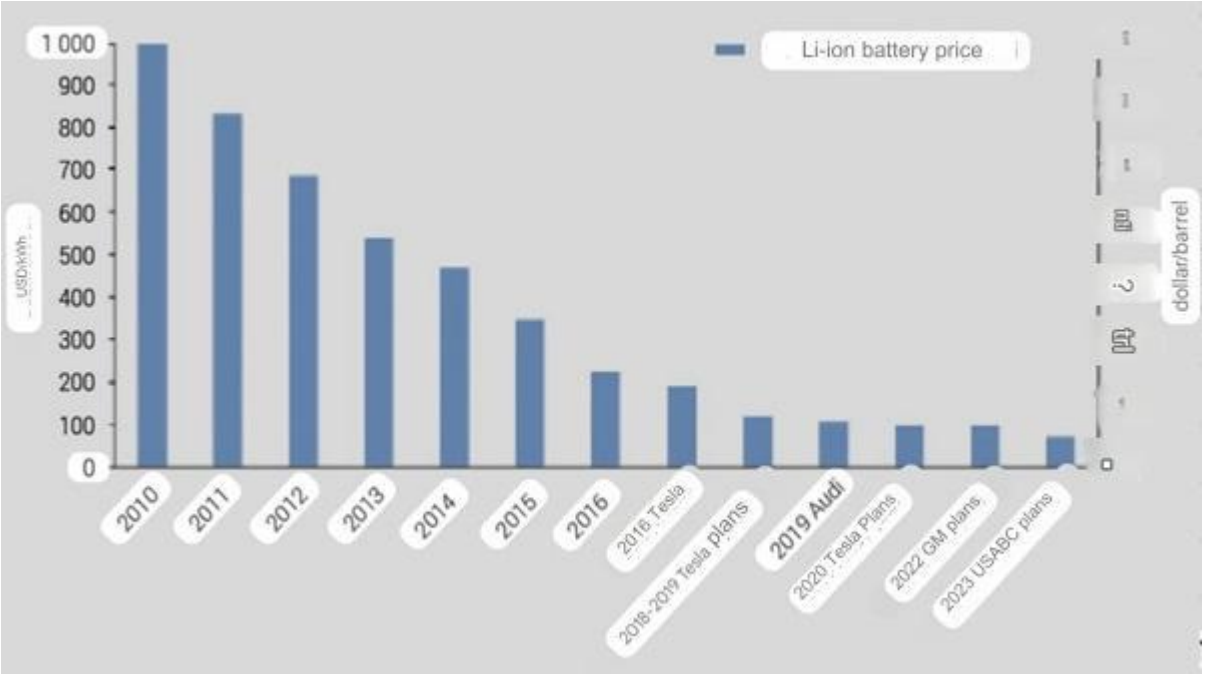

Figure 7. The price of lithium-ion (Li-Ion) batteries for electric vehicles.

It is important to understand that the competitiveness of the electric vehicle directly depends on the price of oil. Thus, at $240 per kWh, lithium-ion batteries are competitive with oil prices at $75 per barrel. At a price of $50 per barrel of oil, the cost of batteries should not exceed $150 per kWh. Improvements in battery technology provide some reason for optimism. If in the 1980s, the specific power of nickel-metal hydride batteries was up to 120 W / kg, then modern lithium-ion batteries used in electric vehicles have a power of up to 2.6 kWh per kilogram of their weight. can hold (Table 1.3).

Table 1.3.

Features of batteries of modern electric vehicles

Battery options	Tesla Model S	Nissan Leaf	BMW i3
Battery capacity, kWh	85	24	22
Cruising distance until fully charged, km	426	175	160
Resource, years	7	5	5
Full charging cycle (220 V), hours	8	8	8
Energy consumption, kW/100 km	27.7	21	12

The main vector for the development of electric cars will be the improvement of batteries. It is estimated that if manufacturers can increase their power by a third (in the current size and weight) and the cost of batteries will be halved, cars with internal combustion engines will immediately lose the competition to electric cars. But completely fantastic methods of storing electricity are still "passable" - for example, the technology of filling liquid batteries with "rechargeable" replaceable electrolytes. Almost like refueling "self-propelled buggies" at the dawn of motoring.

In China, electric cars with standardized replaceable batteries have become widespread - this is a way to solve the problem of charging a car for a long time. The EV enters the box, where a robotic mechanism removes the discharged battery from the bottom and replaces the charged battery. The operation is automatic, without human intervention, and does not take longer than filling the fuel tank of a normal car. This electric car concept may take root in countries with long distances in the future.

Conclusion.

Most car manufacturers have prioritized the development of electric vehicles, and they are not working alone, but in collaboration with chemists and electrical engineers. Every year, companies increase the capacity of batteries, reduce their cost, increase the speed of charging from high-capacity electric charging stations, expand the networks of electric charging stations, and improve electric motors. The further we go, the more electric cars we'll see with the best combination of price and capabilities.

Engineers are also exploring the option of contactless transmission of energy from a coil hidden on the road surface to electric vehicles while driving. Although such technology is very expensive and not efficient enough.

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