

ARTICLE

Mastering the Production of Electric Vehicles as One of the Modern Instruments for the Development of the Iranian Automotive Industry

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ABSTRACT

The article analyzes the problems of introducing electric vehicles, as well as their difference from cars with internal combustion engines. This type of transport has long been included in our everyday life. Today, in the era of the heyday of technology, a person understands that cars with an internal combustion engine (ICE) are almost on the edge of their existence. At present, the development of the production of electric vehicles should be considered as a promising direction of the Iranian automobile industry. At the moment, this market in Iran is not yet occupied by foreign companies, and therefore national companies have a chance to use the strategy of "growth together with the market".

1. Introduction

Despite the constant increase in the reserves of "black gold", in the long term, the oil market will exhaust its possibilities. According to various estimates, with the current and historical production volumes and estimated oil reserves, the oil production volumes of Iran (the sixth world exporters, and the 4th in terms of oil reserves) since 1960 have increased from 1.08 million barrels per day to 3.8 million per day in 2017 year. According to OPEC^[24] statistics, the forecast of production and volumes

of proven oil reserves is estimated at 157,200 billion barrels. According to the forecast of The World bank, provided that such dynamics persist in the coming years, the country will be provided with a resource for about 155 years. However, in connection with this prospect, the question arises about the transition to renewable energy sources. The impetus for this trend can also be called environmental problems. Thus, according to the World Health Organization,^[7] unfavorable environmental factors cause the emergence of more than 100 of the most

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dangerous diseases in the world, which kill 12.6 million people annually. Moreover, about 25% of carbon dioxide emissions into the Earth's atmosphere are produced as a result of the work of various types of transport. According to the IEA, by 2050 ^[2] this number will double and will continue to grow as the number of private cars increases in developing countries.

2. Methodology

The article examines the features of the development of road transport in the category of the so-called "green" transport. In this work, the authors provide a brief historical analysis of the development of vehicles with alternative energy sources, and also consider the advantages and disadvantages of using such technologies in the field of road transport. The importance of transport for humanity can hardly be overestimated. From time immemorial, he played an important role, constantly developing and improving. The scientific and technological revolution that took place in the 20th century, population growth, urbanization and many other factors brought its development to a completely new level. However, at the same time, a problem arose: a huge number of vehicles caused the deterioration of the ecological situation on a global scale. That is why more and more attention is being paid today to the development of ecological modes of transport. These requirements are associated with the introduction of toughening standards for carbon modes of transport, namely the Euro

environmental standards, which regulate the content of harmful substances in the exhaust gases of cars and special equipment, which were introduced by the UN Economic Commission for Europe. In the global automotive industry, in the last decade, there has been a pronounced trend in the development of innovative vehicles based on electric traction. The prevailing production volumes are still for cars based on the internal combustion engine (ICE). However, given the global trends in the fight against environmental pollution, the rapid growth in the number of cars in the world, the development of new technologies and other factors, car manufacturers are actively working towards finding alternative energy sources for use in vehicles. One of the most promising areas is electric vehicles - electric vehicles.

An electric car is a car driven by one or more electric motors powered by batteries or fuel cells. Electric cars have proven to be the best alternative to internal combustion engines to meet the goals of the Paris Agreement. Already, in the course of their life cycle in Europe, 66-69% less greenhouse gas emissions are generated in comparison with gasoline cars, and in 10 years these emissions will be even lower due to the general decarbonization of electricity. Burning carbon-based fuels in the transport sector produces 12 billion tonnes of CO₂-equivalent annually, which is a quarter of the total anthropogenic greenhouse gas emissions. Without widespread restrictions on the operation of vehicles powered by internal combustion engines (ICEs), transport emissions could almost double by 2050 to 21 billion

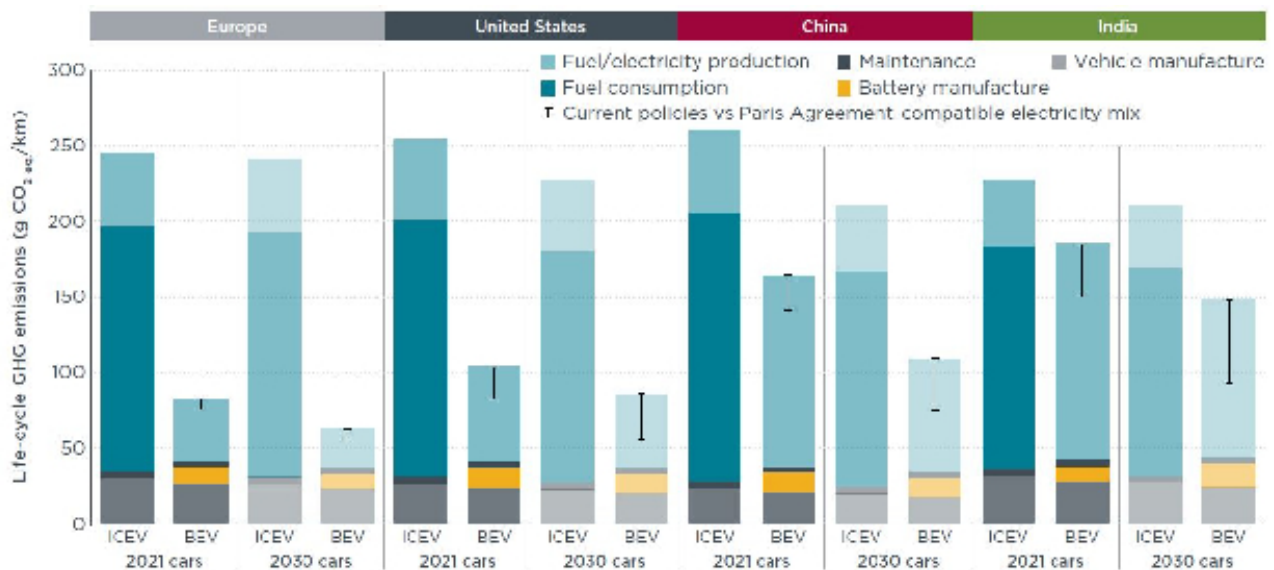


Figure 1. Comparison of greenhouse gas emissions over the full life cycle of internal combustion engine vehicles (ICEVs) and battery electric vehicles (BEVs) in different regions at the moment (2021) and forecast of such a comparison for 2030.

Source: compiled by ^[25]

tonnes of CO₂-equivalent. To achieve the goals of the Paris Agreement, [25] which involve limiting the increase in the average temperature of the planet to 1.5 degrees Celsius, it is necessary to reduce transport emissions by 80 percent compared to current ones and limit them to no more than 2.6 billion tons of CO₂-equivalent per year.

The massive shift from ICE cars to electric cars and hybrid or hydrogen cars is considered a key tool for reducing greenhouse gas emissions from transport, but the environmental friendliness of such vehicles is still disputed. They may not emit greenhouse gases while driving, but their life cycle leaves a carbon footprint, at least through the production and disposal of batteries. The International Clean Transport Council has published a document comparing the greenhouse gas emissions from vehicles with different engine types and fuels used throughout the life cycle. The calculations took into account the full life cycles of ICE vehicles, hybrid and hydrogen vehicles, and electric vehicles. The study covered Europe (EU countries and the UK), the USA, China and India (full description in Figure 1).

It turned out that even now, over their entire life cycle, compared to gasoline cars, electric vehicles produce 66-69 percent less greenhouse gas emissions in Europe, 60-68 percent in the USA, 37-45 percent in China and 19-34 percent in India, with potential for further reductions. By 2030, significant decarbonization of electricity is expected due to a partial transition to renewable sources, and emissions from electric vehicles in the regions under consideration will be lower by 74-77, 62-76, 48-64 and 30-56 percent, respectively. Hydrogen cars are currently not as clean an alternative to gasoline vehicles as electric ones. Their emissions in the studied regions are lower by an average of 26-40 percent. This is due to the fact that while the market is dominated by "gray" hydrogen, that is, obtained from natural gas. The situation could be changed by the transition to "green" hydrogen, obtained with the help of renewable energy from cleaner sources - for example, sea water. Then the emissions of hydrogen cars will be lower by 76-80 percent. The author of the study stressed that he sees no prospects for hybrid vehicles. Their emissions are, on average, 20 percent lower than those of ICE vehicles, and switching to such vehicles will not be enough to meet the Paris Agreement targets. Modern electric cars are becoming more environmentally friendly and user-friendly: Electric cars have proven to be more environmentally friendly than traditional cars in terms of their life cycle.

The topic of electric vehicles remains one of the most relevant in the field of motor transport within the framework of programs to improve the ecological

situation in megacities. Research and development projects are yielding results, and constantly appearing prototypes of equipment allow us to develop and improve the technology of using storage batteries in transport as an alternative to an internal combustion engine. Today, electric vehicles are gradually transforming from the technology of the future into a familiar and popular form of transport, gaining popularity in the automotive market. And it's likely that electric cars will soon replace combustion-powered cars. If we compare the power plants of a traditional car and an electric car, then the advantages of the latter are obvious.

Electric car - cars of the future

As world practice shows, in the context of the growing threat of environmental catastrophe and the limit of oil reserves, innovative trends in the transport industry are aimed at the development of electric vehicles. This is due to the undoubted advantages of these machines. Ecologically clean and resource-saving characteristics, which served as a prerequisite for the development of the market for environmentally friendly modes of transport. To meet more and more stringent requirements, the search for alternative types of fuels for cars - natural gas, biofuels, etc. is being carried out. Emissions from combustion of various types of fuel are shown in Table 1.

In order to get rid of emissions of harmful substances into the atmosphere, you can use electric traction, replacing the internal combustion engine. The advantages of electric transport can also be attributed to the low level of noise and vibration, which helps to reduce noise pollution in the city, good controllability. Nevertheless, the large mass of batteries, the impossibility of long-term storage of electrical energy in batteries, as well as rather complex maintenance does not allow electric transport to take a dominant place in the urban vehicle system. In addition, electric vehicles are dangerous due to the threat of injury to a person by electric shock and electrolytic fluids. Nevertheless, since 2011, the world has seen a real boom in electric vehicles, which is confirmed by the constant growth of sales. Unlike other alternative vehicles, electric vehicles have the lowest cost of ownership. In the urban cycle, a small electric car, without sacrificing mobility, uses on average only 3 kW of engine power, which cannot be compared with the costs of operating a car with an internal combustion engine in this way. The figure for comparing the efficiency of energy use in a classic car and in an electric car (Figure 2) shows that an electric car is almost 2 times more efficient in energy consumption for movement.

Currently, one of the trends in the innovative

Table 1. Emissions from fuel combustion

Fuel	Unit of measure	Pollutant emission factors						
		(CO)	(CH)	(NO ₂)	(C)	(SO ₂)	aldehydes	benzo (a) pyrene
Petrol	t / t	0,44	0,08	0,025	0,0006	0,001	-	0,23 Ч 10 ⁻⁶
Diesel fuel	t / t	0,125	0,055	0,035	0,015	0,0001	-	0,31 Ч 10 ⁻⁶
LPG	t / 1000 m ³ m	0,22	0,05	0,025	-	-	-	-
Biodiesel	t / t	0,03	0,0073	0,054	0,0045	0,0001	98 Ч 10 ⁻⁶	0,175 Ч 10 ⁻⁶
Kerosene	t / t	0,092	0,013	-	-	-	-	-

Source: compiled authors by ^[29]

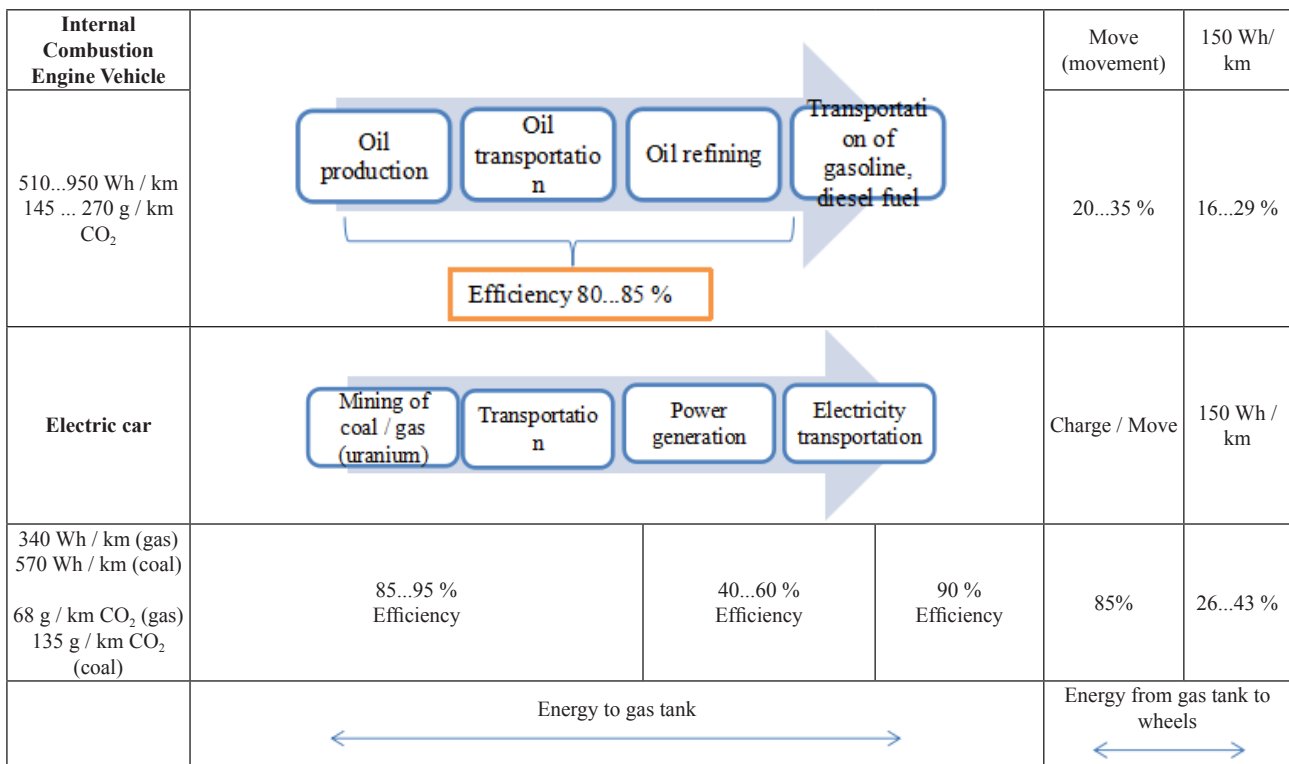


Figure 2. Scheme for comparing energy efficiency in a classic car and in an electric car

Source: compiled authors by ^[15]

development of the world energy is clean technologies, including those based on the use of renewable energy sources. They already account for more than half of all generating capacities commissioned in the world. Their share in the global energy balance by 2035 ^[3] should increase from 15% to 23%, and in electricity generation (excluding hydropower) from the current 7% to 20%. Particularly widespread development of promising technologies for the use of renewable energy sources is received in the automotive industry, since due to the

growth of the world car fleet (an increase of more than 4-6% per year), the problem of environmental pollution is acute. Electric vehicles are considered a universal solution to the problem of air pollution and reducing the world's dependence on hydrocarbons. The growth rate of the electric vehicle market is impressive: in recent years (2010 - 2020). The market volume has grown 10 times more. According to EV-volumes ^[8], in 2020 their number worldwide exceeded 10 million. This is only 2.5% of the world park. At the same time, growth is exponential, and

the picture will change quickly enough. There were 3.22 million new electric vehicles registered in 2020, a 68% increase over 2019. What started with an unprecedented economic downturn during the 1st wave of COVID-19 is the success story of EVs in Europe. Almost 1.4 million BEVs and PHEVs were registered in Europe during 2020, up 137% from 2019, in an automotive market that declined 20% year on year. The global share for the full year 2020 is 4% of global auto sales. Full description in Figure 3.

In recent years, the global EV (Electric Vehicle) market share has grown significantly due to energy security concerns, rising oil price trends, and the improvement in the current state of electricity as the cheapest and most efficient energy source for the transport sector in the near future. The global automotive industry is entering a period of profound transformation. A combination of supportive policies and advances in lithium-ion battery technology have enabled electric vehicles to succeed in a market dominated by the internal combustion engine for over a century. Meanwhile, tightening fuel efficiency regulations and urban air quality concerns are increasing pressure on carmakers to improve the rest of their fleet. Electric vehicles (EVs) represent one of the most promising ways to increase energy security and reduce emissions of greenhouse gases and other pollutants. In the long term, electric vehicles are important for Iran as well, if

the government seeks to reduce the level of hydrocarbon emissions from ground transportation. Bloomberg New Energy Finance predicts ^[19] 54% of global car sales will be electric by 2040, with Europe, China and the US being the largest EV markets. Some countries will get there much earlier. In Norway, a leader in EV adoption, sales are already in excess of 40% and the government is aiming to phase out all traditional car sales by 2025. Many global automotive corporations are predicting a "green" future for him.

The prospect of the development of electric vehicles today is beyond doubt. The efficiency of an electric drive reaches 90%, all its energy is mainly used for movement, in cars with internal combustion engines the efficiency is about 25%, and most of the energy goes into heat. In addition, the electric motor does not emit exhaust gases. So far, an electric car is much more expensive than a car with an internal combustion engine. If we take into account the cost of the components of a light electric vehicle, then its payback will be approximately 2 to 3 years. All components for the creation of an electric vehicle are produced in the world, and today the task is: selection, adjustment of the optimal composition and, if necessary, their adaptation to a specific chassis of the car in order to obtain the expected effect. Table 2 shows the main advantages, disadvantages of electric vehicles, as well as barriers to the development of these vehicles.

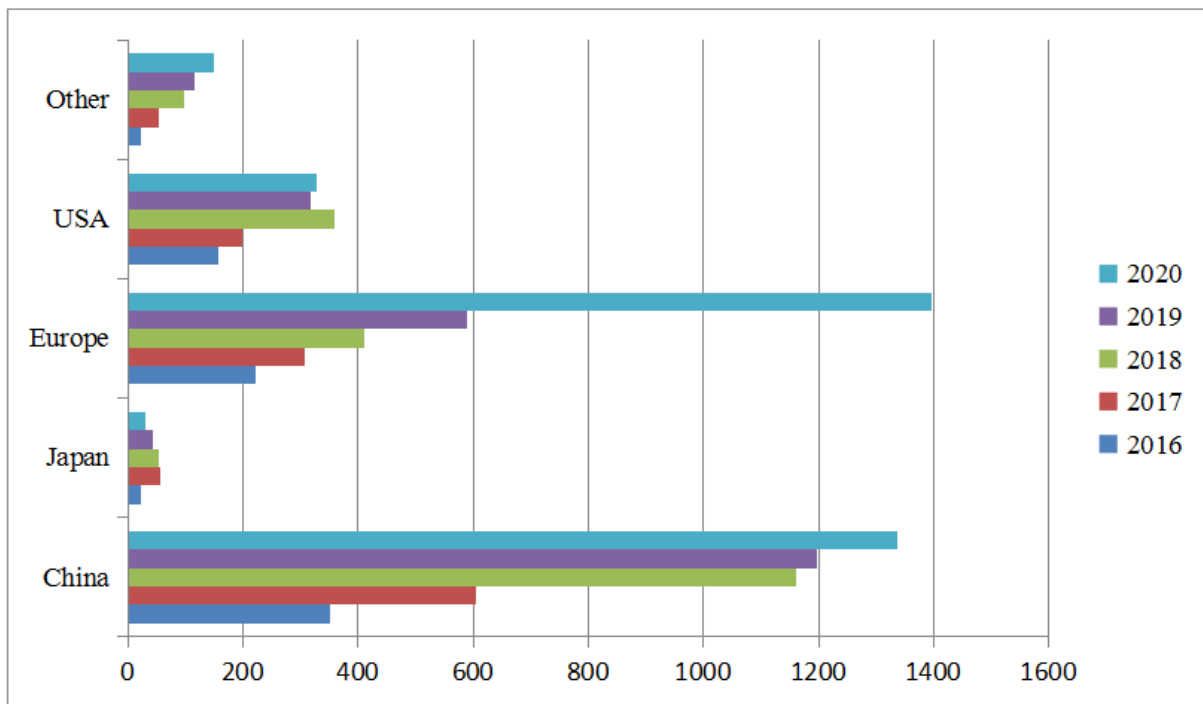


Figure 3. World car sales (BEV - PHEV) and their growth in 2016-2020 (thousand pcs.)

Source: compiled by the author based on ^[8]

Table 2. Main advantages, disadvantages of electric vehicles and barriers to development

Benefits	Disadvantages
- No environmental pollution, as the electric car does not have an exhaust pipe; - Significantly lower cost of maintenance and ownership; the electric car has very few moving parts, there is no complicated gearbox, the engine control system is much simpler, there is no oil in the engine and gearbox, etc. - Ability to increase the efficiency of using network infrastructure; - State support programs; - Safety. In the event of an accident, special collision sensors will disconnect the batteries, which will cause the car to stop; - Low noise operation of the electric motor; - Ease of controls.	- Lack of developed infrastructure of charging stations; - Long charging time; - Relatively low mileage on a single charge (no more than 300-400 km); - The high cost of an electric car (The price of a car varies from 40,000 to 100,000 €); - Inability to reanimate a fully discharged battery; - A narrow temperature range from 25 to 45 degrees (at 55-60 degrees, the batteries begin to break down, they have to be cooled even when parked in the sun); - The need to replace the battery every 5-10 years (replacement costs about € 15,000); - Disposal of used batteries; They contain environmentally hazardous elements and toxic electrolytes. These elements are subject to regeneration.
Barriers	
Technological issues:	- Technology of immature batteries; - Long charging time; - Influence on the battery from weather conditions.
Social factors:	- The consequences of innovation, which means the changes that innovations make to the current practice of society; - Lack of public charging locations.
Economic problems:	- Selling price
Political factors:	- The provision of financial incentives and consumer subsidies; - Strict regulation and aggressive legislation; - Oil and gas companies were against EV.

Source: compiled by the author

The advantages of electric vehicles:

- **Reduced fuel costs.** The cost of gasoline is constantly growing and is often consumed in large quantities, which devastates the family budget, and the consumption the electricity bill for recharging the battery should be much less than these costs.
- **Reducing environmental pollution.** A running electric car engine does not emit harmful gases into the environment. Ideally, to reduce the impact on the environment, it should be produced from clean, renewable energy sources.
- **Reduced noise.** Electric vehicles are capable of quiet and smooth acceleration, with faster acceleration.
- **Security.** Electric vehicles go through the same testing procedures as conventional vehicles. Thus, in the event of a collision, the airbags will deploy, the crash

sensors will disconnect the batteries, so that the electric vehicle will stop. For example, a Tesla electric car The 2013 Model S received the highest safety rating of any vehicle ever tested in the United States.

- **Cost.** Gone are the days when electric cars cost a lot of money. Batteries used to be very expensive, but when they are mass-produced, their cost decreases.
- **Reliability.** Due to the fewer parts and assemblies, the reliability of the electric vehicle increases and, as a result, the cost of repair and maintenance is reduced.

Disadvantages of electric vehicles:

- **Stations for recharging.** So far, the infrastructure is in its infancy.
- **Electricity is not free.** It is worth paying attention to the fact that electric vehicles have different energy consumption.
- **Short mileage and limited speed.** Most EVs can travel anywhere from 160 to 240 km on a single charge. Although some models promise to travel up to 480 km without recharging.
- **Recharge time.** For a full charge an electric car takes about 8-10 hours.
- **They are usually 2-seater.** Electric cars are not designed to transport the whole family, which means that the trip for three may already be inconvenient.
- **Battery replacement.** Replacement is in progress every 3-10 years.
- **In winter, the battery consumption increases for heating the passenger compartment, brushes and headlights.** This leads to the fact that the mileage in winter is reduced by 30-50% compared to the summer period.

Even despite the fact that there are many nuances in the use of electric vehicles, one should believe that they will be resolved in the future. First of all, you need to think about the fact that the main advantage of an electric car is reduction of the degree of environmental pollution. The demand for electric vehicles can change significantly in the following cases. Firstly, with a 10-fold increase in gasoline prices in the country, that is, a worsening situation with exhaustible energy resources (oil and gas reserves). Secondly, the price reduction for electric vehicles, which will be possible as a result of a technological breakthrough.

Table 3. Comparative characteristics of consumer properties of cars

Technology	Passenger car	Electric vehicle
Distance traveled per unit of fuel	18 km/L	110 W * h / km
Charging time, h	0,2	4-8
(CO ₂ emissions) g / km	39,0	12,1
Energy efficiency, km / MJ	0,63	2,18
Noise	+	-
Cost of 1 km, €	0,12	0,008
Service cost per 1 km, €	14	6

Source: compiled authors

It is worth noting that when using an electric car,

the owner gets significantly more privileges. States are striving to bring as many green electric vehicles onto the road as possible by offering instead of exemption from a certain list of taxes, free parking spaces, free charging vehicle, the ability to drive on the line public transport, which reduces the likelihood of getting traffic jams to a minimum, and, of course, profitable interest-free loans for the purchase of an electric car. Nowadays, governments around the world are embracing the development of EV on the road, setting goals to improve this industry. Here it would be appropriate to recall the experience of Ford, who "buried" the entire carriage industry more than a hundred years ago. The experience of Apple, which managed to significantly reduce the personal computer (PC) market by squeezing a PC into a phone, and in a few years became not only the flagship in its industry, but also the largest company in the world, overtaking such giants as General Electric and Exxon Mobil, which recruited its power for over a hundred years. In 2015, Germany announced a complete phase-out of ICE vehicles by 2050. Later, in March 2016, the Norwegian authorities officially announced a complete abandonment of sales of cars on gasoline and diesel fuel in the country by 2025, planning for this goal about 1 billion euros of investments. In general, the authorities of almost 40 countries reacted positively to the introduction of electric vehicles.

Trend, problems and prospects for the development of an electric car in Iran

In recent years, there has been a significant increase in the car park in Iran. The country's motorization rate is not very good even in Asia, with 220 cars per 1000 inhabitants. In total, 19.5 million vehicles are registered in the personal property of citizens [20]. The volume of passenger transportation by road and the share of road transport in the total volume of cargo also increased. Thus, according to the estimates of the Center for the Study of Transport and Traffic Jams [19] in the roads of the city of Tehran with 4 million vehicles, about 17.5 million trips are carried out every day (an increase in the share of trips from 39% in 2011 to 45%). Table 2 shows a general picture of a number of factors from which Iran's motorization can be expected to increase in the coming years.

Table 4. Overview of the automotive market of Iran

		2006		2020		2030	
Population (million People)	Urban	48.2	70.4	57.8	79.4	72.6	95.5
	Rural	22.2		21.6		22.9	
Ground Trips (Millions of Trips)	Bus	121		140		177.4	
	Personal car	313		410		586	
Family of existing car (million people)		28		42.1		64.6	

Source: compiled by the author according to [5]

The data in the table show that the population of the country is growing during the period under review, the more the growth rate of the urban population is much higher than the rural population. Thus, the urban population (from which one can expect more car purchases than the rural population), amounting to about 49 million people in 2006, grew to 58 million in 2020, and is projected to grow to 73 million in 2030, and, accordingly, the total population to the level of 96 million people. Also, following the data on the number of ground trips, we notice that their growth rates are from 20 to 25%. However, the share of trips by private cars is more than 72%, 74% and 79%. According to the researchers [1], due to factors such as cheap fuel, and the development of roads in the country, more than 90% of the transportation of passengers and goods by roads is carried out (Although it should be borne in mind that the shortcomings of Iran's railway and air lines the development of vehicles). As of 2020, the length of the public road network in Iran is [21] 85.6 thousand km, and is expected to increase in the coming years.

According to the Department of Planning and Transport Economics in 2006, only 6% of Iran's passenger traffic was carried out in trains and airplanes, and the rest was carried out using land transport. Considering another indicator (the family of an existing car), the growth of the indicator is immediately noticeable from 28 million people in 2006 to 42.1 million in 2020, and to 64.5 million in 2030. Understanding the fact that the above indicators will affect the increase in the level of motorization in Iran, it is quite possible to expect an increase in the number of cars in the coming years. In addition, it is worth noting that about 1.350 million old cars are driven in the country, and their number is growing annually by about 200 thousand cars, according to "Talai M.", a representative of the country's recycling centers for old cars [6]. Since the average age of passenger cars in the country is more than 10.5 years, and according to various estimates, 26% of the total vehicle fleet in Iran is more than 20 years old. However, the growth of Iran's car fleet leads to the fact that, firstly, emissions and air pollution increase, and secondly, gasoline consumption is growing. Moreover, the cars produced by Iranian automakers do not comply with environmental standards. Below we will consider the consumption of gasoline from 2005-2018 to Iran.

Considering the data in Figure 4 understands the fact that as a result of the massive use of non-environmentally friendly road transport in the cities of Iran (including old and new), more than 90 million liters of gasoline are consumed daily in the country. As a rule, non-rational consumption of gasoline and energy losses for long-

term periods will not be beneficial for the people and the country as a whole. Although the culture of consumption of the population, and the management problems of the government in real life can be considered one of the reasons for the problems. The government sometimes proceeds from the assumption that a solution to the problems can be found through an increase in the price of gasoline, but the research carried out by "Sadeghi H." [26] from the University of Lorestan showed that the price of gasoline strongly influences the inflation rate of a country. So in a study using ARDL models from 1978-2013, the results show that a 1% increase in the price of gasoline - 1.112% increases the country's inflation rate. This is 0.748% for diesel fuel. Since the increase in the price of gasoline, not only does not reduce the consumption of gasoline, but also creates problems with the growth of inflation.

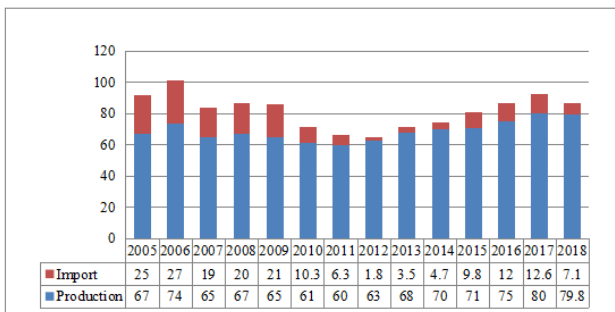


Figure 4. Gasoline consumption by Iranian vehicles (share of imports and production) - million. Liters / day from 2005-218

Source: compiled by the author based on [22,23,31]

Table 5. compares the gasoline consumption of the neighboring country Turkey with Iran.

Turkey		Iran
79 million	Population	80 million
21 млн. 80 million	Vehicle	19 million
8 million	Gasoline consumption liter / day (average)	85 million
3 billion	Gasoline consumption liter / year	30 billion
1.5 \$	Gasoline price	0.18 \$

Source: compiled by the author based on [34,13,35]

The data in the table show that Turkey, having a larger vehicle, consumes 10 times less gasoline than Iran and, accordingly, spends 10 times less money, and clearly much less subsidies for gasoline. Thus, with an average consumption of 30 billion liters of gasoline per year, and with an average world gasoline price of 1.15 \$ [13], Iran spends about 34.5 billion \$. If the compensated amount

is deducted from this amount with the help of gasoline consumers (paying 0.18 \$ when buying gasoline per liter), then it is understood that the state pays subsidies in the amount of more than 29.1\$ billion annually. Confirmation of this can be considered the words of Iranian Oil Minister "Zangane M." [30], according to which the annual subsidies for fuel and energy are estimated at 40 billion dollars, which in turn is considered a threat to the country, but solving problems can turn this threat into an opportunity. It should be noted that a large share of these subsidies, as we said earlier, is the share of gasoline subsidies. It should be noted that a large share of these subsidies, as we said earlier, is the share of gasoline subsidies. Thus, the consumption of gasoline in Iran reduces the country's budget in the amount of 29.1 billion \$, and besides the fact that the state needs to compensate such an amount annually, we must not forget about the creation of environmental problems with the consumption of such a volume of gasoline.

Although, as we said earlier, the new Iranian cars do not comply with international environmental standards, but the majority of Iran's car parks are more than 10-15 years old, which in turn leads to an addiction to the consumption of gasoline, and consequently to air pollution. So in the study of the organization of energy productivity in Iran in 2011, [10] it is shown that the consumption of 60 million liters of gasoline per day creates 138 thousand tons of carbon dioxide. On this basis, the level of generated carbon dioxide is currently growing to 186 thousand tons per day, because gasoline consumption rose to 81 million liters per day. Urban air pollution is a serious health risk in several major Iranian cities. The main drivers of transport, as stated, are the widespread use of fossil fuels, outdated urban fleets of gasoline and diesel vehicles, industrial sources within and near city boundaries, and natural dust. For decades, most of Iran's major cities have faced severe air pollution problems. The problem first became apparent in Tehran, followed by other cities including Mashhad, Arak, Isfahan, Ahvaz and Tabriz. According to the World Health Organization, [28] cities in three countries, Iran, India and Pakistan, are among the most polluted cities in the world. Today, urban air pollution poses an immediate health risk to a large sector of Iran's population. According to the head of the fresh air department of the Iranian Ministry of Health "Shahsovani A.", [17] 33,500 people die in the country every year due to environmental problems. So the average concentration of suspended particles in 2015 in 25 cities of Iran was estimated at 31.7 mg. per cubic meter, although in comparison with 2011 it had a decrease from 39 mg. Also a member of the Tehran City Council "Farahani M." [16] compares the environmental

deaths in Tehran to the crash of an airbus that seats 500 people every week.

Tehran, home to over 8.5 million people, has suffered from high concentrations of carbon monoxide in the past, but has recently suffered from high levels of particles. The contribution of various sources to Tehran's air pollutant emissions is calculated as follows: vehicle 75-80%, industry 10-15%, domestic and commercial 5-10%. Also, Mashhad, Isfahan and Tabriz face similar problems, while Arak's air pollution is mainly due to industrial sources. The variety of sources of air pollution in Iran makes it more challenging. Among the ten causes of death in Iran, four are associated with atherosclerosis with air pollution among its main risk factors. Some air pollutants also irritate the lungs and respiratory system. Short-term effects include discomfort, allergic reactions, coughing, and sneezing. Long-term exposure to certain pollutants can also cause lung cancer. Air pollution is especially harmful to sensitive groups such as small children, pregnant women, and the elderly. Air pollution can also damage historic buildings and structures over time through corrosion. The most hazardous air pollutants are fossil fuel products, primarily a byproduct of combustible fuel engines in most cars. Although their concentrations are regulated in most major cities, they still pose a risk to human health.

The first air quality monitoring station (AQM) ^[14] in Iran was established in 1992 by the Department of the Environment (Sazeman-e Hefazat-e Mohit-e Zist). Since then, around 200 AQMs have been established around Iran. In the capital alone, thirty-nine AQMs are operated by the Department of the Environment in partnership with Tehran Air Quality Control Company (AQCC), a subsidiary of Tehran Municipality. A study by researchers from the Faculty of Medicine of the University of S. Beheshti ^[18] showed a close relationship between various air pollutants and the number of cases of severe acute respiratory syndrome. The relationship between air pollution and acute respiratory symptoms in patients admitted to Tehran's emergency centers in 2013 was assessed. 36,787 patients with acute respiratory symptoms were enrolled in these centers. Data were collected on the number of cases with acute respiratory symptoms and air pollutants at air quality monitoring centers. Moreover, Poisson regression was used to estimate the relationship between the concentrations of air pollutants (PM_{2.5}, SO₂, NO₂, O₃, CO) and the number of cases of severe acute respiratory syndrome. The results of the study showed that CO (average weekly IRR = 1.1) and SO₂ (average for three days IRR = 1.03 and average weekly IRR = 1.04) increased the risk of respiratory diseases by 10%, 3%

and 4%, respectively. Consequently, a longer duration of contaminants will increase the risk of respiratory syndromes. According to the results of this study, elevated air pollutant concentrations may be associated with an escalation in the number of patients with acute respiratory symptoms related to emergency medical centers in Tehran.

Consequently, a longer duration of contaminants will increase the risk of respiratory syndromes. According to the results of this study, elevated air pollutant concentrations may be associated with an escalation in the number of patients with acute respiratory symptoms related to emergency medical centers in Tehran.

Annual estimates of air pollution in Iran ^[12] show that the damage caused by air pollution in Iranian cities is 640 million \$ annually. Thus, according to the World Bank, the damage from the disease caused by air pollution is estimated annually at 260 million \$ for the Iranian economy. According to the studies carried out, all domestic vehicles have a higher fuel consumption, and at the same time do not comply with environmental standards.

It should be noted that cars not only pollute the air with toxic gases ^[36], they also burn oxygen. To burn one kilogram of gasoline, 13.7 kg of air is required, that is, 2.9 kg of oxygen. Already, the planet burns about 90% of all oxygen produced by terrestrial vegetation. Thus, the largest air pollutant in Iran is road transport. Given the difficult environmental situation in Iran, the government will need to introduce stricter requirements at the regulatory level regarding the environmental friendliness and energy efficiency of vehicles.

From the data given in the table, it can be seen that Iranian cars, consuming high fuel consumption, emit more emissions and pollution than similar ones in international production. Thus, the largest air pollutant in Iran is road transport. Given the difficult environmental situation in Iran, the government will need to introduce stricter requirements at the regulatory level regarding the environmental friendliness and energy efficiency of vehicles. Analysis of the situation in Iran shows that most of the light vehicles, which account for the main emissions of harmful substances, are in private use and are concentrated in large cities. Passenger cars are mainly used as personal transport for movement in urban conditions, while the average mileage per day does not exceed 100 km. Thus, the gradual replacement of personal vehicles in large cities with electric vehicles is quite realistic and expedient from an environmental and economic point of view.

The development of electric vehicles is a promising area in the activities of automakers. But the outlook for the

Table 6. Pollution and average fuel consumption of the Iranian fleet

Emission standard	Engine volume (cu. Cm)	Manufacturer	Emission factors (g.km)				FC (liter/100 km)
				CO	HC		
E2	< 1500	Iranian	163.66±10.77	4.16±1.26	0.42±0.12	1.3±0.42	8.98±1.02
	1500-2000	Iranian	233.2±14.92	11.22±3.76	0.70±0.34	1.61±0.35	11.68±0.88
Norms E2				2.2	0.5	0.5	
E4	1500-2000	Iranian	146.91±25.22	1.12±1.15	0.04±0.02	0.04±0.02	6.69±1.48
		Imported	163.55±15.55	0.35±0.36	0.04±0.03	0.02±0.02	7.01±0.67
	>2000	Imported	207.84±17.64	0.80±0.67	0.04±0.02	0.05±0.04	8.91±0.85
Norms E4			155	1	0.10	0.08	
Mini truck			245.70±40.34	8.68±1.18	0.51±0.33	1.47±0.99	11.34±1.61

Source: compiled by the author according to ^[30]

development of electric vehicles is fraught with a number of challenges. These problems depend both on technical progress in the field of energy-saving technologies in road transport and on the geopolitical situation in the country. Their use will significantly reduce oil consumption, increase transportation efficiency, reduce fuel costs, as well as minimize the amount of toxic substances emitted into the atmosphere during the operation of vehicles. One of the significant reasons for the lack of attractiveness of the electric vehicle for the majority of Iranian consumers is its high price. For example, the average cost of an electric car on the Russian market ranges from 12,000 \$ (Mitsubishi i-MiEV) up to 70 thousand \$. (Tesla Model S), and this is a rather high price with an average wage in Iran of 500-600 \$. But dropping the price of EVs, especially early-stage tech innovations without huge demand, isn't easy. However, the situation is changing with an increase in production volumes. Gasoline price is another key factor in EV buying decisions, as evidenced by several studies. The general trend is that EV adoption increases as the price of gasoline rises. The persistence of low gasoline prices for political or non-political reasons has negatively impacted the EV adoption rate in the past.

The main limiting factor in the growth of the electric vehicle market can also be considered the lack of infrastructure for their operation, primarily a developed network of charging stations. So as the number of EVs increases, the demand for their charge will increase. This increase in load can adversely affect the power system if not properly managed. The Vehicle-to-grid (V2G) system can play an important role in smoothing out the demand load. In its study, 'Sierzchula' ^[32] believes that adding one charging station per 100,000 inhabitants will increase the EV market share by 0.12%. Also in his opinion, the addition of one separate charging station could have a double impact on EV market share than a 1,000\$ increase in financial incentives. To overcome the barrier to charging infrastructures, it is necessary to invest in easily accessible charging stations.

According to various data from EVI (Electronic Vehicles Initiative), the deployment of mass consumption of electric vehicles is taking place in the United States, Norway, Germany, Japan and others. In most cases, the government pays attention to supporting both supply and demand. Financial incentives for consumers at national and local levels are well thought out. Such events give confidence to automakers and consumers in the further development of the market. The mix of non-financial incentives is also paying off. The electric vehicle market in Iran is currently still in its infancy. The number of owners of this type of transport is not subject to counting, and official statistics are not presented. The reluctance of Iranian consumers to buy a "green car" is primarily due to the low level of effective demand, the lack of a network of electric charging stations, the lack of incentive policies (subsidies, tax incentives) and public awareness of the benefits of electric vehicles. Also problems with road infrastructure, lack of a service station. The electric vehicle market in Iran will face a wide range of challenges that require active government support. However, the implementation of an effective policy will lead to an increase in the welfare of society, an improvement in environmental performance, and contributes to the energy security of the state. The ongoing research and development work of domestic companies in this area are, in our opinion, the main lever capable of solving this innovative problem.

The relatively low cost of electric energy and low maintenance costs of an electric vehicle are indisputable advantages over vehicles using an internal combustion engine as a power plant. The energy used in electric vehicles is many times cheaper than gasoline. In Iran, electricity is several times cheaper than in other countries, therefore, electric vehicles on the market should be of great interest in order to save money. Thus, according to the report of Bargh News ^[4], the nominal capacity of electricity production in the country was declared 75 thousand 365 MW, which gives Iran a significant

opportunity to lead in the field of electricity in the region. Since assuming the low price of electricity and the ability to generate consumed electricity, the transition from gasoline to electric vehicles is quite expedient.

Table 7. compares electric vehicles with 2 popular Iranian and world gasoline vehicles.

Indicator	Tesla Model S	MB-S Class	Samand Soren
Price,\$	71 070	115 800	7 700
Consumption per 100 km (in gasoline, equivalent), liter	2	13	11,5
Cruising range, km	450-500	600-800	555
Acceleration to 100 km / h, sec	3	5	14.5
Maximum speed, km / h	700	455	185
Possibility of free refueling / charging	Yes	No	No
Government support	Yes	No	Yes
Infrastructure development	Low	High	High
Security level	High	High	Middle
Noise	-	-	+
The cost of 1 km, €	0,009	0,11	0,1
Cost of service per 1 km, €	6,73	13,41	
Charge time, h	4-8	0,2	0,2
(CO ₂ emissions) g / km	12,6	39,0	E-4

Source: compiled by the author

From the table we can see that an electric car is cheaper, although it has significantly better characteristics. The only drawbacks are poorly developed infrastructure, but this problem is already at the stage of solution. However, an electric car is inferior in some characteristics to MB, and in comparison with Iranian cars, it is much better, environmentally friendly, and safe. As a result of the massive use of electric drives in automobiles, by 2050, oil consumption in the world will sharply decrease. This will bring significant losses to the Iranian budget, which is directly dependent on oil prices. As a result, the country will face problems if the economy is not diversified. In this regard, one of the first steps of the government should be to revise the policy in the automotive industry, change the priorities of the country's motorization, and take urgent measures to develop renewable energy, taking into account current trends. This should become one of the priority national projects. Pilot projects for the development of non-polluting renewable energy sources and the use of electric vehicles should be implemented in a blissful future. Only such a decision will make it possible to adequately respond to the challenges of the 21st century in the field of road transport. Otherwise,

our automotive industry will remain completely technologically backward, while others will change the entire road transport system to an innovative one.

One of the problems of modern electric vehicles is the relatively low range on a single charge. At the same time, the average charging time for electric vehicle batteries is about 4-8 hours, depending on the battery capacity and the amount of charging current. According to the International Energy Agency, at the beginning of 2020, there were just over 860 thousand connection points at charging stations in the world. And only a third of them have fast charging capabilities. Research shows that vehicles are not used for active transportation more than 90% of the time, so during this time, electric vehicle batteries can be used to serve electricity markets without damage. Navigant Research estimates that global revenue from V2G solutions will grow to \$ 190 million by 2020, and the global energy storage market will be \$ 80 billion by 2025. Another limiting factor for the mass market entry of electric vehicles is the lack of a viable and cost-effective business model. If you look at the leaders-car manufacturers of electric vehicles, GM, Tesla, Mercedes-Benz, then these manufacturers cover the unprofitability of their electric projects with revenues from the sale of traditional cars with internal combustion engines. In 2020, Ford Motor scrapped plans to produce an electric crossover under the Lincoln premium brand, incurring losses of \$ 500 million. Earlier, Dyson planned to invest \$ 2.7 billion in a new direction and acquired several start-ups in the development of technology for electric vehicles. The company even developed a prototype, but eventually closed the project. "The Dyson team has developed an amazing electric vehicle. But we just don't see how to make it commercially viable," said CEO James Dyson. Finally, the complete or partial abandonment of conventional cars with internal combustion engines can provoke a significant increase in the price of electricity and its shortages. According to BloombergNEF research, the ubiquity of electric vehicles will lead to a 6.8% increase in electricity consumption worldwide by 2040, which corresponds to the additional 1,350 TWh required to charge electric vehicles^[9].

Additional electricity will also be required to mine the rare earth metals used in batteries. All of the above facts indicate that the state has an important, but not a decisive role in expanding the electric transport market. In the era of the global economy, it is necessary to take into account many factors when developing a strategy for an innovative product to enter the market, which even claims to change the paradigm of urban mobility and solve environmental problems. The development of electromobile transport

is considered today by many countries of the world as a way to solve existing environmental problems, the possibility of forming new markets for innovative products and therefore is actively supported by the state in various ways. At the same time, the main barriers to the development of "green" transport are cost (high price for electric vehicles) and infrastructure (lack of the necessary structure for charging, replacement and disposal of batteries). Experts consider measures of state support of demand for environmentally friendly modes of transport adopted in many European countries, the USA and China, as well as technological advances in the production of batteries, which reduce the cost of the most expensive element of an electric vehicle - a battery, as the main drivers of growth in the global electric vehicle market.

The prospects for the development of electric vehicles in Iran are directly related to the general political direction in this aspect. It is important to note that the production of electric vehicles in Iran should be perceived as a new high-tech industry that is a symbiosis of transport, energy and information technology. Targeted investments in electric vehicles as a new industry create new types of goods / services and, as a result, new jobs, while solving important environmental and social problems. Thus, the development of the electric vehicle market for Iran will become one of the innovative and promising areas that will allow utilizing the existing developments of the domestic industry, creating a new high-tech industry, attracting foreign investments and technologies to the country, and solving several social and environmental problems. However, the development of electric vehicles must take place with the active participation of energy companies in the creation of infrastructure, since this infrastructure and new types of unplanned loads will significantly affect the reliability and quality of power supply.

3. Conclusions

The conclusion suggests itself: lower prices for electric vehicles will promote the popularization of this type of transport in Iran, and create demand for them. For the further development of the electric vehicle market in the country, joint efforts and the adoption of initiatives both at the state level and with the participation of private business are needed. Based on the experience of foreign countries that hold leading positions in the global electric vehicle market, the main attention should be paid to the study of such factors that determine the attractiveness of this segment for consumers, such as: economic (purchase price, charging price, number of potential buyers); political (subsidies, tax incentives, customs duties, non-

monetary incentives, etc.); technological (assortment and model range, charging time, technological innovations). The horizon of waiting for a total transition to electric vehicles may turn out to be quite distant, Iran is still at an early stage of their development, so the electric vehicle market has yet to take off, but this must be done, since this is a real world trend, and the only chance to raise the country's auto industry, while the state gets rid of from unnecessary subsidies for gasoline, and the country will have a normal fleet of vehicles with environmentally friendly clean air.

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