

# The impact of electric vehicles on the energy system of Albania for a sustainable transport

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**Abstract.** The economic crises and the increase of oil prices have brought the need to find new ways of transportation with lower costs. One of the most recent trends is the use of electric vehicles. Albania has shown its ambition to become a producer and exporter of electricity produced from renewable sources such as HPP, solar and wind energy. On the other hand, it has improved its policies favoring the increase in the number of electric vehicles. In the paper, a hypothesis related to the number of electric vehicles has been developed. If Albania will have all electric vehicles, what effect will their demand for electricity have on the Albanian energy system? Is it possible to provide the necessary amount of electricity from the current production of the country for these vehicles and what should be done to produce this amount from renewable sources of electricity? Based on this hypothesis, we will analyze the Albanian energy system for the current situation and in the future. By determining the energy demand of electric road transport vehicles, we will give suggestions on what should be done to produce the electricity needed for electric vehicles.

## 1 Introduction

Albania is a rich country in underground natural resources of fuel, but due to their poor quality and the lack of a processing industry, Albania is forced to export this amount of fuel. On the other hand, it is obliged to fulfill the demands for fuel, for road transport vehicles, from imports and as result the price of fuel dependent on the global markets [1, 2].

The major economic crises and the Ukraine-Russia war caused a large increase of the oil price, bringing a large decrease in the demand for transport on the one hand and a large increase in the costs of food and industrial products on the other hand, where the main reason was the high cost of transportation [7].

The pollution levels are further issues that require solutions. The transport sector is one of the main anthropogenic sources of CO<sub>2</sub> emissions. It accounted for 28% of total CO<sub>2</sub> emissions in Europe in 1998, while this percentage was 23.4% for road transport in the same year. In the last years, a willingness to control and decrease CO<sub>2</sub> emissions can be seen through several international initiatives, such as the Kyoto protocol [10].

This difficult situation in fuels has brought the need for people to look for other more economical ways of transport, such as electric vehicles, which are profitable due to the fact that the price of electricity is lower in comparison with the price of fuel.

Almost seven out of ten European citizens (71%) at EU level reported having travelled or having been away from home for at least one night during the same year. Furthermore, less than one out of two Europeans (46%)

who did not travel in 2012, justified their decision on economic reasons [9].

Albania energy system is based on local production, from renewable sources. From the energy point of view, the country has numerous water sources with many rivers that descend from the mountains and are quite favorable for the construction of hydropower plants [1, 2].

The increase of the demand for energy requires the production of electricity from other alternative renewable sources such as solar and wind, which, in the future, will guarantee an increase in the production of electricity.

Albania is a sunny country with more than 300 sunny days and many large international and Albanian companies are interested in building plants for the production of this kind of energy. State policies of recent times aim at facilitating and helping businesses that invest in this direction [2].

Wind energy is a good alternative to be used in coastal and mountainous areas.

All of this makes Albania to have a very good offer in renewable sources of electricity.

Albania managed to keep the price of electricity unchanged during these years of the energy crisis, and the increase of production guarantees that even in the future this price will be competitive, as the internal market will not be affected by the increase in prices energy in the foreign market.

Albania has implemented tax-free facilitation policies for the import of electric vehicles as an alternative to vehicles that work with fuel. Their number keeps on growing and by the end of 2022, we have 1245 only

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electric vehicles, 1236 with gas and electric traction and 439 with diesel and electric traction. The tendency is to increase the number of these vehicles [7, 8].

## 2 Methodology

The methodology that will be followed to evaluate the impact of electric cars in the Albanian energy system for a sustainable transport will be based on the analysis of the current Albanian energy system and its perspective. The production of electricity from renewable energy plants, such as water, solar and wind energy, will be analyzed and should guarantee the increase in production and the fulfillment of electricity needs.

Next, will be analyzed the needs of the current market for fuel for transport vehicles and how the perspective is thought to be in the coming years. The total amount of fuel consumed by transport vehicles, for one year, can be converted into power and indirectly it will be calculated the power produced by these vehicles. Supposing that the vehicles with internal combustion engines will be replaced by electric vehicles, the mechanical power will result the same.

Electric vehicles will be analyzed from the techno-economic point of view and their needs for electricity. From this analysis will be determined the quantity how much electricity will be needed to charge them and what impact these vehicles will have on the Albanian energy system if all transport vehicles in Albania will be electric, as expected in the future.

## 3 Description of the electricity production system in Albania

Albania's current energy system is based on the production of electricity from 100% renewable sources and not from other sources that are based on the burning of carbon or fossil fuels, although Albania has a large amount of coal and fuel resources.

Currently, electricity production consists of two main components.

**Table 1.** Electricity consumption in Albania [1].

Year	Consumption of electricity
2010	6,592
2011	7,342
2012	7,616
2013	7,957
2014	7,793
2015	7,265
2016	7,094
2017	7,439
2018	7,638
2019	7,612
2020	7,788
<b>Avarage</b>	<b>7,449</b>

Most of the electricity production plants are owned by the state and the rest are private operators. The production is carried out by the public company KESH

sh.a. as well as from other subjects that exercise their activity in electricity production. KESH sh.a. is the largest electricity producing company in Albania, by fully state-owned capital [2]. Most of the electricity is produced by water sources and the rest by solar power plants.

The amount of electricity produced by the state operator turns out to be an average value of 5,882 GWh for the period 2009 – 2020 [1]. The production realized for the year 2020 is 5,313 GWh.

The electricity production realized by private operators for 2020 is 2,979 GWh or about 42% of the total of electricity produced by the state operator. For 2020, the number of private operators that have produced electricity is 216 power plants [1, 2].

From the multi-year analysis of electricity consumption for the period 2010-2020, it is observed that the multi-year average is 7.44 GWh, where the highest consumption value was recorded in 2013 and the lowest level of electricity consumption was recorded in 2010, worth 6.59 GWh [1, 2].

Based on different scenarios, it is predicted that the consumption of electricity for the year 2040 will be according to three different scenarios as in the table below.

**Table 2.** Forecasts of electricity consumption in Albania [2].

Years	Optimistic scenario GWh	Real scenario GWh	Pessimistic scenario GWh
2020	7,174	7,174	7,174
2023	7,954	7,658	7,3198
2026	8,750	8,174	7,645
2029	9,478	8,726	7,971
2032	10,227	9,296	8,327
2035	10,992	9,894	8,733
2039	12,086	10,752	9,305
2040	12,360	10,976	9,454

According to the optimistic scenario, the electricity consumption values for the year 2040 will be 12,376 GWh, i.e. 41% greater than the year 2020. For realistic scenarios, these values will be somewhat smaller, i.e. 10,976 GWh [1], i.e. 35% greater than the year 2020.

Albania is also building two large hydropower plants on the Drin river cascade, where the largest number of hydropower plants have been built. The construction of these two hydropower plants will balance the production of electricity and meet the electricity needs of the country with 100% renewable sources and make the country an exporter of green energy. The objective of the Albanian government is to fulfill the country needs of energy before 2030 [1, 2].

Another important source for the production of renewable electricity is solar energy. Albania currently produces electricity from solar plants and has given permission for the construction of such plants for the production of 457,143 MW. This is an open market with more interest from many investors, since the country has about 300 sunny days a year [2].

In Albania, the annual solar radiation is high and theoretically it can provide the necessary energy for half the year for hot water. According to estimates, the cumulative area of solar hot water production systems is 24.5m<sup>2</sup>/1000 inhabitants. For 2020, the solar energy consumed for hot water is 13.46 KTon. This way ensures a great saving of electricity and still has great possibilities for utilization [2].

Albania has potential for the production of wind power, an opportunity that has not been properly exploited. However, there are plans to develop wind projects in the future. The potential of wind energy in Albania is about 2000 MW. Wind generates mechanical power through wind turbines. The coastal lowlands and the South, East, as well as the mountains in the North of Albania are good areas for wind turbines. The wind speed is 8–9 m/s in many areas of Albania [2].

For the production of wind energy in the country, there is interest from foreign and Albanian operators and investors. Currently, 5 permits have been granted for wind power plants with a total power of 15 MW, and permission has been granted for another 7 plants with a total power of 21 MW [2].

Albania, in addition to renewable sources of electricity production, has great potential in the production of electricity from thermal power plants, which use natural gas as fuel. Currently, this possibility can be used by TEC Vlore, with an energy production capacity of 100 MWh/day. Work is underway to adapt and connect it with the TAP gas pipeline [1, 2].

#### 4 Road transport and needs for fuels

Road transport is the main way of transport goods and passengers and occupies an important place in the consumption of fuels in relation to other sectors. Road transport consumes about 42% of energy fuels [2, 7].

**Table 3.** Fuel consumption by sectors [7].

2016	2017	2018	2019	2020	Description
1.917	2.070	2.077	2.067	1.848	<b>Final energy consumption KTon</b>
318	413	416	378	388	<b>Industries</b>
827	828	832	860	627	<b>Transport</b>
669	689	711	710	718	<b>Households, commerce, public authority, etc.</b>

This sector has a great growth, in the absence of rail transport as a more economical alternative.

The number of vehicles has increased year after year and currently, until the end of 2022, their number reached 796438 vehicles in total, of which 639376 cars and the rest are other vehicles for transporting goods and passengers [8].

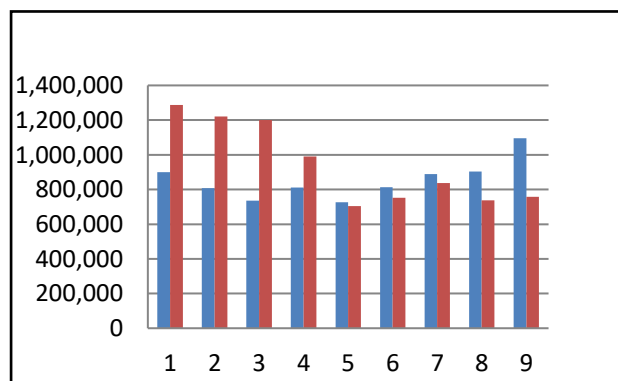
The consumption of fuel by transport vehicles has increased year by year and it can be seen that for 2020 this consumption has suffered a decrease due to the pandemic, while the year with the highest consumption of fuel was 2019 with 860 thousand tons [7].

After 2020, an increase in fuel imports is again observed. The consumption of fuel for transport is limited due to the large increase in the price of fuel [7]. The price of fuel continues to be high and unstable, showing many fluctuations [7].

**Table 4.** Trade balance of imports and exports of fuels [7].

Year	Import (Ton)	Export (Ton)
2013	900111	1286904
2014	807128	1220610
2015	735952	1199865
2016	811344	989587
2017	726335	703603
2018	812469	752338
2019	889426	836885
2020	903896	736895
2021	1094621	756988

In Western Europe, the Association of European Automobile Manufacturers (ACEA) has proposed a volunteer average fleet reduction of CO<sub>2</sub> emissions to 140 g/km in 2008. However, even if CO<sub>2</sub> emissions of each vehicle decrease during the last few years, the CO<sub>2</sub> emissions of the transport sector increase, mainly because of the increase in the passenger car. The decrease of CO<sub>2</sub> emissions is one way to minimize climate changes [11].



**Fig. 1.** Import/export graphic of fuel trade in Albania [2]

If we take a look at the demand for fuel in Albania, we notice that the demand for fuel from year to year, as shown graphically, has been increasing [7].

However, even if modern vehicles emit less CO<sub>2</sub> emissions compared to the older ones, the total CO<sub>2</sub> emissions of the transport sector increase, due to the increase of the passenger car fleet, but also because of other fuel-consuming factors. The current percentage of new diesel personal cars registrations is quite high in all

European Union (EU) countries (average value of 40% in 2003), and can even reach 60% in the case of Austria or France [12].

All this uncertainty about the future of energy fuels brings the need for Albania to take part in the new world trend to introduce electric vehicles to the market, which are set in motion by battery energy. As is known, electric vehicles use lithium batteries and have an engine efficiency of 90% and have autonomy of movement depending on the type of vehicle [4, 6].

These vehicles have a great growth in recent years and the leaders in their use are the USA, China and Europe [5].

World trends show that the number of these vehicles is increasing, occupying a very important place in the world trade of road vehicles. Thus, for the year 2022, the number of electric vehicles that were on the road exceeded 16.5 million, while in 2012 the number of electric vehicles sold was only 120 thousand [5].

Currently, electric vehicles occupy about 9% of the world vehicle market, which is attributed to technology and sustainability. Leaders in the use of electric vehicles are European countries such as Norway with 67% of the total number of vehicles, Sweden and the Netherlands with 20%, USA, Canada and China with 3.5% [5].

Currently, electric vehicles are a reality in Albania and their number increases every year. For 2020, 566 vehicles have been registered, of which 317 are electric vehicles and the rest are hybrids. In 2021, 1006 vehicles were registered, of which 370 were electric vehicles and the rest were hybrids, and in 2022, 1543 vehicles were registered, of which 675 were electric vehicles and the rest were hybrids.

Only for the period January - June 2023, 426 vehicles with electric traction were registered. In total, we have 3684 electric and hybrid vehicles or 0.5% of the total number of vehicles in Albania [8].

**Table 5.** Number of registered electric cars by year [8].

Year	Number of electric vehicles
2020	566
2021	1006
2022	1543
January - June 2023	706

The General Directorate of Albanian Customs, in implementation of the European directives, has been the first among the customs administrations of the region to embrace the environmentalist approach regarding the fiscal benefits for new electric vehicles. For this reason, since 2020, the payment of Value Added Tax (VAT) at customs for the import of new electric vehicles has been removed.

The high price and the lack of supporting infrastructure are a negative factor that prevents the increase in the number of these vehicles in the Albanian market. Another problem that needs to be solved, in the future, is the provision of the amount of electricity

needed to charge these vehicles. If we look at the trend of the number of electric and hybrid vehicles, it is increasing from year to year.

## 5 Results and discussion

All electric vehicles need electricity to charge the batteries. With the increase in the number of these vehicles, the needs for electricity will also increase and their impact on the balance of the energy system will be more visible.

Assuming Albania to have all the vehicles powered by electrical energy, can calculate how much electricity will be needed to charge the batteries of these vehicles.

It is known that every vehicle with an internal combustion engine has a certain power which is generated by the burning of the fuel and further converted into mechanical power. This power is different for different vehicles and depends on their type and destination.

It can be considered that the power of electric vehicles will be the same as the power of vehicles that use fuels.

In this way, if is known the power of vehicles with an internal combustion engine, the power of electric vehicles is known as well, so is known how much power will be needed to charge the electric cars that will be supplied from the Albanian energy system.

To calculate the total power of vehicles with internal combustion engines in Albania, must add the power of each vehicle. This is almost impossible, due to the lack of this data. To calculate the total power of these vehicles, it will be used an indirect method.

In Albania, these vehicles consume fuel and its quantity is as much as the imported quantity, since as mentioned above, the needs in the country for fuels are fulfilled by imports [7].

By calculating the average amount of fuel consumed in a year, the annual average amount of fuel can be converted into KW power. Referring to the American ENVIR215 standard, for converting the amount of fuel into power, one barrel of oil is equivalent to 1700 KWh and 7.2 barrels are equal to one ton of fuel [3].

In order of the calculation some choices have been made. The efficiency of a road vehicle with an internal combustion engine reaches up to 20-40% of the total amount of energy in effective energy [6].

Accepted the best case of energy utilization, the efficiency equal to 40%, since the largest number of transport vehicles, about 80% of them are diesel and are the consumers of the main amount of fuel and vehicles with gasoline have had a minimal effect on fuel consumption [7, 8]. Also, the efficiency of an electric vehicle with a lithium battery has been accepted as 90% [4, 6]. Is calculated:

$$E_{Barrel} * 7.2 = E_{Ton} \quad (1)$$

$$E_{Ton} * F_{Total} = E_{Total} \quad (2)$$

$$40 \% Efficiency * E_{Total} = E_{Mechanical} \quad (3)$$

$$E_{\text{Mechanical}} = 90\% E_{\text{Electrical}} \quad (4)$$

Where:

$E_{\text{Barrel}}$  is the energy possessed by a barrel of fuel;

$E_{\text{Ton}}$  is the energy that a ton of fuel possesses.

$E_{\text{Total}}$  is the total energy produced by burning fuel in one year.

$E_{\text{Mechanical}}$  is the mechanical energy produced by burning fuel in one year

$E_{\text{Electric}}$  is the electrical energy that will have to be used to produce the same mechanical energy produced by burning fuel in one year.

**Table 6.** Calculation of power from fuel combustion and conversion to electricity for electric vehicles.

Average fuel consumption K Ton/year	Energy for a Ton MWh	Total energy GWh	Energy converted into energy GWh for 40% efficiency	Total electrical energy for electric vehicles
840	12.240	102.816	411.264	45.696

From the calculations, results that the total power produced by the combustion of fuel in transport vehicles with internal combustion for one year is 10.2819 GWh. Continuing with the choices made above, from all this amount of energy, only 40% of it is converted into mechanical energy and this amount is 4.11264 GWh.

This amount of mechanical energy must be equal to the amount of mechanical power that electric vehicles will have to transmit and since the efficiency of such vehicles is 90%, then the total amount of energy needed to set electric vehicles in motion from the calculations results 4.5696 GWh, so it is 10% larger.

This is the total amount of power needed to power all electric vehicles in Albania for one year, if today all vehicles were with lithium batteries and electric traction. This amount of electricity is equal to 60% of electricity consumption for the year 2020. This is a significant amount and must be provided by the Albanian energy system.

If calculate the cost of one KWh of energy consumed by a vehicle with internal combustion engine and an electric vehicle, will result:

1. The vehicle with an internal combustion engine, knowing that the price of one liter of fuel in Albania is currently 1.8 Euro/liter, calculating 1 KWh by the current exchange rate of Euros, will costs on average 0.173 Euro/KWh.
2. The price approved by the Energy Regulator Authority of Albania for the electric vehicles, is 0.092 Euro/KWh [14].

The price of one KWh consumed by an electric vehicle is 54% less than the price of one KWh consumed by vehicles with an internal combustion engine.

This shows the usefulness of using electric energy for vehicles for the actual conditions in Albania, which is not only related to the costs of use but also to the protection of the environment for a sustainable transport.

If take a look at the progress of the number of vehicles with internal combustion, on average their annual growth is 8-9% [7, 8]. Even fuel consumption will increase as the need for these energy vehicles.

The introduction of electric vehicles into the market and the gradual replacement of vehicles with internal combustion will reduce fuel consumption until it will become zero, but on the other hand, precautions must be taken to ensure the necessary electrical energy, knowing that in the years in the future, the need for electricity will be very large, as the number of these vehicles will continue to grow in the countries of the region and beyond, being the main vehicles of transport, and as a result, the demand for electricity will increase.

The reduction of the number of internal combustion vehicles goes in the same direction as the country's strategy to implement the agreements with the EU for decarbonisation by 2030.

This is a process that requires time and the economic level of the population. Both of these factors should be stimulated by the government with different supporting policies.

The consumption of electricity from these vehicles, due to their small number, is negligible today, but the time has come to take measures to ensure the necessary amount of electricity for the future. The amount of energy that will be needed in the future, as calculated, will be considerable.

Electric vehicles are a very good opportunity to protect the consumer from high fuel prices. The cost of using an electric vehicle will be lower and this type of transport will be more sustainable and environmentally friendly.

This situation brings the need to find renewable sources such as solar energy, wind energy, etc., in addition to hydro resources, for which the Albanian government is working and must work to utilize these resources as much as possible.

Albania is a candidate country for the EU and is working to adapt its legislation to that of the EU. In these conditions, it is mandatory to take measures to adapt the legislation for electric vehicles and look at the possibilities of these vehicles being the main vehicle for transport in the future.

Considering the large amount of electricity that is needed to set electric vehicles in motion, other alternative ways to reduce this consumption should also be considered. A good alternative to save electricity in the future is the promotion of bicycles.

During the period of the COVID-19 pandemic, a very large decrease in vehicle traffic and a large increase in bicycle traffic were observed, and many cities invested in the construction of bicycle lanes [13].

Moreover, there is an expressed intention to make these new bicycle lanes permanent even after the pandemic. Therefore, the crisis of the COVID-19 pandemic seems to have become an opportunity for the promotion of active mobility. Active mobility is not so easy to promote, as the mobility patterns of commuters follow specific habits. It is difficult to fight the inertia of travel habits, and in this fight, the COVID-19 pandemic seems to have become an excellent ally [13].

Albania is in a very good position as far as these resources are concerned, with the aim of being a country that exports electricity from renewable sources by 2030 [1, 2].

Although these years there was a big energy crisis and the prices of electricity increased a lot in the world market, luckily Albania faced this crisis by not having changes in the price of energy. This is due to its internal production and compensating small quantities from imports, which have no effect on the price [1, 2, 8].

## 6 Conclusions

Frequent economic crises have influenced the increase of the price of fuels and the future does not guarantee sustainability in transport. As a consequence, alternative ways of energy sources must be found. The use of electric cars is an important step in this direction. Albania has become part of this change.

Electric vehicles, although with a modest number, is a step in the right direction and a solution to the problems that come from the use of fuels. The increase in the number of electric vehicles should also be accompanied by a planning of electricity sources.

The analysis showed that if replace the internal combustion vehicles with electric cars, the amount of energy needed to charge them is considerable, as much as 60% of the amount of energy produced in 2020.

From the calculation of the price of one KWh of energy, is seen the superiority of electric vehicles, where the price is 54% less of a KWh produced by burning fuel.

Albania is a country that produces electricity from only renewable sources and has the opportunity to increase the production of electricity to cover the electricity needs that will come in the future. On the other hand, Albania fulfills its obligations as a candidate country for decarbonisation.

What should be considered at the current stage is that the institutions become aware of electric vehicles as a reality and should take measures to make forecasts and plans for the future years to increase the amount of electricity in the national electricity balance to complete the needs of electric tools.

Planning the amount of electricity, in this case it will make a better management of the use of energy and meeting the needs from renewable sources of the country. This will result in the price of electricity being low and making it very economical to use electric vehicles in Albania.

The facilities for the import of electric vehicles should be continued and measures should be taken to build the necessary infrastructure to access the use of these vehicles in the entire territory of the country.

## References

1. Energy Regulatory Authority (ERE), *Gjëndja e Sektorit të Energjisë dhe Veprimtaria e ERE-s gjatë Vitit 2020* (2021)

2. National Agency of Natural Resources, *Bilanci Kombëtar i Energjisë 2020* (2021)
3. ENVIR215, 1-8 (2005)
4. F. Synák, M. Kučera, T. Skrúcan., Article in *Komunikacie* (2020).
5. Sh. Li Binglin, W. Muxi, Y.F. Zhang. *Infrastructure Chief Economist Office* (Policy Research Working Paper 9882, 2021)
6. J. Woo, C.L. Magee, *Int. J. Energy Res.* **44**(8), 6483-6501 (2020)
7. Institute of Statics of Albania, INSTAT, *Themes Environment and Energy* (2022)
8. DPSHTRR, *Vehicles registrations in the Republic of Albania* (Open Data, 2022)
9. E. Chita, E. Drimili, Z. Gareiou, C. Milioti, A. Vrana, S. Pouloupoulos, E. Zervas, *Promet–Traffic & Transp.* **32**(3), 347-360 (2020)
10. E. Zervas, C. Lazarou, *Energy Policy* **36**, 248–257 (2008)
11. E. Zervas, *Energy Policy* **34**, 2848–57 (2006)
12. E. Zervas, S. Pouloupoulos, C. Philippopoulos, *Energy* **31**, 2915–25 (2006)
13. D. Nalmpantis, F. Vatavali and F. Kehagia, *IOP Conf. Ser.: Earth Environ. Sci.* **899**, 012057 (2021)
14. Energy Regulator Authority, *Tariffs* (2021)