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DEVELOPMENT, CHARACTERISTICS AND PROSPECTS OF THE ELECTRIC VEHICLES

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Development, advantages and disadvantages of EV are presented in this paper. Future of the electric vehicles largely depends on the price of oil in the world market, environmental and technical characteristics of the EV drive system. As a result of the first oil crisis, in the seventies of the last century, there are some first thoughts on electric vehicles in our country. The first electric vehicle had been made in the former Yugoslavia, under the leadership of Academician A. Despić. Today, they are mostly, all electrical component needed to drive high quality and have a degree of efficiency, at a high level, so that the overall efficiency of passenger electric propulsion system (battery-wheels), is around 75%. The biggest problem remains a "reservoir of energy." Even the best batteries today have a mass energy density to 200 Wh/kg, the electric vehicles can not, in terms of performance, compete with the vehicles with conventional drive. Promising battery system with 1700 Wh/kg will be able to provide a comparative performance and to, thereby, make the transition to completely clean vehicles. As far as researches do not invent such battery, now used HEV will be solution for reducing emission which vehicles produces and fuel consumption, in order to reduce gradually dependence on oil imports.

Key words: electric vehicles, hybrid vehicles, electric drive, batteries, Li-air, TAM 2001-E

INTRODUCTION

The electric vehicle (EV), in the context of this paper, is a motor vehicle powered by an electric motor and feed from an electrochemical power sources. Often, such an electric vehicle called the vehicle a zero-emission (ZEV), because particulates are not emitted into the atmosphere. In the older literature, the electric car used the terms electromobil (EM) or an autonomous electric vehicle (AEV) [15], while in the recent literature, these vehicles are called battery electric vehicles (BEV). In addition to battery-powered, which are the subject of this work, in vehicles with electric drive include: hybrid electric vehicles (HEV), plug in hybrid electric vehicles (PHEV) and electric vehicles with fuel cells (FCV).

The EV,s have been designed, since the beginning of the present on the same principles (Figure 01). Driving electromotor, in past for DC, and asynchronous today for AC, through mechanical transmission power, drives the wheels. Electric motor speed controller, in past chopper and inverter today, regulates the speed of vehicles, in both directions and recuperative braking also. Driving electric energy is stored in battery that the vehicle carries [18].

Recharging the battery pack is done through the charger which EV also carries with it. If the vehicle has a small engine with internal combustion engine (IC) equipped with a generator, this vehicle is called HEV.

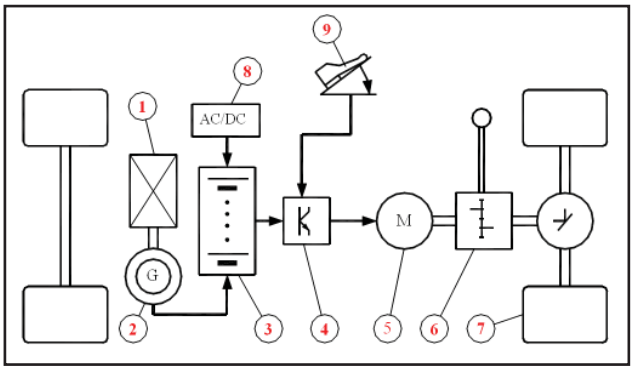

Figure 1. The basic components of the electric drive. Rechargeable battery pack (3), through speed regulator (4) supply an electric motor (5) which, through mechanical transmission (6) turn on wheels (7). If the vehicle has the IC engine (1) equipped with a generator (2), such a vehicle is called a HEV

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The beginning of electric drives used in motor vehicles had begun along before the vehicles with IC engines, and had marked the entire nineteenth century. Nevertheless, they could not stand the competition vehicles with engines that were faster, stronger and more robust. The main reason for leaving the electric drive, at the early twentieth century, lies in the fact that rechargeable battery can accumulate about 35 Wh energy and liquid fuels about 12,000 Wh. This means, that the reservoir of the classic vehicle with IC engine, which weighs about 40 kg, can store about 480 kWh energy, but in leaded of, about 300 kg about 10.5 kWh electric energy. Modern lithium-ion batteries have the option of storing about 40 kWh electric energy in the battery of the same weight. Till today, this stay the main reason, why there has been no massive production and use of EV.

DEVELOPMENT OF THE ELECTRIC VEHICLES IN THE WORLD AND IN OUR COUNTRY

Although the first electric motor drive had been made in 1838. on the river Neva, where professor Moric Jacobi [04], for a short time, powered a boat with 14 people, the beginning of creation and use of electric vehicles on the land, can be taken 1839. when Robert Davidson [14], from Scotland, had made the first vehicle powered by electric energy, in order to replace the steam locomotives, rated as heavy, noisy and dirty, due to smoke and coal. This EV on the rails, that is moved on the railway Edinburgh - Glasgow, about 130 km with one coach and incorporating more primitive electric motor, had used, as a source of electrical energy, primary battery. The achieved speed was about 6,5 km/h, and the vehicle had a modest payload carrying capabilities. A suitable battery pack had been found in 1860. year, what was enabling the commercialization of EV,s.

The first production of small batch EV had began in 1892., in Chicago. These vehicles had been very cumbersome but even so had a very good pass by customers also. They had look like of carriages (Figure 02), with large wheels, no roof, with eaves that protected passengers from rain and sun. They were used for trips, in order to perform some business, and even as a taxi to transport more passengers. Passenger's EV had the engine up to several kilowatts, which were allowed at the maximum speed of about 20 km/h, and cross a distance over a hundred kilometers on a single charge of batteries. Series DC electric motors were used, usually. Batteries have a high capacity, as far as 400 Ah, and voltages up to 100 V. Proportion of battery weight, compared to a fully loaded vehicle with passengers, was over half, which allowed so many autonomous movement radius.

Figure 2. First EV was possible to cross up to 100 km, moving with speed below 20 km/h

Disadvantage of EV had been relatively short range between battery charging. In the late of 19. century, the energy density in storage batteries had been around the 10 Wh/kg. In the early 20 century, this value had improved to a level of 18 Wh/kg, and only a decade later, 25 Wh/kg. In addition, the rechargeable stations were not widely spread, although the situation began to improve in the early 20 century. EV had been cumbrous with large mass of batteries, at contributed their small speed. But, they had met the modest needs of owners until the stronger vehicles emerged.

Discovering oil resources had led to the low price of gasoline and the advancement of technology in production of IC engines had created the conditions for rapid progress in production and use of cars with this engines. Those vehicles were allowed a greater speed and virtually unlimited radius of movement. The highways were made and people began to live "on wheels". Therefore, the development of EV remained by sidelines. Formed habits of drivers were affected by that but even with significantly improved storage batteries, couldn't completely replace existing vehicles.

Early production of EV had been made manually. The mass production of vehicles with IC engines on the moving assembly line [03] had begun in 1908. Infrastructure for EV did not exist outside of urban areas so that their drive was limited to urban areas. Another factor that contributed to the decline of EV was the invention of electric starting IC engines in 1913. year, so that were eliminated all the difficulties and dangers in putting these vehicles into service. This had resulted that, at the end of World War I, production of EV stopped and they become only a technical vehicles - serving as taxis, small trucks, vans and trolleys to transport cargo. In the late sixties and early seventies, the results were fueled by the rebirth of EV due to air pollution and oil embargo by OPEC. Recognizing that EV still can not apply for its performance to vehicles with IC, the big automakers had turned to the development of HEV. This reduced fuel consumption in city driving and emissions of exhausted gases.

Cars with IC engines were, the main means of mass transportation, marked the twentieth century. However, the consequence of this form of mass transport was a large amount an exhaust of harmful substances that pollute the environment. Search for an alternative energy source that would drive vehicles could solve out this problem.

The renaissance of EV began in the seventies of last century. A constant race in prices of oil, which had less and less, and problems related to its production and transport, were leading to repetition interest in EV. It had appeared that at that time, the coal and oil reserves quickly wearied out, predicted already. In the end of second millennium, it began to think about “energy conservation”. In addition, a constant technical progress had given the quality and effective solutions to handle the speed of electric motors, lighter batteries and lighter materials for the vehicles body.

In our country, the beginning of the EV development was related to commercial “TAM 2001-E” and Bureau of autonomous electric vehicles of the Institute of Technical Sciences SASA, in the mid-seventies. The first EV, in the former Yugoslavia, and the Balkans, called “Commercial autonomous electric vehicle” was built in 1976. under the leadership by Academician Aleksandar Despić. EV for bread transport,“TAM 2001-E” (Figure 03), had a DC drive rated power 27kW, thyristor chopper and lead battery voltage 108 V and capacity of 350 Ah The vehicle had a top speed of 42 km/h and autonomous movement radius 48 km [21]. This vehicle had initiated several attempts of making delivery EV. So, the Institute of chemical power sources (IHIS) had reconstructed, in the 1979th, the delivery vehicle “Zastava 435” which was registered and driven.

Figure 3. The first EV in the country had DC series motor 27 kW and could reach speed of 42 km/h, battery voltage 108 V, a capacity of 350 Ah which allowed radius of the 48 km

The first passenger car with an electric drive that appeared in the streets of Belgrade, was made in 1980, by professor Zoran Stojiljkovic. During the oil crisis, this vehicle “Trabant” had been used about 4 years, everyday. Original design of the drive transistor and power regulator, proved as a reliable and qualitative, and allowing the vehicle to move about 20,000 km. With the electric motor, rated power of 4 kW, a transistor chopper and storage batteries voltage 54 V and capacity of 240 Ah, the vehicle could reach a speed up to 60 km/h. After that, there were several attempts to make a passenger car by enthusiasts or professionals, but it has never been realized to a series production.

Interest in EV,s in our country had been rapidly increased during the oil crisis and during the sanctions. At that time, interest had increased especially in various EV,s for special purposes. In addition, there was interest in the floating EV,s, so, the firm “Melbat” made a several environmental and tourist boats, on the river Sava powered electrical rated power in range 1,5 - 7,5 kW. The first commercial electric car made the same company, too. It was the reconstruction of “Lada Niva”, at the end of 1994, and it was for

every day use, in municipal purposes. This vehicle with the mass of 1.820 kg, with the electric motor 5 kW, the battery voltage 72 V, and capacity 350 Ah could reach the top speed of 32 km/h. At the end of 1996, the vehicle "Lada" was reconstructed with a more powerful motor power of 12 kW and could develop the speed of 65 km/h.

Within the Institute of Technical Sciences of SASA, in July 1996, were reconstructed and registered two EV type Yugo-E. The vehicles were able to develop a maximum speed of 75 km/h and a radius of autonomous movement of the 45 km, with the electric motor of 6.3 kW, 72 V of storage batteries voltage and capacity of 143 Ah, EV were thoroughly tested and provided data on energy efficiency in the amount of 5 km/kWh on the open road, and the specific energy consumed was 0,2 kWh/km. In city driving, the results were about 10% weaker.

At the end of the 20. century, has begun the construction of EV with the alternative electric motors. The company "Raskovnik" made some very interesting and light EV in range of electric power 2 – 4 kW. Independently, in cooperation with the institutes "Crvena Zastava" and Electrical Engineering Faculty, under the leadership of Professor Slobodan Vukosavić, vehicle Yugo-Electra is reconstructed with a driving motor rated power 7.5 kW.

In our country, development of EV had been gradual, according to "step by step" system. Although there were a number of smaller and larger trials, virtually the only program that found commercial application was so-called "Black Lada".

Big support to development of EV had given the United States, where was formed an anti air pollution program in 1989. with the aim of preventing air pollution. In Los Angeles, had passed a law that until 1998 the 2 % of vehicles have to be to "zero emissions" of harmful substances ZEV. In some countries, for example in Switzerland, local regulations on air pollution were also given support to the implementation of EV.

The Law about Prevention of air pollution and economic opportunities the United States, urged the automobile manufacturers to engage in making EV, so the company General Motors made the first real EV named EV-1 [06], which, was producing in a series later satisfied most of the drivers habits. The vehicle has an asynchronous motor and inductive charger with no possibility of electric shock. In addition, it was made the first station for recharging batteries in California.The modified vehicle type EV1 had reached in 1994. the largest measured speed of EV from 295km/h.

Understanding that EV couldn't quickly replace existing vehicles, U.S. president made a new plan. One of the objectives of the plan, which Mr. Obama described as "historical", is to replace the present complicated system of federal and state laws and regulations on exhaust emissions and fuel economy. Announcing the plan [05], Mr. Obama said that "the status quo is not acceptable anymore" as it creates dependence on foreign oil and contributes to climate changes. Effects of new measures will be as if the roads in the United States removed 177 million vehicles and state saving in oil as much as when was imported from Saudi Arabia, Venezuela, Libya and Nigeria in 2008. The work on the application of HEV has been accelerated.

PROBLEMS WITH CONVENTIONAL MOTOR VEHICLES

Modern transport with conventional motor vehicles contributed to overall economic progress but also caused the problems of environmental pollution and energy supply difficulties – especially, in times of energy crisis.

Air pollution from IC engines that use oil products is not limited to the immediate surroundings, but there are also regional and global significance. Air pollution by burning fuel in motor vehicles becomes a major problem of urban areas, worldwide. Emissions of pollutants, originated from motor vehicles, caused by the level of traffic, road negotiability and weather conditions. Pollutants from exhaust systems of motor vehicles due to the atmosphere depend on the composition, combusting and volatility of fuel.

In terms of impact on global atmospheric pollution and associated problems, the most important consequence is increase of global mean temperature. From the standpoint of global warming, the greatest danger is carbon dioxide, an unavoidable ingredient of combustion of petroleum products [26].

In order to reduce air pollution from vehicles and to build more economical cars, to combat global warming and reduce U.S. dependence on oil, new standards are preparing in the U.S., to re-

duce emissions of cars and fossil fuel consumption. The intention of the administration is that these measures, by 2016. decreased for 30% the emissions from vehicles. It is expecting that the new proposals increase as the price of new cars, in an average of about U.S. $ 1,300, by 2016. year.

Energy consumption in transport has a steady growth, so that today it represents nearly half of oil consumption. To reduce consumption of oil and oil products is the economic and environmental necessity but it can create a technological problem. In this situation, the development of environmental facilities and EV are becoming one of the possible solutions.

As world population are increasing, so and need for all types of energy. Today, more than half, 56 % of the world energy consumption is in the U.S., Japan and the European Union. As these countries are relatively poor in energy sources, they represent the largest energy importers. In addition to high economic dependence on oil and its derivatives, there are constantly in present the problem of protecting environment, reduce emissions and greenhouse gases. Estimates indicate that due to increasing consumer demands particularly because of increasing demands for transport of goods and people, demand for energy is constantly increasing by about 1.5 to 2% per year. It is expected that in the period from 2007. to 2035. the energy needs will increase by about 47% [26].

Although the share of oil, in total primary energy percentage is decreasing, the production and consumption of oil is generally increasing. In finding a new sources have been investing great efforts but inevitable facts are indicating that this form of energy has been slowly reducing and scientists expect that, for some time, will dry up sources of this energy. Forecast growth in consumption of liquid fuels, by end users, according to the U.S. Energy Information Administration (EIA) [11], shows that the consumption of liquid fuels, in this period will increase from about 13,7 million tons per day in 2007. to 17,6 million tons per day in 2035, or 28,5%. The price of oil had reached the maximum value of 147 dollars for a barrel (159l) in 2008, and although, there are forecasts that will not exceed the value of 133 $ to 2035 years, less optimistic forecasts are indicating that it may reach a value over $ 200. Earlier made analysis, suggests that oil price of over $ 100 per barrel, and is creating real conditions for broader use of EV. Oil becomes the cause of wars and on the other side, directly affects increasing in its price in world market.

As production so and consumption of electricity will have, from 2007 to 2035, the highest increase of all other forms of energy, for about 87%.

ADVANTAGES OF ELECTRIC VEHICLE AND BATTERY CHARACTERISTICS

EV, electricity needed for power derives from batteries, which carry with itself, and it has many advantages over cars that have power with IC engines [20, 19, 1]:

- There is no need for petroleum derivatives
- It is, the environmentally absolutely accepted
- It does not produce exhaust gases
- It has a quiet operation
- Vibrations in operation are at the minimum
- It is easy to manage
- There are no problems with starting, in the winter time
- It is immediately ready for operation at full power
- Operational characteristic of the electric motor is very good
- There are possibilities of overloading, especially by accelerating
- Recuperation of electric energy by breaking regime
- It has a high efficiency
- It requires a little maintenance and
- Operation costs are low.

It is normal that electric drive has a certain disadvantages, compared to existing vehicles: reducing speed, reducing the autonomy of operation without recharging, possibly increasing the mass of the drive device, and vehicle and batteries recharging problems.

The main problems in the application are rechargeable batteries. It is expecting, that significantly greater improvement.

Key criteria's for broader use of the battery are performance, such as energy density, volumetric energy, the price of investment, duration (measured by years and kilometers road EV), and safety.

The energy density of gasoline is 13,000 Wh/kg, which is shown as "a theoretical energy density" (Figure 04). The average utilization rate of passenger cars with IC engine, from the fuel tank to the wheels, is about 13% in US, so that "useful energy density" of gasoline for vehicles use is around 1.700 Wh/kg. It is shown as "practical" energy density of gasoline. The efficiencies of autonomous electric propulsion system (battery-wheels) is about 85%.

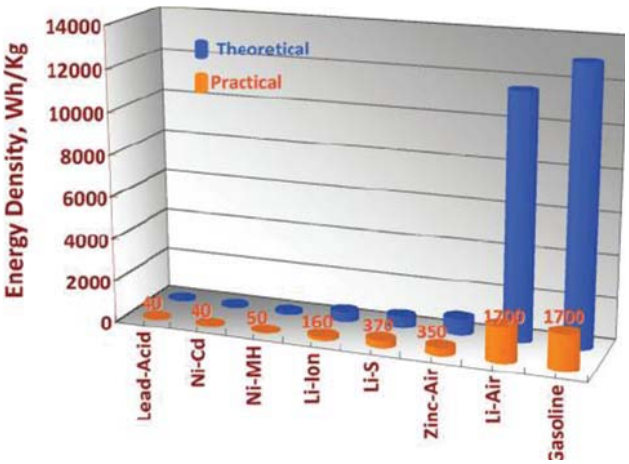

Figure 4. Image Energy density of different types of batteries and gasoline [07]

Significantly improvement of current Li-ion energy density of batteries is about 10 times, which today is between 100 and 200 Wh/kg (at the cellular level), could make that electric propulsion system be equated with a gasoline powered, at least, to specific useful energy. However, there is no expectation that the existing batteries, as Li-ion, have ever come close to the target of 1,700 Wh/kg.

Oxidation of 1 kg of lithium metal, releases about 11,680 Wh/kg, which is slightly lower than gasoline. This is shown as a theoretical energy density of lithium-air batteries. However, it is expected that the real energy density of Li-ion batteries will be much smaller.

The existing metal-air batteries, such as Zn-air, usually have a practical energy density of about 40-50% of its theoretical energy density. However, it is safe to assume, that even fully developed Li-air cells will not achieve such a great relationship, because lithium is very lightweight, and therefore, the mass of the battery casing and electrolytes will have a much bigger impact.

Fortunately, the energy density of 1700 Wh/kg for a fully charged battery pack, fits only 14.5% of the theoretical energy content of lithium metal. It is realistic to expect, achieve mint of such energy density, at the cellular level, considering the intense and long team's development [07]. Energy density of complete batteries is only a half of density, realized at the cellular level.

It is interesting to mention, that the significant results in development this type of battery are achieved in the laboratories of the Institute of Electrochemistry ICTM and the Institute of Technical Sciences SASA, where they were working on development of aluminum-air battery with the aluminium anode alloyed with small amounts of alloying components and the neutral aqueous solution NaCl, as the electrolyte [02]. The prototype of such batteries, had achieved a power density of 34/39 W/kg, and energy density of 170-190 Wh/kg, by optimal current density between 50 and 100 mA/cm2.

Volumetric energy (in Wh/l) in the storage batteries is an important feature of the design considerations also. This requirement is the best expressed by condition that there is a maximum capacity of 300 dm3 (family car) for battery pack and auxiliary systems. A driving range of 500 miles (800 km) requires that the reservoir of energy, store energy of 125 kWh (with power consumption of 250 Wh/km), so that the volume of 300 dm3 is limiting specific gravity of the battery pack, including space for air circulation, must not be less than 0,5 kg/dm3.

Power density: While Li-air systems imply an extremely high energy density, their power density (measured in W/kg of batteries weight) is relatively low. The prototype of Li-air cells achieves current density, in average 1mA/cm2, which is insufficient and is expecting significantly increase of the current density for at least 10 times.

One way to achieve the required power density is the creation of a hybrid electric drive system, where a small, high power battery, for example, on the basis of Li-ion technology, would provide the power in short periods of high demand, such as it is acceleration. Supercapacitors could be used instead of these batteries.

Duration: The current Li-air cells show a possibility of full charge cycles, only about 50, with less capacity loss. Future research efforts must be directed towards improving the accumulated capacity in multiple discharges. In addition, the total number of charge cycles and discharge do

not mean to be very large, due to the high energy capacity of Li-ion cells. For example, a battery, designed for duration of 250,000 km, and projected to cross the EV radius of movement of 800 km, should be charged only 300 times (Full cycle equivalent) [22]. It is necessary to keep in mind that a lot of air will go through the battery during operation, and even a short-term accumulation of moisture, can be harmful to duration.

Safety: EV batteries will be, especially in the beginning of the application, complying with extremely high safety standards, even more strictly than at gasoline car.

Price: Design requirements of high-capacity battery for the drive EV are quite strict, but they are quite well defined. They will serve as guidelines for the scientific research, conducted on the Li-air battery system. Batteries for EV power have been just carrying out the transition from nickel metal hydride to Li-ion batteries, after years of researching and developing. Transition to the Li-ion batteries should be viewed in terms of a similar development cycle. It is known that, the price of each product, decreases with increasing mass production. It is expecting that the EV prices will decline, because of falling down prices of Li-air batteries, including the price of EV. However, support to introduction of new vehicles in traffic would be systematically addressed.

Accommodation of batteries as a power source, for vehicles with electric drive, is a big problem also depending on technological solution of batteries. As it can be seen, in table 1, [09] lead-acid batteries have a low energy, per unit mass and volume and a relatively small number of charge cycles. In contrast, modern Li-ion batteries and NaNiCl, have significant energy capacity, with a larger number of charges and are of a stable voltage. However, the latter ones are sensitive to warming and may have an energy loss up to 7.2%.

Battery duration should be, always, taken into account, when their price is consideration. The duration depends on several factors, such as how often the vehicle is in use and how many times the batteries have been filled up. In Table 1, there are data on duration expectancy of certain batteries types and price per unit of energy.

Table 1. Characteristics of different types of batteries

Battery types	Energy density Wh/kg/ Wh/litar	Spec. power W/kg	Number of rechar. cycles	Energ. efficiency	Energ. density, % based on PbO	Self discharge for 24 hours	Duration years	Price US$/ kWh
PbO	40/60-75	180	500	82%	100%	1%	2,5-4	100-150
NiCd	50/50-150	150	1.350	72,5%	150%	5%		
NiMH	70/140-300	250-1000	1.350	70,0%	175%	2%	5-7	300-500
Li-ion	125/270	1800	1.000	90,0%	313%	1%	5-10	>>1000
Li-ion polymer	200/300	>3000	-	-	500%	-		
NaNiCl (Zebra)	125/300	-	1.000	92,5%	313%	0%		

PROSPECTS OF ELECTRIC DRIVE OF EV

Car driver's habits and their way of living and work cause the appropriate technical features and characteristics of the car. EV does not have yet enough energy to compete the existing vehicles, with IC engines. It means that EV does not have enough energy for consumers such as air conditioners, for example (Figure 05). Reservoir of energy in EV can't be quickly recharged and there are no distribution stations to supplement electricity.

Testings of EV, made in our country, show that reconstructed EV with 300 kg batteries with a specific electric energy of 35 Wh/kg, can reach 50 km and to developing maximum speed 75 km/h [10, 18]. EV can achieve range over 150 km and to develop maximum speed of 130 km/h with more quality Li-ion batteries [10, 08]. Conditions for rapid transition to vehicles which would be fully able to replace existing vehicles, when battery of much higher specific power, will develop.

It will take some time, until then. As an interim solution, have been producing a HV with a larger or smaller batteries, so they are called "pure HV" or "plug-in HV". Sometimes the electric drive is used only to improve acceleration and braking energy stored in electrical energy, but in any case, gets more efficient use of fuel and reduced emissions of particulates (Figure 06). Towards the new standards for passenger vehicles, the fuel economy must be reduced to a level of 15 km/l fuel, which represents the consumption of (6.6l/100km) [05].

Figure 5. Typically EV, as the producer MiEV Mitsubishi Motors [08], is shown at the Belgrade automotive Fair in 2011., has exterior dimensions less than 3.5 x 1.5 m and 35 kW AC electric motor, developing a maximum speed of 130 km/h and Li-ion accumulators that allow a maximum range to 150km

The world's leading car manufacturers participate in the race, trying to develop EV successfully. The U.S. government has recommended to manufacturers, as reducing emission which vehicles produces so and fuel consumption, in order to reduce gradually dependence on oil imports. In Detroit, are preparing for the production of EV,s all three major car manufacturers General Motors (GM), Ford and Chrysler. In the U.S. automotive industry, widely accepted solution is a highly sophisticated one the electric drive with IC motor, which increases the radius of movement. It is believed, that the share of vehicles with alternative drives in selling new vehicles in the world, will grow up, but it is, also, considered that in the near future, will be dominance of vehicles by IC engines.

Figure 6. The most famous HV, Toyota Prius, which is registered for 5 passengers, has a IC engine power 73 kW, electric motor power 60 kW, so that the urban driving consumption is 4,6l/100km, on highway 4,9l/100km, and combined 4,7l/100km.

CONCLUSION

It is believed that future, so and past belongs to EV [23]. Even there have been constantly finding new sources of liquid fuels, their exploitation are becoming more and more expensive and there existence less and less, in the world. It is necessary, to preserve oil as a resource for other industries, where there is no alternatives. On the other hand, electricity has been usually enough. If it will start soon, running more efficient renewable energy, it may open a possibility of its cheaper production. It means that environmental and economical conditions will extend use of EV,s.

Almost, all the problems related to production EV technology are resolved well enough, except energy storage. New electrochemical sources

upon Li-air base, made enough a cheap and compact, would allow, in the near future, transition from vehicles that use liquid fuel to EV [07]. EV batteries price seems more expensive than buying a suitable vehicle with the classic drive. Accordingly, the price of EV,s, by kilometer, comparing with IC vehicles powered, would be the same. Fuel for EV is cheap, maintenance is minimal, and the duration of electric motors is significantly longer than the IC engine. Taking into consideration the price of air pollution, gas emissions that contribute the "greenhouse gases" effect and other market conditions, factors, that society have to pay, it is believed that the time of EV is certainly coming.

Probably, it will not be a rapid transition from IC vehicles to EV vehicles [25]. The latter ones are still inferior and can not satisfy potential customers, in all circumstances. Batteries development has been made great progress, but still, not enough. The introduction of EV into service, no doubt, pure the environment, where vehicles are used. However, in case of EV that are supplemented with electricity, emissions of carbon dioxide only transferred it to the combustion of fossil fuels, in power plants. The introduction of renewable energy sources, such as the use of solar, wind and hydro resources, will be providing a real transport of people, with zero emissions. In the world, currently are making a great efforts, to move in that direction.

As a transient solution, to clear EV, there are developing HV,s today. This vehicles are operating like EV in urban areas, and outside the city, it is used IC power engine or recharging batteries. In this way, HEV contribute, greatly to the ecology, affecting the economy of operation [24], and at the same time, intensively developing new types of batteries as a promising reservoir of energy for application in EV.

The most recent technology developments and the clear interest of many European countries have strongly accelerated the mass market introduction of EV. Probably, the most effective measures for the implementation of the environmentally friendly vehicles are economic measures[13]. Taxes and fees are economic measures in the transport sector that can reduce pollution and preserve the clean environment [12].

The Renault-Nissan Alliance estimates that around 10% of the world automotive market will be full electric by 2020 [16], and even more in Europe (10 to 15%) if the necessary conditions are fulfilled (i.e. infrastructure, public incentives). Hybrid one will be an interim solution bridging the way to pure electric cars. As regards hydrogen vehicles, the Alliance Considers this technology as a medium to long term development.

On informal Competitiveness Council in San Sebastian, at 2010, ACEA president, Dieter Zetsche [27] was clear: The question is no longer if diesel and petrol will be replaced by electricity and hydrogen as the dominant means to fuel a car. It's just a question of when.

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ABBREVIATIONS

AC	Alternating current
AEV	Autonomous electric vehicle
BEV	Battery electric vehicle
DC	Direct current
EM	Electromobil
EV	Electric vehicle
FCV	Fuel cell vehicle
GM	General Motors Company
HEV	Hybrid electric vehicle
IC	Internal combustion engine
Li-air	Lithium air
Li-ion	Lithium ion
NiMH	Nickel-metal hydride
OPEC	Organization of the Petroleum Exporting Countries
PHEV	Plug-in hybrid electric vehicle
ZEV	Zero emission vehicle

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