# DA LI HIBRIDNO VOZILO REALNO POMAŽE U UŠTEDI ENERGIJE?

## DOES HYBRID CAR REALLY HELPS IN ENERGY SAVING?

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*Hibridno vzilo je opremljeno sa dva nezavisna motora: motor sa unutrašnjim sagorevanjem i električnim motorom. Svaki motor je sačinjen od hiljade komponenti, koji sigurno nisu nađeni u prirodnom obliku, već mnogo energije, alata i materijala mora biti utrošeno u njihove proizvodne cikluse. Cena hibridnog vozila ovde nije predmet diskusije.*

*Istrošene baterije obično pripadaju štetnim materijalima, koje nije lako reciklirati, već suprotno, one zahtevaju visok nivo znanja iz (elektro)hemije, utrošenu energiju, obrade materijala i novca. Odatle, glavno pitanje još uvek je: koliko hibridno vozilo u celom ciklusu od proizvodnje, korišćenja i kada postane otpadni materijal, doprinosi uštedi energije?Pob0ornici zaštite životne sredine daju dugačku listu razloga za recikliranjem baterija iz hibridnih vozila ili ostalih izvora. Obnovljeni materijal se može upotrebiti u izradi novih baterija.*

***Ključne reči:*** *hibridno vozilo; potrošena energija u proizvodnji; istrošene baterije; energija za recikliranje*

*Hybrid car is equiped with two independent motors: combustion engine and an electric motor. Every motor is made from thousand components, which obviously were not found as native components but a lot of energy, tools and materials must be engaged in their production cycles. The hybrid car price is not a matter in this discussion.*

*Waste batteries usually belong to a hazardous materials, which could not be easilly recycled, just contrary, they need high level of knowledge from the (electro)chemistry, spent energy, material treatments, and money. So, the main question still is: how hybrid car in entire cycle from production, usiness and when became a waste material, contributes to enegy savings? Environmentalists give a long list of reasons to recycle batteries from hybrid vehicles or other sources. The recovered materials could be used for making new batteries.*

***Key words:*** *hybrid car, spent energy in production, waste batteries, energy for recycling.*

## 1. INTRODUCTION

One of the main concept of a hybrid motor is in providing the sustainable exploration, and this a reason why this type of vehicle posses one fuel engine and another electromotor with many (electro) chemical devices. By the way, the hybrid motor usually is double weighter than vehicle with one motor. In the periode of using is absolutely clear that the electrovehicle does not emmits a $CO_2$ or other harmfull exhaust gasses. No duobt that the electromotor offers high energy efficiency during exploration periode.

Any of these engine contains a pretty large number of components: let say that each motor is composed from a few thousand components. The cycle in any product must contin next main stages: designing (construction), production, montage and at the end the exploation. But, also must be clear that the exploration itself is not a final stage in the cycle of existing a vehicle – the final stage is recycling (on anyway) of such vehicle.

No doubt that when hybrid vehicles are in use, the emissions of smog forming pollutants, Fig. 1a), as like $CO_2$ which is reduced up to 90%. The case without pollutant, as in Fig. 1b), still is unpopular.

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a)


b)

*Fig. 1. Emission of pollutant gases from a fossil fuel engine a) and environmentaly safe solution b)*

When the petroleum has had a low cost the hybrid car seemed just unnecessary, and when the price of petroleum is increased many automakers accept that hybdrids in the late 2000s are an imporntnt segment at the automotive market.

## 1 CONCEPT OF HYBRID CAR

It´s clear that the hybrid vehicle achieves and low emissions than conventional internal combustion engine. A hybrid car, in the simplest terms, combines two different energy sources: the electrical energy stored in batteries and fossil fuel (petrol or diesel) engine to move the car. There are a few concepts and types (over hundred) in producing a hybrid car, some of them are shown in Fig. 2.

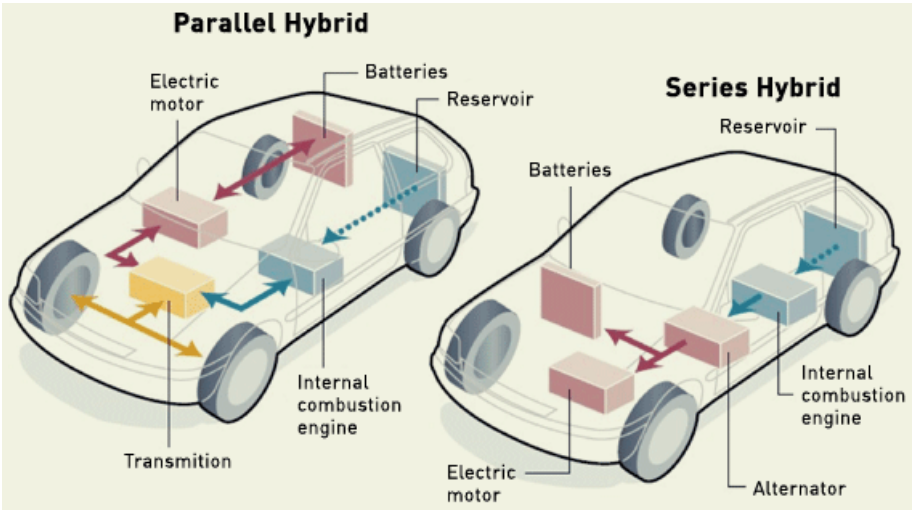


*Fig. 2. Concept of two types of hybrid vehicles*

The fossil fuel engine in hybrids is used for charging and maintain battery. Sometimes the electric motor does all the work, sometimes it's the gas engine, and sometimes they work together.

Chemical processes in battery are pretty complex, one of them is based on Li-sulfur, which schematic illustration of the reduction processes at the negative electrode during discharge of a $Li/S_8$ battery is shown in Fig. 3.

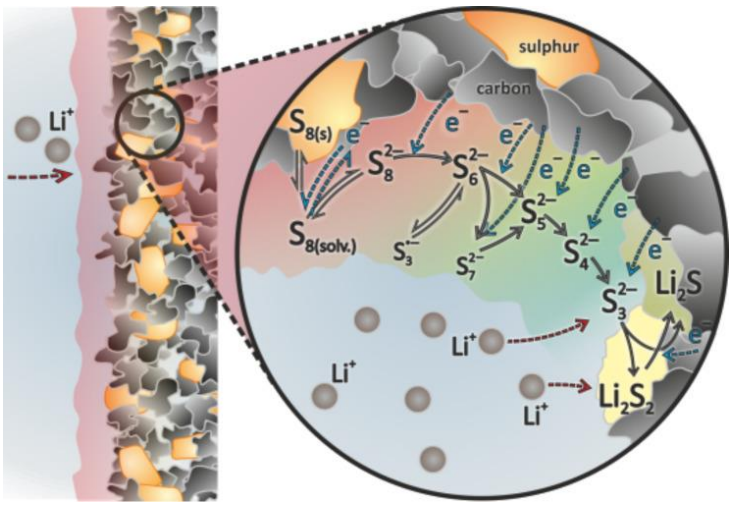


*Fig. 3. Part of process in Li/$S_8$ battery [1]*

Reduction of sulfur $S_8$ proceeds over several soluble polysulfide intermediates ($Li_2S_x$) before the final precipitation of solid phases, $Li_2S$ and eventually $Li_2S_2$ occurs. Lithium–sulfur and lithium–oxygen cells have attracted enormous interest in the last fefteen years.

These batteries must be large or present in great number and costly to be able to travel long distances. Now, batteries in a car have a limited range of 130 to 500km. Batteries normally differ in how long they last, but many of them may last from five to 10 years.

On Fig. 3. is presented just one examle, but there are wide versatility in using of cathodic materials, as like: $Na_{0,7}CoO_2$; $Na_{0,7}CoO_2$; $Na_{0,6}Ni_{0,25}Mg_{0,1}Mn_{0,65}O_2$, and many others. So, sodium-ion batteries now are not a theoretical concept. If graphene electrodes were to be incorporated into lithium batteries instead of the graphite anodes commonly used today, it might be possible to achieve significantly higher storage capacities.

## 2 PROBLEMS IN RECYCLING OF WASTE HYBRID CAR

Crucial question is: what after life of used batteries? Recycling of used (dead) batteries still are concentraded in small number of academic researchers/groups, who working independetly.

Sometimes, but frequently, it is underlined that conception of a hybrid motor enables a reduction of consumed recources. But how the doble motor at vehicle vehicle can reduce the costs of used material, and components? Further, what about the spent energy for production of a hybrid car? Those are open questions. A lot of efforts must be done in recycling procedures of used electrochemical components, first of all for the waste (dead) batteries. For suchr recycling must be used many chemicals, a lot of them in their nature are harmfull. There are not yet known all procedures for providing such chemical processes or the total sum of used energy for production and recycling proceses of a hybrid car. It seems that now there is no obligation for sustainable recycling of used batteries! From that, how we can talk about the reduction of consumed materials, energy for their production and recycling of a hybdid motor? Does the human life is too cheap to produce more expensive hybrid car with still unknown recycling procedures?

It is clear that emission from fosill fuel motor engines contain harmfull gases, but until now there are no serious wornings about harmull effects of waste batteries. High efficiency (in the sence of operating parameters) of new materials could not be neglected, however. The job about hybrid car is not finished by their production, it is clear that there are more activities after their production and usiness. From the mentioned reasons must be provided many researches for understanding technical, ecogical and economical effects in providing the obvious recycling processes of used batteries, condenser, and/or other (electro)chemical components.

Many ordinary batteries as regular alkaline, manganese, and carbon-zinc batteries are not considered as hazardous waste and can be disposed of with ordinary trash. Other common single use or

rechargeable batteries such as lithium and button batteries are recyclable, but access to recycling may not be available in all locations.

It is not enough to declare "DISPOSE PROPERLY USED BATTERIES" but no way that "BATTERY MUST BE RECYCLED" should exist. For recycling of dead batteries is needed pretty solid knowledge about (electro)chemistry, technology and even metallurgy. Most of the batteries that for recycling undergo to high-temperature melting-and-extraction, or smelting, quite similar processes to ones used when their resources have mined.

### *2.1 Health impact*

Lead and cadmium are toxic heavy metals that can cause severe health effects depending on the total concentration a person is exposed to over time. The effects of cadmium depend on whether it was ingested or inhaled. Some of waste components may cause cancer. The effects of lead and cadmium exposure on fetuses and young children include delays in physical and mental development, lower IQ levels, shortened attention spans, and increased behavioral problems.

In addition, sodium-ion technology does not consume any scarce resources. The production of the cathodes does not require rare lithium salts; simple table salt is sufficient. As suggested [1-4] powerful anodes can be produced from lignite, wood and other biomass. Cobalt or similar rare substances are also not required.

Some safety and environmental regulations could not be accepted in Europe or Western countries as like in China [5], one of the greater producers of batteries.

### *2.2 Raw materials increasing costs*

In manufacturing of hybrid car many rare materials (dysprosium, neodymium and another rare earth metals) are used. The resources in the Earth´s core of those materials are limited, their costs are increasing, and in the future is expected a further rise. The prices of two common cathode metals, cobalt and nickel, are of the most expensive components.

Another option is to use alternative fuel composition (i.e. biofuels) in conventional fossil fuel-based vehicles, making them go partly on renewable energy sources.

The plants are also costly to build and operate and require sophisticated equipment with well trained stuffs to treat harmful emissions generated through the smelting and other (electro)chemical processes. And despite the high costs, these plants don't recover all valuable battery materials.

## 3 CONCLUSION

New hybrid motor in exploatation undoubtely offers some advantages, one of them is low emission of pollutant gases. It is evident that more energy is needed for producing hybrid than one conventional car.

Replacing the waste battery could be provided pretty fast and this activity is not a problem, while the recycling of dead battery is something another.

The efforts for improving the recycling of Li-ion and other batteries still are concentrated in a relatively small academic reseaerch groups. The recycling of used components from an exhaust motor is pretty well known and established, but this could not be said for many components, firt of all at batteries as main component from an elestochemical device.

So, the problem of using and recycling of dead batteries seem to be a classic chicken-and-egg problem. And more scientists have started to study the problem, expanding the pool of graduate students and postdoc, well trained in battery recycling but not from economy, law or managers just from the science.

## 4 References

[1] Ph. Adelhelm, P. Hartmann, C. L. Bender, M. Busche, Ch, Eufinger, J. Janek: From lithium to sodium: cell chemistry of room temperature sodium-air and sodium-sulfur batteries, Beilstein J. Nanotechnol, 6/2015, p. 1016-1055.

[2] T. Perveen, M. Siddiq, N. Shahzad, R. Ihsan, A. Ahmad, M. Imran Shahzad: Prospects in anode materials for sodium ion batteries – A review, Renewable and sustainable energy review, 119/2020.
[3] www.novatoyota.com
[4] Zoran Karastojković, Nikola Bajić, Milesa Srećković, Zoran Janjušević: Potrošnja energije i potrebe za obrazovanjem kadrova, Zbornik radova sa VII Međunaarodne konferencije o obnovljivim izvorima energije, Beograd 2017, p. 77-82.
[5] Emma Woolacott: What will happen to all the dead batteries", BBC News 27.4.2021.