NOVE TEHNOLOGIJE ZA ENERGETSKE UŠTEDE U TRANSPORTU

NEW TECHNOLOGIES FOR ENERGY SAVINGS IN TRANSPORT

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Tehnološki razvoj u oblasti transporta postaje sve značajniji za mnoge životne sfere, privredu, domaćinstva i javna dobra. Usled realnih problema sa nedostatkom energetskih izvora koji moraju da se uvoze, zbog finansijskih poteškoća i prilagođavanja na svetskom tržištu, važan fokus je na transportnim tehnologijama i motorima koji koriste različite energente.

U radu se analiziraju postojeće tehnološke operacije, mašinske konstrukcije i elementi u motorima koji prilagođavanjem, tranzicijom izvora, supstitucijom resursa i prostora za transport, mogu da doprinesu održivom korišćenju prevoznih sredstava, uz energetske uštede, efikasnost korišćenja alternativnih izvora energije, automatizacije i uvođenja Energetics of Things.

***Ključne reči**: tehnologije, energetske uštete, transport, obnovljivi izvori, energija*

Technological development in the field of transport is becoming increasingly important for many spheres of life, economy, households and public goods. Due to the real problems with the lack of energy sources that have to be imported, due to financial difficulties and adjustments in the world market, an important focus is on transport technologies and engines that use different energies.

The paper analyzes existing technological operations, machine constructions and elements in engines which, by adapting, transitioning sources, substituting resources and transport space, can contribute to sustainable use of vehicles, with energy savings, efficiency of alternative energy sources, automation and introduction of Energetics of Things.

***Key words**: technologies, energy savings, transport, renewables, energy*

1 Introduction

All activities should correspond to society's aspirations for people to live better, which largely depends on the increased needs of the population in various areas, as well as in scientific and research areas that should respond to given needs in a timely manner. Accelerating the process of urbanization increases the need for fast, efficient, and cheap transport, regardless of the sector under consideration. Consumers want products available at all times, and the manufacturing industry wants raw materials to be JIT (Just-In-Time), with both groups aiming to pay less. If we look at the types of transport on land, water, and air transport, road transport can be technologically modernized with the help of new technological solutions, which include artificial intelligence, renewable energy resources, integrated technological solutions, and Energy of Things (Energy of things). In order to meet the needs of the growing number of inhabitants, the most rational solution is the moderate consumption of resources, so that energy efficiency is achieved by introducing new technologies, renewable energy sources, and integration through information systems.

2 Contemporary trends in transport

Transport consists of necessary activities that transfer, store and deliver objects from one place to another. In a narrower sense, transportation is thetransfer of things from one place to another. There is a difference if passengers, goods, raw materials, materials, or documents are transported, whether the transport takes place within the production or service industry, whether it serves for

distribution, sale, or final use, and whether it is exported or raw materials are stored and cooled. Land transport is the oldest, while road transport is the most developed, because it is carried out on roads and highways, there is also railway transport, which is carried out via rails, electric trains or magnetic rails (eg Maglev). Air and water transport is interesting because it represents a modern form of transport that is continuously developing and where a rapid transformation of motor drive technologies from fuel cells to renewable resources, such as solar and wind drives, is possible. Energy demand in the transport sector has been growing steadily in recent years, consuming one-third of the total final energy demand in the European Union (EU) over the last decade. The transition of this sector to a sustainable one faces many challenges in terms of appropriate technology and energy resources. A particularly challenging transition is foreseen for long-range heavy vehicles and aircraft. In order to calculate the resources needed for the transition to a completely renewable transport sector, four main alternatives to the existing fossil fuel systems were evaluated and their potential was quantified, i.e. biofuels, hydrogen, synthetic fuels (electric fuel), and electricity [1]. Electric modes of transport have the greatest benefits in the transport transition so that 72.3% of transport energy demand at the EU level can be directly electrified with existing technology.

2.1 Vehicle classification and management technology

Vehicles can be road, rail, off-road, agricultural, and combat vehicles, and the most commonly used road vehicles are motorized, i.e. cars. Cars can be used for transporting passengers, personal or passenger cars, collective transportation of passengers, transporting cargo, towing trailers, carrying out work, road trailers, trailers and semi-trailers, special trailers, and sets of vehicles. Internal combustion car types have a built-in gasoline engine, diesel engine, or hybrid drive. Cars with a built-in electric charger (plug-in), or with a fully electric drive, with bioethanol, liquid petroleum gas (LPG), as well as with compressed natural gas (CNG) are appearing more and more often.

The aforementioned division was made based on the way energy is used, where the type of power units with the transformation of some energy into mechanical work is considered and in terms of the use of accumulated energy that is with charging. Due to the development of technique and technology, engine drives have experienced enormous progress, which is reflected in energy efficiency, reduction of pollution, and the use of new materials, so that there are heat engines with internal combustion, piston engines with axial pistons, with rotary pistons, with external combustion, and then also electric motors (battery drive, electric drive with fuel cells) and hybrid drive.

In transport, fossil fuels are most often used in the internal combustion system, which is normally imported, and in conditions of an energy crisis, it can significantly affect prices, delivery dynamics, pollution, or depletion of resources [2]. When looking at transit mechanisms in transport, it can be seen that gas is a fuel that is delivered by tankers, ships, or pipelines and that the optimal solution would be the use of renewable energy sources from direct sunlight, wind, or the use of chemical elements such as hydrogen.

Electric motors have an electric drive, so some vehicles have batteries, and the other group has a hydrogen fuel cell.

Vehicles with battery-electric drive (Battery Electric Vehicle - BEV) have batteries that are charged from the external electrical network via an adapter. The voltage and switching on of the electric motor are regulated by the controller. The spread of use depends on the progress in battery technology, with special reference to lithium-ion batteries which should ensure the best performance of the vehicle (acceleration, radius). Charging/discharging is faster than lead (Pb) and nickel metal hydride (NiMH) batteries; they are smaller in volume (typically 40%) and less in weight (50%) than NiMH. Lithium-ion batteries are more environmentally friendly than nickel- and lead-based batteries.

Vehicles with a battery electric motor have advantages because they have zero emission of exhaust gases (Zero Emission Vehicle - ZEV standard), so the global emission is lower by about 70% than conventional drives (SUS engine). The disadvantage is that BEVs are supplemented with

electricity produced by power stations, they are much more expensive than vehicles with SUS engines due to the pricebattery. BEVs offer a quiet ride, and good performance, but the limit is up to 150 km of the length of the journey with one battery charge.

Electric motors with fuel cells (Fuel Cell Electric Vehicles - FCEV) use hydrogen as fuel in the power unit. Hydrogen passes through the channeled chamber on the anode side, while oxygen from the air flows through the channeled chamber on the cathode side. Hydrogen is becoming an increasingly viable option for energy transport and storage, as it has the highest energy content by weight, and when used in fuel cells produces only water as a by-product. The conversion of hydrogen into electricity in a fuel cell is possible at 50-60%, while practically it ranges from 25 to 30%. Figure 1 shows FCEV and V2G, where electrolyzers and hydrogen storage provide all of the necessary balancing requirements.

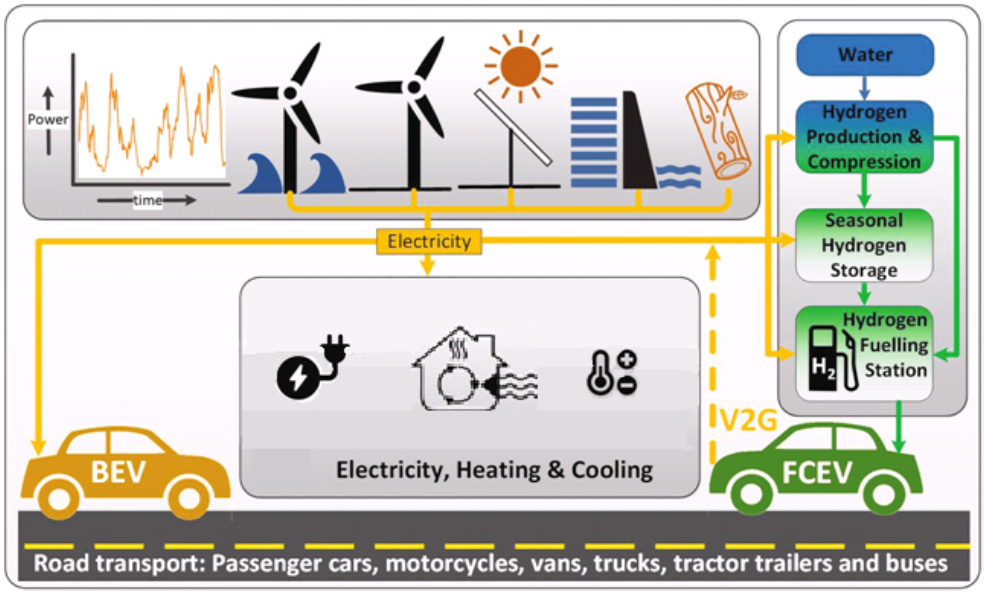

Figure 2. Model of FCEV and BEV (Modified from: [3])

2.2 Hybrid vehicles in transport

Electric vehicles (EV) and industrial machines are growing significantly with the advent of Smart Grid (SG) in the EV integration system. The smart grid uses information technology with the electrical transmission of electricity in both directions, thus replenishing the grid through EVs, which means a vehicle-to-grid operation. Recent literature has shown the importance of electric vehicles to overcome energy and environmental problems using an energy management strategy [4].

Global industrialization has caused the energy imbalance to increase. Electric batteries can be an important source of energy for new vehicles. Electric batteries are expected to meet the increasing demand, but the problem of storage, conversion, transmission, and maintenance of energy vehicles must be observed. What characterizes these batteries is the innovation with fast charging, and nano-electrode system with high capacity and energy density [5]. Nanotechnologies in energy systems should improve the capacity, operability, and durability of batteries, along with the development of electric-electrode models and the evolution of transport systems.

Hybrid technology in the automotive industry enables the improvement of vehicle performance and efficiency saves fuel and promotes an environmentally friendly environment. The technology of the hybrid electric car is complex, and sustainable, but there are large investments in the transfer. Innovation in hybrid technology uses the technology of compressed air and components to drive fluids and the energy of compressed air as an energy source. When the energy in the storage is low, the system uses the braking energy losses and returns to useful energy [6]. The design of the compressed air hybrid system is functional, but the commercialization of the dual subsystem can be

addressed by further research in the area of lightweight system design and related energy efficiency. If a triple system were to be used, then fuel consumption would be reduced and energy would be saved, thus reducing the effects of environmental pollution. Hybrid drive refers to the propulsion of a vehicle using several different energy sources. The main advantages of the hybrid drive are low noise level, low exhaust gas emission, and high level of utility. The main disadvantages are the high price of the vehicle, the greater mass of the vehicle compared to the same one with classic drives, and less luggage, i.e. cargo space.

Hybrid electric vehicles (HEV-Hybrid Electric Vehicle) are a combination of electric motors and SUS engines. A hybrid car has two engines, each of which operates depending on the conditions drive in which the car is located. A vehicle with a serial hybrid drives when driving at a constant speed is driven by an electric motor, which is supplied with electricity from the batteries. During this time, the SUS engine starts the generator, which supplies electricity to the electric motor, while the batteries are charged with excess electricity. In case of higher load, the parallel hybrid drive means that the traction torque will be provided by the SUS engine when the batteries are recharged.

Plug-in hybrid electric vehicles (PHEVs) use rechargeable batteries by connecting the plug to an external source of electricity (to a normal wall electricity socket). Other components are the same as other electric drives. Today, the PHEV are mostly used as passenger cars, but there are also commercial vehicles and utility vans trucks, buses, motorcycles, scooters, and military vehicles.

2.3 Renewable fuels and transmission of energy over the grid

Renewable fuels are fuels made from renewable electricity and can reduce the negative impact on the environment in transport. Adoption of renewable fuels in transportation is different, with trucking taking longer to adopt, while SMEs have greater barriers due to fluctuating prices, technical setups, and limited administrative support [7]. Three moments of acceptance were identified: practical application of renewable fuels (levels of readiness and knowledge for vehicle technology), secondary effects of renewable fuel production (environmental burden), and the relationship between renewable fuels and electric vehicles.

The use of renewable transport fuels reduces import-export dependence, improves air quality, and reduces the effect produced by greenhouse gases, thereby affecting the energy transformation and transition of technological solutions in transport and other related areas. By combining renewable fuels, efficiency, and electric drives, it is possible to realize market demands that will accept energy efficiency in hybrid vehicles.

Vehicles with renewable energy started from the installation of drives that use electrical energy obtained from renewable energy sources (OIE), ignoring individual or direct chargers from solar panels or smaller wind generators with dynamo motors.

However, the main problem of RES is the instability of the input, which is affected by conditions such as solar energy and wind energy. Independent charging stations from renewable energy require the integration of batteries that will not be too expensive and limited by charging time. Renewable energy integration systems cannot withstand the reverse current flow from the EV charger, so a current loss prevention section is installed or a power source inverter with built-in reverse current protection is installed (Figure 2).

Integrating a power source inverter into a wireless power transfer (WPT) network will implement an energy extraction circuit together with an energy harvesting device (solar panel/wind turbine), which takes up more space. With intelligent design, the space limitation can be overcome by placing a solar panel on the roof or being connected to a charger while in the garage.

Wireless Power Transmission (WPT) is based on magnetic resonance as oscillatory energy between two different forms. The concept developed by Nikola Tesla way back in 1889 has been perfected over time in vehicles so that they are freed from wire transmission by electromagnetic induction. Optimization of power transfer efficiency depends on switching frequency, resonant fre-

quency, load resistance, and winding resistance, which means that more stable, reliable, and efficient designs should be proposed [8].

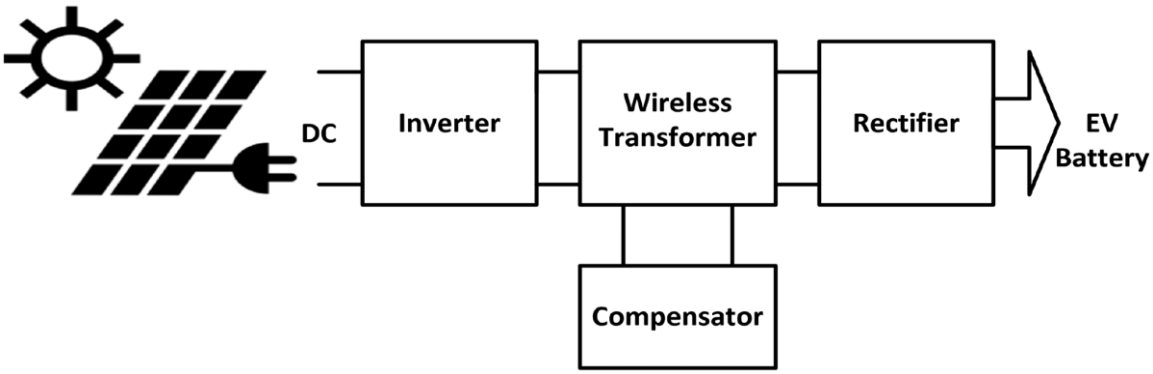

Figure 1. Electric vehicles with renewable energy [8]

In conventional designs, the transmitter and receiver coil pads are placed not directly in front of the vehicle's circuit or chassis. Poor shielding arrangement will lead to interference of the emitted electromagnetic wave with circuit components and objects in the vehicle, which may result in electric shock. To avoid this, designers should strictly follow different safety standards based on frequency bands for general exposure and professional and maximum exposure.

Vehicle to Grid (V2G) integration is an innovative application of electric vehicles to mitigate the impact on the grid. It is an advanced form of technology "from vehicle to home" (Vehicle to Home - V2H). The surplus in the EV battery is transferred to the home electrical grid to meet energy needs or to save energy. When AC power transitioned to the smart grid, innovators were able to incorporate demand control and load-sharing capabilities. Grid and renewable energy are integrated with the primary wireless charger. As most electric vehicles are parked during the day, and there is plenty of sunlight available, a vehicle connected to the grid via a charger transfers the stored energy from the car's battery to the grid.

3 Energy of Things in Transportation

The Internet of Things (IoT) is all smart versions of digital devices, with special attention being paid to Internet sensors that are installed in cars and trucks so that they can communicate with the command post, in a group of the same devices, or in a group of owners with mandatory internet connectivity. The Internet of things is a complex and necessary system composed of sensors for the recognition, transformation, communication, transfer, and storage of data [9].

IoT is most prevalent in manufacturing, transportation, and utility organizations, using sensors and other IoT devices. Private companies and policymakers are accelerating the deployment of smart grid technology that supports smart energy systems. The modern technological development of sensors and measuring elements and the aspiration toward optimal integration of distributed sources of electrical energy conditioned the idea of an innovative form of electrical power system called the Internet of Energy [10].

The application of IoE (Internet of Energy) reduces inefficiency, making energy transmission much more productive, creating savings in money, and reducing energy wastage. To connect the energy, information, and network subsystems, an energy router is used that "intelligently" distributes communication flows from transformation, monitoring, and detection to optimization of energy consumption. In the technological development of devices, an important segment is the energy of those devices that apply standards of energy efficiency, less energy consumption, reduction and neutralization of harmful gas emissions, the transition of energy sources, locational energy sources, information connection of devices, and the Internet, acceptance of energy philosophy, the use of renewable and alternative sources of electricity, which in one word is considered Energy of Things (IoT). Table 1 shows the most important advantages of the Energy of Things that are integrated into the given systems, where the benefits of means of transport that have on-board computers connect-

ed through electric drive are highlighted, as well as the disadvantages of EoT, which are reflected in autonomy, errors, standards, and attacks.

Table 1. Advantages and disadvantages of EoT

Advantages	Deficiency
1. Quick and easy access to information on consumption, savings and technology transfer	1. The number of connected sources and devices increases the likelihood of a hacker attack
2. Connection of electronic devices with energy sources	2. Businesses are becoming dependent on internet technologies to display consumption, efficiency and location of energy devices.
3. Representation of energy consumption in the network system of devices	3. If there is an error in the system, every connected device is likely to be damaged
4. Automation of the routine, with a higher quality of services without the need for human intervention	4. Harmonization of manufacturer standards

4 Aerodynamics of transport vehicles

The improvement of the aerodynamics of transport devices takes place in several stages, of which we should mention the flow through the fenders, fender drive, fender end masks, drive wheel armor, chassis, wheel covers, cabin extensions, a continuation of the rear part of the roof. Most often, the body shape or mechanics of the truck cannot be changed, but modifications can be made to redirect airflow and reduce drag. These additions will direct the air away from the gaps that would create pressure resistance and protect the long sides of your truck from friction. Reducing drag will result in lower fuel consumption.

Apart from the internal improvements of the engine through technological solutions, it is possible to improve the external characteristics of the vehicle, which will reduce the resistance to the movement of the given vehicle. Drag can be reduced by changing tires, installing lighter masks, and designing masks that will create less drag so that they are adaptable, elastic, and cheap. An integral solution would imply that the fuel drive should be hybrid or with electric charging, while the best results would be observed with the installation of solar cells on the roof of the vehicle (Figure 3).

Figure 3. Aerodynamics of trucks and solar cars [11]

Air resistance, i.e. wind, occupies an important place in the aerodynamics of a vehicle, so nowadays special attention is paid to the shape of the vehicle, i.e. aerodynamics, as one of the important factors that affect fuel consumption and the dynamic behavior of the vehicle on the road.

Special attention is also paid to the construction of the shape of the side surfaces, given that the force side wind does not act in the center of gravity of the surface, but in its metacenter, such

mutual position of the vehicle's center of gravity and the metacenter of the side surface, truly depends on what the vehicle's stability will be on a crosswind.

4.1 Future solar transport

Solar panels and cells can be used to heat water in households, store energy in panels that light up rooms, run machines, and refrigerators, or operate televisions. Nanoparticle panel technologies are expected to become even more efficient and cost-effective in the coming years, so it's possible that vehicles with solar panels on the roof will soon be on the road. The aerodynamics of solar vehicles would be similar to the existing ones, with the fact that the engines would not be heavy, but would be batteries in which energy would be accumulated. In addition, the possibility of efficiently using the energy of solar cells on the roof without transferring heat to the vehicle is being considered, which can be contributed by a dynamo engine with a wind turbine on the corners.

A solar car is a vehicle with a solar panel, which depends on the connected charger. It is expected that with one charge such a car can be autonomous for 200-400 kilometers. The biggest drawback is batteries that charge slowly, and the battery replacement process wears out quickly, which would mean that research is being done to compensate cells for elements that would last longer, use energy efficiently and produce satisfactory engine power. Covering the roof, hood, and trunk panels are facilitated by the sunlight collection surface on direct light, reflection, and radiation on snowy days.

The solar-powered bus is important because it involves the collective transportation of people. Although the first solar bus was introduced in 2007 in Australia, it was quite expensive and was made with the aim of reducing carbon dioxide emissions. Some solar buses have combined solar energy and electric charging, and there they can be energy efficient and reduce consumption in urban transport. Since buses are large and have a larger roof area, solar panels can be installed on them, and batteries can be located in the baggage area. Also, in addition to solar battery charging, they can also have electric charging for longer trips. Good examples of the practice of production and application of solar buses are in Uganda and Great Britain.

The anticipated solar-powered transport is a train that could combine light metals on the surface and liquid solar cells on the roof and walls of high-speed trains. Trains are known to run on rails, so in this case, many of the habits of the inhabitants who climbed to the top could go into the past because then the trains would not move. It is very convenient because the solar drive allows direct arrival without delays due to power outages, and integrated solar farms for railway stations are possible, as well as wind generators that, in addition to helping solar panels, could be used for air conditioning due to longer trips.

Transport on land can replace transport on rivers, seas, or oceans, so yachts are equipped with solar panels. It is obvious that the combination of solar and wind energy pays off the most because it can be a quiet, cheap, and energy-efficient drive. There is no evaporation, no limited range of motion, and no noise, and solar yachts are not complicated to maintain, but the price could be high. The aerodynamics of solar-eolic yachts can be integrated with large propellers of the open type and in a circular shape, where there would also be a solar panel on the roof, due to autonomy and safe operation.

It is known that Daedalus and his son Icarus wanted to fly, but the heat of the scorching Sun was a problem for them. Solar-powered airplanes are a centuries-old desire of people to get closer to the sky, so a breakthrough in this market can be expected soon. The military industry is interested in solar-powered aircraft because they can stay in the air for long periods of time, be silent, and fly long distances without needing to land for fuel. Installation of solar cells in airplanes is possible, and batteries are required to store excess energy used during night flying. The use of solar-powered aircraft is possible not only as an unmanned project but also as a project that would have over a hundred passengers.

Figure 4. Electric wind yachts with the addition of solar panels [12]

5 Conclusion

Special care for transport and connection with other sectors was assigned to logistics sectors, which include modern information technologies, reduction of queues, storage, shipping, delivery, and manipulation of means of transport, cargo space, and cargo. A very significant contribution to energy savings can be made by alternative sources of electrical energy supply, as well as technological innovations, energy transition, innovative solutions, integrated energy sources, and constant research.

It is observed that solar energy has the greatest propulsiveness in energy, where its input is seen as a benefit for savings from expensive fossil fuels. Not only is the environment protected from pollution produced by gasoline, oil, or gas, but resources available to everyone can be saved and managed independently. The use of solar energy and wind energy in transport is possible, and the benefits are in the reduced import of expensive and foreign energy sources, the pollution of air, water, and soil is reduced, and the domestic economy and domestic intelligence are encouraged to research and develop new technological solutions.

The energy of things and the Internet of Things can increase the energy efficiency of vehicles by over 50% with a system of information, control, and needs with sensors of heat, sound, presence of people, and location. Electric vehicles have batteries that accumulate energy and enable a certain autonomy, while hybrid vehicles run on multiple sources, whereby vehicles on renewable sources are the future that fully enables energy savings for both private individuals, companies, and the state.

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