ELEKTROMOS JÁRMŰVEK ALKALMAZÁSAI

OPPORTUNITIES OF ELECTRIC VEHICLES

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ABSTRACT: Nowadays, the number of vehicles with minimum emissions that meet environmental requirements is increasing. In this paper, we present a comprehensive technological study and comparison of clean electric vehicles. This paper addresses this issue and summarizes current and future strategies. Environmental guidelines and policy incentives are constantly increasing the number of electric vehicles and the rapid development of technology.

1. INTRODUCTION

The literature review clearly shows that the conditions for the introduction of electric vehicles (EV) need to be examined on a country-specific basis. A good example is European countries that are heavily relying on renewable energies, such as France or Norway. Countries like Germany, the United Kingdom, and the US should focus on significantly reducing greenhouse gas emissions from electricity generation [1]. The tendency to purchase electric vehicles is influenced by several factors, such as price, driving experience and availability of the necessary infrastructure. During the investigation, special attention is paid to environmental awareness among the customers of electric vehicles. These analyze aid policy makers and researchers to introduce and encourage the utilization of new technologies.

2. ENVIRONMENTAL EFFECTS

Vehicle manufacturers need electric vehicles at fleet level to comply with ever-changing regulations. At EU level, Regulation 2019/631 sets the new directions and expected emission standards that vehicle manufacturers must follow [2]. Currently reducing emissions of internal combustion engines is stressed, however, this is no longer adequate. It is important to emphasize that each vehicle manufacturer should examine the emission limit value for its entire vehicle fleet. Nowadays, this has brought about changes that seem to be narrowing the category of mini-cars in the manufacturers' fleet. The reason for this change is multi-directional compliance with environmental norms and commercial demands.

Table 1. summarizes literature data, which reflect the targets set by different manufacturers (in terms of adverse environmental emissions) well [2]. Compliance with the 95 gCO_2 / km benchmark will be introduced internationally by vehicle manufacturers (fleet level) in 2021.

Table 1. CO_2 emission target [gCO_2/ km]

Manufacturer	2020	2030
BMW (incl. Mini)	102	64
Daimler	102	64
Fiat	92	58
Ford	95	60
Hyundai Kia	95	59
PSA	90	56
Renault-Nissan	91	57
Toyota	92	58
Volkswagen Group	95	60
Volvo	107	67

The conclusion can be drawn from the table data that it is essential to increase the fleet level of electric vehicles in the future in order to meet the expected targets at fleet level. Electric vehicles in the fleet produce 0 gCO_2 / km and thus have a positive impact on the fleet average.

The primary limiting adverse emission parameter of car manufacturers is compliance with the CO_2 standard. Examining several air quality parameters from a health perspective may be important for further investigations. With the continuous reduction of emissions, NO_x and PM_{10} particulates remain a problem in the automotive industry [3]. Today, air particle filters are the solution for PM_{10} emissions of vehicles. Auto-ignition diesel vehicles produce much higher levels of NO_x than petrol vehicles. Since the introduction of the Euro 6 directive series in 2014, only new diesel vehicles equipped with a

NO_x-trap or SCR (Selective Catalytic Reduction) can be placed on the market.

For NO_x, Fig. 1 clearly shows that transport causes the highest emissions. Fig. 2 shows the composition of the sources of PM_{10} particulate emission. Commercial, institutional and household sectors contribute the most to PM_{10} emissions. The introduction and distribution of electric vehicles are essential to reduce environmental impacts (emissions).

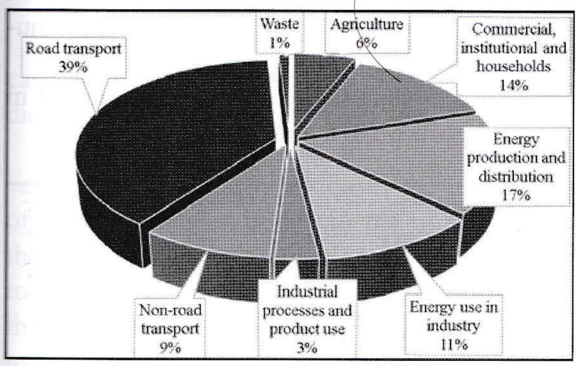

Fig. 1. Sectoral composition of NO_x emissions [3].

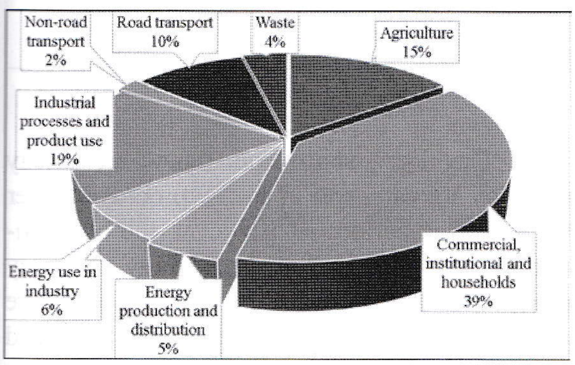

Fig. 2. Sectoral composition of PM_{10} emissions [3].

The measurements and compliance of the previously described adverse environmental emissions do not include further vehicle related emissions. PM_{10} particulate emissions are greatly contributed by brake dust from vehicle braking systems.

Today, the Euro 5 and 6 directive series typically feature higher particle emissions from the road and the tires and in the form of break-dust than directly from exhaust gasses.

Fig. 3 shows the origin of various PM_{10} particles within the toxic emission in Germany.

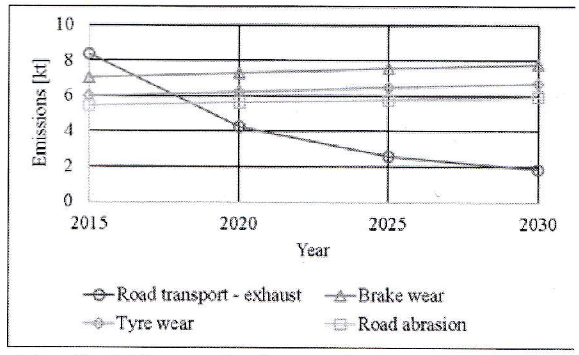

Fig. 3. PM_{10} particulate emission composition in road transport [4].

3. SELECTION PRINCIPLES

While studying environmental impacts and parameters, it is necessary to examine the consumer's choice principles. With this knowledge, we can estimate future trends and processes.

Fig. 4 shows the decision framework [5]. Consumer decisions greatly influences the future growth of the number of electric vehicles. The decision framework illustrates the decision-making processes and decision-making principles among internal combustion engines (ICE), hybrid vehicles (HEV) and electric vehicles (BEV).

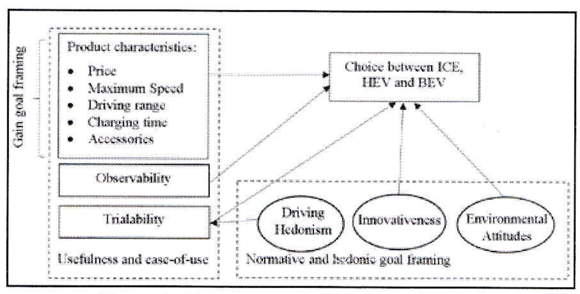

Fig. 4. Decision Framework [5].

The design of the decision framework is based on the Rogers Innovation Model (Diffusion of Innovations – DIM) [5]. There are two types of application motivation in making a decision: product characteristics and individual attitudes and attributes. The model also takes the utility and ease of use of the product into account, and it also considers the acceptance of innovation as essential. If a particular innovation is only available on the market, its usefulness and ease of use cannot be reliably evaluated. Instead, potential consumers judge the product on the basis of expected properties, feasibility and observations.

The application of the decision framework also requires the development of a discrete test model. During the discrete investigation, vehicle profiles that are currently available in the market, and profiles that will be available in the future may be taken into account. A detailed evaluation procedure is described below [5]. During the evaluation, the following three options were developed:

- ICE – internal combustion engine.
- HEV – hybrid system (consisting of internal combustion engine and electric battery). The battery is charged while driving.
- BEV – fully electric vehicle with rechargeable battery. Charging can be done while driving (recharging) and from an external charging source.

Table 2. Attributes and attribute levels employed in the design [5].

Attribute	ICE	HEV	BEV
Price (in thousand €)	2 levels: 33.5, 40	2 levels: 36.5, 40.5	3 levels: 36.5, 44.5, 54
Accessories standard	3 levels: standard, upgraded luxury	3 levels: standard, upgraded luxury	3 levels: standard, upgraded luxury
Maximum speed (km/h)	2 levels: 180, 210	2 levels: 180, 210	3 levels: 135, 175, 210
Driving range in km	660	990	3 levels: 150, 175, 200
Charging/ fueling time	5 min	3 min	3 levels: 4h, 6h, 8h
Number of people you know who drive that car	Many	3 levels: no one, few, more than 10	3 levels: no one, few, more than 10

Parameter tests in Table 2. must also comply with applicable laws and regulations in the particular country. Car pricing does not take the country's tax policy (incentives for electric vehicles) into account. Based on the primary results, it can be concluded that hybrid and electric vehicles will be competitors in the future. In the case of electric vehicles, it must be kept in mind that consumers are also changing their basic vehicle usage patterns. As a result of the model tests, the use of fully electric vehicles is not expected in the near future. Hybrid drive systems are a compromise for consumers switching from internal combustion engines.

4. ELECTRIC VEHICLES

It is important to mention the LCA (Life Cycle Assessment) when inspecting electric vehicles. It is a widely used method in the automotive industry, which, with the right basic knowledge, can bring significant decision benefits to both manufacturers and society.

Fig. 5 shows the energy mix expected in the EU between 2015 and 2050 [6].

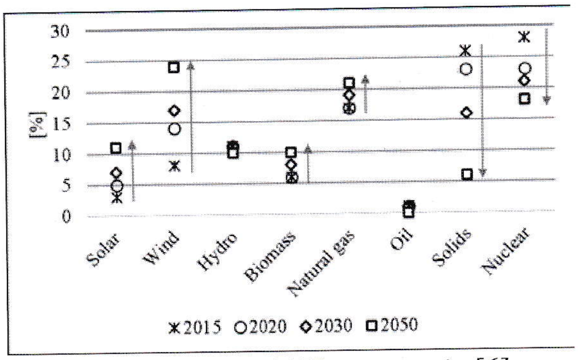

Fig. 5. EU 2015-2050 energy mix [6].

The figure shows that renewable energy will play a greater role in energy production over the projected period. At EU level, the contribution of solid fuels and nuclear energy to energy production is planned to decline. The future growth tendency of electric vehicles is analyzed in the light of this basic information and current legal principles.

There are several studies in the literature examining where electric vehicles stand based on their CO_2 emissions in a life-cycle [7, 8]. The aim is to identify large differences between diesel and electric vehicles. It is only possible to determine exact results when analyzing the parameters presented in the previous chapters together. When testing diesel vehicles, the primary consideration is the application of emission standards and test methods in accordance with these laws. In the case of electric vehicles, the main considerations are the battery capacity and the ratio of renewable energies in the production of electricity in connection with LCA [7, 8].

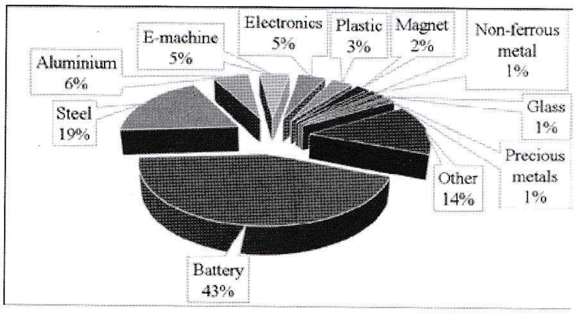

Fig. 6. Pollutant emissions from VW electric vehicle production [8].

It is important to note in the LCA that, in case of electric vehicles, most of the carbon dioxide is released during production.

Fig. 6 clearly shows that the highest adverse environmental emission in the production of electric vehicles is due to the production of the battery. During production, the reduction of toxic emissions can be achieved by increasing the renewable energy content of the energy mix used.

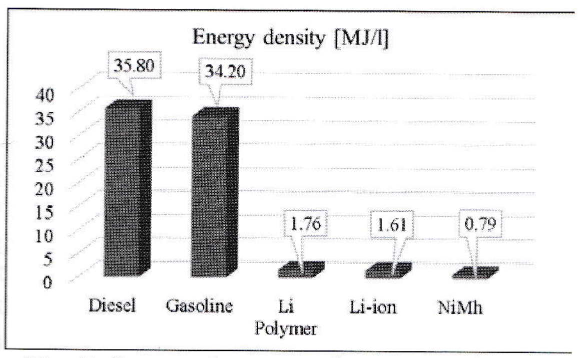

Fig. 7. Energy densities of energy media [9].

We have to keep the special needs of installing and using batteries in mind. Primarily due to their energy density, as shown in Fig. 7, their installation size can cause problems during design [9]. In addition to size, it also represents a significant weight increase for vehicles. When designing vehicles, they are trying to make the most of this feature, so there are new ways to adjust the vehicle's center of gravity by repositioning the battery packs. The battery pack is interchangeable with many manufacturers to maintain the long-term use of the vehicle. Manufacturers are also trying to utilize the high rigidity of battery packs when designing the vehicle body structure [9].

Batteries are constantly being developed, and there are many directions in professional scientific journals. There is great potential for silicon-carbon hybrid composite anodes (cheap and high performance), while commercially available lithium-ion batteries use graphite anodes [10].

When using batteries, it is important to consider that a cycle consists of a discharging and a recharging process. The definition used for general characterization of batteries is the number of cycles. The cycle can consist of a given charge level, a charge to another level. As the number of cycles increases, the battery capacity drops. A property of a charged battery is its capacity, which supplies a certain amount of electrical energy (Ah) at a given current for a given period of time. Nowadays, managing rechargeable batteries is a problem that remains unresolved, as a result of which heavy-duty equipment is simply landfilled. However, there is a practical, economical and environmentally friendly solution: recycling batteries. The most common way to do this is to use it in industrial energy storage devices that help to stabilize the electricity grid [11].

Table 3. Cost of electricity storage [12]

Type	Unit cost [€/kWh]	Investment cost [€]
VW e-up! Li-ion battery	1.09	27 000
Toyota Prius NiMH battery	2.07	10 845
Gyrodrive HP MK4 flywheel	0.12	58 450
Goldisthal power plant Pumped Hydro	0.001	623 000 000

Based on the research detailed above, energy storage is a major issue in the distribution of electric vehicles. The cost of energy storage is an important consideration when optimizing the price of electric vehicles. The use of renewable energies can reduce their emissions. We have also seen examples of the recycling of batteries from electric vehicles. Looking at several lines of research, it can be stated that the development of appropriate energy storage methods is a question of the future. Hydroelectric power stations are currently well suited for increasing the stability of electricity networks. An energy storage method used today is flywheel energy storage.

Table 3. shows four energy storage methods and their unit costs [12]. It is clear from the table that the unit cost of energy storage is the highest when using electric vehicles. Evidence shows that reservoirs are still the most efficient systems, but have the highest investment costs [13].

5. SUMMARY

In this study, we have summarized the factors influencing the future growth tendency of electric vehicles. The effect of standards that limit toxic emissions has a positive effect on the production of electric vehicles. It is clear that manufacturers will increase the proportion of electric vehicles in their fleet due to lower emission standards. In addition to the much-used CO_2 limits, other pollutants need to be taken into account as well. Other pollutants include, for example, NO_x, which is primarily related to road transport and transportation, shipping. The research methods required for the social acceptance of electric vehicles were also presented in this study. The inspection method will help decision makers and electric vehicle manufacturers alike. Today, hybrid vehicles are the primary competitor for electric vehicles. We also discussed the challenges and issues encountered in the production of electric vehicles in detail. LCA research shows that electric vehicles are constantly improving their image (they produce less adverse environmental emissions than internal combustion engine vehicles). Further development of energy storage is essential for further development and increasing production.

6. ACKNOWLEDGMENTS

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