



CAPACITY OF CONTRIBUTING TO SUSTAINABLE DEVELOPMENT OF CARS WITH DIFFERENT PROPULSION SYSTEMS – WESTERN BALKAN STUDY

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Abstract: Sustainable development and ways to contribute to its goals are topics with increasing importance. This study aims to highlight what are the capacities of different solutions of propulsion systems of cars to support those efforts in the region of Western Balkan. Based on wide research done several years ago and the development of automotive technology in the meantime, some significant conclusions have been drawn. Analysis covers five alternatives of car propulsion systems, taking into consideration their advantages and disadvantages. After identifying 90 indicators of sustainable development, the AHP method of analysis has been employed with interviewing 73 professionals from Western Balkan countries. The results are shown in a graphic illustrative way. As an addition, an analysis of further development of automotive technology has been analyzed, and shorter AHP analysis has been done again. These additional results show the direction of change in this area of transport and its capability to contribute to the sustainable development goals.

Key words: Car, Electric, Propulsion systems, Sustainability.

1 INTRODUCTION

The road transport and road vehicles are of enormous importance for many countries, including the ones in the Balkan region. Moving of goods and people from one location to other, as a main mission of the road transport should be done while fulfilling the needs of the economy without endangering lives and health of the people, plus taking care of the environment. At the same time natural resources should be used in best possible way to make them available for generations to come. All these aspects are in line with the UN strategy of sustainable development (figure 1) [1].

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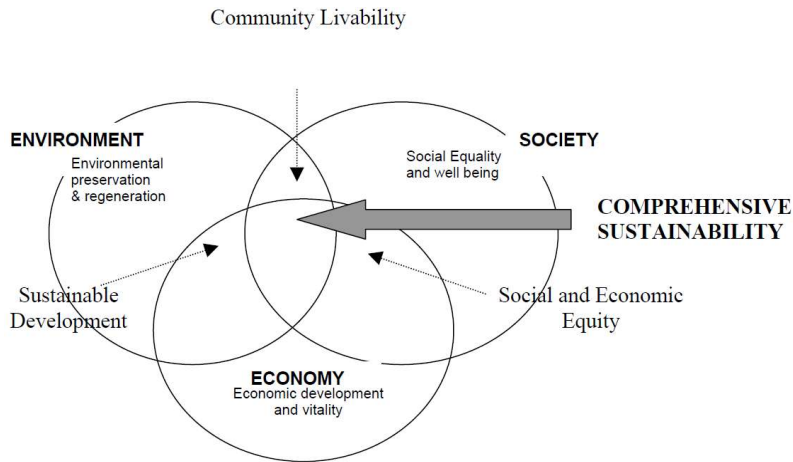


Figure 1. Sustainable development – graphic presentation [1]

Contributing to the goals of sustainable development is a task for everyone involved in the transport industry, as one of the most important economy fields. Therefore everyone is obliged to contribute in the area of his/her competences, including political (government, municipality) levels, non governmental organisations, car manufacturers, customers, etc. On each of these levels, appropriate decisions have to be taken. Around 7-10 years ago a large research has been done to help responsible people take appropriate decisions on the choice as to which alternative of car propulsion system has best chances of contributing to the general sustainable development goals [2]. A number of published papers emphasize different aspects of that research [3-6].

Due to the dynamic nature of the automotive technology, in the last several years there have been significant improvements like improving the performances and range of battery electric vehicles, but also improving the economy of the cars equipped with internal combustion engines (ICE) leading to further reducing their gas, particule and noise emmisions. The latest movement in the area of car prices shows tendency of reducing the price gap between battery and hybrid cars, from one side, and ICE equipped cars on the other.

The changes mentioned above raise the question whether the overall picture of the capacity of different car alternatives that contribute to the sustainable development has changed and getting the answer to that question is the main goal of this research.

2 METHODOLOGY OF RESEARCH

This research is based on the same, already proven methodology used previously ([2], [4]), which employs AHP methodology as a reliable one for processing a lot of data in the context of decision making processes. The types of car alternatives has not been changed: A1 - electric; A2 - plug-in hybrid; A3 – hybrid; A4 – car with ICE with alternative fuel (gas or similar); A5 – car with petrol ICE, and A6 – car with diesel ICE. The indicators have not been changed, as well ([2], [4]). The importance of the indicators has been taken the same as judged by 73 experts from Western Balkan countries.

The computer model previously developed in Expert Choice software package ([2]), has been used in this research as well. The goal of this research is to find out if

changes of vehicle technology and new market trends have any significant influence in terms of the capacity of different car alternatives that contribute to the sustainable development. Such changes and trends have been identified and implemented in the existing software model where the simulation was done.

In the end an analysis took place, comparing the results from seven years ago, and nowadays. Based on such analysis, appropriate conclusions have been drawn.

3 MAIN CHANGES IN AUTOMOTIVE TECHNOLOGY AND MARKET TRENDS

The automotive technology in the last decades is in a phase of intensive development marked by several trends. While still a lot of questions exist about which powertrain solution offers best economical and environmental capabilities in terms of their life cycle [11], [12], [14], electric vehicles globally attract a lot of attention [13]. Besides technical and ecological aspects, the market also shows changes [7], [8], [9], [10].

At the same time, under pressure of public ecology demands, the test cycles and criteria for approval of vehicles equipped with internal combustion engines (ICE), have been pushed towards heavier test cycles and lower emission limits [15], [16], [17], [18]. According to that, the car manufacturers have taken serious measures to reduce the emission, and by that, to prolong the life of such vehicles [19].

In brief, the accents of relevant changes could be summarized as:

- Electric vehicles have best capacity of contributing to lowering of life cycle emissions;
- The range and performances of electric vehicles has been improved significantly;
- The prices of electric vehicles are lowering, but still are above those equipped with ICE engines while state incentives are very different and changeable;
- The prices of second hand electric vehicles are approaching the prices of such ICE vehicles, in some cases even below them;
- The infrastructure of charging stations is highly dependant on the region and country;
- New types of vehicles equipped with ICE have significantly lower emissions compared to those one decade ago. Different technologies have contributed to that (downsizing of engines, improving of combustion processes, introduction of different levels of hybrid technology, etc.).

4 SIMULATION OF THE NEW SITUATION AND COMPARISON OF RESULTS WITH BASIC RESEARCH

In order to understand how the changes in the automotive technology have influenced the capacity of different alternatives that contribute to the goals of sustainable developments in the region of Western Balkan, a new simulation has taken place. Compared with the situation seven years ago, the changes in technology development, and other aspects (prices, ranges, charging stations network and similar) regarding different types of car alternatives has been done in the same simulation model. No changes in the indicators and the views of the experts was done. Therefore, it is expected that with this approach it will be visible if the described changes will have any important change on the previous results of the simulation.

In summary, the results of the simulations can be illustrated in several

diagrams. The software package used has many forms of outputs (tables and diagrams) and a possibility to choose and show results on different levels of indicators, including different alternatives, etc. One illustration, namely figure 2, shows performances of different alternatives of cars on first hierarchical level towards the overall goal – sustainability (from basic research done in year 2017 [2]).

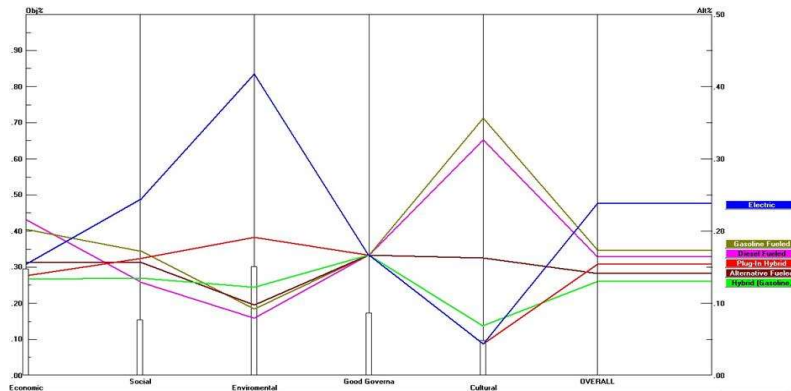


Figure 2. Diagram of the performance of the individual alternatives in relation to the indicators on the first hierarchical level, as well as in relation to the overall goal

The diagram on figure 2 shows that electric vehicles appear to be the best alternative in terms of overall goal – sustainability and the best alternative in the Environmental and the Social columns. In the Economic column the best results come from the cars equipped with Diesel ICE, while at the same time they are the worst in the Environmental column.

Since the specific goal of this paper was to research and present if the last changes of automotive technology has noticeable impact to the capacity of different car alternatives that contribute to sustainability, the results of old (done in year 2017) and new (done in year 2024) simulations are shown on figure 3.

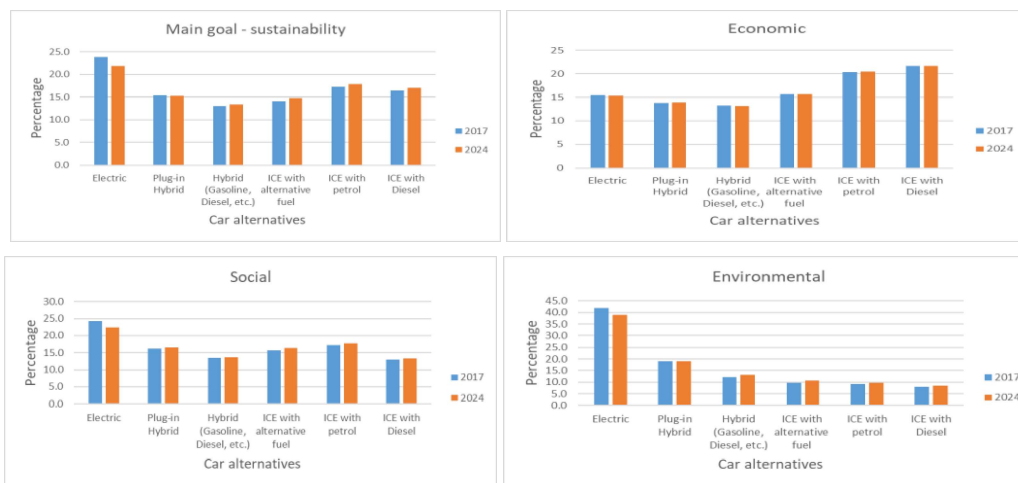


Figure 3. Capacity [%] of the contribution of different car alternatives to the main goal – sustainability, economic, social and environmental area

Analyzing the data shown on figure 3 shows no significant change of the results in the simulation. That means that reducing of the prices of electric vehicles, and their improved technical parameters (performances, range), are still not enough to change the overall picture in the Western Balkan region since there still are a lot of aspects to be solved (significant incentives, development of charging station networks, changing of the taxation policy of old vehicles, etc.). At the same time car manufacturers have improved emission and energy efficiency of ICE equipped vehicles to make them more competitive on the new vehicles market.

Going back to the style shown on figure 1, figure 4 gives a visual presentation of the capacities of different car alternatives to contribute to the sustainable development [2]. It is easy to recognize that electric vehicles have the best chances to do so (cross section of all three circles). To achieve larger field of sustainability, there is a need of making them more affordable, i.e. to enlarge their economic circle by the measures mentioned above. The second best chance have the plug-in hybrids. The alternatives of cars equipped with ICE engines have less chances due to the limitations of fossil fuels and especially due to the extreme difficulties to further reduce their emissions.

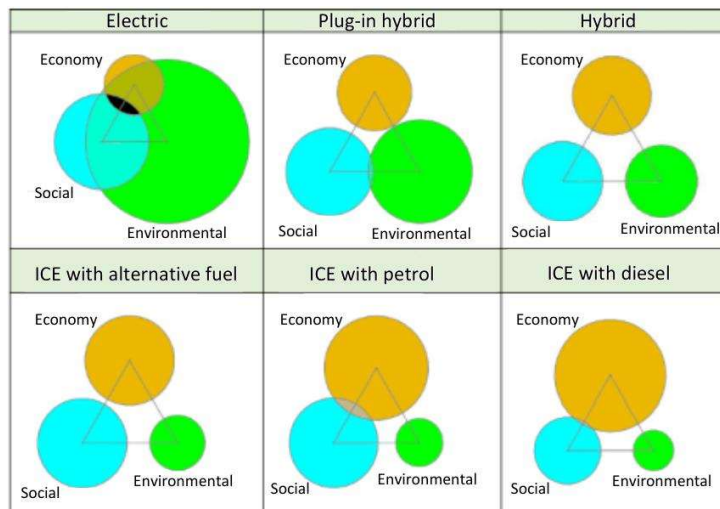


Figure 4. Visual presentation of the ratio of the three basic pillars - indicators of sustainable development: economic, social, and environmental, for all alternatives.

5 CONCLUSION

The results of the simulations confirm that the developed tool can be used both for analysis of the actual situation and for developing of policies and decision makings on different levels (state, municipalities, large and small bussinesses, and personal, as well).

The results show that there is no significant changes in the results received by the simulation seven years ago and now, despite the technology changes described above. This can be explained by the fact that the main group of alternatives (electric vehicles and vehicles with ICE and no hybrid technology) move towards each other. In other words, enhancing the performaces and increasing the range of the electric

vehicles, as well as reducing of their price, in one hand, is almost in balance with the improving of energy efficiency and lowering of emission of gases and noise from the vehicles equipped with ICE, on other hand. In such way, electric vehicles have advanced in the column of economy, and ICE vehicles have improved in the area of ecology.

The electric vehicles advantages in this region are still hampered by the lack of appropriate infrastructure of charging stations, lack of more significant incentive measures, low consumer power, and similar.

Relying on the developed model, more simulations could be done in order to find how different ideas of measures could lead to achieving wanted results.

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