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E-MOBILITY AS A SUSTAINABLE SYSTEM IN RURAL AREAS

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***Abstract:** Electric mobility in Bulgaria is not very common at the moment. However, people are becoming much more interested because these vehicles have many advantages. This type of transport is not only environmentally friendly but also much quieter and cheaper. The government is trying to integrate economic and environmental strategies into public transportation. It is not easy because the entire infrastructure needs to be changed. I think we can start by integrating eco-friendly transport in rural areas because the distances are longer, so the cost savings will be greater.*

***Keywords:** Electric mobility, Advantages, Eco-friendly, Rural areas, Cheaper.*

INTRODUCTION

The transport sector currently represents one of the key challenges for future sustainable development. Nearly one-third of the world's total energy consumption can be attributed to the transport sector. This is not only because the transport sector has a significant direct and negative impact on global ecosystems, but also because mobility is an integral part of modern societies, thus being a root cause and dangerous consequence of the current unsustainable development. Here comes the solution: electric vehicles, which can reduce harmful emissions.

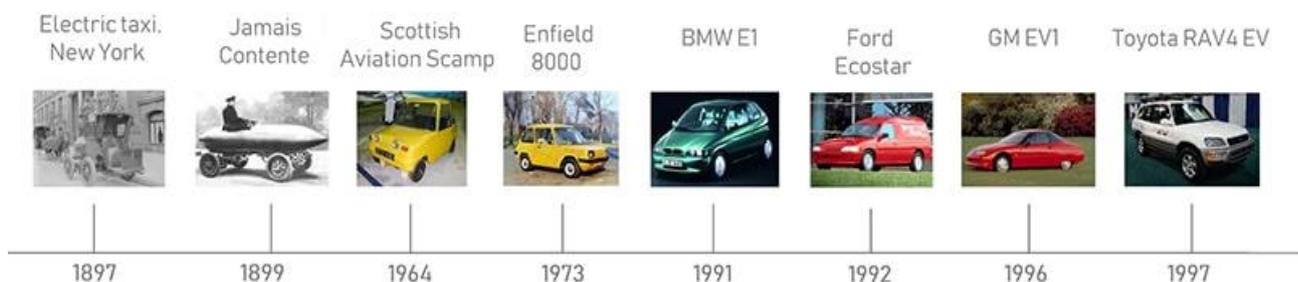


Fig. 1. Development of Electric Vehicles

Electric vehicles were invented as early as the 19th century in the early days of the automobile era (Fig. 1). An electric car or electric vehicle (EV) is a passenger car that is powered by an electric traction motor using only energy stored in onboard batteries. E-mobility has re-emerged as a viable solution because it promises emission-free mobility. Compared to conventional internal combustion engine (ICE) vehicles, electric cars are quieter, more responsive, have superior energy conversion efficiency, no exhaust emissions, and lower overall vehicle emissions. The battery of an electric vehicle typically needs to be plugged into an electric power source for recharging. Charging stations can be installed in large shopping centers, hotels, parking lots, private homes, and more.

Thanks to Electromaps, there are more than 267 charging stations in Bulgaria. Most of them are located in Sofia. There are also places where anyone can charge their car for free. The infrastructure is developing very rapidly, as are the legislation, taxes, subsidies, education, and information. Bulgaria participates in many European programs for cleaner and more efficient transport.

EXPOSITION

The need to reduce the environmental burden caused by fossil fuel-based transportation has been recognized, and environmental regulations regarding CO₂ emissions have been increased. Climate change has led to some concern and efforts for sustainability-oriented change. Battery electric vehicles could address some of these issues, especially those related to local air pollution, CO₂ emissions, and oil dependency.

There are also many obstacles to the introduction of electric vehicles in suburban transportation. The main issues are limited access and connectivity, long distances that need to be served by the transport service, partial or complete lack of public transport and non-polluting transport alternatives, and a lack of funding sources for mobility projects.

Mobility is fundamentally important to enable people to access services that can improve their quality of life. The car is also a symbol of modernity and prosperity, which is why people use their personal transport. Infrastructures are shaped by the growing dominance of car-based individual mobility, and the current transport strategy in Bulgaria is strongly focused on urban conditions. This is especially important in rural areas, where the scope and reach of public transport services are significantly lower than in urban areas. One way to get people to use public transport more is to have role models in this regard. It is argued that the role of large demonstration projects is important.

On the other hand, the use of autonomous vehicles (AV) could make public transport in rural areas cheaper to operate in the future. Since human error causes most road accidents worldwide, autonomous vehicles are expected to be a safer presence on the roads. Volvo is already conducting successful full-scale field trials with autonomous driving in a controlled environment. There are many other aspects to consider as artificial intelligence takes control of the vehicle and decision-making.

This e-mobility solution with autonomous buses has several important operational requirements that may be more difficult to meet in rural areas:

- Digital connectivity, such as underdeveloped telecommunications networks and lack of reliable supporting infrastructure
- Variable landscapes and infrastructure specific to rural areas may contain more unexpected obstacles, as well as more challenging natural environments and infrastructure.
- Distance can be an issue, especially in villages or small towns with large and dispersed hinterlands.

A study was conducted in rural areas of two European countries to choose innovative mobility solutions evaluated by residents. Nine proposed innovations were assessed by respondents on a scale ranging from "no impact" to "significant impact" and "critical impact." The results are presented in Figures 2 to 10.

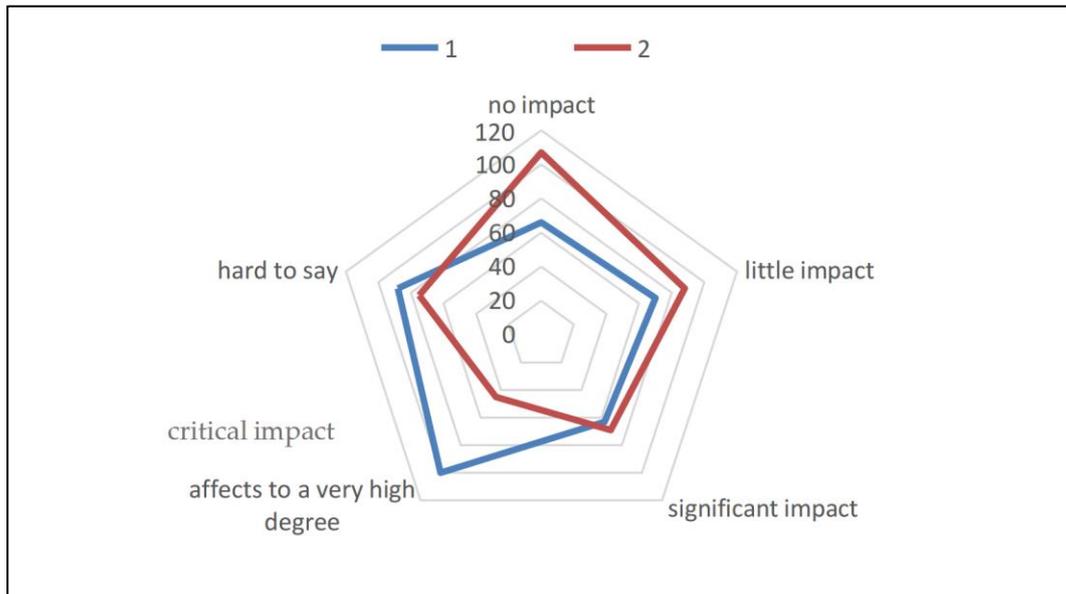


Fig. 2. Municipal bicycle system

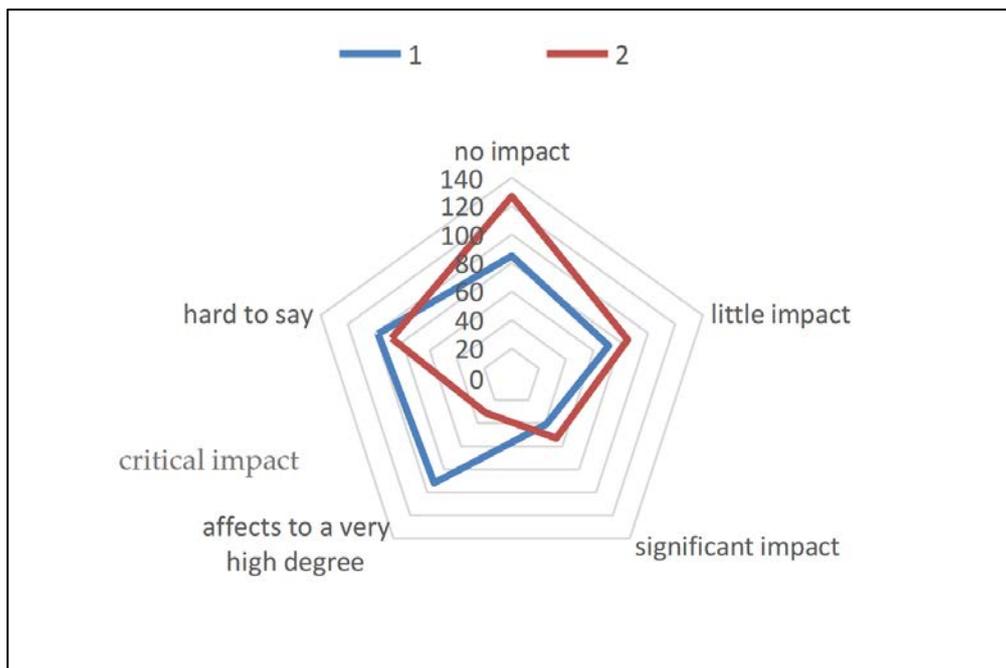


Fig. 3. Assessment of the e-car system

The notable difference in assessment between the two groups of respondents highlights that the municipal/district bike system could significantly enhance mobility in the first region, as indicated by 26% of the respondents. Conversely, the majority of the second country respondents were skeptical, with most selecting "no impact" (107 responses), though "little impact" was the second most popular choice, selected by 23%.

When comparing opinions on the introduction of e-cars and the necessary infrastructure, it is noteworthy that a substantial number of the first country respondents supported such innovation, with 24% indicating a "critical impact." In contrast, the second country residents were more skeptical, with 33% believing this solution would have no impact on improving mobility in their region. The results presented in Figure 3 show a significant divergence in opinions: the e-bike (scooter) system was strongly supported by the first respondents, with 34% indicating a "critical impact," while the second respondents were more skeptical, with 28%

choosing "no impact." Nevertheless, a slightly smaller group of the second country respondents (23%) considered this innovation to have a "significant" impact.

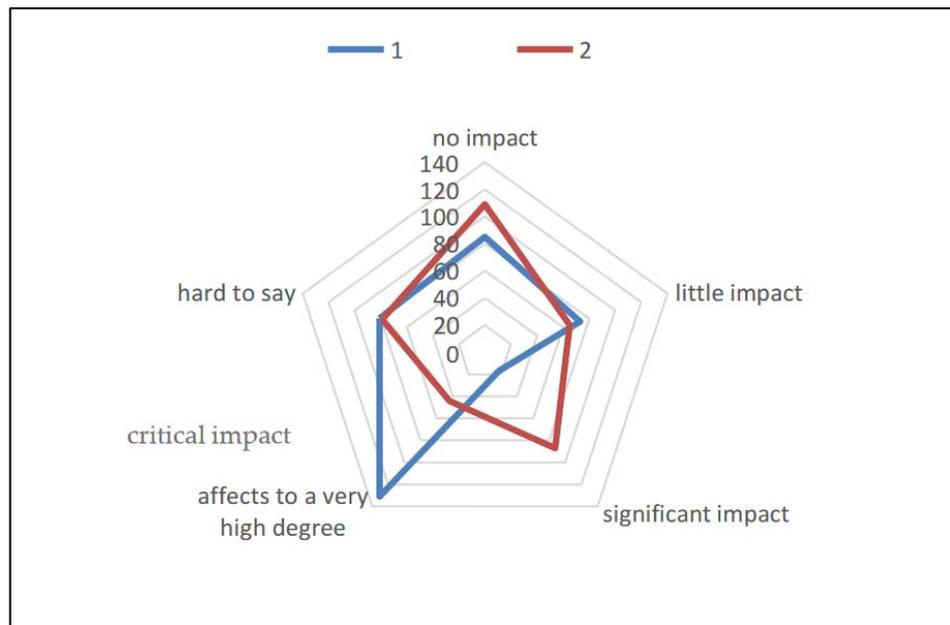


Fig. 4. Assessment of the e-bike/scooter system

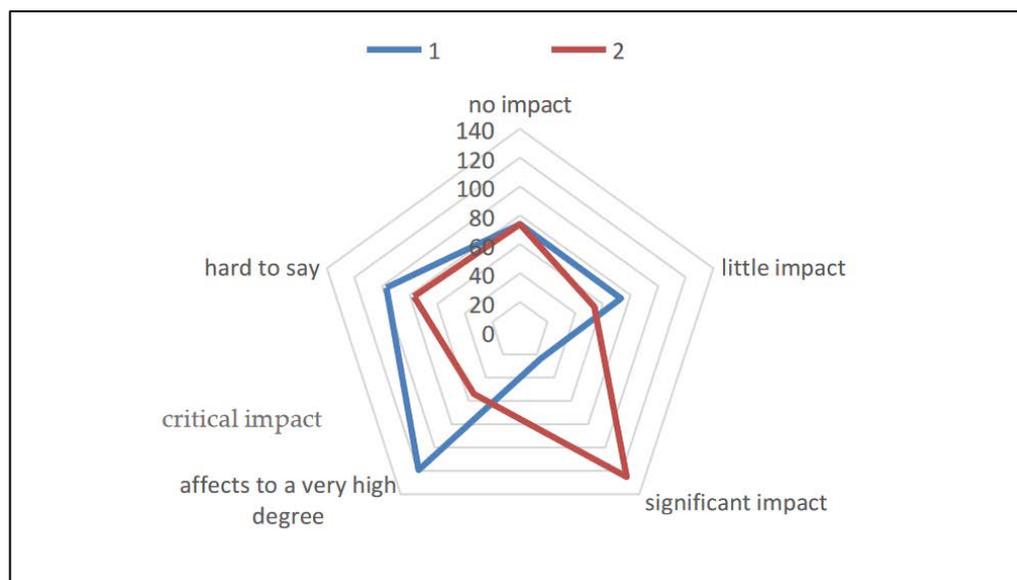


Fig. 5. Mobile application enabling the search for transport in a ridesharing system

Both respondent groups generally value the proposed solution. However, similar to the e-bike/scooter option, the residents of the first country leaned towards the "critical impact" choice (31%), while the residents of the second country favored the "significant impact" option (33%).

Figure 6 demonstrates a notable acceptance of a mobile travel planning application and the integration of various transportation modes. The second respondents were more positive, with 30% choosing "significant impact," whereas 25% of the first respondents opted for "critical impact." Notably, there was significant skepticism among the first group, with 28% selecting "hard to say" as their response.

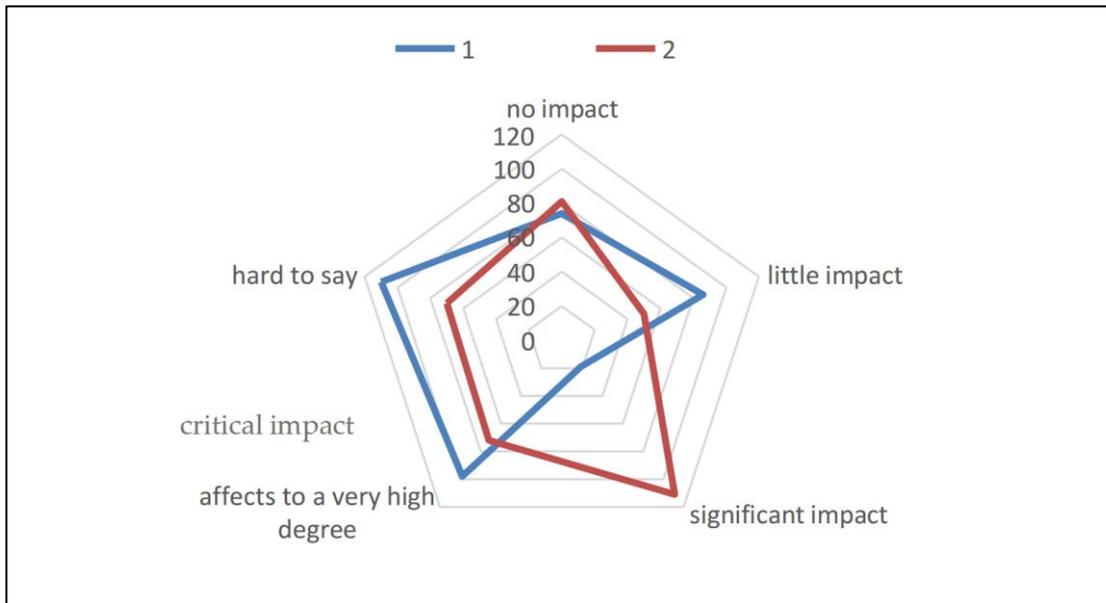


Fig. 6. Assessment of a mobile travel planning application integrating various means of transport

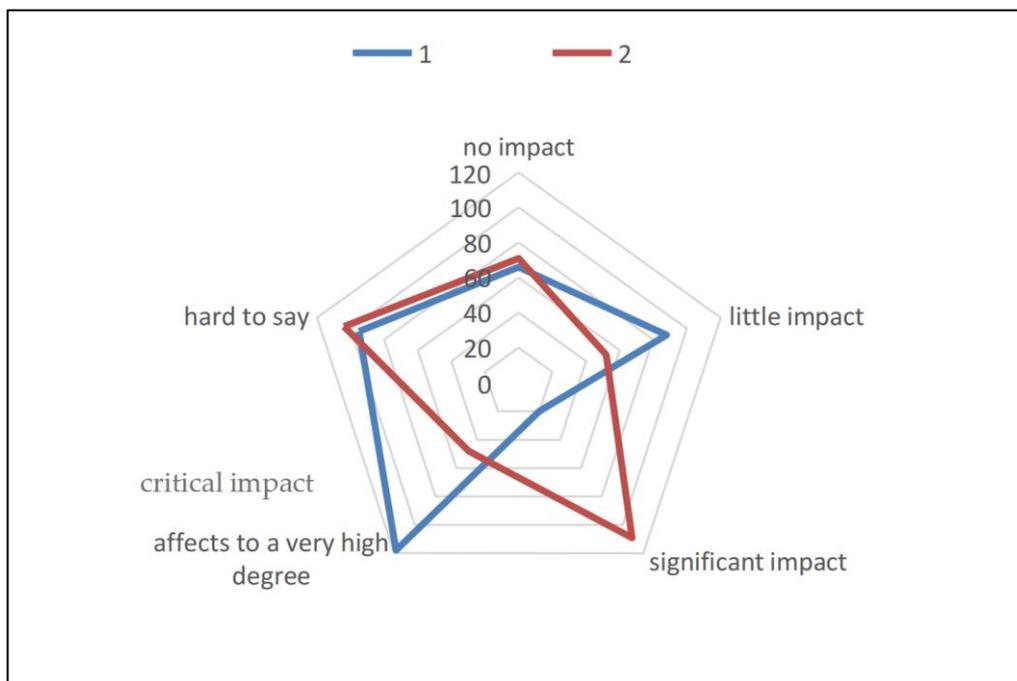


Fig. 7. Assessment of a mobile application for travel planning integrating various means of transport and linked with an internet payment system

Among the respondents of the first country, a significant 30% approved of a mobile travel planning application integrating various transport modes alongside an online payment system (Figure 7), indicating a "critical impact." In contrast, 28% of the second respondents believed it would have a "significant impact." While there were some uncertainties among the second country respondents ("hard to say" - 28%), a notable portion of the first respondents (23%) chose the "little impact" option.

The respondents' skepticism towards the proposal for a bus-on-demand service with a call center likely stemmed from doubts about its feasibility, as evidenced by the prevalence of "hard to say" and "little impact" selections. These doubts may be attributed to the relatively low

population density of the assessed areas, rendering the proposed solution potentially unprofitable. Conversely, the subsequent proposal received a much warmer reception (Figure 9).

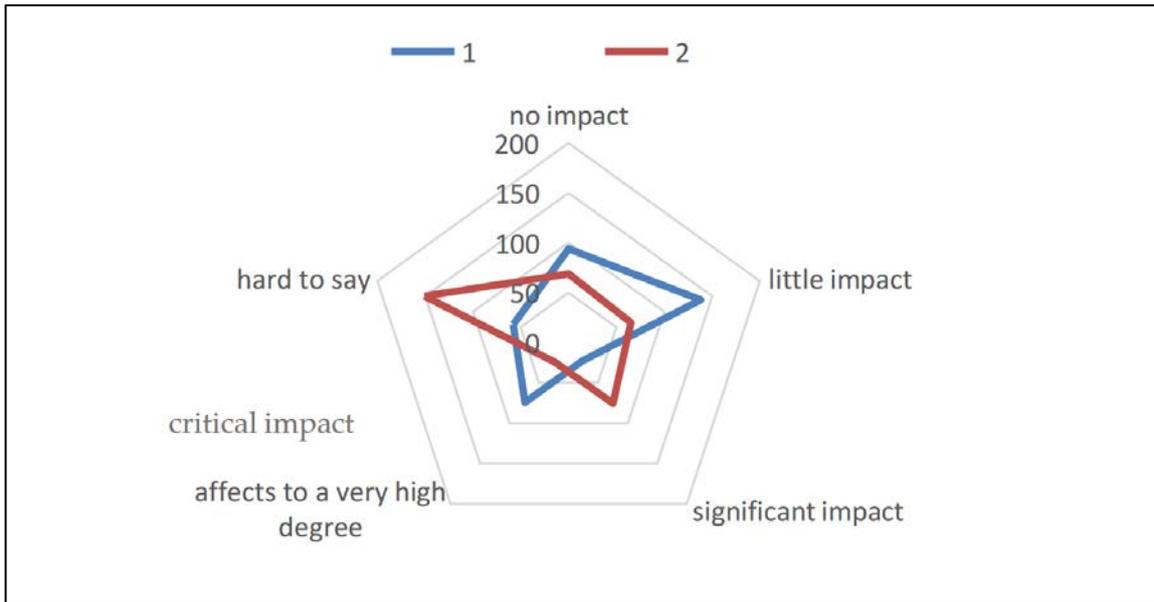


Fig. 8. Assessment of a bus-on-demand service with a call centre

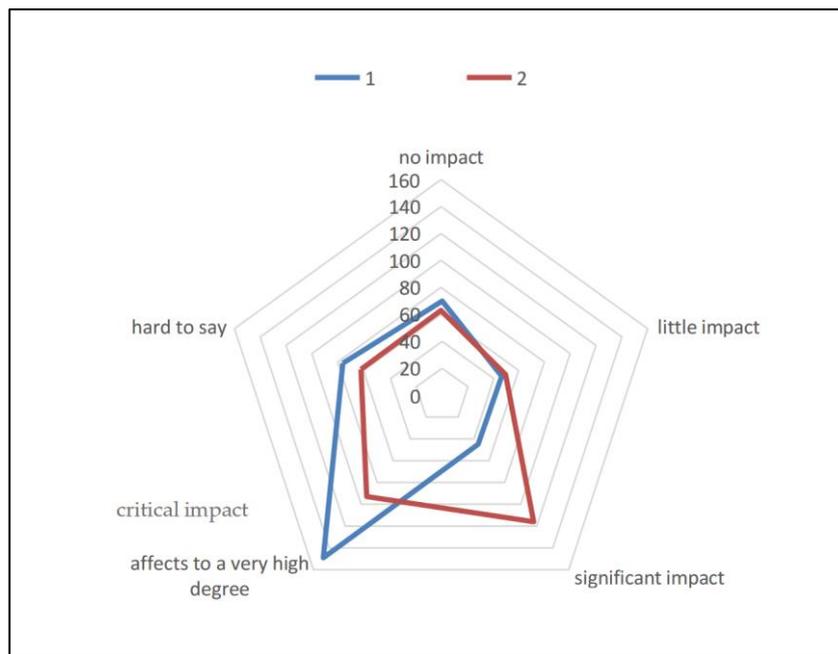


Fig. 9. Integration of transport systems (one common ticker for all means of transport)

Both respondent groups acknowledged the significant benefits of integrating transport systems through a unified ticket for all modes of transportation, seeing it as highly advantageous for enhancing residents' mobility. Residents of the first country were particularly supportive of this solution, with 39% expressing approval. While the other respondents showed less interest, the majority (30%) still viewed it positively, indicating a "significant impact."

Figure 10 reflects a response distribution similar to the previous figure, albeit with a lower level of acceptance for a system of guaranteed connections between individual transport modes. This solution was highly rated by 34% of the first country respondents and approximately 30% of the second country respondents. Regarding the innovations mentioned earlier, a

correspondence analysis was employed to evaluate the degree of correlation between the proposed solutions and respondent characteristics such as age and education.

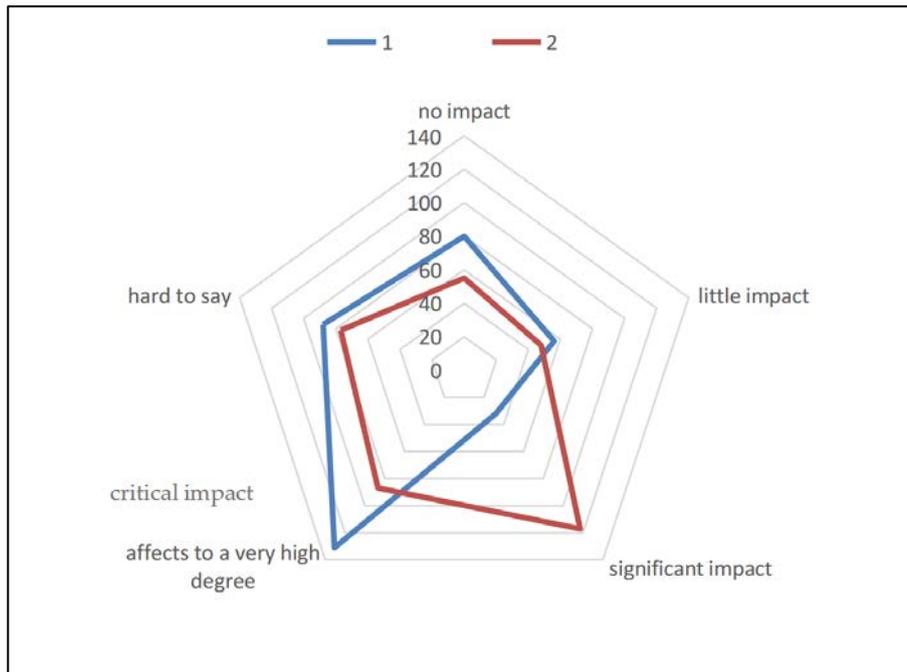


Fig. 10. Assessment of a system of guaranteed connections between individual means of transport (one vehicle waiting for another one that is delayed)

CONCLUSION

This article explores the alternatives and challenges of electric mobility in rural areas in Bulgaria, as well as in Europe. There are many steps that need to be taken before this type of transportation can be used in most Bulgarian rural areas. The vision for future mobility involves a more organized and environmentally friendly infrastructure with far fewer vehicles on the roads than there are now. Additionally, new models where people use a combination of transportation means.

Undoubtedly, rural areas require improvements to ensure sustainable mobility and increase their scale. This is also expected by the residents of these regions. Respondents from both sides chose the most optimal innovative mobility solutions. Despite different conditions, their choices were relatively similar and revolved around modern technologies and environmentally friendly transportation means. Among all presented options, the synchronization of schedules for different transport modes raised significant interest in both countries. It constitutes an organizational innovation and does not require additional investments, only agreement among the owners of different transport companies. Among the possible innovative and fully accessible (product innovations) solutions, residents of the second country considered the introduction of electric bicycles to be the most desirable.

Residents of the first country chose an innovative initiative focused on autonomous vehicles, namely an automated transport system. While automated vehicles may ultimately emerge and change the service from conventional car-sharing to an on-demand bus-style solution, implementing such technology is complex. Technological solutions aimed at increasing reliability and reducing costs for automated driving are necessary. Artificial intelligence and technologies may affect the functional safety of the vehicle. The proposal for the creation of an integrated and unified ticketing transport system was highly rated between the two respondent groups. Participants in the first country expressed much more favorable opinions about the introduction of proposed innovations. When giving the highest ratings, respondents from there usually choose "critical impact", while residents of the second country usually choose

"significant impact". It is difficult to determine the reason behind this discrepancy in this stage of the research. This issue requires further investigation.

In the second country, no significant differences in responses due to respondent age and education were noted. The only exception was responses regarding the introduction of a unified ticket for all types of transport. In contrast, such differences are observed in the case of the first country. No respondents offered any additional mobility suggestions.

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