Optimization of WEEE collection system: Assessment of key influencing factors for different scenarios in Novi Sad, Serbia

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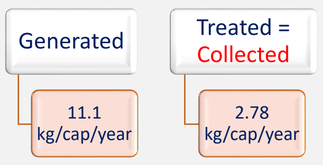
INTRODUCTION

Intensive economic development in terms of increasing productivity, introducing new technologies, and establishing employment dynamics within industrial activities contribute to a better standard of living in Serbia and play a key role in the increased demand for electrical and electronic devices. Waste electrical and electronic equipment is considered an emerging environmental problem because, in addition to its potentially hazardous nature, it is characterized by a high rate of obsolescence, while the rate of collection and recycling is at a very low level worldwide. The special feature of e-waste is that it has "significant" value even after the end of its useful life in developing countries such as Serbia. After the guaranteed lifetime, the e-waste material changes hands more than once and usually ends up in the hands of informal recyclers or household warehouses. This phenomenon makes it extremely difficult to estimate the generated amount of e-waste, while data on the collected amount is not available because municipalities do not implement an organized system for the collection of e-waste. This study aims to first identify different e-waste management scenarios in Novi Sad, the second-largest city in Serbia. The second goal is to identify the main influencing factors for each of the scenarios and subsequently analyze those factors that need to be addressed urgently to manage this issue.

WEEE management in Serbia:

- The Republic of Serbia is in the process of approximating its environmental legislation with the EU acquis.
- E-waste is disposed of mixed with MSW in landfills.
- There is no regular system of collecting WEEE from households and small businesses.
- Municipalities do not provide collection facilities for separate waste collection from households.
- The main players in waste collection are recycling companies and the informal sector.



The current situation in the e-waste management system in Serbia does not follow any compliance scheme to meet the objectives of the EPR principle.

RESULTS AND DISCUSSION

Three scenarios have been developed that may offer solutions to the problems associated with the collection of WEEE in Novi Sad.

Waste collection system	The efficiency of the collection system	Amount of waste that can be collected
	(%)	(t/y)
Stationary system	2	37,835
Mobile system	8	151,340
Recycling yard	89	1683,663

The scenarios vary depending on the management system and infrastructure options that require the implementation of different types of waste collection systems, considering economic and social criteria so that the system accepted by the local population is efficient and financially sustainable.

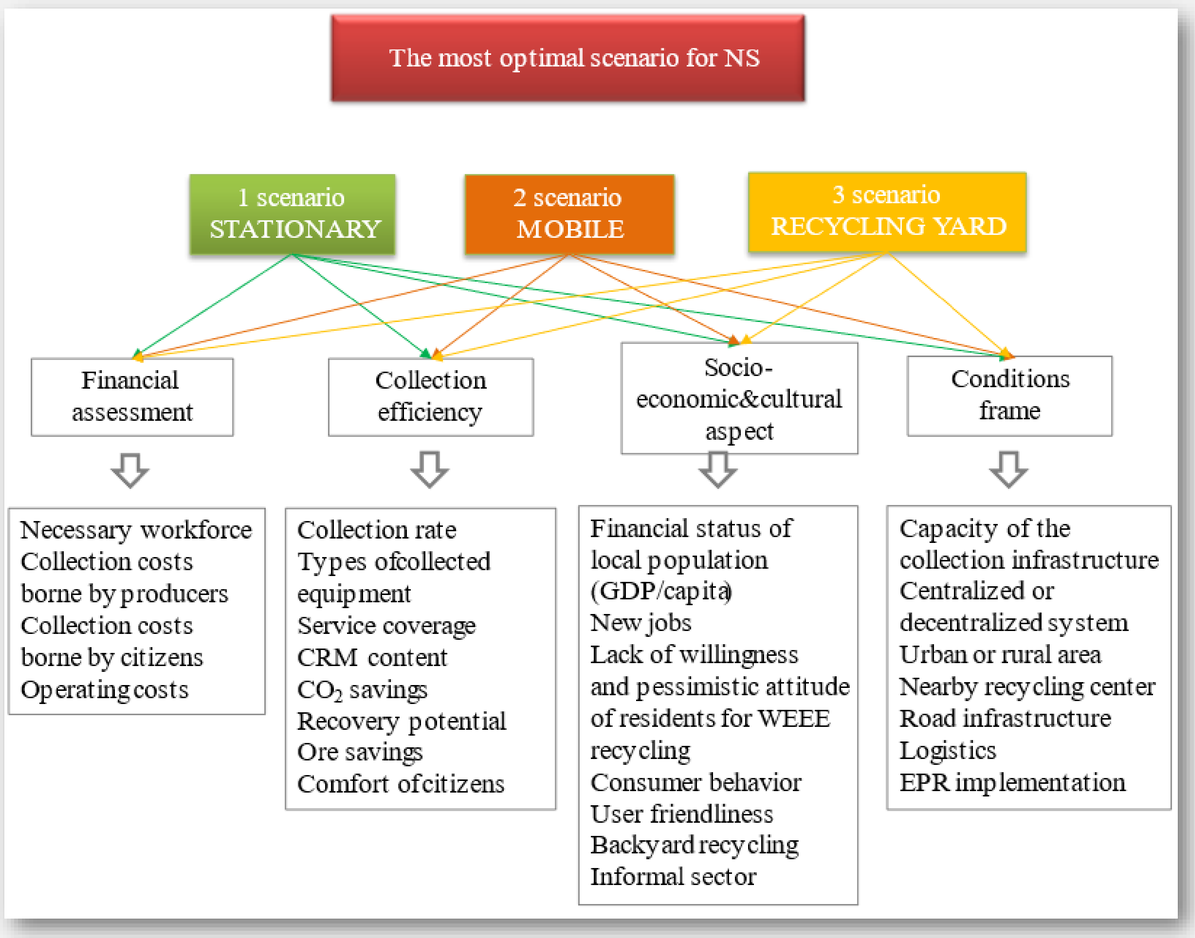


Figure 1. Main variables used to compare different collection schemes

Four primary factors and 26 sub-factors were identified!

- In the stationary system, the physical and financial responsibility is shared between the citizens and the waste collection company. It is possible to ensure good service coverage in each part of the city, and therefore great comfort for citizens.
- Mobile systems describe decentralized collection at the point of waste generation and are associated with the lowest costs. Collection in remote areas can be quite expensive due to the long distances between collection points.
- In the recycling yard scenario, all costs are borne by the end users, and it is the least convenient for citizens.
- Waste collection under the first and third scenarios is centralized, therefore it is most economical in areas with high populations and is particularly suitable for source-separated recyclables. The mobile system has the disadvantage of being inefficient for cities with high traffic volumes or poorly developed road infrastructure.

CONCLUSION

Most of the published studies deal with the economic aspects, system efficiency, socio-economic and cultural barriers, and technical capabilities to set up the system such as infrastructure and logistics. In developing countries, such as Serbia, the main actors in the collection of e-waste are informal collectors. It is necessary to take care of this sector's inclusion when planning to introduce a new collection system. After the first study on this topic in the Novi Sad region, twenty-six factors were identified. Many of these factors have a contradictory relationship with each other, and it is not easy to decide which of them has greater or lesser importance.

The application of decision support systems based on multi-criteria analysis is planned for further research and will help the decision maker to find one of the best solutions by reconciling all criteria, different preferences, and conflicting interests. Results can significantly contribute to the selection of appropriate guidelines for the establishment of an adequate system of e-waste management in Novi Sad.