

Collection of Dry Recyclables as an Effective Step in Waste Management?

JIŘÍ GREGOR, JIŘÍ KROPÁČ & MARTIN PAVLAS

Abstract Current trends in European waste management (WM) focus on technologies and methods. Currently, European Commission adopted a new set of measures in Circular Economy Action Plan, the main motivation is according to an economic point of view a minimization of the collection costs. The costs of municipal waste collecting and transporting are a significant part of municipal budgets. Therefore the need for analysis and subsequent evaluation of claims and options of different systems for the collection of municipal waste usable components is motivating. The separate municipal waste is transported by garbage trucks to a sorting line for secondary raw materials production. The author's team develops a complex set of innovative tools in the context of WM. The tools are able to evaluate the current situation, to prepare forecasts and especially to propose optimal and effective solutions for selected territorial units. This paper describes the potential of separate collection dry recyclables (plastics, paper, glass, metals) into one container. The comparison with standard collection system is mentioned (separate containers for individual fractions). The main objective of this article is to compare the costs of material recoverable municipal waste collection, treatment and transport to final processing in conditions of Czech waste management.

Keywords: • Sorting line • Waste management • Dry recyclables • Techno-economic assessment • Collection model • Transport •

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1 Introduction and motivation

Current trends in European waste management (WM) focus on technologies and methods that comply with preferred procedures of waste treatment hierarchy. The Member States are encouraged to increase the preparing for re-use and the recycling of waste materials (such as paper, metal, plastic and glass) from households at least (and possibly from other sources as far as these waste streams are similar to waste from households) to a minimum of overall 50 % by weight by 2020 (directive 2008/98/EC). Further, in January 2018 the European Commission adopted a new set of „Circular economy package“ measures, including the Europe-wide EU Strategy for Plastics, options to address the interface between chemical, product and waste legislation and a Report on Critical Raw Materials and the circular economy (Brouwer et al., 2018).

Based on prepared legislation and European targets, the main goal is to increase recycling rate. This key milestone is planned until 2035 when the following recycling targets are forced:

- 70 % recycling of all packing material;
- Plastics 55 %;
- Wood 30 %;
- Metal 80 %;
- Aluminum 60 %;
- Glass 75 %;
- Paper and cardboard 85 %;

According to these goals, it is necessary to obtain the secondary raw material from the producers (inhabitants) in a certain quality and quantity. The very important aspect is China and its market - Chinese market has limited the import of plastics from Europe and is only interested in a high-quality secondary raw material, especially the PET fraction (white or mix). In Europe, a large number of secondary raw materials, especially plastics, are currently being accumulated. There are not relevant capacities in Europe which can handle plastic fractions or other secondary raw materials from the separate collection. At first, it is necessary to build new facilities for recycling paper, plastics, metal, glass, others and find correct utilization for each of interested streams.

The author's team is interested in the development of relevant tools for waste management assessment. The key element is the *NERUDA* tool (Šomplák, 2014), which is based on complex logistic optimization supporting decision-making in waste management. *NERUDA* tool works with various types of facility models e.g. (waste-to-energy plant, transfer station, MBT plant, sorting line and others key elements) – Figure 1. The main principle of *NERUDA* tool is the transportation task, therefore, it is necessary to improve the accuracy of input parameters calculated by transportation models. Gregor et al. (2017) described techno-economic models of transportation systems. Each transportation model has been analyzed according to its specific parameters (transport distance, amount of waste transported) and the main output is transportation cost. Models can calculate the linear or variable cost of transportation. Both types of costs have advantages and disadvantages. The main differences between the approaches are computation times in *NERUDA* tool, where it is more time-consuming for variable cost of transportation. Another key step is the preparation of techno-economic models for various types of facilities, e.g. transfer station for transportation of pressed waste or non-pressed waste (Gregor et al., 2017), sorting line (Gregor et al., 2018), MBT technology (Fei et al., 2018), Waste-to-energy plant (Ferdan et al., 2015).

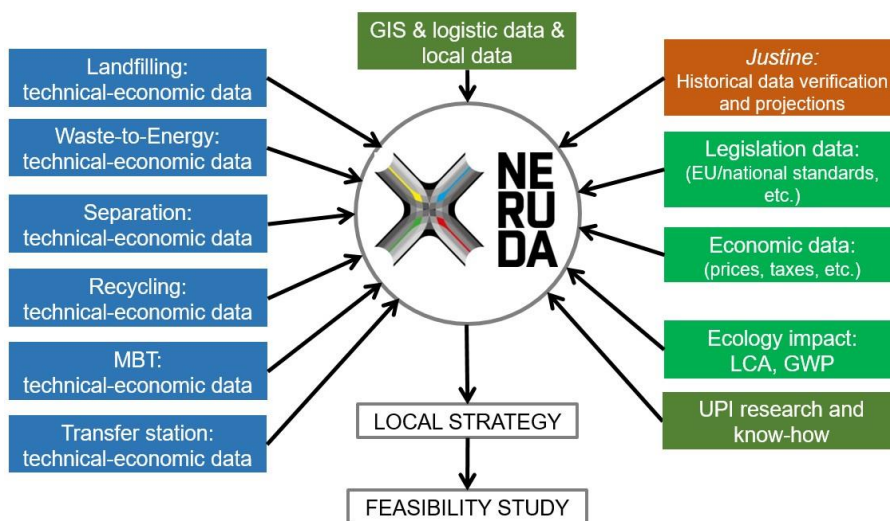


Figure 1: NERUDA tool – modular structure

Forecasting of future amounts of waste is based on *JUSTINE* tool, see (Šomplák et al., 2017). For the purpose of complex modelling in the field of waste management it is necessary to be able to take into account current legislation, economic data and environmental impact. Subsequently, with *NERUDA* tool and other sub-models (mathematical and techno-economic models), it is possible to prepare feasibility study which can be applied within any territory. The case study in a specific region using the main outputs from *NERUDA* tools were presented by Kropáč et al. (2016). Details about the potential of environmental impact are described in (Nevrlý et al., 2018).

2 Waste management in the Czech Republic

In 2016, the Czech Republic produced ca. 34.2 million tons of all waste. A total of 85 % of all wastes were recovered – 82% material recovery and 3 % energy recovery, while 9 % of all waste was transported to the landfill. In the same year – 16 % of the production was the municipal waste, which corresponds to 5.6 million tones in total and 531 kg of municipal waste per year and inhabitant. From the municipal waste point of view, 38 % were material recovery, 12 % energy recovery and 50 % was landfilled.

The support of the CEP concept and increased recycling rates will be facilitated by the introduction of compulsory sorting of metals and bio-waste, and the current ban on landfilling of mixed municipal waste, recyclable and recoverable waste from 2024, which has been in Czech legislation since 2014.

2.1 Waste transportation chains in the Czech Republic

Waste collection and transportation of waste is in the Czech Republic divided according to three systems:

- Garbage trucks + direct transport to the nearest landfill site, transfer station or sorting line;
- Garbage truck + transfer station with press equipment + vehicle with containers + pressed waste;
- Garbage truck + transfer station + handling equipment + vehicle with Walking Floor semitrailer + non-pressed waste;

3 DRY recyclables and comparison with standard systems

The system of DRY recyclables is operating in some regions in England or Germany. Dry recyclables have big potential for a waste management system when they use a returnable package (plastics bottle, glass bottles, tins and others). Inhabitants have a motivation to return package (potential of saving money) and package which are damaged can be thrown away to the bin with DRY recyclables. The main advantage of this system is that biological waste is not collected together with DRY recyclables, because it can decrease the quality of materials, especially paper. Subsequently, it is not difficult to sort the flow of DRY recyclables.

Dry recyclables consists of paper, plastic, metal and glass. Paper and plastic can be divided into more fractions, see (Gregor et al., 2018) for more details about fractions and sorting. For calculation of transport (non-pressed) and sorting, the bulk density 80 kg/m^3 of dry recyclables was considered. Density was determined according to the production of a waste and operating experience from the collection and sorting lines.

4 Case study related to the dataset from the Czech Republic

Authors of this paper have analyzed waste production in 206 Czech municipalities. Datasets describing 206 regional waste productions were prepared on the basis of the data from 2015. Representative waste production of all examined commodities (plastic, paper, glass and metal) were estimated for each municipality. For further analysis, an exemplary municipality was chosen. The calculations were performed with regards to the data of all municipalities (average and median). The expected composition of dry recyclables is stated in Table 1.

Table 1: Waste production of 206 Czech municipalities (year 2015)

Commodities	Median	Average	Production of Czech Republic	
			t/y	-
-	t/y	t/y	t/y	-
Metal	916	1 386	285 461	25%
Paper	1 678	1 981	408 102	36%
Plastic	1 402	1 316	271 012	24%
Glass	814	821	169 028	15%
Dry Recyclables	4 811	5 503	1 133 603	100%

With respect to values in Table 1, the characteristic transport route was generated with the following parameters:

- The distance of 30 km for one collection route;
- Working hours – 8 hours per day;
- Working days per week – 5 days;
- Collection of separate commodities by garbage trucks with two axles;
- Collection of dry recyclables by garbage trucks with three axles;

The costs for the collection of separated commodities (plastic, paper, glass and metal) and potential of dry recyclables were calculated, see Figure 2. Evaluation of the collection costs was established according to Table 1.

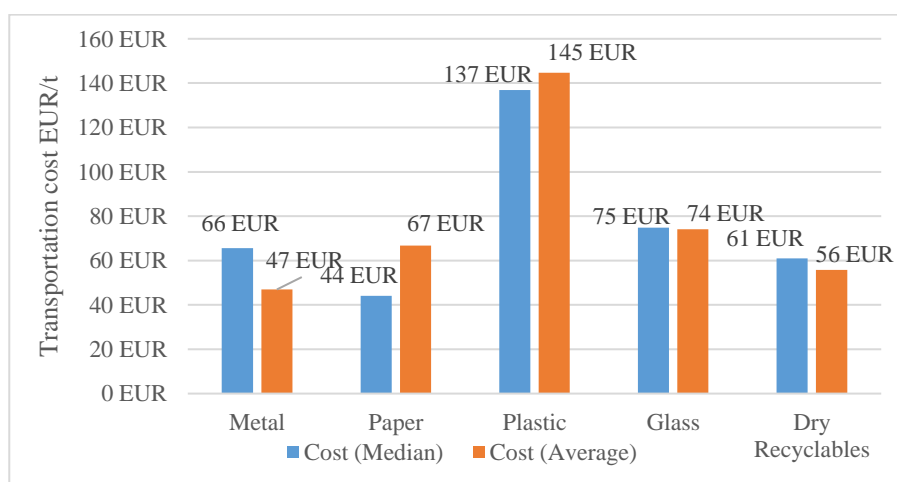
**Figure 2: Transportation cost of selected commodities**

Figure 3 presents the comparison of annual transportation cost for both collection systems. There are lower annual costs in the context of the considered average and median capacities. The use of dry recyclables evinces savings of up to 30% in the collection costs.

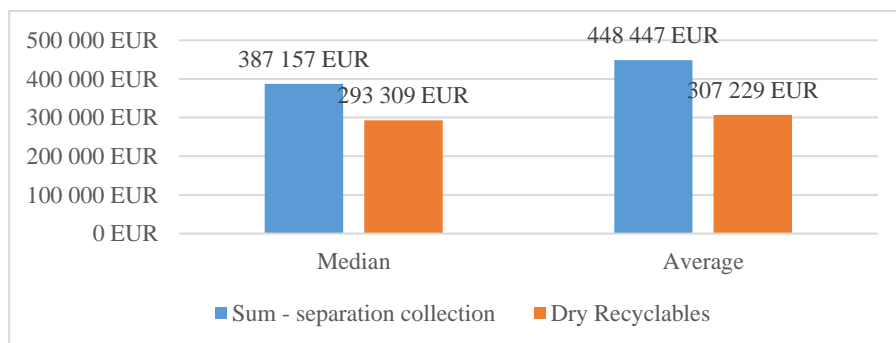


Figure 3: Annual transportation cost of selected commodities

The next analyses assess the operating costs of sorting lines. Due to low capacities, the manual line has been selected and operating costs set. The calculation takes into account operating and wage costs, while construction and technology are not included. The calculation was made with the following assumptions:

- Separated commodities: sorting of the paper and the plastic, in the case of glass and metal it is a temporary warehouse;
- Dry recyclables: sorting of selected fractions;

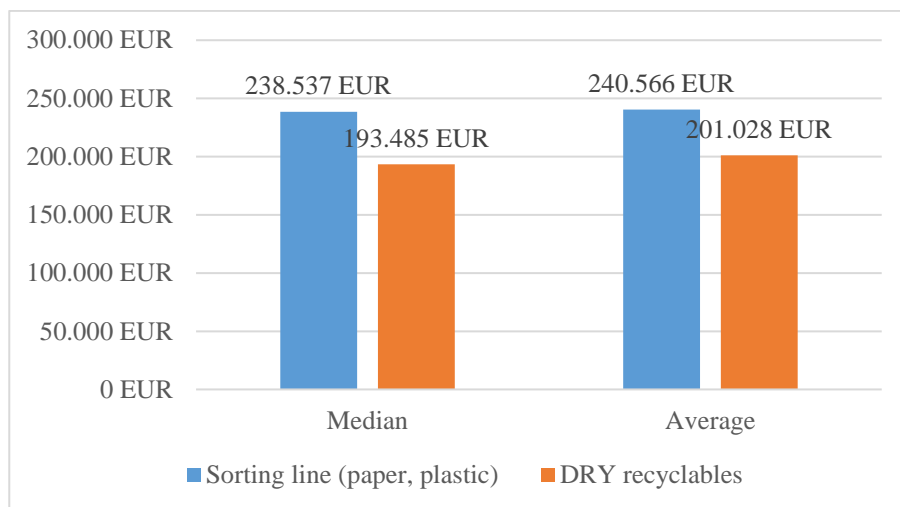


Figure 4: Annual operating cost for sorting line

After processing of separated commodities from MSW, respectively dry recyclables, the pressing into bundles follows. Then the bundles are transported for final treatment which may be:

- Separated waste;
 - Metal – metallurgy;
 - Glass – glassworks;
 - Paper: Secondary raw material – paper mill, residual flow – waste-to-energy plant, landfill;
 - Plastic: secondary raw materials – recycling plant, selling material with profitable cost, residual flow – waste-to-energy plant, landfill, others;
- DRY recyclables;
 - Secondary raw materials – see above;
 - Residual flow – waste-to-energy plant, landfill, others;

The transport from sorting lines to recycling plants or energy recovery is carried out by vehicle with containers. The corresponding cost per ton varies between 10 and 35 EUR depending on the distance and the quantity transported.

In the overall assessment in terms of operating costs, it can be stated that the dry recyclables system is economically more lucrative, see Figure 5. The respective savings are 29 and 38 % related to current system and the savings can be considered as economically significant.

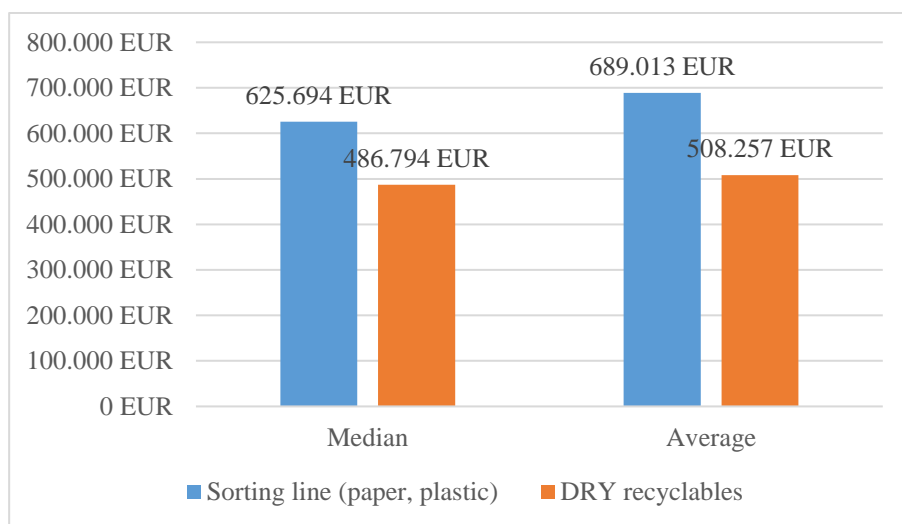


Figure 5: Annual operating cost related to two waste streams (transportation and sorting)

The main disadvantages of DRY recyclables:

- Use of more expensive sorting technology (automated sorting elements);
- Dry recyclables are not economically supported by authorized packaging companies in the Czech Republic;
- Higher residual stream from sorting;
- The lower purchase price of secondary raw material in terms of purity;
- New implementation of infrastructure needed;
- Social acceptability of a completely new system;

The main advantages of DRY recyclables:

- More economical option than the standard collection system from the operational costs point of view;
- Less amount of containers to be serviced;
- The compliance of the European recycling targets;

- Possible interconnection with the system of returnable packages – profit from the secondary raw material of high-quality;
- Financial incentives for inhabitants (returnable packages);

5 Conclusion

The proposed analysis revealed the DRY recyclables system as a great potential for possible further research because it is an economically interesting solution which minimizes the cost of transport and improves the overall waste management system. From one point of view, it is necessary to expect a higher rate of discard which may arise from contamination of the paper fraction. Economic analysis proved that DRY recyclables system is a meaningful system that can be economically viable when properly configured.

The applicability of DRY recyclables depends on local conditions, which must always be properly evaluated. The particular project needs a techno-economic assessment, however, for deeper analysis, it is better to use the complex computational or optimization tools. It is also necessary to correctly identify whether it is economically advantageous to use manual or fully automated lines, which range from EUR 6,000 (technology only). The advantage of automated lines is the component identification with a minimal error rate of selected fractions (Gundupalli et al., 2017). Combining the right system and the returnable packaging represents an interesting solution for high recycling targets proposed by EU legislation.

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