

Article

Using the Amount of Plastic Packaging Placed on the Market to Determine the Annual Amount of Plastic Packaging Waste Generated in Poland to Enable Sustainable Waste Management

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Abstract: A new category of own resources based on national contributions, which are calculated on the basis of the amount of non-recycled plastic packaging waste (PPW) (EUR 0.80 per kilogram), was introduced in 2021 by the decision of the EU Council (EU, Euratom, 2020/2053). In accordance with the European strategy for plastics, the Union budget can contribute to reducing pollution from PPW, which is consistent with sustainable waste management. To calculate the own resource of plastics, it is necessary to determine the amount of non-recycled PPW by taking the difference between the amounts of generated and recycled PPW. Data on the amount of recycled PPW can be obtained from recycling facilities. The challenge, however, is to determine the actual amount of PPW generated in a given year. For this reason, the present study was undertaken to determine the amount of PPW generated annually, based on the amount of plastic packaging placed on the market (PPM) (i.e., with the use of the placed-on-the-market approach). To perform the calculations, the Polish entities that place products in plastic packaging on the market were identified. It was assumed that the amount of PPM was the sum of the amounts of packaging stated by producer responsibility organizations (PRO), as well as self-compliers (SC), private imports (I), and free-riders (FR), minus the amount of packaging privately exported (E). To obtain the relevant data from the records linked to the amounts of plastic packaging imported to and exported from Poland, a detailed methodology was developed. A complementary analysis was concurrently conducted to estimate the amount of plastic PPM by free-riders. The results of these analyses indicate that the amount of packaging transparently reported by the PRO accounted for almost 97% of the total amount of PPM. The analysis found 19,728 SC who placed 2.22% of the total plastic packaging on the market. The total amount of privately imported plastic packaging was 17,304,666 kg (1.37%). Plastic packaging placed on the market by FR is 24,788,196 kg (1.97%). However, the amount of plastic packaging privately exported was 30,571,691 kg (2.43%). Thus, in 2021, the amount of plastic packaging placed on the Polish market was 1,259,345,296 kg; this figure constitutes the basis for determining the own resources based on non-recycled PPW. It also indicates the potential of PPW to serve as a resource for the production of new products, which is in accordance with the principles of a circular economy.

Keywords: own resources; non-recycled plastic packaging waste; producer responsibility organization; free-riders; private exports/import; plastic tax; sustainable packaging waste management



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1. Introduction

It is impossible to imagine the transport and delivery of goods without packaging. Paper (36%) and plastics (34%) dominate as packaging materials. Due to their cost efficiency and versatility, plastics have seen significant growth since the 1940s [1]. Plastic packaging, which is mainly used for food and beverages, accounts for 39.1% of European plastic demand [2]. Despite the significant role of plastic packaging, it has gained particular attention

in public discourse, with many images of land and marine plastic waste [3–5]. It is impossible not to mention the problem of microplastics spreading in all places and environments, which is currently so widely discussed in world literature (for example, [6–8]). Improperly managed plastic packaging waste (PPW) not only poses a threat to the environment but also raises awareness of the need for responsible disposal [4,9,10]. Despite initiatives aimed at reducing the impact of PPW on the environment, it is difficult to determine the actual amount of PPW produced in a given year. Moreover, the Council of the European Union requires each Member State to submit an annual report containing data on the weight of PPW generated and recycled, as well as an estimate of the own plastics resources, based on the amount of PPW that is not recycled. According to Article 2(1)(c) of Council Decision (EU, Euratom) 2020/2053 [11], the own resources budgeted by the EU consist of revenue derived, *inter alia*, by applying a uniform rate of collection (EUR 0.80 per kilogram) to the weight of PPW generated in each Member State that has not been recycled. Poland and some other Member States are entitled to an annual flat rate reduction of EUR 117,000,000.

The Council Regulation (EU, Euratom) 2021/770 [12] was adopted on 30 April 2021 and established rules for (i) calculating the own resources based on non-recycled PPW and (ii) making data on these resources available to the European Commission (entry into force: 1 January 2021). The report form was established on 16 March 2023 [13], and thus, in 2021 and 2022, the Member States were able to submit only their forecasts for the weight of non-recycled PPW. The first national reports should be submitted 19 months after the end of the respective year (e.g., for the year 2021, by 31 July 2023). To calculate the amount of own resources based on non-recycled PPW [12], it is necessary to determine the amount of PPW generated and PPW recycled. The weight of non-recycled PPW is the difference between generated PPW and recycled PPW.

To estimate the amount of PPW generated, the Commission Implementing Regulation (EU) 2023/595 of 16 March 2023 [13] allows two methodological approaches. The first one is based on the morphological analysis of municipal waste. The methodology for determining the morphological composition of municipal waste is well-known, but it requires long-term, preferably year-round, and widely conducted research, as well as precise determination of waste composition, *i.e.*, not only the total amount of plastics but the specification of types of PPW. A study conducted in 2021 found that 1,057,721,191 kg of PPW were present in generated municipal waste [14]. However, this study did not consider sources of PPW other than municipal waste. The second methodological approach for estimating the amount of generated PPW is to determine the amount of this type of packaging placed on the market. The Regulation [13] defines this as a method for estimating generated PPW based on data on the placement of plastic packaging on the market. The placed-on-the-market approach makes it possible to include all sources of PPW, not just municipal waste.

The present study aimed to determine the amount of plastic packaging placed on the market (PPM) in Poland in 2021 and, thus, to determine the amount of plastic packaging waste generated, which is necessary to directly determine the own resources. It should be noted that, until 2023, the own resources of each Member State, due to the lack of an applicable methodology, were only estimated and did not take into account the guidelines provided in the newest regulation. Poland was one of the first EU countries to prepare a report for 2021 that contained data on the amount of plastic packaging waste generated. To achieve this, it was necessary to identify all sources introducing products in plastic packaging and propose a methodology for calculating the amount of plastic packaging or PPW from these sources. To date, this methodology has not yet been presented.

2. Materials and Methods

To calculate the amount of PPM in 2021, entities that place products in plastic packaging were identified (Figure 1).

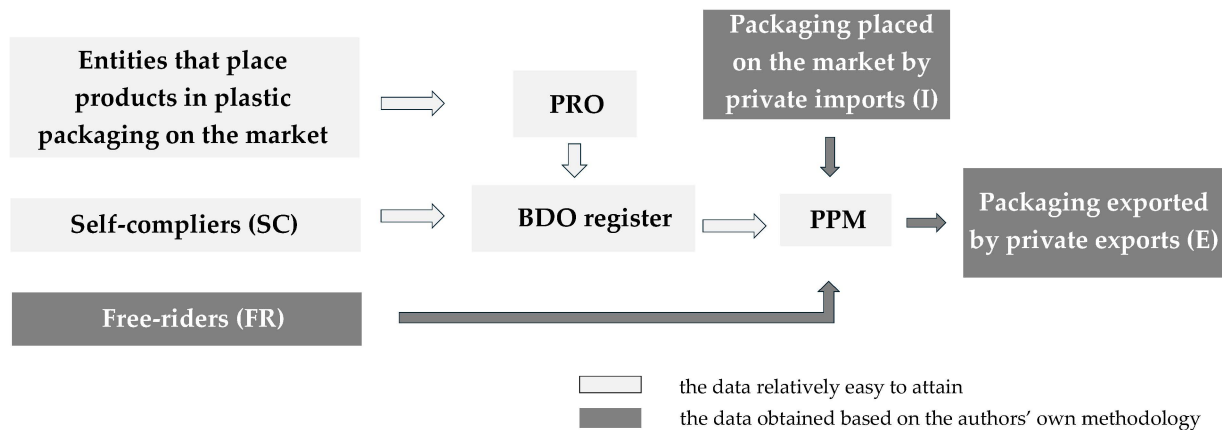


Figure 1. Schematic diagram used to identify all sources of plastic packaging placed on the market.

It was assumed that the amount of PPM (Figure 2) could be calculated as follows:

$$PPM = PRO + SC + I + FR - E$$

where:

PRO—the amount of packaging reported by producer responsibility organizations (PRO),

SC—the amount of packaging placed on the market by self-compliers,

I—the amount of packaging placed on the market by private imports,

E—the amount of packaging exported by private exports,

FR—the amount of packaging on the market by free-riders.

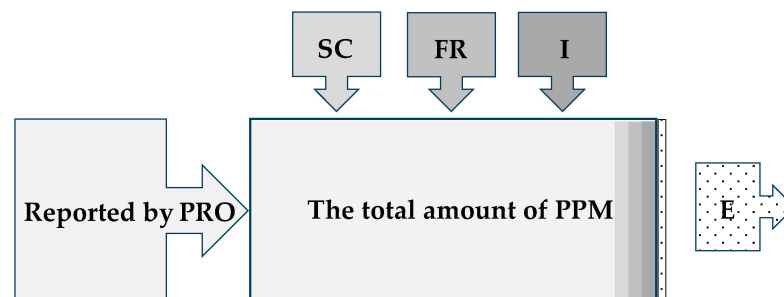


Figure 2. Schematic diagram to determine the amount of PPM.

The primary source of data used in the present study was information from the national waste register, i.e., the database on products, packaging, and waste management, abbreviated in Polish as BDO. The BDO register is an integrated ICT system that has been in operation in Poland since 2018, with the record-keeping and reporting modules launched on 1 January 2020. The BDO is administered by the Ministry of Climate and Environment, and the register of entities is maintained on an ongoing basis by the Marshals of Voivodeships (the highest-level administrative divisions of Poland). Polish law regulates the obligation of certain entities to register and the type of information collected in the BDO.

Subject to registration and reporting are, among others, entities that place products in plastic packaging on the market, those engaged in intra-community delivery of products in plastic packaging, and plastic packaging recovery organizations. The entities who place products in plastic packaging on the market include:

- entrepreneurs who perform business activity in the field of marketing of packaged products, in particular, those who do so under their own trademark,
- entrepreneurs who carry out packaging of the products manufactured by other entrepreneurs and place these products on the market,

- retail units that sell products packaged in these units.

Excluded from the regulation in connection with packaging are entrepreneurs who place plastic-packaged products on the market in a given calendar year, and then in the same calendar year, exported or made an intra-community supply of plastic packaging with or without products. Among others, the BDO register contains data on the types and weights of plastic packaging in which products were placed on the market in Poland. The analysis carried out in the present study included:

- 23 packaging recovery organizations who reported to the BDO for the year 2021 the amount of plastic packaging in which products were placed on the market,
- 19,728 entrepreneurs who independently submitted reports to the BDO for 2021 on the amount of plastic packaging in which products were placed on the market,
- 11 economic self-government organizations who submitted to the Minister of Climate and Environment reports in compliance with the agreements concerning the obligations that the organizations took over from entrepreneurs who placed on the market products in multi-material packaging and hazardous substances in plastic packaging.

For the placed-on-the-market approach, it was necessary to develop a methodology to determine the amount of PPM by free-riders, including private exports/imports of plastic-packaged goods.

3. Results and Discussion

3.1. Amount of Plastic Packaging Reported by Producer Responsibility Organizations (PRO)

The PRO include packaging recovery organizations and economic self-government organizations. Consistent with Polish legislation, entities that place plastic-packaged products on the market are divided into those that place hazardous products in plastic packaging and products in multi-material packaging and those that place products in plastic packaging other than multi-material packaging. The first group may delegate their obligations as regards management of packaging and packaging waste to economic self-government organizations, whereas the other entities may delegate their obligations to packaging recovery organizations. These organizations assume their obligations, on the basis of an agreement concluded in writing (otherwise being null and void), for the total mass of packaging for one or more types of products in packaging placed on the market in a given calendar year. The economic self-government organizations enter into agreements with the entities that place hazardous products in packaging and products in multi-material packaging.

Entities that place products in packaging on the market are obliged to keep records in either paper or electronic form, including information on the mass of plastic packaging that they place on the market in a given calendar year. At the same time, they are responsible for providing PRO with the data necessary to fulfill the obligations taken over by those organizations, including information on all products in plastic packaging placed on the market in a given calendar year. The packaging recovery organizations prepare annual reports in the BDO register and provide lists of entrepreneurs who commissioned them to prepare the reports. In contrast, economic self-government organizations are obliged to prepare and submit annual reports to the competent Marshal of the Voivodeship (via the BDO register) separately for each entity placing plastic-packaged products that the organization represents. Additionally, based on the agreements mentioned above, the economic self-government organizations submit annual reports to the Minister of Climate and Environment.

The analysis indicated that, in the year 2021, PRO took over reporting for 97% of the packaging in which products were marketed.

3.2. Amount of Plastic Packaging Reported by Self-Compliers

According to the provisions of Regulation 2023/595 [13], self-compliers are entities responsible for placing products in packaging on the market. They independently fulfill the obligation to ensure the recycling of the waste from the packaging that they place

on the market. These entities are obliged to independently prepare and submit annual reports to the Marshal of the Voivodeship regarding, inter alia, the amount of packaging that they place on the market. These entities authorize a producer to take financial or financial/organizational responsibility for the management of PPW and, thus, are not obliged to report PPW to PRO. Regulation 2023/595 indicates that, when using the placed-on-the-market approach, producers below the de minimis threshold should be included. The de minimis threshold is “a minimum threshold that can be defined by the Member States, below which reporting is not required towards a producer responsibility organization or a public authority”.

Polish law states that all entities that place products in plastic packaging on the market are subject to annual reporting to the BDO national register, irrespective of the amount of plastic packaging. De minimis aid applies only to the entrepreneurs who, in a given calendar year, placed on the market plastic-packaged products with a total weight not exceeding 1 Mg, as long as the required levels of packaging waste recycling are achieved and the related product fees are paid. The entities who wish to receive de minimis aid have to submit the relevant certificates or statements to the responsible Marshals of Voivodeships. The entrepreneurs must meet the conditions for de minimis aid eligibility specified in the applicable provisions of EU law. The aforesaid certificates/statements are submitted through the BDO register. The analysis found 19,728 self-compliers who placed 2.22% of the total plastic packaging on the market in 2021.

3.3. Amount of Packaging Privately Exported

Because of free movement throughout the Schengen area, goods crossing the borders of the Member States are not controlled by any authorities; thus, data on products in plastic packaging migrating between the countries are not available. The private export examined in this study refers to packaging of products exported by a natural person for their own final use to another Member State or to a third country from a brick-and-mortar store [13]. In this study, to estimate the amount of plastic packaging from private exports, data from statistics related to retail sales [15] and non-resident expenditures [16] were used, as well as statistics from the Border Guard Headquarters [17] (Table 1).

Table 1. Data on plastic packaging exported by natural persons for their own final use to another state [13,15–17].

Data Related to Exports of Plastic-Packaged Products from Poland	Quantity
Number of border crossings to other countries (from Poland to other countries)	101,516,866
Retail sales, excluding services, in Poland in 2021 (million PLN)	1,000,028.20
Expenditures of non-residents in Poland who indicated shopping (excluding services) as their destination (million PLN)	24,520.80 (2.45%)
Weight of plastic packaging in which products were marketed—BDO data (kg)	1,247,824,125
Quantity of plastic packaging privately exported (kg)	30,571,691

The share of non-resident expenditures in retail sales in Poland was 2.45%. It was assumed that the weight of plastic packaging exported by private exports was proportional to the share of the weight of plastic packaging in plastic waste registered in the BDO register. The calculated amount of plastic packaging privately exported in 2021 was 30,571,691 kg. The per capita amount of plastic packaging exported from Poland was 0.3 kg.

3.4. Amount of Plastic Packaging Resulting from Private Imports

Here, the term private imports refers to “packaging of products imported by a natural person for own final use from another Member State from a brick-and-mortar store, or from a third country from a brick-and-mortar store or via an online marketplace” [13]. To estimate the amount of packaging imported into Poland in 2021, the data presented in Table 2 were used. In the study year, Polish citizens spent a total of PLN 15,058.90 million when they were out of the country on food and non-food items from other countries. As in

the case of exports, the largest share of imported goods was imported through land borders in the European Union, accounting for 67.6% of the total expenditure of Poles importing products to Poland. The highest total expenditure was registered on the border between Poland and Germany, and the lowest expenditure was related to goods transported across the external borders of the EU. Statistics from the Border Guard Headquarters [17] show that the Polish border was crossed in total 102,431,215 times.

Table 2. Data used to determine the amount of plastic packaging in which products were imported into Poland in 2021 by individuals [13,17].

Data Related to Imports of Plastic-Packaged Products	Quantity
Number of border crossings (from other countries to Poland)	102,431,215
Retail sales, excluding services, in Poland in 2021 (million PLN)	1,000,028.20
Expenditures of Polish citizens abroad, excluding services (million PLN)	15,058.90
Mass of packaging waste in municipal waste based on an analysis of the composition of generated waste (kg) [13]	1,137,051,270
Amount of plastic packaging privately imported (kg)	16,828,359

Plastic packaging imported to Poland by natural persons is not registered as marketed packaging but does constitute a share of packaging waste generated. In this study, a calculation was made to determine the amount of plastic packaging imported by natural persons (privately imported). To the value of retail sales in Poland in 2021, which amounted to PLN 1,000,028.20 million, was added the expenditure of Polish citizens abroad (PLN 15,058.90 million). Thus, the share of spending abroad amounted to 1.48%. This share was multiplied by the weight of plastic packaging waste identified in the composition of municipal waste generated in the country in a given year [14]. Thus, privately imported plastic packaging amounted to 16,828,359 kg, or 0.16 kg per person, that came to Poland.

According to the definition provided in Regulation 2023/595 [13], private imports should also include product packaging delivered to the country via the online marketplace (applicable to third countries). For this purpose, the study used data on the postal market in Poland in 2021 [18] (Table 3).

Table 3. Data on the postal market in 2021 in Poland related to the amount of packaging in which products were imported [18].

Data Related to the Amount of Plastic-Packaged Products Imported to Poland in 2021	Amount
Number of consumers in Poland (million)	30
Share of consumers making private purchases in foreign stores (%)	32
Number of consumers shopping privately in foreign stores (million)	9.6
Number of incoming cross-border parcels (pcs.)	37,700,000
Number of parcels delivered from third countries (pcs.)	11,400,000
Amount of plastic packaging of goods purchased online (kg)	476,308

The share of cross-border parcels and those delivered from third countries accounted for 30.2% of all parcels delivered in Poland in 2021 [18]. This figure was related to the number of consumers shopping privately in foreign stores, which was 2.899 million internet users buying from stores outside the European Economic Area. This number was multiplied by the amount of plastic packaging imported to Poland by one person (0.16 kg) to estimate that the total amount of plastic packaging of goods purchased online was 476,308 kg. Together, the amount of plastic packaging imported by private individuals (16,828,358 kg) and the amount purchased online (476,308 kg) resulted in a total amount of privately imported plastic packaging of 17,304,666 kg.

3.5. Amount of Plastic Packaging from Free-Riders

The term free-rider refers to “a producer or distributor placing on the market plastic packaging or packaged products who does not report to a producer responsibility organi-

sation or a public authority, nor otherwise taking financial responsibility or financial and organisational responsibility for the management of the plastic packaging waste; or reports a smaller amount than actually placed on the market". This study estimated the amount of plastic packaging placed on the market by free-riders.

Using the business profiles of enterprises available on their websites, a random sample was selected consisting of 2100 entities engaged in catering, the florist business, the pastry business, bakeries, and internet commerce businesses, i.e., potential marketers of plastic-packaged products. The geographic location of the entities, i.e., the voivodeship and municipality, was recorded. Each randomly selected entity was checked in the BDO register to verify whether they were registered as a marketer of plastic-packaged products. A total of 1616 free-riders were identified, which constituted 77% of the total. The largest percentage of free-riders was recorded in the Warmińsko-Mazurskie Voivodeship (99%) and the smallest in the Śląskie Voivodeship (63%). The share of free-riders was 77% in rural municipalities, 87% in rural–urban municipalities, and 78% in urban municipalities.

It was assumed that the percentage of free-riders that place plastic packaging on the market is the same as that of the self-compliers (60%, according to the BDO register). Thus, to estimate the number of free-riders placing plastic packaging on the market, the value of 1616 free-riders identified in the study was multiplied by 0.6, for a total of 970, which was 47% of the entities included in the survey sample. The 47% was assumed in this study to be the percentage of plastic packaging placed on the market by free-riders, which means it is 24,788,196 kg (Table 4). This also means that the share of plastic packaging reported in BDO by self-compliers accounted for 27,952,646 kg, being 53% (Table 4).

Table 4. The amount of plastic packaging waste (PPW) generated, calculated based on plastic packaging placed on the market (PPM) in Poland, in 2021; PPM = PRO + SC + I + FR – E.

Data on the Sources of Plastic Packaging	Mass (kg)	Share (%)
PRO:	1,219,871,479	96.87
• Packaging recovery organization	1,172,292,077	93.09
• Economic self-government organization	47,579,402	3.78
Self-compliers (SC)	27,952,646	2.22
Private imports (I)	17,304,666	1.37
Private exports (E)	30,571,691	2.43
Free-riders (FR)	24,788,196	1.97
Total	1,259,345,296	100

3.6. Amount of Plastic Packaging Placed on Poland's Market in 2021

The amount of packaging transparently reported by the PRO accounted for almost 97% of the total amount of PPM. However, it should be noted that the packaging recovery organizations report just over 93% of the total amount of plastic packaging placed on the market, and these data are relatively easy to obtain. All plastic packaging, including plastic elements in multi-material packaging, should be included in the calculation. The lack of detailed reporting in this regard in the BDO register makes it necessary to obtain and analyze the data submitted and compliant with the agreements signed with the Ministry of Climate and Environment by economic self-government organizations. The analysis conducted in this study showed that plastic packaging recorded by economic self-government organizations constituted 3.78% (47,579,402 kg) (Table 4).

The results of this study indicate that data on the amount of plastic packaging imported and exported privately should not be ignored. In 2021, plastic packaging introduced into the country with imported products accounted for 1.37% (17,304,666 kg) of the total. It should be noted, however, that privately exported packaging (30,571,691 kg) was included in the records concerning the amount of PPM, even though this quantity should not be included in the amount of packaging waste generated in the country.

In order to include all the sources of plastic packaging, it was also necessary to estimate the amount of packaging not recorded in the BDO register, which was introduced by free-riders (almost 2%, i.e., 24,788,196 kg).

Taken together, these amounts sum to a total of 1,259,345,296 kg of plastic packaging placed on the market in Poland in 2021. This quantity is of key importance for financial accounting of the calculated own resources, to which a collection rate is applied for each kilogram of non-recycled plastic packaging waste. This identification of all the sources aims to obtain reliable data and enables comparisons between the Member States. This is the most important step to standardize uniform conditions for data reporting by the Member States in order to ensure equal treatment of the countries when data are verified at the EU level.

4. Conclusions

The establishment of own resources based on mandatory contributions that are proportional to the amount of plastic packaging waste that is not recycled in individual Member States will provide an incentive to reduce the use of plastic packaging, including single-use plastic products, and promote recycling and a circular economy. Data on the generation and recycling of plastic packaging waste constitute the basis for the calculation of national contributions to the general budget of the Union. The methodology for determining own resources based on non-recycled plastic packaging waste should be developed jointly by all Member States, taking into account the applicable uniform collection rate pursuant to Art. 2 section 1 (c) of Council Decision (EU, Euratom) 2020/2053 [11]. In order to obtain reliable data that can be compared with other countries, the methodology for calculating the amount of packaging placed on the market should be clearly defined. Due to the lack of records on plastic packaging imported to and exported from a country, attaining the relevant data is quite problematic. This study used a methodology developed based on an extensive analysis of the available data. This methodology and the results of the research presented here meet the EU's expectations in terms of data reliability as well as the inclusion in the calculations of all sources of products in plastic packaging placed on the market. In 2021 in Poland, the amount of packaging transparently reported by the producer responsibility organizations accounted for almost 97% of the total amount of PPM. The self-compliers and free-riders placed 2.22% and 1.97% of the total plastic packaging on the market. The amount of privately imported plastic packaging was 1.37%. However, the amount of plastic packaging privately exported was 2.43%. Thus, the final amount of plastic packaging placed on the Polish market was 1,259,345,296 kg. Although SC, FR, and I placed only a small percentage of the total plastic packaging on the market, when converted into kilograms, this is a significant share. Thus, any entities that place products in plastic packaging on the market cannot be omitted in the calculations because each kilogram of non-recycled PPW requires a payment of EUR 0.80. The data can constitute the basis for the preparation of a common methodology for determining the amount of plastic packaging placed on the market and the own resource contribution based on non-recycled plastic packaging waste.

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