Technical annex

to the analysis "Real price of deposit (Analysis of the introduction of the deposit-refund system for single-use beverage packaging in the Slovak Republic"

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1 Current state of PET bottles and beverage cans in Slovakia

The financial analysis of the introduction of the deposit-refund system for single-use PET bottles and beverage cans is based on the number of bottles and cans placed on the market and their processing within wastes. Moreover, we took into account consumer habits in purchasing PET bottles and cans as well as the size and character of the retail network in Slovakia. The data available for 2016 and 2017 were considered the starting point.

1.1 The number of PET bottles and aluminium beverage cans placed on the market

There is no exact data on the quantity of PET bottles and beverage cans placed on the Slovak market. According to the data of various exploring organisations and associations of producers (AVNM, Slicpen, Nielsen, Canadea), about 537 to 833 mil. pieces of beverage PET bottles are placed on the Slovak market annually. For cans, we managed to gather only the data on the consumption of soft drinks in cans (AVNM). The data often do not cover the entire market and are based rather on the consumption of individual products provided in litres and not the quantities placed on the market. Similar disadvantages are represented by the data in the reports of producers provided by producer responsibility organisations, which mention only the aggregate types of packaging (plastic or metal packaging).

Due to the incompleteness of these data we estimated the quantity of PET bottles from the data on municipal waste provided by the Statistical Office of the Slovak Republic. The weight of sorted plastics in 2016 was 36,123 ton. According to the analyses of collection companies provided by General Plastic, a. s. and Natur-pack a. s., about 60 % of sorted plastics are beverage PET bottles, i.e. 21,674 ton. The analyses of mixed municipal waste composition of the Institute of Circular Economy have shown that at an average, PET bottles represent 0.87 % which means about 10,307 ton. Moreover, we estimate that additional 2,556 tons are in the waste from street cleaning and at least 81 tons are in the litter lying around. These data show that about 34,618 ton of beverage PET bottles are placed on the Slovak market annually. We estimate the average weight of one PET bottle including the lid at 35 grams, based on the estimates of the company Limo Špes, the Spanish study (Eunomia, 2012), Latvian study (Dace, et al., 2013), and Czech study (Jílková, et al., 2008). Thus, total 989 million beverage PET bottles are placed on the market annually.

As regards the cans, there are no estimates of their share in sorted metals or metals in the mixed municipal waste. The estimated amount of beverage cans was provided by the producer responsibility organisation ENVIPAK on the basis of data from the reports from producers and by extrapolating them to the entire market. Thus, we took into account 5,513 tons of beverage cans. Provided that the average weight of a can is 16 grams according to BevCan East, we estimate that 345 million cans are placed on the market annually.

Table 1: Estimated quantity of beverage PET bottles and cans placed on the market

Beverage packaging	Placed on the market (in mil. pieces)	Placed on the market (in tons)	Average weight (in grams)
PET bottles	989.09	34,618	35
Aluminium cans	345	5,513	16

Source: IEP

During the preparation of the analysis, we obtained data on municipal waste also for 2017. These data show, under the same preconditions as in calculation for 2016, that the total number of PET bottles is 1,131 million. The dependence of financial costs on the quantity of packaging placed on the market was examined in Chapter 7.

1.2 Sale of PET bottles and aluminium beverage cans

The number of selling units with the sale of food is various in the statistics. The number of hypermarkets, supermarkets and discount shops is estimated to be 567 to 799 shops (statistics of the Statistical Office of the Slovak Republic on the retail network of large companies for 2016, Association of Trade of the Slovak Republic, Nielsen for 2017). The categories and numbers of the other types of shops differ depending on the statistics, e.g. the Statistical Office of the Slovak Republic provides the total number of mixed shops and smaller grocery stores as 2,944. The Association of Trade of the Slovak Republic provides registered shops in accordance with the Act on Foodstuffs and Act on Veterinary Care as follows: the number of medium shops is 4,195 and small and specialised shops 7,726. According to the estimates of Nielsen, in 2017, total 7,673 organised and unorganised shops were in Slovakia with a sales space of up to 400 m^2.

In our analysis we used the number of hypermarkets, supermarkets based on the estimate of the Statistical Office of the Slovak Republic; the number of discount shops (Lidl) was excluded from the number of supermarkets according to the data of SAMO (Slovak Alliance of Modern Trade). According to this statistics, the number of hypermarkets was equal to the number of hypermarkets, which we determined on the basis of communication with individual chains. For other types of shops, we used the statistics of Nielsen dividing them into organised and unorganised shops with a sales space up to 400 m^2 and with the total number of shops being 7,673. Based on the communication with several chains and franchising networks (Fresh, Coop, Delia, Milk-Agro, Terno) we assume, that 3,056 such shops belongs to the category of organised shops, the other are not organised. For the purpose of analysis, we additionally divided this number of shops to large and small organised shops according to the list of shops of Coop, which contains sales spaces of individual shops. We approximated the share of Coop shops with a sales space from 200m^2 to 400m^2 and under 200m^2 to all organised shops. This share is considered representative as the number of Coop shops with a sales space under 400m^2 represents 66 % of all organised shops with a sales space under 400 m^2 in Slovakia.

According to the research of GfK Slovakia hypermarkets, supermarkets and discount shops (Lidl) are the most preferred types of shops of Slovak consumers. In total, 79 % of shopping takes place in these shops. Smaller shops represent only a 21 % share in sale, despite their grate number in comparison with the number of hypermarkets and supermarkets. We divided the sale share of these shops among the large and small organised shops and unorganised shops according to the Czech research INCOMA Research mentioned in the study of IEEP (Jílková, et al., 2008). The estimated numbers of individual types of shops and their sale shares are shown in Table 2.

Table 2: Number of shops selling food and beverages in Slovakia

Shop type	Sales space (in m^2)	Number of selling units	Market share (%)
Hypermarket	over 2,500	133	36
Supermarket	400 – 2,500	535	24
Discount shop (Lidl)		131	19
Large organised shop	200 – 400	568	6
Small organised shop	under 200	2,488	10
Unorganised shop		4,617	5
Total		**8,472**	

Source: IEP pursuant to the SR Statistical Office, Nielsen, grocery store chains

Based on the share in the food sale market we estimated the average annual sale of beverage packaging in individual types of shops. Besides retail, single-use beverage packaging is also sold by filling stations, hotels, restaurants, cafés (HORECA), sports arenas etc. For filling stations, the annual sale of beverage PET bottles and cans was estimated according to the data of OMV, their share in the sale of refreshment at filling stations

and the total number of filling stations according to the Association of Trade of the Slovak Republic. We assumed that the beverage packaging will be handed over within the deposit-refund system in retail shops. The data on the sale in other institutions were not available.

The average annual sale per one shop was calculated as a share of annual sale, the number of selling days in the year and the number of shops of that type. The expected number of returned packages with the respective rate of return, i.e. also the amount of individual costs depends on the number of sold packages.

Table 3: Estimated annual sale of single-use beverage PET bottles and aluminium cans

Shop type	Estimated sale per year (mil. pcs)	Estimated sale per year per one shop (mil. pcs)
Hypermarket	467.2	3.51
Supermarket	311.5	0.58
Discount shop	246.6	1.88
Large organised shop	83.3	0.15
Small organised shop	124.4	0.05
Unorganised shop	64.9	0.01
Filling stations	35.7	0.06
Total	**1,334**	

Source: IEP pursuant to the SR Statistical Office, Nielsen, marketing chains

1.3 Rate of recycling

1.3.1 PET bottles

The initial rate of recycling of PET bottles was estimated to be 63 %, based on the data on sorted plastics in the municipal waste for 2016 from the statistics of the Statistical Office of the Slovak Republic, of which PET covers about 60 %.

1.3.2 Aluminium beverage cans

As regards aluminium cans, we are not able to determine, what part from the mixed waste or sorted metals they represent. Therefore, as the initial rate of recycling of aluminium cans we selected 77 %, i.e. the estimated rate of recycling of municipal metals in 2016 based on the quantity of sorted metals and metals in mixed waste, which represent about 3 % (according to INCIEN).

1.3.3 Municipal waste

The rate of recycling of municipal waste for 2016 reached 23 %. The rate of recycling is determined as the ratio of recycled waste to all waste produced. According to the methodology of Eurostat, small construction waste is not included.

1.3.4 Municipal waste packaging

Plastic packaging

In calculating the rate of recycling of plastic packaging we used as a basis the reports of producer responsibility organisations on waste production and management. According to the data, 119 thousand tons of plastic packaging were placed on the market in 2016, of which 62 thousand tons were recycled. As we assume that the quantity of PET bottles is actually higher than reported, the total quantity of packaging is estimated to be 129 thousand ton.

Metal packaging

The rate of recycling of plastic packaging in 2016 is estimated to be 48 %. For metal packaging, we used the data from reports for 2016. The rate of recycling reached 80%.

Packaging total

We assume the rate of recycling of all packaging in 2016 to be 64.6 % taking into account our estimate of plastic packaging.

2 Basic rules and preconditions of the system

In setting the basic rules and preconditions of the deposit-refund system we used as a basis the Scandinavian model, which is transparent and achieves a high efficiency. Basic rules of our system include:

- **Beverage PET bottles and aluminium cans will be included in the deposit-refund system.**
- **If a producer decides to not join the deposit-refund system, they shall pay an environmental tax of 24 cents for a beverage packaging.**
- **The mandatory deposit-refund system for bottles will take place in retail shops with the sales space exceeding 400 m².**
- **Most bottles and cans will be collected by reverse vending machines, in small shops also manually.**
- **The whole system will be coordinated by the so-called Central System (CS) owned by producers.**
- **The amount of deposit will be determined by the Central System.**
- **The Central System will be in charge of the procurement of the infrastructure necessary for collection.**
- **The system will be financed by producers through the administrative fee per one placed bottle/can.**
- **The retailer's costs connected with collection will be settled through the handling fee.**
- **The system does not allow for the provision of advantage to reusable bottles, the current deposit-refund system of reusable glass bottles will remain unchanged**.

2.1 The amount of deposits and rate of return

In practice we propose that the central system alone determines the deposit amount so that it achieves the prescribed target of rate of return. For the purposes of the model we determined the deposit amount from the relation between the amount of deposits and return rate according to (Eunomia, 2012). We used as a basis the data for individual countries, in which it was possible to differentiate between the return rate of PET bottles and cans and their deposit amount (Reloop, 2016 updated according to the information available on the internet). According to such data converted through the purchasing power parity to the price conditions in Slovakia, the rate of return of PET bottles depends on the deposit amount as follows:

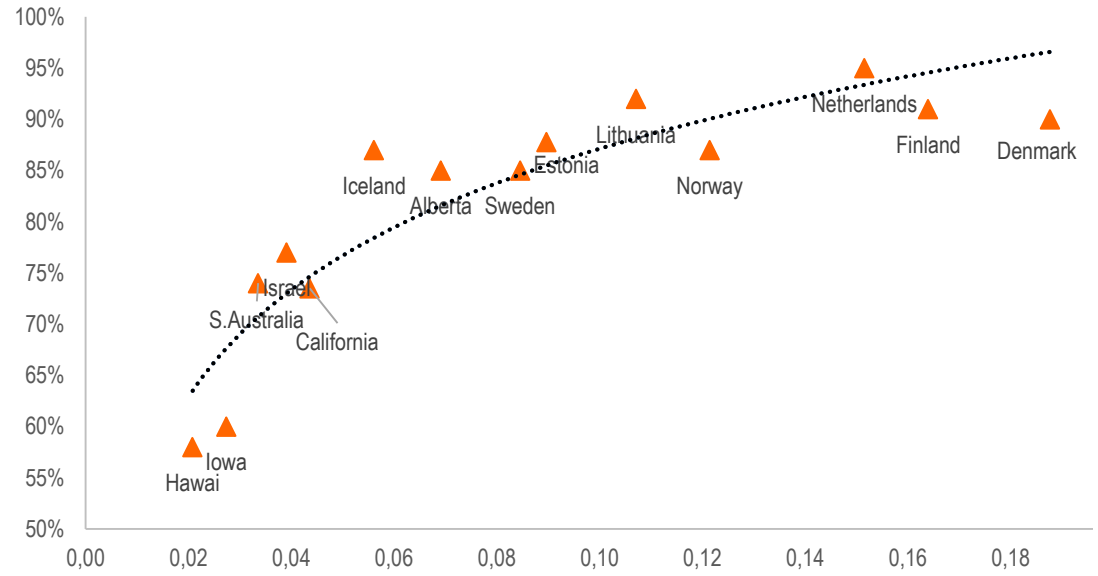
$$Rate\ of\ return = 0.1504 \ln(deposit\ amount) + 1.2176$$

For cans:

$$Rate\ of\ return = 0.0805 \ln(deposit\ amount) + 1.0894$$

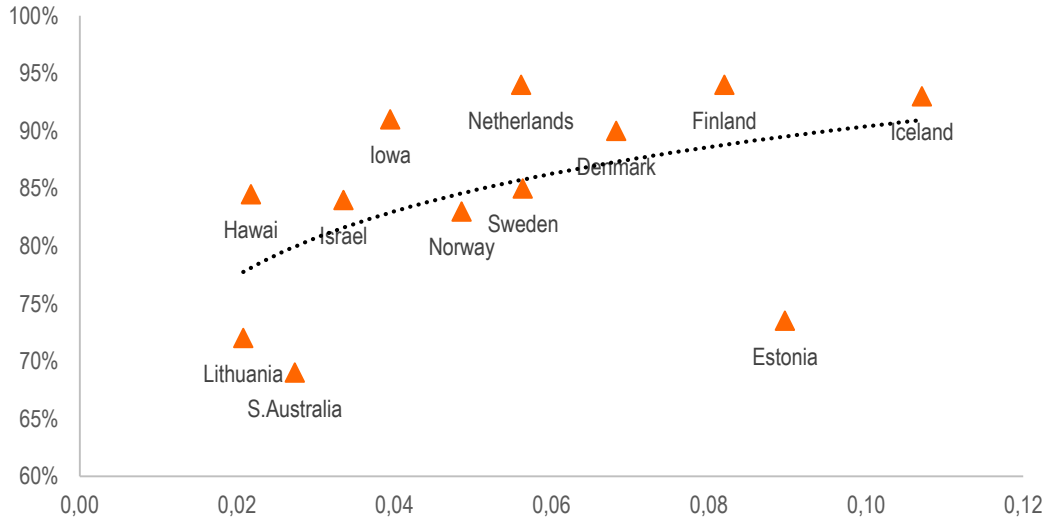
To reach a 90 % rate of return of both types of packaging we set in the model the deposit amount as 12 cents for PET bottles and 10 cents for cans.

Chart 1: Logarithmic function of an optimum deposit amount for PET packaging (rate of return vs. deposit in PPP SVK EUR)



Source: IEP pursuant to reloop data

Chart 2: Logarithmic function of an optimum deposit amount for aluminium packaging (rate of return vs. deposit in PPP SVK EUR)



Source: IEP pursuant to reloop data

Table 4: The amount of deposits and rate of return in the deposit-refund systems for single-use beverage packaging

	PET		cans	
Country	**Deposit amount (in PPP SVK EUR)**	**Rate of return (in %)**	**Deposit amount (in PPP SVK EUR)**	**Rate of return (in %)**
Finland	0.16	91 %	0.08	94%
Norway	0.12	87 %	0.05	83%
Sweden	0.08	85 %	0.06	85%
Denmark	0.19	90 %	0.07	90%
Estonia	0.09	88 %	0.09	74%
Netherlands	0.15	95 %		
Iceland	0.06	87 %	0.06	94%
Israel	0.04	77 %		
Lithuania	0.11	92 %	0.11	93%
South Australia	0.03	74 %	0.03	84%
Hawaii (USA)	0.02	58 %	0.02	72%
Iowa (USA)	0.03	60 %	0.03	69%
California (USA)	0.04	74 %	0.02	85%
Alberta (Canada)	0.07	85 %	0.04	91%
New Brunswick (Canada)	0.04	71 %	0.04	80%
Quebec (Canada)	0.08	78 %	0.02	70%

Source: IEP pursuant to Reloop

2.2 Involvement in the system and the form of collection of individual types of shops

The collection of PET bottles and beverage cans can take place through a reverse vending machine or manually. The reverse vending machine will recognise the packaging registered in the system, include it into the database of returned packaging, compact it and place in the rear part of the machine. At the same time, it will issue to the customer a bill with the number of returned packages and adequate amount for the deposit, which the customer will pick up. In case of manual collection, the trader will take over empty packaging from the customer, verify visually whether the packaging is included in the deposit-refund system and pay the deposit to the customer. They will store the intact returned packaging in the shop.

The decision on which form of collection is optimal for the shop depends on the daily or annual sale of packaging in the shop and on the capacity of individual types of reverse vending machines. In case of certain smaller shops, no form of collection may be profitable. The voluntariness of collection exists in several countries (e.g. Sweden) and has a considerable impact on the efficiency of the entire system. It means that collection is provided only by the trader for whom the activity is economical. Therefore, we propose voluntary collection of beverage packaging for the shops with a sales space of less than 400 m^2.

In our model we assume according to (Eunomia, 2012) a 100 per cent participation of retail shops in the deposit-refund system except for the unorganised shops. The unorganised shops include late-night shops, snack shops, attended and smaller self-service shops, in which even manual collection may not be economical despite the repayment of costs connected with collection through the handling fee. As more detailed information on unorganised shops are not available (sales space, etc.), for the purposes of the model we consider that a half of them will join the system and the other half will not join it.

It results from the average annual sale provided in Table 3 and from the recommended volume for individual types of reverse vending machines according to RVM Systems that hypermarkets, supermarkets, discount

shops and large organised shops will join the deposit-refund system with the use of reverse vending machines.

In the case of organised small shops and unorganised shops, the average annual sale per one shop is lower than the lower limit of the recommended volume of the smallest reverse vending machine. This would mean that collection of packaging through reverse vending machines would not be economical for any small shop under 200 m^2. The reason is the large number of shops of this type and the low share in the market of food sale. In reality we can assume that a shop with a sales space of 200 m^2 will sell in comparison with a shop with a sales space of 10 m^2 much more bottles and it may be economical for it to collect through reverse vending machines. Therefore, for small organised and unorganised shops we estimated the number of sold bottles per 1 m^2 of sales space. As a basis, we used the average sales space of Coop shops with a sales space of up to 200 m^2 and the average daily sale per shop. With respect to the lack of more detailed data, we considered the same average sales space also for unorganised shops. Based on the number of packages sold per 1 m^2 and the recommended volume of returned packaging, a minimum sales space will be specified, for which collection through reverse vending machines will be economical. Subsequently, the share of shops will be calculated, whose sales space is identical or bigger. According to these assumptions, 26 % of small organised shops will join the system with automatic collection. Unorganised shop will only get involved with manual collection.

The resulting involvement in the system and the form of collection of individual types of shops are provided in Table 5. Thus, total 73% of the total number of shops will join the system, of which 33 % will collect using reverse vending machines. The rate of automation, i.e. the number of bottles collected through reverse vending machines to the total number of collected packages is estimated at 90 %. It means that with the expected rate of return of 90 %, annually 1,082 mil. packages will be returned through a reverse vending machine and 118 mil. packages through manual collection. Thus, in the zero scenario we take into account that all shops with a sales space of over 200 m^2 will join the system with collection through reverse vending machines.

Table 5: Involvement and type of collection in individual types of shops

Shop type	Involvement in the system	Collection with a reverse vending machine	Manual collection
Hypermarket	100 %	100 %	0 %
Supermarket	100 %	100 %	0 %
Discount shop	100 %	100 %	0 %
Large organised shop	100 %	100 %	0 %
Small organised shop	100 %	26 %	74 %
Unorganised shop	50 %	0 %	100 %
Total	**73 %**	**33 %**	**67 %**

Source: IEP according to Eunomia, RVM Systems, Coop

3 Investment costs of the deposit-refund system

The majority of investment costs of the deposit-refund system are investments in the reverse vending machines for packaging. Moreover, the introduction of the deposit-refund system requires initial costs for the modification of the shop space for manual collection, central system establishment, construction of a sorting and counting centre and the system securing costs.

3.1 Purchase, installation and service of reverse vending machines

The price of one reverse vending machine ranges from EUR 11,900 to EUR 80,000 depending on its size and capacity. The price quotations were provided by RVM Systems and TOMRA. The number and type of reverse vending machines necessary to reach the required rate of return were estimated on the basis of daily or annual sale of PET bottles and beverage cans in individual types of shops (see Table 5). The total number of necessary reverse vending machines and their investment costs in total amounting to EUR 61.8 mil. are provided in Table 6. The investment costs per one reverse vending machine are calculated as the sum of the price of the reverse vending machine, installation and service agreement. The annual costs of service agreement amount to 9 % of the price of the reverse vending machine (RVM Systems) and they are included 10 times for the life period of the reverse vending machine (10 years). The total investment costs of reverse vending machines are multiplied by the number of reverse vending machines in all shops.

Table 6: Investment costs of reverse vending machines in individual shops

Shop type	Number of reverse vending machines per one shop	Total number of reverse vending machines	Investment costs of reverse vending machines (in mil. EUR)
Hypermarket	2	266	121.4
Supermarket	1	535	14.1
Discount shop	1	131	8.5
Large organised shop	1	568	12.6
Small organised shop	1	650	14.5
Unorganised shop	0	0	0
Total		**2,150**	**61.8**

Source: IEP according to RVM Systems, Coop

Today, there are about 800 reverse vending machines for glass bottle collection in Slovakia, of which 12 % can be converted to be able to collect PET bottles and cans. Although modification of a reverse vending machine is cheaper than the purchase of a new one, the shop will lose a part of the capacity of the reverse vending machine for receiving glass bottles. Moreover, according to the examples from abroad we consider that the collection of glass bottles will stay apart from the deposit system for single use beverage packaging. If the reverse vending machine would collect all the types of beverage packaging, it would be difficult to estimate the costs connected with the collection of single-use and glass bottles separately.

3.2 Costs of manual collection space modification

Based on the Spanish study (Eunomia, 2012) we expect that the manual collection will require initial costs of efficient use of space for packaging collection. We consider the costs of EUR 81 per shop for all the necessary changes of storage area and one hour of trader's time. The total investments to modify the space for manual collection amount to almost EUR 335 thousand and they are calculated as the product of cost per one shop and the number of shops with manual collection.

3.3 Costs of sorting line and counting machine

The deposit-refund system will require the construction of a sorting line that will separate cans and PET bottles by means of a magnetic separator and then, by means of an optical line, it will separate PET by colours. The sorted material will be compacted and sold to recycling facilities. Moreover, the PET bottles and cans returned through manual collection must be counted before they are compacted. The counting takes place in large-capacity counting machine which recognises and registers the returned packaging similarly to

reverse vending machines. The price quotation and technical parameters of counting machine are available from Anker Andersen and TOMRA. According to the annual capacity of the counting machine, three such machines would be necessary in Slovakia to cover the volume of packaging returned through manual collection. We also communicated with Vassal EKO and Marius Pedersen that have built sorting lines in Slovakia. However, the parameters and specialisation of the lines do not fully correspond to our needs, therefore we could not use their data.

The investment costs of sorting line and counting machine were estimated based on the investment costs of the line Heia of the Norwegian system Infinitum, which also contains three counting machines. After the conversion by means of the purchasing power parity we estimate that the investment costs amount to approximately EUR 0.003 per one returned package. In total, the investment costs of sorting line and counting machine are estimated to be EUR 3.9 mil.

3.4 Costs of central system establishment

Central system establishment will require the costs amounting to EUR 10.7 mil., which include planning, design of the system, its implementation, conclusion of contracts, communication, costs of rooms, equipment and the information system that will gather and process all data. The costs were estimated according to the study for the deposit-refund system for single-use beverage packaging in Scotland (Hogg, et al., 2015).

3.5 System securing costs

The packaging included in the deposit-refund system becomes valuable, therefore, it is important to secure the system against abuse (imitation of identification marks, import of foreign packaging etc.). In general, the higher the deposit, the higher the rate of securing. Moreover, Slovakia is surrounded by countries without a deposit-refund system for single-use packaging. The packaging included in the deposit-refund system has usually a marking on the deposit amount, deposit logo, and a specific EAN code. The change of bottle and can labelling will require the costs amounting to EUR 3.4 mil. It can be noted that although producers will have to change the design of labels, the change can be identical with the periodic changes of labels provided that a sufficient period is provided for the transfer to the system.

4 Operating expenses of the deposit-refund system

The annual operating costs result from the costs of retailers for the collection of empty packaging. These are costs of operation of reverse vending machines, labour costs, the storage space and logistics. Besides that, the central system has costs of transportation of empty packaging to the sorting and counting centre, costs of operation of this facility and administrative costs.

4.1 Retail costs

4.1.1 Costs connected with reverse vending machines

To reach the set rate of return, we estimate the total number of necessary reverse vending machines to be 2,150. According to communication with RVM Systems, we took into account only the reverse vending machines, which are able to receive both PET bottles and cans. According to the estimate of RVM Systems, these reverse vending machines reduce investments and the necessary space by 30 to 35 %.

Wage costs

For the calculation of wage costs, we need to know the average size of the reverse vending machine container which can be various depending on the type of the reverse vending machine. The container of the

reverse vending machine is a vessel to which returned compacted packaging is collected. For example, the capacity of one container of the reverse vending machine PROLINE 1 from RVM Systems is 870 PET bottles or 3,500 cans. The capacity of a free-standing reverse vending machine in a shop is 400 PET bottles or 800 cans. In comparison with PET bottles, cans are smaller and the reverse vending machine is able to compact greater quantities of cans thus more of them can be stored in the reverse vending machine. As we considered the reverse vending machines, which are able to receive both the PET bottles and the cans, the capacity of the reverse vending machine has to be calculated with respect to the number of any beverage packages. Based on the ratio of PET bottles and cans on the Slovak market and the ratio between PET and cans in the container we estimate that the average capacity of one container of the reverse vending machine is 1,080 packages. Similarly, we estimated the capacity of the other reverse vending machines.

The replacement of the reverse vending machine container lasts about 5 minutes and the number of necessary replacements depends on the capacity of the reverse vending machine and the number of returned packages. Further 10 minutes per are necessary to clean the reverse vending machine. These assumptions come from RVM Systems. Moreover, according to the Spanish study (Eunomia, 2012) we consider three seconds to issue a bill with the returned packaging, where each bill contains 10 returned packages.

The total annual wage costs were calculated as the product of time necessary for the mentioned items multiplied by the average hourly wage in retail amounting to EUR 5.77 according to the Statistical Office of the Slovak Republic for March 2018. The total estimated costs amount to EUR 1.7 mil.

Costs of energy

The quantity of electric energy needed for the operation of one reverse vending machine is one of the technical parameters provided by RVM Systems and depends on the machine type. Annually it ranges from 600 to 1 200 kWh per reverse vending machine. Additional 0.83 kWh of energy is necessary to compact 1,000 packages by means of a compactor that is part of the reverse vending machine. The price of electric energy in 2017 according to Eurostat was EUR 0.0771/kWh. The total costs of energy are estimated to be EUR 181 thousand annually and they are calculated as the product of the number of returned packages, energy needed to compact 1 package and the price of energy, to that the product of energy needed for one reverse vending machine and the price of energy is added.

Logistics costs

The compacted bottles and cans are collected in the container into a plastic bag intended for storage and transportation. The capacity of one plastic bag is the same as the capacity of the container. The price quotation was worked out by the Danish company Trioplast, which also provides such equipment in Norway. The price of one bag is EUR 3 or 5 depending on size. The total costs reach EUR 4.9 mil. and are based on the total number of returned packages annually and the price of one bag divided by the capacity of one bag.

Storage area costs

The reverse vending machines cover about 1 m^2 of the sales space and the storage area of 5 to 8 m^2 depending on the reverse vending machine. The free-standing reverse vending machine Stand Alone RVM X2 does not cover any storage area, only 1.63 m^2 of the sales space. The area also includes the handling area of the customer and of the trader. In addition to the reverse vending machine area, a storage area is necessary to store temporarily the returned packages in a plastic bag prior to transportation. One plastic bag from the container of the reverse vending machine covers the area of one euro pallet, i.e. about 1 m^2. For the Stand Alone RVM X2 reverse vending machine, it is only one half of euro pallet. The necessary area for bag storage was calculated as the quotient of the product of the area needed for one plastic bag, the number

of container replacements per week and the number of removal of bags per week. According to the internet survey, the average price of monthly lease of commercial premises is EUR 9 per m^2.

The total costs are calculated as the sum of the area of reverse vending machines, the area needed for manipulation and the area needed to store the bags in one shop multiplied by the total number of shops and the price of lease. They amount to EUR 2.3 mil.

Opportunity costs

Installation of the reverse vending machine in a shop will require sales and storage space, which cannot be used for sale anymore. The opportunity costs are equal to the product of the area covered by the machine, the price of lease and 5 % of the retail turnover per 1 m^2. This approach was taken over from the Spanish study (Eunomia, 2012). The estimated turnover comes from the average of randomly selected shops and it is about EUR 5,190/m^2 annually. The annual opportunity costs amount to EUR 758 thous.

4.1.2 Costs connected with manual collection

Wage costs

Wage costs represent the biggest item of operating costs of manual collection. According to the Czech study (Jílková, et al., 2008), the employee spends 15 seconds on the collection of one beverage package. The total annual wage costs are equal to the product of the necessary time for the collection of all packages returned manually, the wage of the retailer and the number of packages returned manually per year. Their amount is estimated to be EUR 2,8 mil. annually.

Logistics costs

The manually collected packaging must remain in the original shape so that it is possible to count them later in the counting machine. They are stored in plastic bags whose capacity is 200 packages according to the Swedish system Returpack. The plastic bag is closed by means of a plastic seal and labelled to provide information on the shop so that the deposit and handling fees are later correctly paid. The price of the equipment was converted based on the data from Returpack and in Slovak conditions it achieves a value of EUR 0.002 per package. The total number of necessary bags was estimated based on the manually collected packaging and the capacity of one bag. The total amount of costs is EUR 187 thousand per year.

Storage area costs

The plastic bags containing the collected packaging take on average area of 0.5 m^2. It is possible that some small shops will have to store the bags in the sales space. However, we assume that most shops will store them in the storage areas, so we do not expect any opportunity costs. Thus, the total storage area costs equal to the product of the area necessary for storage of all bags depending on the number of manually collected bottles and the average lease of the sales space. This amounts to EUR 608 thousand per year.

4.2 Central system costs

4.2.1 Transportation costs

Transportation to the interim storage facility

The estimate of the costs of transportation was based on the adjustment of transport of the Norwegian system Infinitum. The returned packaging is temporarily stored in the stores of shops and subsequently transported to so-called interim storage facilities. From there, they are transported to the counting and sorting centre.

The amount of transportation costs depends on several factors, such as the frequency of removal from shops, the number of interim storage facilities, the distance to the interim storage facility and then to the sorting facility.

According to Infinitum, the carrier is obliged to pick up the returned packaging from shops if 6.5 bags are full with a size of an euro pallet regardless of the type of the shop; full loading of truck during the transportation to the interim storage facility is not required. According to these assumptions, the estimated number of returned packages per shop and the capacity of one plastic bag we calculated the number of necessary pick-up rounds from individual types of shops per week. At the same time we assumed that a truck may carry out a pick-up round from several shops per one drive. The average number of pick-up rounds per one drive is calculated as the quotient of the number of euro pallets per one drive and the number of euro pallets from one pick-up round. As we do not have any map of shops and distances among them, it was estimated by means of the methodology used in the Czech study (Jílková, et al., 2008).

Using the area of Slovakia and the total number of shops we calculated the average aerial density of shops per km^2 and from it, the average geographic distance among the shops. Similarly, we also estimated the average geographic distance between the shop and the interim storage facility. By comparing the geographic distance and the road distance between randomly selected municipalities we obtained the index for transport - 1.64. It means that 1 km of geographic distance is on average 1.64 km of road distance. Using the index, the average number of pick-up rounds per one drive and the average geographic distance we obtained the road distance to be driven by a truck during one drive from the first shop to the interim storage facility.

The price of one drive to the interim storage facility was estimated from the price quotation of BM Transport and the assumptions of the Czech study (Jílková, et al., 2008). Loading of empty packaging lasts 15 minutes, mandatory breaks approximately 15 minutes and the average speed of the vehicle is 40 km/h. The price of one hour of work, down-time and one kilometre driven depends on the type of vehicle. We considered two types of cars, IVECO Eurocargo and MB Sprinter. IVECO Eurocargo has an area for 17 euro pallets. According to Infinitum we assume that plastic bags with returned packaging can be placed on each other in three layers. It means that one car will carry total 51 plastic bags per one drive, i.e. about 55 thousand pieces of returned packaging. MB Sprinter belongs to the category of delivery van and can carry 13 euro pallets per one drive. The delivery van was considered for pick-up rounds from small organised shops and unorganised shops because the volume of returned packaging is relatively small. As the manually collected packaging cannot be compacted, the delivery van will carry only 5,200 packages per one drive. The total costs of transportation to interim storage facilities reach EUR 3.9 mil. per year.

In practice, backhauling is often applied, which means that the truck supplying new goods to the shop uses the emptied space and fills it with empty returned packaging and transports them back to the interim storage facility. Thus, the costs of this part of transportation would consist only from additional fuel costs in comparison with the transportation of an empty truck.

The number of interim storage facilities, to which the empty packages will be transported, was also estimated by means of information from Infinitum. The number of interim storage facilities depends on the position of shops and volume of returned packages so that one interim storage facility per week is filled with a volume of at least 1 TEU, i.e. 75 to 80 thousand packages. We estimate that 34 interim storage facilities will be needed in Slovakia; they should be uniformly distributed throughout Slovakia depending on the number of inhabitants in individual districts. In each interim storage facility, transport containers will be located outdoors, which will be filled gradually and then transported to the sorting facility. Empty packaging will be stored in the containers so that no storage area is needed inside the interim storage facility. We also assume that the already existing interim storage facilities will be used so we do not expect any investment costs of construction.

Transport to the counting and sorting centre

The filled containers will be transported by means of the road container chassis to the sorting facility. We assume that one counting and sorting centre will be necessary and it will be situated in Žilina. It is possible to place 25 euro pallets with plastic bags in two layers into the 40“ High cube type container. Thus, the total capacity of a container is 54 thousand compacted packages or 20 thousand non-compacted packages. The lump-sum price of transportation was provided by the carrier Lőrincz, it EUR 1.15/km including the toll. The total costs of transportation to the sorting facility were specified as the product of the number of necessary containers for the transportation of returned packaging per year, the transport route and road distance from the interim storage facilities to Žilina and back. They amount to about EUR 10.3 mil.

The costs of transportation from the sorting to the recycling facility are included in the reduced price for the sale of raw material (EXW), therefore we do not take them into account.

4.2.2 Administrative costs

Operating costs were similarly to the Scottish study (Hogg, et al., 2015) based on the Finnish system Palpa, which provided information on their total operating costs. These costs include the wage costs of administrative employees, the lease of office premises, IT solution etc. The estimated annual administrative costs amount to about EUR 1.6 mil.

4.2.3 Sorting and counting centre costs

Similarly to investment costs, also the operating costs of the sorting and counting centre were based on the Norwegian system Infinitum. After the conversion using the purchasing power parity we estimate that the operating costs per one packaging amount to EUR 0.003. The annual costs for all returned packages amount to EUR 3.9 mil.

5 Revenues of the deposit-refund system

The revenues of the deposit-refund system include the uncollected deposits from consumers and the sale of the returned material. In total, they amount to EUR 28.3 mil. annually.

5.1 Revenues from uncollected deposits

The revenues from uncollected deposits depend on the achieved rate of return and on the beverage deposit amount. In our case we consider the rate of return of PET bottles and cans 90% and the amount of deposit 12 or 10 cents respectively. Under such conditions, the annual revenues from uncollected deposits is about EUR 15.2 mil.

5.2 Revenues from the sale of material

The revenues from the sale of material depend on the rate of return and on the prices of materials with a relatively high volatility. For PET material, we used the price quotation of the recycling facility General Plastic as a basis. The price of PET material was determined as a weighted average of prices of individual PET types (transparent, blue, green, etc.), which was increased by 10 % as a consequence of improvement of the quality of collected material in comparison with the presence. Thus, we considered the price for PET in the amount of EUR 290 per ton. The share of individual PET material types was determined according to the estimate of ENVIPAK. For beverage cans we used the recommended price of secondary aluminium from cans according to TOMRA amounting to EUR 800 per ton. PET and aluminium prices are EXW. The total revenues from the sale of material are estimated to be EUR 13 mil.

6 Administrative and handling fees

Based on the total balance of the system, administrative fees for the producer will be calculated, and based on the costs of retail, the handling fees paid to retailers. Both fees are in compliance with the "polluter pays" principle. The producer pays the administrative fee to the central system for placing the packaging on the market, i.e. for being the polluter. If the consumer fails to return the packaging, they will pay for pollution through the unreturned deposit. The retailer being only the packaging mediator and not polluter in any phase of this chain must receive compensation for additional costs resulting from the participation in the system.

6.1 Administrative fees

The administrative fee paid (along with the deposit) by the producer or importer of the packaging to the central system for each packaging placed on the market shall be calculated as the difference of operating revenues, operating costs and investment costs distributed to 10 years. In our analysis we consider a different administrative fee for PET and for cans. In most countries this fee is differentiated due to the high difference of aluminium and PET prices. For cans it is common that the balance of revenues and costs is zero, i.e. the producer pays no administrative fee. In our model we estimate the administrative fee for a PET bottle placed on the market to be 1.5 euro cents and a zero administrative fee for a can.

6.2 Handling fees

The central system pays to the retailer the so-called handling fee reimbursing all the costs incurred during collection of beverage packaging. The amount is also differentiated depending on whether it is manual collection or collection through reverse vending machines. The compensation of retail costs is a common practice in a large majority of countries using the deposit-refund system. We estimate that the amount of the handling fee for a retailer with collection through a reverse vending machine will achieve 0.9 euro cents per returned package and 3.1 euro cents per a manually returned package. The fee for manual collection is higher as a consequence of higher time demands of the trader.

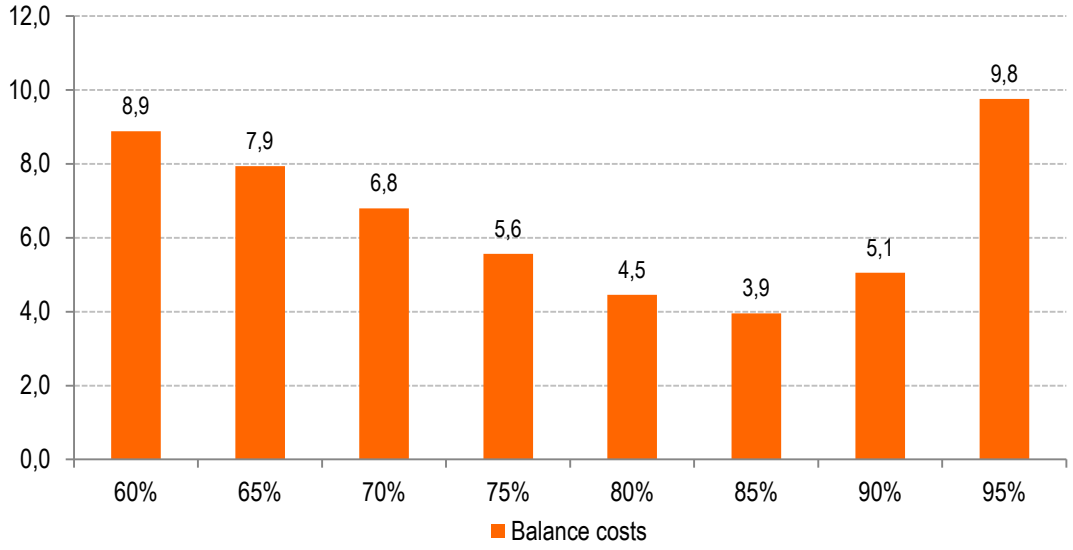
7 Sensitivity analysis

The theoretical model of the introduction of the deposit-refund system in Slovakia includes a considerable number of variables and assumptions affecting the analysis results. To understand the robustness of the results mentioned above we performed several sensitivity analyses of individual costs of the deposit-refund system with respect to the key preconditions of the model.

7.1 Balance costs depending on the rate of return

The rate of return affects both the operating costs and operating revenues. The higher the rate of return, the higher the costs of system operation and revenues from the sale of material. On the other hand, the revenues from uncollected deposits decrease with the rate of return. An increase in the rate of return by 5 % in comparison with the zero scenario leads to almost doubled balance costs.

Chart 3: The amount of balance costs for various rates of return (in mil. EUR)



Source: IEP

7.2 Cost sensitivity to the rate of automation

In the basic scenario we consider that all the hypermarkets, supermarkets, discount shops and organised large shops will collect packaging through reverse vending machines. For small organised shops, we consider a 26% share of shops with a reverse vending machine. The rate of automation, i.e. the number of packages returned through the reverse vending machine to the total number of returned packages, depends on the number of shops with a reverse vending machine. The lower and upper limit for the rate of automation in case of 0 % or 100 % involvement of small organised shops in the automated collection correspond to the scope of rate of automation abroad.

Table 7: Sensitivity to the rate of automation

Share of small organised shops with a reverse vending machine	Rate of automation	Balance costs (in mil. EUR)	Total investment costs (in mil. EUR)
0 %	88 %	5.2	65.8
26 %	90 %	5.1	80.2
100%	97 %	4.7	120.9

Source: IEP

With the growing rate of automation, balance costs decrease as a consequence of lower costs of inefficient manual collection, on the other hand, investment costs of reverse vending machines will rise.

7.3 Sensitivity of costs to the selection of reverse vending machines supplier

The zero scenario was based on the price quotation for reverse vending machines of RVM Systems. Moreover, we obtained an alternative offer from TOMRA. In both cases, the balance costs are almost identical. The investment costs in the alternative scenario are higher by EUR 3.9 mil., whereas the rate of automation is lower by 2 %. The reason is that TOMRA does not offer smaller reverse vending machines suitable for shops with smaller sale, thus, with smaller expected collection.

Table 8: Sensitivity to the selection of reverse vending machines supplier

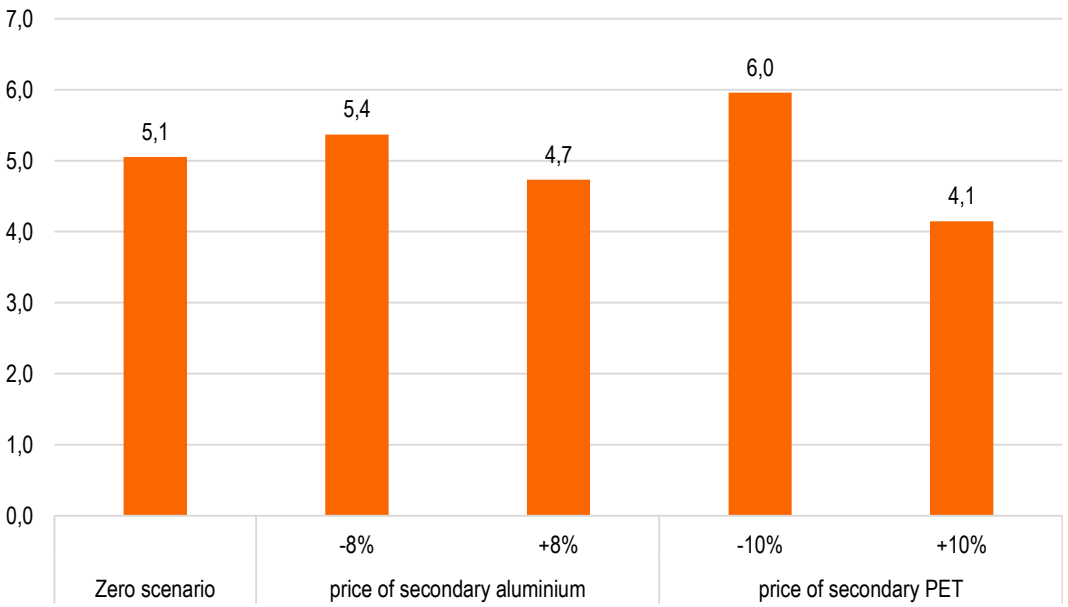
Supplier of reverse vending machines	Investment costs of reverse vending machines (mil. EUR)	Rate of automation	Balance costs (mil. EUR)
RVM Systems	61.9	90 %	5.1
TOMRA	65.7	88 %	5.1

Source: IEP

7.4 Balance costs depending on prices of secondary materials

The prices of secondary PET and aluminium from cans vary within the range of +/- 8 % for aluminium and +/- 10 % for PET. The unstable prices affect the revenues of the system, thus, they affect also total balance costs which can rise or drop by EUR 1 mil.

Chart 4: The amount of balance costs depending on prices of secondary materials (in mil. EUR)



Source: IEP

7.5 Balance costs depending on the number of packages placed on the market

The number of PET bottles and cans placed on the market is a key precondition for the analysis of the financial costs and revenues of the deposit-refund system. According to the information available, the number of PET bottles ranges from 537 to 1,132 million per year. As for the number of beverage cans we received only one estimate, for the purposes of sensitivity analysis we specified the same range as for PET bottles. Thus, total 723 to 1,526 million beverage PET bottles and aluminium cans are concerned annually. The expected number of packages affects all types of costs. In case of a lower number of packaging in comparison with the zero scenario, the deposit-refund system is more expensive in terms of balance costs as well as administrative costs.

Table 10: Analysis of sensitivity to the number of packages placed on the market

Number of packages (mil. pieces)	Balance costs (in mil. EUR)	Investment costs (in mil. EUR)	Administrative fee amount (euro cent/ packaging)	
			PET	can
723	5.8	58.3	2.2	0
1,334	5.1	80.2	1.5	-0.5
1,526	5.0	90.6	1.5	-0.6

Source: IEP

7.6 Sensitivity to the rate of involvement in the system

In the zero scenario we consider a 100 % involvement of hypermarkets, supermarkets, discount shops and organised shops, and with a 50 % involvement of unorganised shops in the deposit-refund system. In case of unorganised shops, their number is estimated to be 4,617 of shop units selling annually total 67 mil. pieces of PET bottles and cans. In examining the robustness of results, we considered the limit of involvement of unorganised shops, i.e. 0 % and 100 %, from which it results 51 % or 100 % of involvement of all shops. From the sensitivity analysis it results that the involvement of unorganised shops in the system, thus the total involvement of all shops has no significant impact on the investment costs. The balance costs vary within the range of +/- EUR 1 mil.

Table 11: Analysis of sensitivity to the rate of involvement in the system

Rate of involvement	Balance costs (in mil. EUR)	Investment costs (in mil. EUR)	Administrative fee amount (euro cent/ packaging)	
			PET	can
51 %	4.1	80.1	1.4	-0.6
73 %	5.1	80.2	1.5	-0.5
100 %	6.1	80.4	1.6	-0.4

Source: IEP

8 Indirect and social costs of the deposit-refund system

In addition to direct costs and revenues, the system will also create indirect positive and negative social impacts. It must be noted that individual figures cannot be counted as not all estimates are equally robust. So where it was possible, in assessing them we monitored the upper and lower limits of the impacts. Moreover, not all impacts (in particular environmental benefits) can be expressed financially – for example, an increase in the value of recreational territories where litter lying around is removed or a lower load on ecosystems due to the lower presence of non-biodegradable material in the wild.

8.1 Indirect revenues (savings)

The introduction of the deposit-refund system will have a positive impact on littering reduction, it will create approximately 250-360 jobs and environmental benefits due to increased recycling resulting in lower consumption of materials and energy and lower emissions of CO_2.

The saved costs of littering removal and of landfilling of mixed municipal waste

The most accurate data are the data on the estimated quantity of litter removed from streets, where PET represent 7-8 %, but the quantity of aluminium cans is negligible due to their collection and sale to metal

repurchase facilities. With the costs of EUR 42 per ton of landfilled waste (the estimated average gate fee including tax in Slovakia) and wage costs of EUR 5/hour, when one worker collects about 200 kg of waste (estimates of several workers working in the branch), the saved annual costs with the reduction of littering from these products by 90 % amount to EUR 1.2 mil. The upper limit of the estimate is the estimate of IEEP converted through the purchasing power parity and adjusted for inflation in the amount of EUR 2.7 mil. (Jílková et al.; 2008).

The data on the pollution of rivers and reservoirs are only available for the Košice region, for the activities executed by Slovenský vodohospodársky podnik Košice in cleaning Ružín, Zemplínska šírava and Bodrog river-basin. The average annual costs related to the removal of PET bottles from these water bodies (the costs of removal of cans are not registered) amount to EUR 432.9 thousand. The data for the other areas of the Slovak Republic and their costs of cleaning of water courses were not available. The upper limit of the estimate is also represented by the IEEP estimate amounting to EUR 78 thousand.

The last littering item monitored is the waste along the roads. Based on the data on road cleaning in Bratislava from Slovenská správa ciest (SSC - Slovak Road Administration) and the analysis of waste near the roads carried out by the civil association Ekoton (Tomáš, 2014), we estimate the costs connected with PET bottles and cans at EUR 147.8 thousand per year. The data represent 50 % of theoretical estimate as based on the communication with SSC workers we decreased it arbitrarily because there will be some cost savings, however, the amount will not correspond to the decrease in the collected material. It is because there would not be any savings due to a lower extent of utilisation (the trucks are not full), but there would be savings concerning the collection of waste along the road by workers. This figure represents the upper limit of estimate as the estimate according to IEEP amounts to EUR 78 thousand.

There are no data on the costs of littering removal in forests, national parks and protected landscape areas because it is carried out on a voluntary basis and there is no record of the quantity of collected waste. Thus, the lower limit is EUR 0 and the upper limit is the approximated IEEP estimate in the amount of EUR 57 thous.

The costs of landfilling of mixed municipal waste amount to EUR 54 thous. to 690 thous. per year depending on the applied estimate of PET material quantity in mixed municipal waste. According to INCIEN analyses, mixed municipal waste with a weight of over 1 mil. tons contains 0.1 to 1.5 % of PET material.

Benefits of increased employment

A single benefit of increased employment was estimated based on the Scottish study of Eunomia. As regards the population, Scotland is roughly as large country as Slovakia, therefore we used their estimate of benefit of 250-360 new permanent job wages, which is equal to a single benefit for economy in the amount of EUR 3.4 to 4.8 mil. (Hogg, et al., 2015). The estimate is based on the expert estimate of the Institute of Financial Policy as a weighted added value in common prices per employee, where the benefit is priced at EUR 13,402 as a weighted average of maximum benefit (unemployed in the long term) and minimum benefit (change of job from “worse” to “better“), a higher weight is on the minimum.

Environmental benefits

The environmental benefits consist of two large parts: the saved energy and material and saved emissions of CO_2. The saved energy and materials of aluminium are based on the study of AlSaffar&Bdeir (2008), where the assessment says that the recycling of one kilogram of aluminium is able to save 8 kilograms of bauxite and 14 KWh of electric energy; the upper limit of electric energy savings with aluminium recycling is set as 372 MJ/kg, i.e. approximately 93 kWh/kg (Johnson, 2015). The price of electric energy comes from Eurostat and the price of bauxite from the stock exchange (Shanghai Metal Market, 2018).

For energy savings in PET recycling, the estimates of the University of Cambridge (2005) are used, which mention that one kilogram of recycled PET requires 60-64 MJ/kg, whereas the primary material 75-88 MJ/kg. By combining the maxima and minima from both materials and after converting to KWh, we reached a minimum saving of 3.06 kWh and a maximum saving of 7.78 kWh.

The savings resulting from lower CO_2 equivalent emissions come from Turner, et. al. (2015). For aluminium cans, savings range from 5,040 to 19,340 kg of CO2e/t and for PET from 566 to 2,324 kg CO2e/t. The price EUR 31 per kg of CO2e/t was taken over from EPA (EPA, 2016).

The total environmental benefits from the saved energy, material and CO_2 emissions represent the savings amounting to EUR 3 to 11.6 mil. per year.

8.2 Indirect costs

The main indirect costs include the reduced revenues in the system of separate collection, and the reduced comfort of the population, which will have to return bottles to shops.

Net influence on separate collection

The influence on separate collection was calculated as the difference between the sum of lost revenues from the sale of PET material and aluminium, the lost revenues from the fees from producers and the saved costs of collection of PET bottles and cans within separate collection. The price of PET material was considered according to the data of General Plastic, the price of aluminium according to TOMRA. The revenues from fees were determined on the basis of the amount of fees of Naturpack per one ton of PET and aluminium placed on the market. The costs of separate collection are about EUR 253/ ton of waste and they represent the average value of the data provided by Naturpack, Envipak and the Association of Municipalities Rajecká Dolina. We estimate that annually the revenues amounting to EUR 4.1 to 10.7 mil. in the current system will be lost.

Costs of the reduced comfort of consumers

As the inhabitants will have to return empty beverage packaging back to shops, the introduction of the deposit-refund system will bring **reduced** comfort for inhabitants with a value of about EUR 13.9 to 21.4 mil.

In evaluating the costs of reduced comfort of consumers, we expect that they will connect the returning of packaging with shopping, thus, the discomfort itself represents only the time necessary for returning the beverage packaging as well as the space of the households for temporary storage. We base it on the fact that one person will return on average 12 beverage packages and their work is evaluated by the average hourly wage in the economy (Statistical Office of the Slovak Republic).

The costs of storage are based on the current average price of a square metre of flat area in Slovakia amounting to EUR 106/m^2, the area covered by one 1.5 L PET bottle - 0.008 m^2 and a can - 0.004 m^2 (1.5 L Bonaqua, or 0.33 L Coca-Cola), and on the number of households in Slovakia 1.85 million. We assume that consumers will have to reserve the place for 12 beverage packages to store them next to each other (the upper variant), or in a bag partly placed on each other (partially on each other; lower variant). The rent was calculated from the average purchase price for one m^2 of flat from the website nehnutelnosti.sk converted into the value of rent using the calculator at sme.sk.

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