BIO INTELLIGENCE SERVICE

Environmental- and Cost-Efficiency of Household Packaging Waste Collection Systems: Impact of a Deposit System on an Existing Multimaterial Kerbside Selective Collection System

APEAL

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Summary

Contact BIO Intelligence Service

- Véronique MONIER
  Tel : +33 (1) 56 20 28 98
  E-mail : veronique.monier@biois.com

- Cécile DES ABBAYES
  Tel : +33 (1) 56 20 28 98
  E-mail : cecile.desabbayes@biois.com

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Introduction

This document is a scientific communication paper from Apeal that targets the main stakeholders (institutions, waste management and environment experts) in the waste management field.
A town of 100 000 inhabitants collecting 100% of its household recyclable packaging waste could recycle 780 tonnes of steel, 200 tonnes of aluminium, 470 tonnes of plastics, 2300 tonnes of paper and 2200 tonnes of glass per year[1]. This is why it is important that local authorities implement an efficient waste collection system, which enables them to maximise the recyclable packaging collected with minimum environmental impacts and costs.
In 2004, Apeal, which represents all the key producers of steel packaging in Europe, commissioned *BIO Intelligence Service* consulting company to carry out an environmental- and cost-efficiency analysis to assess the efficiency, costs and environmental impacts of alternative collection systems representative of existing situations in Europe. The objective of this study is not to be exhaustive in covering all the collection systems but rather to provide national and European decision makers with an answer to the following question: what are the benefits and impacts of combining a deposit system with an existing multimaterial collection system?

Incineration plants with magnetic extraction and also equipped with Eddy current separation systems are voluntarily not taken into account here. This explains the lower efficiency of the systems as compared to the real-life situation that also takes on board the amounts of packaging collected through these systems for the final calculation of the recycling rates.
This is the first study ever carried out where efficiency, costs and environmental impacts are studied simultaneously when considering kerbside and deposit systems to collect used packaging.

Methodology

At a time when the European legal agenda is taking on board broader society issues, global warming for instance, it seemed obvious to us that it was important to check whether the national collection systems that are being implemented are in line with these policies and not working against them.

To allow a three-dimensional evaluation (cost, efficiency and environment) of multi-variable collection systems, an Excel simulation tool was developed by BIO Intelligence Service. This tool enables users to adjust the different parameters of the collection schemes under study to make them reflect a specific national or local situation (collection rates, collection distances, energy consumption of sorting and transfer plants, etc.).

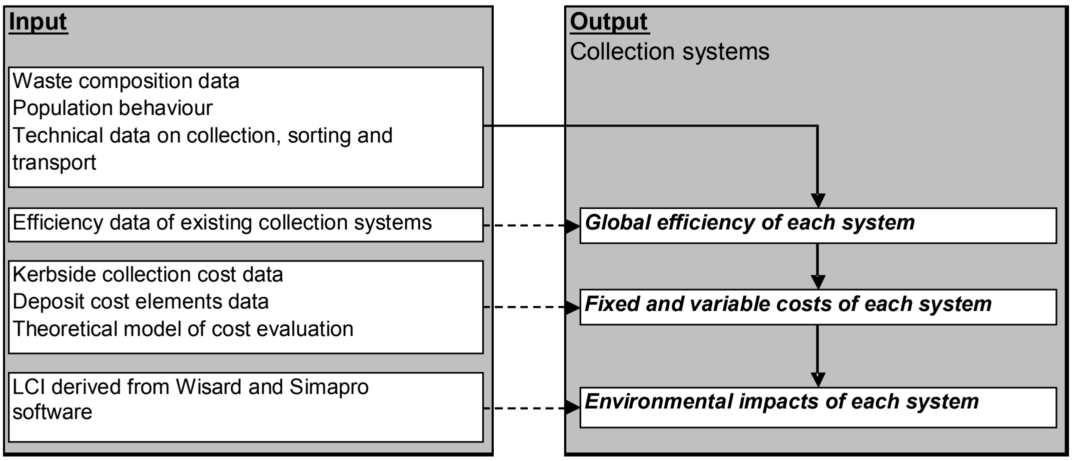


Fig 1: Model structure and relationship

[1] Source: data derived from Canadean & BCME, 2002, and "Performance, feasibility and cost of different collection systems", Coopers & Lybrand, 1995

Scope of the study

The simulation tool represents two different collection schemes:
- A multimaterial collection of recyclable packaging waste: kerbside collection of non-glass packaging waste and bring-back collection of glass.
- A combined scheme, where beverage packaging waste is collected in a deposit system, and non-beverage packaging waste is collected through a multimaterial collection scheme similar to the first system under study.

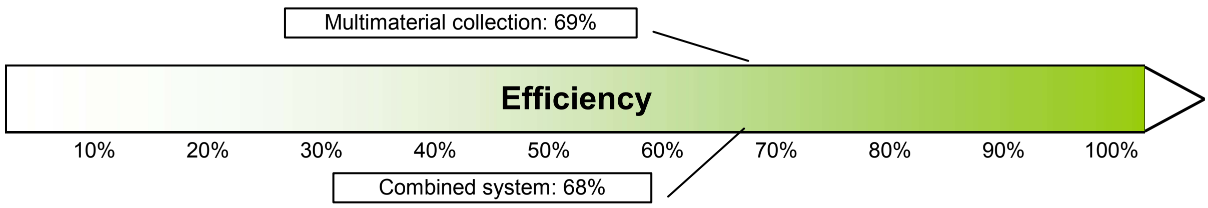
Data representing an average European situation in 2004 was entered into the simulation tool.
The multimaterial collection system (collection rates, costs and technical data about collection material) is based on observations of existing collection systems in France, Belgium and Germany.
The combined system under study is a theoretical system (which may exist locally), where all kinds of materials used for beverage packaging are accepted in the deposit system: steel and aluminium cans, plastic and glass bottles, beverage cartons. Technical data on automatic deposit machines is derived from data about machines used in Nordic countries; all other technical data (collection vehicles, sorting plants, trucks, etc.) is similar to that used for the multimaterial collection system. A cost model for the deposit system was built taking into account all the different cost items involved (investments in automatic deposit machines, energy consumption, loss of sales due to the space occupied by machines in shops, etc.).

Results

The results in terms of efficiency, costs and environmental impacts for the two collection systems modelled are presented here.

Efficiency

The efficiency is the global collection rate of a system, i.e. the % of recyclable packaging waste collected versus the amount available for collection (according to collection scheme requirements). It reflects the participation of citizens in the selective collection of packaging waste as well as the quality of their sorting.

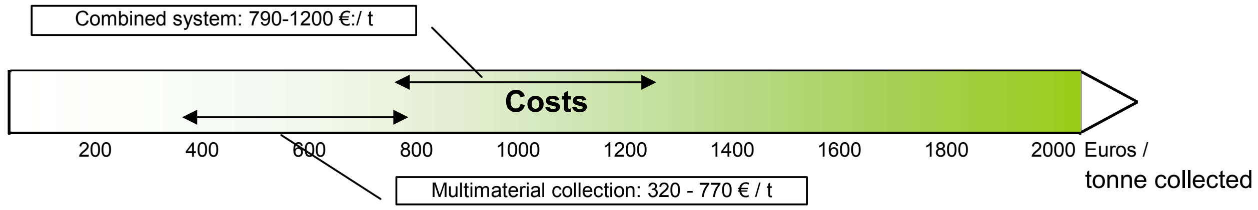


Comments

- The efficiency of the two systems is **equivalent**: each of them manages to collect about 70% of packaging waste available for collection.
- Regarding the combined system, collection rates for multimaterial selective collection of non-beverage packaging and the deposit system for beverage packaging were estimated 5 points lower than what is observed in countries implementing only one type of collection system. Such a decrease has been observed for example in the USA. The reason for this decrease in collection rates is most likely the confusion of the messages given to citizens, who have to deal with a double system and may be discouraged.

Costs

Gross costs were evaluated: investment, operation and variable costs for collection, sorting and transport were taken into account. Due to the system's limits (it stops at the entrance to the recycling plant), income from sales of recyclable materials is not included in the systems under study (and neither are environmental impacts and benefits from recycling).



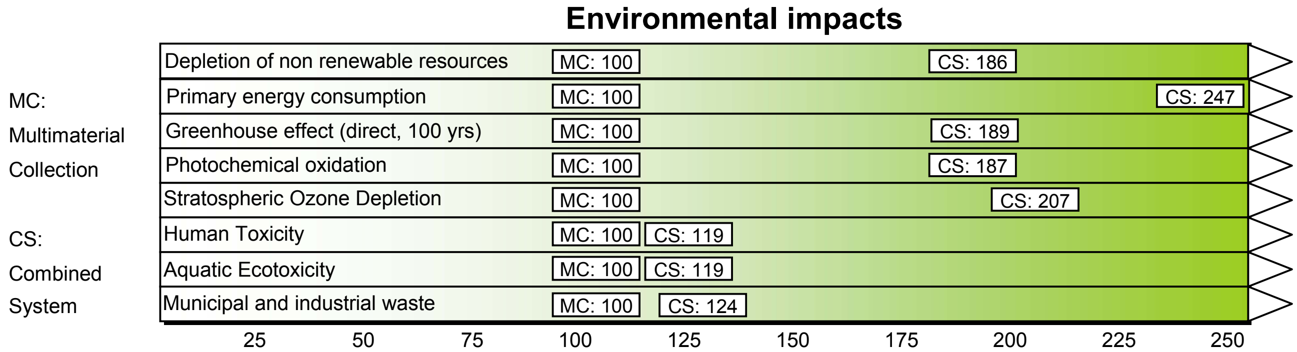
Comments

Costs for the combined system are higher than costs for the multimaterial selective collection system.

Costs vary widely, mainly due to the diversity of equipment and operation conditions for deposit collection, and various organisational options for multimaterial selective collection.

Environmental impacts

Life Cycle Assessments were performed to evaluate the environmental impacts of the two systems. 8 environmental indicators were used, presented here in base 100 for the multimaterial collection system.



Comments

The **environmental impacts of the combined system are higher than the ones of the multimaterial selective collection system** for all the indicators.

For the multimaterial selective collection system, the main environmental impacts come from the kerbside collection of non-glass packaging waste: e.g. it is responsible for 80% of total greenhouse gas emissions. More precisely, it mainly comes from the use of collection vehicles - these are responsible for 75% of the greenhouse gases emitted by the kerbside collection sub-system.

The environmental impacts of the combined system are mainly due to two different steps:

- The use of collection vehicles for the kerbside collection of non-beverage packaging waste (e.g. it is responsible for 25% of the total greenhouse gas emissions of the global system).
- The distance travelled by citizens in their private cars to bring their beverage packaging waste back to stores. Most of the time, people will return their packaging when going shopping but not necessarily each time. The environmental impacts of a deposit system prove to be extremely sensitive to the proportion of the trips people make to do their shopping that is allocated to the return of packaging waste. For instance, if 20% of these trips are allocated to packaging deposits, they will be responsible for 45% of the total greenhouse gas emissions of the combined system.

Environmental- and Cost-Efficiency of the two collection systems

As a conclusion, **for the set of hypotheses considered, the multimaterial selective collection system presents better environmental- and cost-efficiency compared to the combined system** (equivalent efficiency with lower costs and lower environmental impacts). In other words, adding a deposit system to an existing multimaterial selective collection system deteriorates costs and the environmental profile.

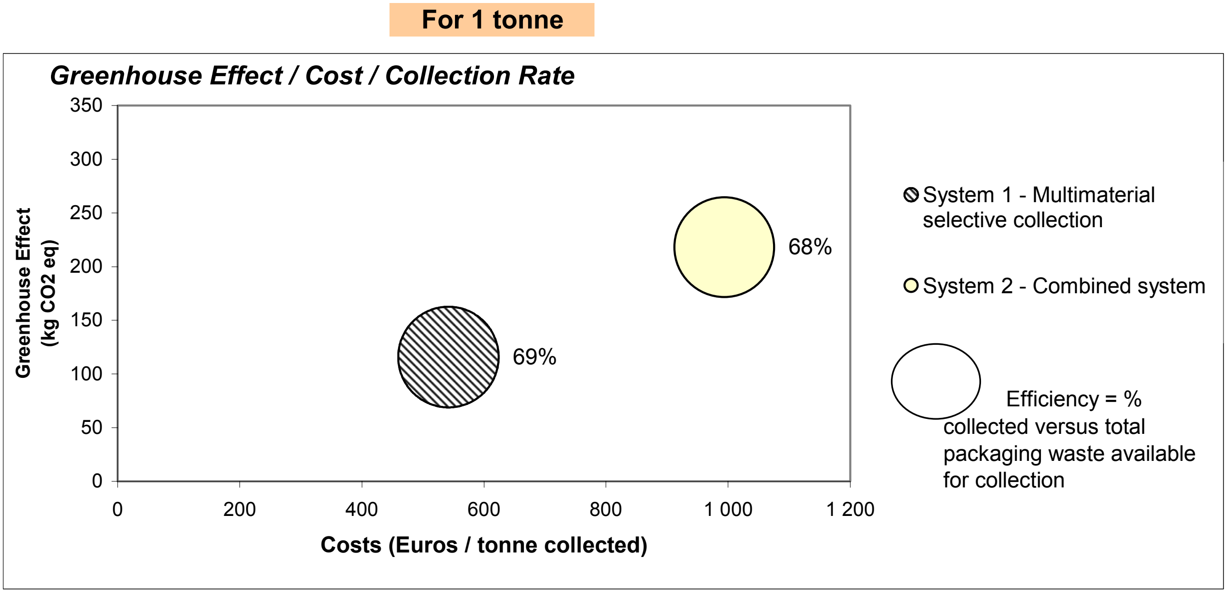


Fig 2 : Environmental- and Cost-Efficiency of the two systems, using the Greenhouse effect as environmental indicator

At this stage, it was necessary to analyse the robustness of this conclusion. We performed several sensitivity analyses testing the main parameters of the model.

Sensitivity of the results to key parameters

Four parameters proved to be key parameters to which results are very sensitive. Simulations were carried out, with variation of these parameters, as described below:

- Collection rates of the combined system (variation: +/- 5 points).
- Space costs and sales losses due to the space occupied by the Reverse Vending Machines (variation: +/- 50%).
- Allocation, to the deposit system, of the trips made in private cars by customers to return their beverage packaging waste to stores (variation: +/- 100%).
- Collection distances (variation: +/- 50 %).

The results of these simulations performed one by one, and then altogether, can be found below, using the Greenhouse effect as the environmental indicator (the other indicators vary in the same way).

For 1 tonne

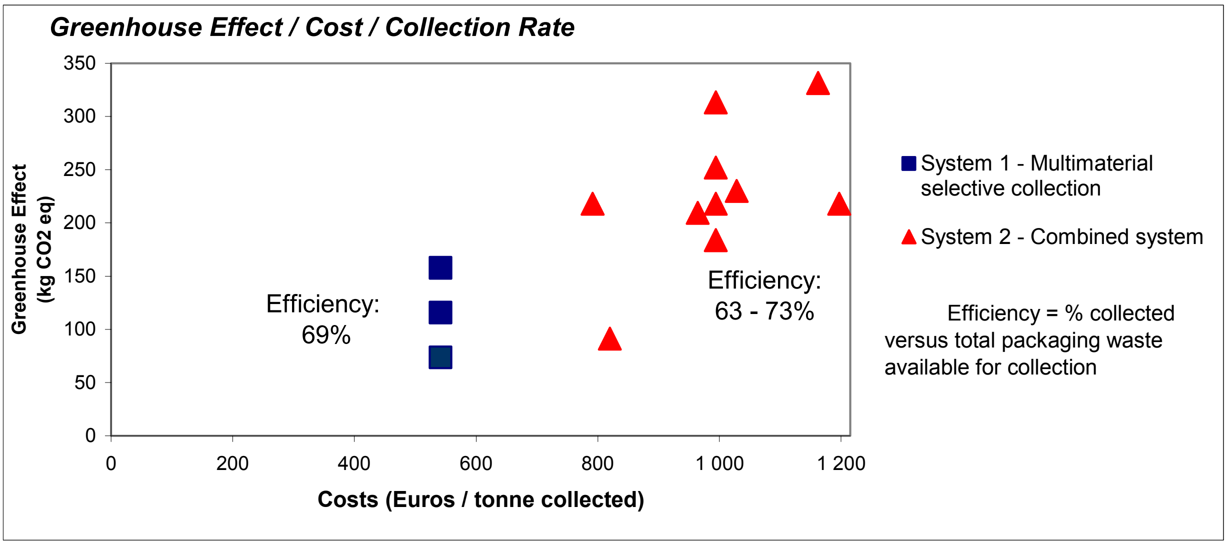


Fig 3: Relative positioning of both systems when different sensitivity analyses are performed

Changing these parameters one by one or altogether does not affect the global results of the study, i.e. the better environmental- and cost-efficiency of the multimaterial selective collection versus the combined system:

- The combined system never appears significantly better than the multimaterial selective collection for any of the aspects under study (environmental impacts, costs and efficiency).
- The combined system may be equivalent in terms of environmental impacts or slightly better in terms of efficiency compared to the multimaterial selective collection in some specific situations, but its costs always remain higher.

Conclusion

The environmental- and cost-efficiency analysis carried out does not allow us to recommend implementing a deposit collection in addition to an existing multimaterial selective collection in any circumstances. If Europe were to implement a deposit system for one-way beverage containers in all countries were a green dot system already exists, this decision would generate an increased greenhouse effect equivalent to that of an extra 500,000 to 700,000 cars put on the roads of Europe, each car travelling an average of 10,200 km per year. Local / regional analyses are necessary to determine the best solution in a given perimeter taking into account local specificities (distances, etc.), citizens' expected behaviour (participation in multiple collection systems), technical and organisational options (possibility of optimising existing collection means, space where deposit equipment can be located, etc.).

Contact

If you have any questions please contact Renaud Batier, Apeal. www.apeal.org

Appendix: Main hypotheses and results for the two systems analysed

Legend: **key parameters (i.e. inputs to the simulation model) are in yellow**; *main variables calculated from parameters are in italic*

Multimaterial selective collection

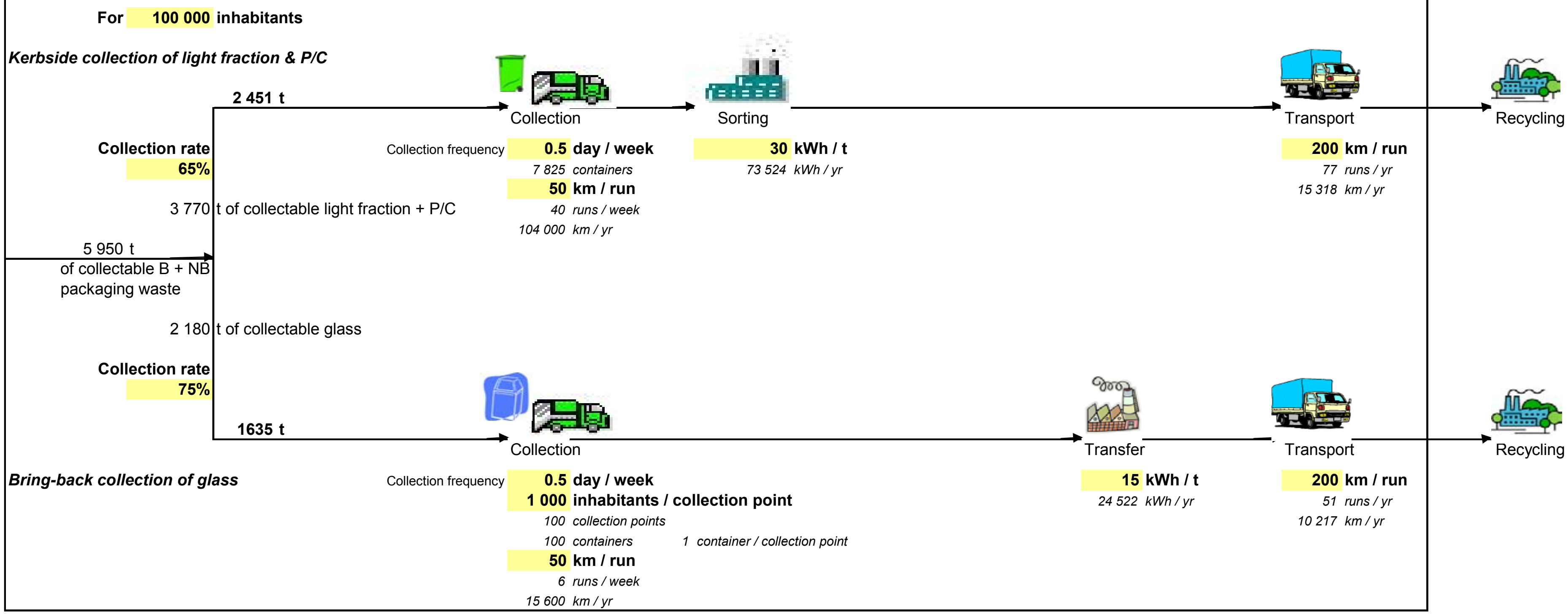
Multimaterial selective collection is widespread in different countries in Europe, with some variants according to countries and regions (glass may be collected in separate colours, newspapers and cardboard may be collected separately from other materials, etc.).

In the system analysed, households put non-glass packaging waste together in an individual rubbish bin (or common to their building). These bins are emptied on a regular basis (e.g. once every two weeks) by municipal employees. Glass packaging is brought to specific bins common to many inhabitants (e.g. 1,000 inhab.), which are also emptied regularly (e.g. once every two weeks).

System 1 - Multimaterial selective collection

kerbside collection of light fraction & P/C + bring-back collection of glass

System boundaries studied, main inputs (hypotheses) and main intermediary indicators calculated



Main inputs (hypotheses) about costs

		Glass - Bring Back *Euros / t of glass*			Light fraction & P/C - Kerbside *Euros / t of light fraction & P/C*		
		Total	Fixed	Variable	Total	Fixed	Variable
Collection		45	70%	30%	400	70%	30%
Sorting		0	0%	100%	383	85%	15%
Overhead	10%	5	100%	0%	87	100%	0%
Total		**50**			**870**		

Eco-efficiency indicators obtained

		For 100 000 inhab. / yr	For 1 tonne
Efficiency indicator	*% collected vs total packaging waste*	69%	69%
Cost indicator	*Euros*	2 213 942	542
Environment indicators			
Depletion of non renewable resources	*kg antimony eq.*	2 734	1
Primary energy	*MJ*	6 644 698	1 626
Greenhouse effect (direct, 100 yrs)	*kg C02 eq*	472 691	116
Photochemical oxidation	*g ethylene eq.*	993 527	243
Stratospheric Ozone Depletion	*g CFC-11 eq.*	216	0.05
Human Toxicity	*ton eq. 1-4-dichlorobenzene*	57 787	14
Aquatic Ecotoxicity	*ton eq. 1-4-dichlorobenzene*	11 622	3
Municipal and industrial waste	*kg*	6 098	1

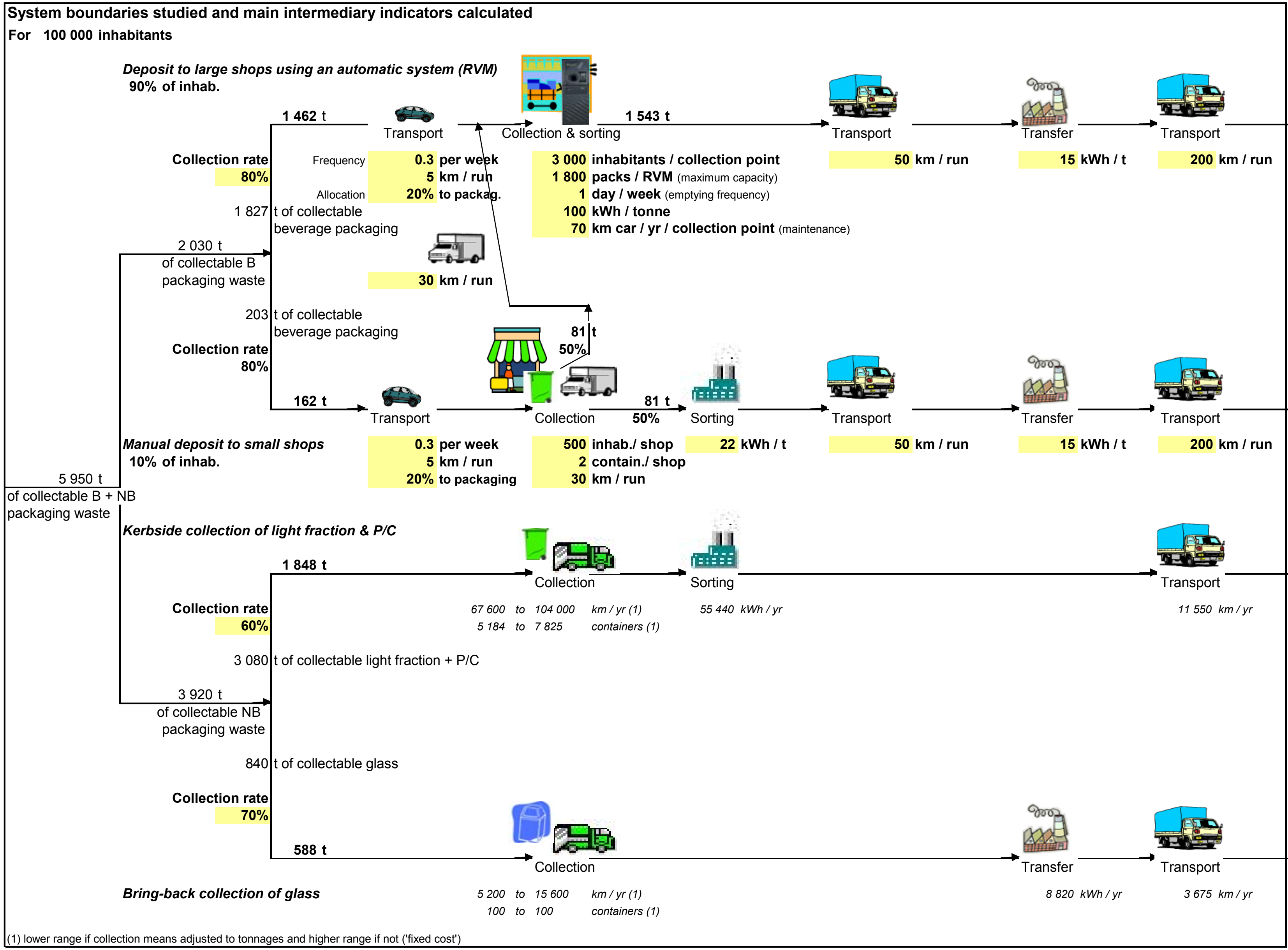
Combined system

Deposit systems are well-implemented in Scandinavian countries (Norway, Sweden and Denmark) and are being developed in Germany. The materials accepted in a deposit system vary according to the countries. The system under study here is a theoretical system (which may exist locally), where all kinds of materials used for beverage packaging are accepted: steel and aluminium cans, plastic and glass bottles, beverage cartons.

The system analysed considers a town of 100,000 inhabitants where 90% of the population bring back their beverage packaging to large shops (supermarkets, petrol stations, etc.) and the rest to small shops. Large shops are equipped with Reverse Vending Machines (RVMs) which automatically sort and compact the beverage packs, whereas small shops sort packaging manually. The non-beverage packaging waste is collected through a multimaterial selective collection similar to the first system under study.

System 2 - Combined system

deposit system of beverage packaging + multimaterial selective collection of other packaging



Main inputs (hypotheses) about costs

Investment cost		Min	Max
RVM purchase	*Euros / RVM*	15 000	20 000
RVM installation	*% of investment price*	5%	15%
Containers	*Euros / container*	25	30
Investment depreciation (straight-line depreciation)			
Life duration	*years*	10	
Debt financing rate	*%*	6%	
Operation cost			
RVM + containers included (large shops)	*Euros/ RVM/ yr*	665	2 275
Containers alone (small shops)	*Hours / day / container*	0.5	
	Euros / hour	14	
Space	*m² / RVM*	5	
	m² / container	4.0	
	Euros / m² / month	9	
Specific packaging labelling	*Euros cents / pack*	0	0.15
Sales losses	*Euros / m² occupied / yr*	281	1 248
Transport	*Euros / (t x km)*	0.2	
Sorting	*Euros / t*	145	620
Transfer	*Euros / t*	3	8
Overhead	*% of total costs*	10%	

Eco-efficiency indicators obtained

		For 100 000 inhab. / yr		For 1 tonne	
Efficiency indicator	*% collected vs total packaging waste*		**68%**		**68%**
		Min	Max	Min	Max
Cost indicator	*Euros*	**3 218 956**	**5 429 644**	**793**	**1 195**
Environment indicators					
Depletion of non renewable resources	*kg antimony eq.*	**4 657**	**5 463**	**1.1**	**1.3**
Primary energy	*MJ*	**15 383 877**	**17 163 027**	**3 789**	**4 227**
Greenhouse effect (direct, 100 yrs)	*kg C02 eq*	**812 364**	**957 977**	**200**	**236**
Photochemical oxidation	*g ethylene eq.*	**1 681 513**	**2 011 885**	**414**	**496**
Stratospheric Ozone Depletion	*g CFC-11 eq.*	**405**	**480**	**0.10**	**0.12**
Human Toxicity	*ton eq. 1-4-dichlorobenzene*	**60 178**	**78 087**	**15**	**19**
Aquatic Ecotoxicity	*ton eq. 1-4-dichlorobenzene*	**12 098**	**15 700**	**3**	**4**
Municipal and industrial waste	*kg*	**6 591**	**8 538**	**2**	**2**