Economic assessment of separate collection cost: tools to optimise it and the advantage of operative integration

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Integrated Waste Management of wet/dry collection

The basic feature of Integrated Waste Management programmes of wet/dry collection is that organic waste collection is seen as part of the redesign of the collection system as a whole. One of the aims of the new system is to remove a large enough portion of putrescibles, and to reduce volume sufficiently, to allow residual waste to be collected less regularly. In southern countries like Italy and Catalunja (Spain) this means reducing the collections of residual waste from 4 to 6 times a week up to 2 or 3. In the northern areas of Italy near the Alps, whose climate is closer to Central European countries, it is more a question of moving towards weekly to fortnightly collections. In order to do this the capture of food waste through separate collection must be such that the its amount in residual waste is cut down to 10%-20% and less in weight. Considering concentration of materials, which occurs in residual waste and often in Central Europe takes percentages of food waste in residual waste around 30 or even 40%, this implies the need to have a very comfortable and user-friendly collection scheme, so that participation be enhanced.

The importance of this point is economic. If the source separation of food-waste is added as a further service, with no modifications to the previous scheme for MSW collection, the total number of collection rounds and (obviously) the cost of the collection service is bound to increase. But this does not happen when and where food waste collection and the source separation of key dry recyclables are integrated within the overall collection scheme. Separating out food waste allows the issue of collection frequencies, vehicles, containers, and logistics to be reviewed across all the waste streams. This is why it must be seen as an integrated rather than an 'add-on' service.

The correct parameters for cost analysis

One of the major concerns in waste management is the lack of cost-competitiveness of innovative schemes for source separation aiming at reaching high recycling rates through the separation of compostables [1]. Operators in general think that sorting food waste leads to higher costs of the overall collection scheme. We've therefore considered it to be useful to analyse main systems for source separation currently in operation, and to make a cost-assessment [2].

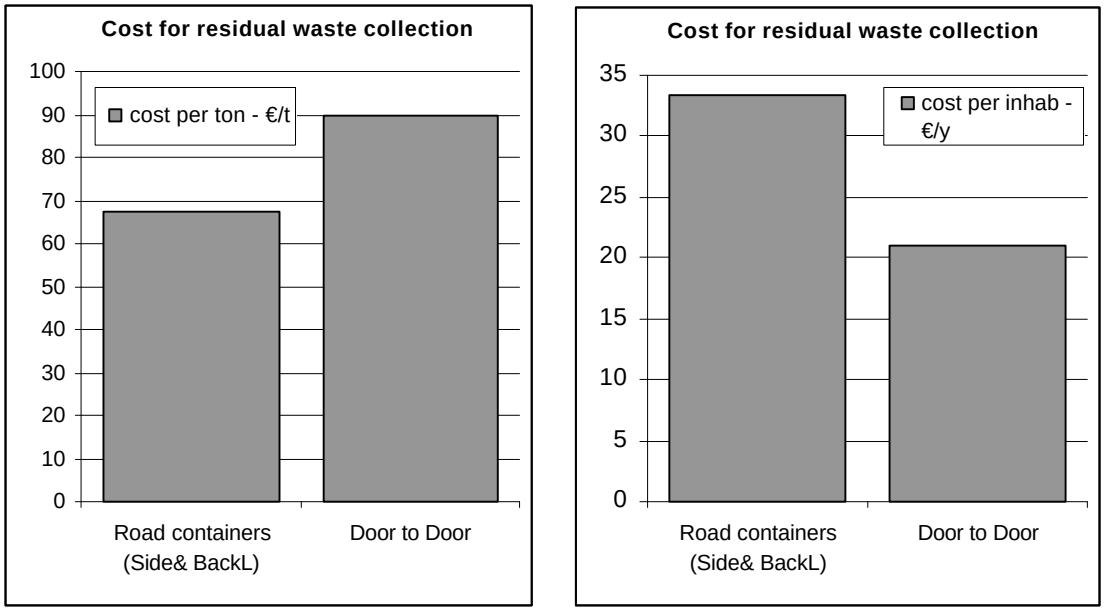
Cost analyses carried out so far across Europe have traditionally focused on costs *per kilogram (*or *per ton) for a single waste stream collected*. However, there is evidence that this distorts the true picture, because *the more the waste collected, the lower the costs of the collection service per kilogram*. This distortion obscures some important outcomes of integrated source separation and waste management:

- the much lower delivery of industrial waste to the MSW collection route where large-volume road containers get substituted by kerbside collection with low-volume bins and bags
- the contribution of home composting programs to the overall reduction of organic waste collected, etc.
- the reduction of total waste delivered as a consequence of effective waste reduction policies, f. example applying PAYT schemes

In a few words, one could say that " the more the waste collected the lower the costs of the collection service per kilo". Moreover, it has to be stressed that the cost of the system (collection plus transport) is not paid for by the Municipality considering the amount of the waste collected, but considering the general operational scheme (the number and frequency of collection rounds, the number of workers, vehicles, pick-up points, etc). It is therefore incorrect to express the cost of this service per unit mass, and we shall evaluate it in **cost 'per person'**, i.e. in **€/inhab.year (**or **€/household.year)**; this will allow us to compare the actual cost-competitiveness of different systems (in parallel, of course, to their effectiveness in terms of quantity and quality of the waste materials recycled).

The different indications resulting from these two parameters (cost/kg and cost/inhab) can be clearly shown in figure 1, where the mean-cost for different collection systems for residual waste are compared; data refer to a survey recently performed by Federambiente, the Italian Association of Public contractors [3]. The different response of the parameter in €/t is related to the amount of residual waste collected; it is about 235 kg/inhab per year in kerbside collection (which will be worded in this paper also as collection at the "doorstep" or "Door-to-door", DtD); collection through road containers, instead, determines much higher amounts of residual waste, of about 460 kg/inhab per year.

Figure 1: Collection cost for residual waste - medium values [3]



Furthermore, the evaluation of the *cost for a single waste flow, does not allow one to compare advantages to collection costs for other materials,* following from "operational integration". As a matter of fact, the collection of food waste – above all when it shows high captures - allows important changes in the collection system, by reducing, for instance, frequencies of collection for residual waste (or "restwaste"). This permits a fair comparison of the competitiveness of different systems (in terms of cost, quantity and quality of materials recycled). Once the overall cost of a certain management-scheme is given, the Municipality could only be happy with lower deliveries of waste – that would on the contrary affect negatively the cost per kilogram!

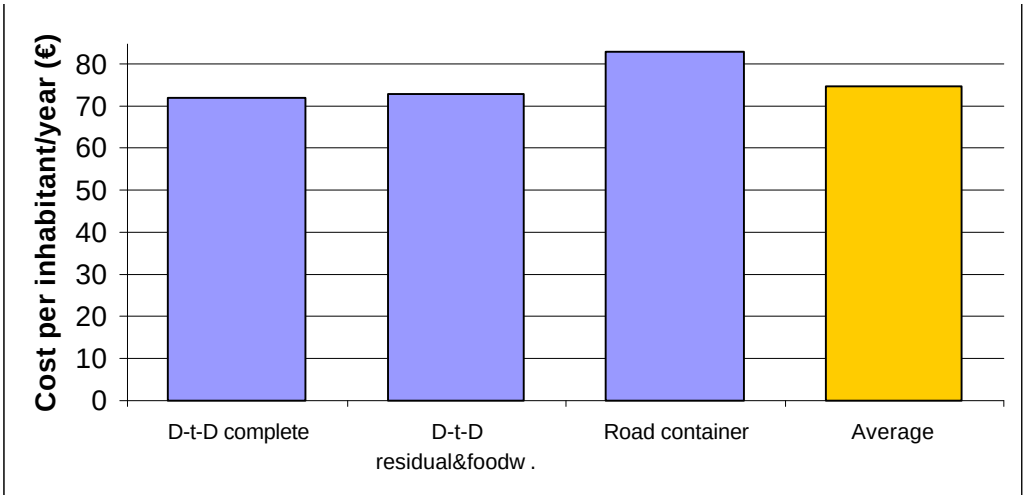
Again this can be shown effectively in figure 2, comparing the cost per inhabitant (including collection, transport and treatment) for different management schemes in Veneto Region (Italy), hence comparing different approaches on a sample of comparable municipalities:

- road containers collection of both food and residual waste and road-container collection of dry recyclables (mostly packaging waste);
- Door-to-door (DtD) collection of food & residual waste and road-container collection of dry recyclables
- DtD collection of food & residual waste and dry-recyclables

The graph clearly shows that the **overall** specific cost (i.e. per person served, and including collection, transport and treatment/disposal) for waste management shows to be lower in those strategies where DtD collection is considered *at least for most important waste fractions* (namely, food waste and residual)

Admittedly, the limiting aspect of the information shown in figure 2 is that we cannot know how much money is being spent to perform collection-rounds of waste and what share of it is due, instead, to treatment and disposal of the various materials collected; hence it might be difficult to compare efficacy and cost-competitiveness of the collection itself, since the overall cost may be affected by higher costs for disposal, relative to recycling (although this latter aspect is not trivial and should already by itself foster strategies aiming at highest capture of recyclables through collection at the doorstep).

Figure 2: Total management cost (collection and treatment) comparison for different collection schemes – Veneto Region, Italy 2001 [6]

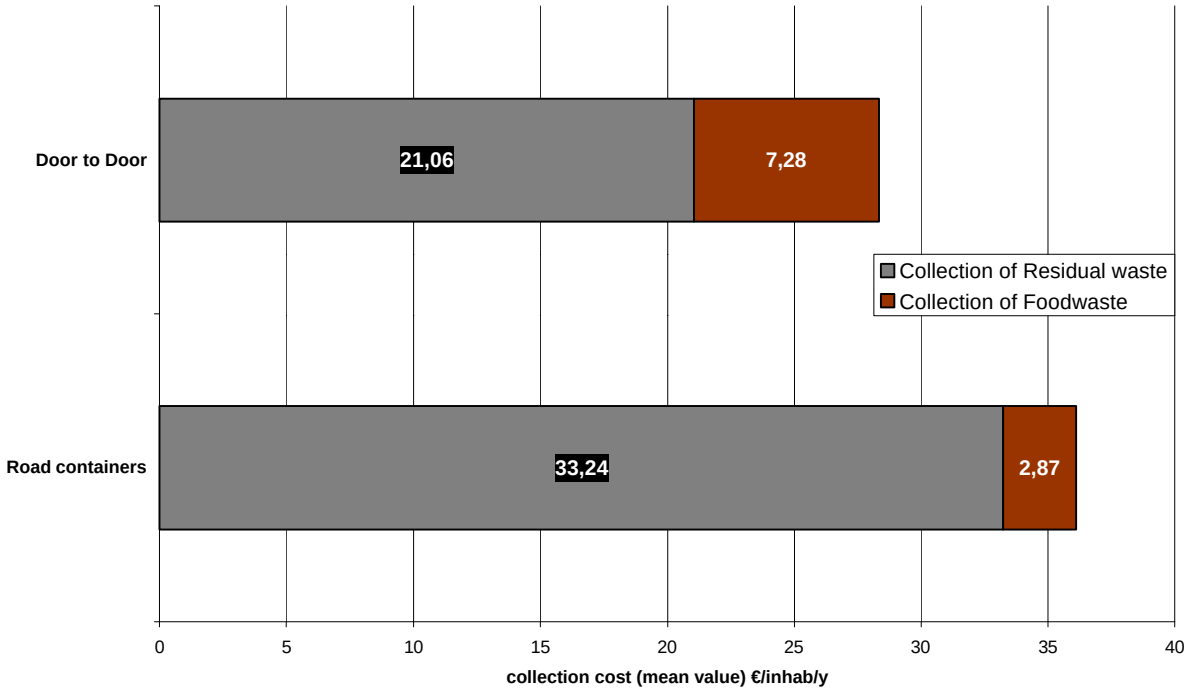


Therefore, in order to deepen views on optimisation of the collection step, it is also *advisable to split the cost for collection from those regarding treatment and disposal options*, which often represent "external condition" and gate fees that Municipalities have to pay with no possibility to

influence them. Again this can be considered on the example in figure 3, which shows the sum of the DtD collection cost for residual & foodwaste to be highly cost-competitive to the traditional collection performed using road-containers. Another key element we may derive from figure 3, is that collection of food waste at the doorstep is more expensive (given the higher number of pick-up points) than collection by means of road containers; but this leads to a wide reduction of cost for collection of residual waste, which leads, overall, to a reduced cost of collection of waste on the whole.

We may therefore say that collection at the doorstep may be made cost-competitive already by itself; moreover, the lower capture of residual waste reduces also the cost/inhabitant for disposal of waste; it turns out from the survey [3] that in many cases it has been the high cost for disposal of residual waste that has driven local authorities towards an implementation of DtD collections in order specifically to reduce the amounts of waste to be collected and disposed of.

Figure 3: Integrating collection schemes for food &residual waste; cost per inhab/year – [3]



Tools to optimise separate collections

Designing a collection scheme that clearly distinguishes between food waste and garden waste, according to their bulk density and production rates in each season of the year, determines specific operating advantages that have been shown elsewhere[1] during this conference (see following table). We will therefore consider more deeply some specific details of this choice, summed up in the table below.

[1] Favoino, E: "*Recent optimisation of source separation in Mediterranean Countries: schemes for sparsely and densely populated areas*"

Tool	Details	Applies where.....
Reduction of the frequency for collection of "Restwaste"	**Effective systems to collect biowaste make its percentage in the "Restwaste" fall down to 15 % and less..**	**...frequent collection rounds are under use (warmer climates)**
Use of bulk lorries instead of packer trucks	**Bulk density of food waste is much higher (0.7kg/dm3) than that of yard waste**	**...tools for collection of food waste prevent deliveries of yard waste**
Reducing/avoiding Washing rounds	**Making the system comfortable promotes self-management of receptacles**	**... watertight bags are combined with collection at the doorstep**

Own-management of buckets and bins

Door to door collection schemes request that households and activities are made responsible for the maintenance and cleaning of the receptacles (buckets, bins, etc) assigned to them; this can be achieved by providing each household/producer with specific tools as bags that can be used to easily manage the more putrescible and critical fraction of waste (i.e foodwaste).

Avoiding or reducing the number of washing rounds can have a significant effect on cost savings; table 1 shows the specific cost for the team deputed to perform these tasks relative to a waste management district in northern Italy [5].

Table: 1: Cost for washing bins and road-containers

Team	cost (€/h)	N
Vehicle	28,53	1
Driver	21,17	1
Operator	17,36	1
Total	**67,06**	

Source: public authority Consorzio West Milan *year 2000*

performance

	type		**cost/receptacles**
Road containers	2400 l	.@ 10/h	**2,85**
Road containers	1100 l	.@ 15/h	**4,47**
Trolley bins	120-240 l	.@30/h	**2,24**

Note: In schemes with collection at the doorstep, trolley bins are adopted at high-rise buildings instead of buckets, so that many families (up to 15-20) are served with one single pick-up

These savings should be compared to the cost of providing each household with an adequate number of bags in order to allow the separate collection of foodwaste; table 2 shows different annual cost per inhabitant by assigning each household a minimum of 2 bags/week of 6-10 lt.

Table: 2: Cost of bags for separate collection of foodwaste - different materials considered

	Starch based		PE - Polyethylene		Paper	
Cost	0,034	€/bag	0,010	€/bag	0,052	€/bag
Spec. cost	**1,41**	**€/inhab/y**	**0,43**	**€/inhab/y**	**2,15**	**€/inhab/y**

Note: assuming 2,5 inhab/household

The choice of the bags raw-material is usually determined by the characteristics of the composting- or digestion plant; the major cost of the bags made of biodegradable materials is usually more than compensated by a reduction of gate fees due to the minor presence of rejects to be screened, separated and disposed of.

Hand-picking versus mechanical picking

The introduction of transparent bags for residual waste and small buckets (up to 30 lt) for foodwaste collected at semi-detached and detached houses (with gardens) allows to speed up significantly the pick-up rate of a collection team, relative to schemes adopting only trolley bins and road-containers that need a mechanical lifting device. A rough comparison of pick-up rates and specific needs on manual or mechanical emptying is shown in the following table.

Hand picking is fully practicable given the low weight of food waste included in small buckets, when garden waste is not collected with it. A weekly collection of food waste should imply a weight of food waste from a family with 3 persons, and considering a capture of 200 grams/inhabitant a day, of around 4 to 4,5 kg. A twice weekly collection (typical in North Italy) should cut it to 2-2,5 kg

Equipping the collection vehicles for food waste both with a mechanical device and a manual emptying allow collection teams to pick up during the same collection round buckets (with hand pick-up) and larger bins (with a mechanical lifting device); trolley-bins are used at high-rise buildings, where one bin serves up to 15-20 families (hence cutting the specific pick-up time in seconds per household) and large-producers as canteens, restaurants, etc.

Table: 3: Food waste collection - DtD

Buckets	Trolley bins	Road container
volume: 10 to 30 l	volume: 80 - 240 l	volume: 700 - 1100 l
hand-loaded	mechanically loaded	mechanically loaded
specific loading time: 12” - 30”	specific loading time : 2’ - 4’	specific loading time : 2’ - 4’

Choosing a varied fleet of collection vehicles

Collection vehicles should be chosen to suit the features of single waste materials, mainly their bulk density. Food waste on its own has a high bulk density (0,6 to 0,8 kg/litre). It does not need compaction. Instead it can be collected and hauled by means of small lorries (see pictures in figure 4). This does not apply to schemes where food waste gets collected along with yard waste (whose

bulk density ranges from 0.15 to 0.30 kg/litre). The use of small bulk lorries is suitable only when schemes do effectively prevent the delivery of yard waste along with food waste. This is one of the reasons for limiting the size of the containers supplied to single households. This very important opportunity is unfortunately neglected in schemes based on joint collection of food and yard waste, as e.g. in most Districts in Central Europe and North America, as houses with gardens are usually provided with a large trolley bin (80 to 240 litres) – food waste gets mixed with a very high percentage of garden waste and therefore the biowaste has to be collected by packer trucks.

The significance of being able to shift to small non compacting vehicles for food waste is one of convenience, cost and environmental impact. A small vehicle can if necessary be operated by a single person and limits congestion. Its investment cost is only a third of those of a compacting vehicle (see Table 4) and from an environmental standpoint, while it adds one further vehicle movement, it allows the substitution of a light (in some cases electric) vehicle collecting twice a fortnight for a weekly heavy compactor vehicle (which shifts to a fortnightly schedule).

Table: 4 Estimated specific data of collection vehicles – cost in €

	Open, Bulky vehicle	**Compacting vehicle, Rear loading**
Investment cost	**27.372**	**139.443**
Depreciation cost / year (7 years)	**3.910**	**19.920**
Running cost (€/h) including maintenance, fuel, etc and without driver or operator cost	**9,43**	**29,35**

Figure 4/1: Vehicles for the door to door collection of food waste

Open vehicle with 1 driver-collector

Hand pick-up of buckets

Emptying of trolley bins by use of lifting device

A picture of collected materials

Figure 5/2: Vehicles for the door to door collection of food waste

Electrical vehicle

Downloading to a transfer vehicle for long-distance transport

Foto Scuola Agraria del Parco di Monza

Results of operational integration and optimisation of collection rounds

The cost-competitiveness of schemes switching from traditional collection (e.g. by means of road-containers) towards integrated schemes, can be found in further literature. Table 5 reports on its effects in the case of a pilot scheme [7] in Tiana (Catalunia, Spain). The table clearly shows that a higher cost for an intensive collection at the doorstep of food waste is more than compensated by savings on collection of residual waste, and this refers basically to the possibility to cut frequencies for collection of residual waste, where a user-friendly system enhances participation and captures for food waste.

Table: 5: Collection cost for Tiana, Catalunja (S)

Residual & Foodwaste collection	**Residual+Food Waste (€/y)**	**Foodwaste collection (€/y)**	**Residual collection (€/y)**	**Cost per inhab/year (€)**
DtD (res 2/wk + food 3/wk)	173.068	100.243	72.825	**29,4**
Road Containers (res 3/wk + food 6/wk)	173.463	58.386	115.077	**29,5**

The cost-performance of schemes with intensive collection of food waste and lower frequency for residual waste looks particularly important in warm climates (where collection of MSW starts from very high frequencies of collection) but may yield good results also in Central and Northern Europe; it is again confirmed in Italian experiences as can be seen from literature data [8] or by the medium cost (see figure 3) resulting from the recent study performed on behalf of the Italian Association of Public Cleansing Services.

Moreover, as stated before, the use of buckets, besides avoiding high deliveries of yard waste and allowing the use of lorries, makes it also possible to cut the pick-up time for each household at detached houses, and this entails large savings on the overall time taken for the service and on its cost. This tool for operational optimisation (which has been fairly neglected so far in schemes based on large trolley “biobins” even at houses with gardens) may of course be widely effective in any type of climate, yielding important savings relative to collection of biowaste with bins even at detached houses (traditional Central European approach).

In our Italian surveys (table 6) performed on optimised and "mature" schemes we found out that a twice weekly collection for food waste using small lorries tends to equal the cost of a once weekly collection for residual waste with packer trucks. This is partly due to the higher cost of purchase and use for a packer truck itself, partly to the much higher time taken by each pick-up with bins. Costs [8] refer to real costs paid by municipalities to local contractors providing for services of collection and transport.

Table: 6: **costs of collection schemes for food waste and residual waste in doorstep schemes. Costs are expressed per capita, in € inhab^{-1}.year^{-1}**

Municipality	**Population**	**Cost for collection of Restwaste** ***(once weekly, with packer trucks)***	**Cost for collection of food waste** ***(twice weekly, with bulk lorries)***
Calcio	4.765	5,14	4,21
Caravaggio	14.181	5,46	6,01
Arzignano	26.036	7,28	8,88
Sommacampagna, Sona	26.036	7,28	8,88
Cinisello Balsamo *	74.300	12,90	5,23
Busto Arsizio	78.000	8,52	6,26
District. Cremasco (anno 2000)	63.750	8,78	8,26
District. PD 1 (26 municipalities)	250.000	7,23	6,71
District. EST Milano (35 of 48 municipalities)	280.000	6,00	5,50

Note: * 2 collection rounds per week

Conclusions

The cost parameter to evaluate the economic effort regarding different collection schemes for MSW should be based on cost per inhabitant (or household) served. According to the numbers shown, it is clear that the main mistake made when planning sorting schemes, is the fact that new schemes are often “added” to previous one, with no effort for their integration. It is vital – on the contrary - that the new separate collection scheme is integrated into the established waste management system, e.g. changing frequencies and volumes to collect residual waste, and this can best be done where the collection of food waste yields high captures through a comfortable scheme, namely collection at the doorstep with specific tools to make it “user friendly” (e.g. watertight bags to be used as a liner for the bucket). The reorganisation also allows to get savings on additional services as rinsing and maintenance of receptacles (e.g. containers, buckets and bins). Cheaper vehicles may be adopted to collect food waste (in this case bulk lorries are suitable), due to its high bulk density when the collection scheme prevents yard waste from being delivered in the same containers. It is furthermore evident that one of main lessons to be learned from these outcomes is that “the more flexible and varied the fleet of collection trucks, the better it is”.

We may therefore sum up the following key point for operational optimisation of schemes, to make them cost-effective:

- the collection of food waste (which calls for an “intensive” scheme to be made user-friendly) has to be kept separated from that o yard waste (which may be collected in a less intensive way)
- hand-picking should therefore be made possible, and preferred to cut pick-up times and costs at houses with gardens.
- cheap lorries may be used instead of packer trucks to transport the food waste, given its high bulk density relative to “biowaste”, when this latter includes also garden waste

- washing rounds may be reduced or even avoided, shifting towards own management of buckets, thanks to the use of watertight bags (which also increases captures making the system user-friendly)
- thanks to high captures of an intensive and comfortable collection scheme for food waste, the frequency of collection of residual waste (which implies higher costs for each pick-up point, given the need for packer trucks and mechanical lifting devices) may be reduced.

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