COMMISSION OF THE EUROPEAN COMMUNITIES
DG XII – RESEARCH, SCIENCE, EDUCATION

RAW MATERIALS

RESEARCH AND DEVELOPMENT

STUDIES ON SECONDARY RAW MATERIALS

VI. SORTING AT SOURCE OF CONSUMER WASTE

September 1979

COMMISSION OF THE EUROPEAN COMMUNITIES
DG XII – RESEARCH, SCIENCE, EDUCATION

RAW MATERIALS

RESEARCH AND DEVELOPMENT:

STUDIES ON SECONDARY RAW MATERIALS, Vol VI

VI. SORTING AT SOURCE OF CONSUMER WASTE

September 1979

XII/697/79

L E G A L N O T I C E

This document was prepared under the sponsorship of the Commission of the European Communities.

Neither the Commission of the European Communities, its contractors nor any person acting on their behalf, guarantee the accuracy or completeness of the information herein contained, or are responsible for the use which might be made of such information.

P R E F A C E

This volume is part of a series of assessment studies on Secondary Raw Materials that have been prepared under the sponsorship of the "Commission of the European Communities" (Directorate-General for Research, Science and Education).

The decision to carry out such studies, as well as other work to be published under the general heading "Raw Materials Research and Development", results from current concern about prospects of supplying the European Community with raw materials in sufficient quantities and at acceptable costs in the mid- to long-term. An essential part in defining the purpose and scope of the work was played by a Sub-Committee of CREST (1), established to investigate on-going activities in the member states, both in the areas of primary and secondary raw materials, in order to determine what R & D actions, if any, should be undertaken by the Community to alleviate its supply problems.

The volume comprises 3 reports, prepared under contracts with the European Economic Community:

1. SORTING AT SOURCE OF CONSUMER WASTE IN THE EEC.

   Report from STICHTING VERWIJDERING AFVALSTOFFEN (S.V.A.), Amersfoort.
   (Contract no. 275-76-9 ECI N)

2. SORTING AT SOURCE OF CONSUMER WASTE IN DENMARK.

   Report from ENVIROPLAN A/S, Copenhagen.
   (Contract no. 276-76-9 ECI DK)

3. SORTING AT SOURCE OF CONSUMER WASTE IN THE U.K.

   Report from the DEPARTMENT OF ENVIRONMENT (Directorate General of Water Engineering), London.
   (Contract no. 277-76-9 ECI UK)

---

(1) Set up by the resolution of the Council of Ministers of the European Communities of 14 January 1974, the Scientific and Technical Research Committee (CREST) is responsible for assisting the Community Institutions in the field of scientific research and technological development.

COMMISSION OF THE EUROPEAN COMMUNITIES

(Directorate General XII - Research, Science, Education)

SORTING AT SOURCE OF CONSUMER WASTE IN THE E.E.C.

Report by

Drs. J.M. Joosten (SVA)

January 1978

STICHTING VERWIJDERING
AFVALSTOFFEN
Postbus 184
Natriumweg 7
3800- AD Amersfoort
(Netherlands)

Originally submitted
as report "SVA 2575"

Contents

Conclusions and Recommendations.

Conclusions.

1. In every country sorting at source is considered an important method to reclaim materials which can be re-used in industry.
2. Sorting at source activities, especially the collection of the materials, can be carried out by whether voluntary organizations or by the municipality (the public cleansing service or a private firm indicated by the municipality).
3. In general voluntary collection tends to be less regualer as collection by the municipality which means at the same time that the collected quantities are not as big as possible.
4. In the case of municipal collection the collected quantity turned out to be bigger but consequence of this is higher collection costs.
5. In principle the demand for secondary raw materials depends on the economic situation in industry. In this context voluntary collection is much more flexible that is to say that in times of falling prices supply decreases.
6. The two main methods of collection are house to house collection and container collection. In general container collection turns out to be less expensive but on the other hand the amount of reclaimed materials tends to be smaller.
7. The same relation can be found speaking about the frequency of the collection. In general a higher frequency results in bigger quantities. However, costs will raise too.
8. Special arrangements in the form of special bags or dustbins are positively of influence on the collected amount. But here too we can say that as a consequence of this, costs will be higher.

9. As the social level of the population concerns in my view there is no impermeable prove that a relation exists between social level of the population and the collected quantity. Though the figures show more materials from the higher social levels we think not all possible causes (less consumption, lack of storage space) are taken into account.
10. About the economic profitability the conclusion can be drawn that in general all acitivites (except voluntary collection) show a loss.
11. Comparing the economic results of the activities it turned out to be very difficult to find a common basis. Due to different economic circumstances in the countries, the presence of raw materials and basis industry, the accounting system and the way of collection (one or more components; only households and household and shops) only a shallow evaluation was possible.

Recommendations.

The knowledge of reclamation of waste materials from households is to a great extent based on accidental information from the collections. In some cases a great effort has been made to obtain information of the possible relationship between different parameters influencing the amounts yielded. But it is probable that not all parametres have been disclosed, and it is obvious that those focused on in the past and at present are not measured with the degree of exactitude which is necessary to make correct conclusions.

To increase the knowledge of reclamation of waste materials from households research studies must be undertaken.

In this section research is proposed on subjects on which lack of sufficient knowledge has been found. Recording of fundamental data as well as detailed studies of already developed processes are proposed.

During the preparation of this study exchange of views on needed research and development has taken place with Stichting Verwijdering Afvalstoffen, Holland, the Department of the Environment, United Kingdom and the Danish National Agency of Environmental Protection.

1. Standard definitions of terms, waste components and analyzing should be agreed upon.
   The definition of waste components should be related to both "waste" and to "secondary raw material".
2. Standard definition of costs and benefits in connection with retrieval of "secondary raw materials" from households.
   The costs and benefits should be evaluated from a profitability point of view which also includes environmental and resource oriented aspects both locally and nationally.
3. Amounts of waste produced by the household and composition of the wastes should be recorded in detail.
   A necessary and sufficient knowledge of amounts and composition of wastes is needed to enable a usage of statistical predictions on a national scale. Influence of social and sociological parameters should be disclosed. The relationship between amounts reclaimed from households and materials from other sources should be established.
4. A more detailed knowledge is needed about when and how products become waste during the flow through the household. This knowledge is essential in order to establish a relationship between quality of potential reclaimable waste material and the moment at which the waste is retrieved for reclamation.
5. Research should be undertaken on the possible degree of extraction of reclaimable waste materials from the households.

   This includes research into possible parametres influencing the motivation for participation in reclamation. The impact on way of life and waste handling traditions in the households according to type of collection (collection by voluntary organization, as part of Total Waste Collection Arrangement by municipality, collection by reclamation industry) should be evaluated.

Amounts collected in relationship to collection method, collection frequency, type of residence, etc., should be studied.

Research and development studies are needed especially for apartment houses where the recorded results generally show smaller collected specific amounts (i.e. per household) than for single-family houses. Specially applied collection methods have indicated during a field trial that increases of specific amounts are possible. Introduction of two or more refuse chutes in apartment houses would possibly yield greater specific amounts.

6. Degree of efficiency in collecting and transporting of reclaimed wastes should be recorded and relationship to methods and techniques established.

   Design of collecting vehicle related to types of wastes to be collected from the households should be studied. Lower costs have been recorded per ton of collected reclaimed waste when collection was part of a Total Waste Collection Arrangement comprising garden and bulky wastes as well. Type, number and design of vehicles used in the collection rounds influences to a great extent the costs of collection because man-hours spent are directly related to these parametres.

   All handling of reclaimable wastes must be regarded in relation to material quality wherefore a necessary and sufficient degree of sorting is interrelated with the sensivity of the industrial processes when using secondary raw materials.

7. Research should be undertaken of the changes in waste production by households and in the flux of the amounts of reclaimable and reclaimed waste materials as a result of introducing intensified or mandatory collections and recycling. It is important to obtain a knowledge about possible introduction of substitutional materials in the household due to alteration of waste flow. The relationship between proposed changes of collections and the resulting reactions in household behaviour should be known to prevent unnecessary and unwanted changes in amount and quality of reclaimable waste materials.

1. Terms of references.

By order of the European Committee (contract no. 275-76-9 ECI N) a study has been made concerning the present situation in the field of separate collection of components of domestic waste. Partly this study is made by the Institute for Waste Disposal (Amersfoort, The Netherlands) of the situation in Belgium, France, Western-Germany, Italy, Ireland, Luxemburg and the Netherlands. A similar study of the Danish situation has been made by Enviroplan in Copenhagen. Finally the Department of Environment in London gave a description of the situation in the United Kingdom. This final report gives a compilation of the Dutch study, the Danish and the English study. Unfortunately Italian activities on sorting at source are not included because no information could be supplied in time.

2. Introduction.

Sorting at source can be defined as a form of recycling of components of domestic waste whereby on one side one or more components of domestic waste are sorted by the households and whereby on the other side these components are collected separately. It will be clear that several definitons are possible. The UK final report uses the following definition: "All activities necessary to make certain components available to collecting parties and to transport those components to recovery industries". Reading both definitions one thing is important: Mechanical sorting is excluded.

Recycling of waste materials has existed at all times in the communities. According to period and place the motives behind recycling have been different. Until the ecological conscience appeared in the industrial societies economic evaluations have dominated to a great extent.
Nowadays stimulation of recycling and especially sorting at source is based on environmental considerations. This means that making an evaluation of recycling projects not only the economic motive has to be considered.
In this report, however, we agree upon two principles.
In the first place sorting at source can give us secondary raw materials which is important in view of our future material supply. And secondly sorting at source diminishes the quantity of waste to be disposed of.

In this report we only pay attention to consumer wastes. Recycling of these wastes can be done by sorting at source and by mechanical separation. As we have said before in this context only sorting at source interests us.
Though it is indicated that recycling activities have to be evaluated on a great number of aspects, our main interest will be efficiency and costs. This because no sufficient data on the other aspects are available and because of the restriction made in the technical annex of the project description.

That is why our investigation studies two aspects, that is to say the technical-organizational aspect and the economical aspect.

The information received shows a great number of activities. We thought it impossible and not very useful as well to give a detailed description of all projects.
Our main interest has been to investigate certain similarities in the activities as well as significant differences. As we will explain later in this report it is hardly possible to compare the results of the projects in detail. That is why in chapter 3 we will give some general remarks and considerations concerning parameters which can be of influence on the results of the projects.

The chapters 4, 5, 6, 7 and 8 do content more detailed information per component studied namely paper, glass, iron and non-ferrous metals, plastics and textile.

3. General remarks and considerations.

As we have said the results of sorting at source activities depend on quite a number of parameters. In this chapter we would like to give some general remarks and considerations on the following questions. What should be preferred collection by volunteers or collection by the municipality?
Is there any difference in result between house to house collection or other forms of collection (containers)? The collection of recyclable materials, is it carried out simultaneously with the collection of domestic waste or is it carried out by separately operating collection units? Is there any relation between frequency of the collection and the quantities collected?
Can we expect better results when specific bags or dustbins are made available? Can we say that a relation exists between social level of the population and collected quantity? And finally the question about the profitability of the activities.

3.1. Voluntary organizations or municipalities.

Collection of reclaimable waste materials from households is today executed by both voluntary organizations and the municipalities. In this context I think it is better to speak of non-professional and professional collectors because of the fact that in several sorting at source activities private firms are operational, however, with the permission of the municipality.

The motives on which separate collection is based, however, are quite different. It will be clear that voluntary organizations or private enterprises almost only collect reclaimable materials because of the economic profit. There are some exceptions especially in the case of voluntary organizations. However, the greater part of the collection is done by schools, clubs etc. Though they are aware of the environmental considerations their main interest will be some additional income.

The collection by the municipality is predominantly based on environmental motives. Furthermore the opinion is gaining ground that voluntary collection does not give enough guarantee for future material supply. It will be clear that voluntary collection and collection by private firms depend on the price fluctuations. When prices are relatively low there will be less spirit to collect the reclaimable materials. As a result of this the supply decreases. In this case one could say that there does not exist a stable pattern in the collection and in the supply of materials.
Another motive which can result in collection by the municipality can be found in the fact that voluntary and private collectors often only are interested in the larger quantities in view of collection costs. In that case the collected quantity does not reach the possible maximum.

Though understandable motives some remarks are justified. In general we can say that prices are a reflection of demand and supply. That means that when prices are relatively low there obviously exists a limited demand for raw materials by the industry. One of the main problems of municipal collection is that the supply stays at the same level. In times of falling prices the consequence of a stable supply can be a further fall of prices. The same applies to mechnanical separation. In principle this system is not very flexible too. When prices are high there will be less reclaimable material (especially paper) in domestic wastes because of the fact that these materials are kept separate because of their value. The mechanical separation system is confronted with excess capacity. However, when prices are low we meet the same problem as has been described before concerning municipal collection.
In the case of mechanical separation the problem can be even worse because of the fact that more reclaimable materials are not kept separately. So more materials are supplied to the separation system which has its consequences for the prices.

Summarizingwe can say that collection by the municipality has the advantage that there will be a contineous collection and a rather stable supply of materials. It will be clear that the advantage of voluntary collection lays in elimination of the disadvantages of municipal collection.
So voluntary collection is rather flexible. When prices are falling, supply decreases. Furthermore voluntary collection is less costly.

3.2. The way of collection.

In principle two systems of collection can be distinguished, collection house to house and collection by means of containers placed in the area. Generally speaking the containersystem is used in particular for glass collection, while home to home collection covers all components. The reason why in various actions (especially in the Netherlands) containers are used is just the economical side of the collection. Studying the results the container collection turned out to be much cheaper than house to house collection.

However, comparing the quantities collected the house to house collection gives the better results. It will be clear that the motivation to cooperate is much higher when the component is collected at regular times house to house. Container collection just depends on the willingness of the population to bring their bottles to a container. But in spite of the bigger quantities collection costs per ton are higher in a house to house system. Nevertheless it is believed in the Netherlands that the efficiency of the container collection can be much improved. That is why a large scale experiment has been set up in the southern part of the Netherlands. In an area of 1.000.000 inhabitants 500 containers will be placed with a contenance of 2,2 m^3, which means one container on every 2100 inhabitants.

In general container collection is carried out by means of rather large containers (up to 9 m^3). Using smaller containers we hope the quantities collected will increase because of the fact that people have to go a shorter distance.
When 30% of the population cooperates it is calculated that the collection trucks of 20 m^3 each will be almost full after one day collection. If one succeeds to attain a 40% cooperation the action does not give any loss.

Summarizing we can say that in principle house to house collection gives higher quantities. However, the costs per ton will be higher. All will depend on the leading principle on which the recycling activity is based. If one has the intention that in principle the total possible amount of a component must be collected, house to house collection is preferably. Costs, however, will be very high.

3.3. Simultaneous collection?

Studying the various experiments we can say that with the exception of one activity the collection of the components is carried out by separately operating collection units.
The traditional collection frequency of domestic waste is at least one a week. Besides this collection of domestic waste most countries have a monthly collection of bulky waste.
In a few cases the separate collection of certain components takes place on the day of this bulky waste collection.
In view of future research the question can be put if a system is thinkable which combines the normal collection of domestic or bulky waste with the separate collection.
It can be expected that especially costs of wages and possible material costs can be saved. In this context we would like to mention a separate collection activity in Belgium. On behalf of this activity the collector is using a more-compartment car, in which he collects both domestic waste and glass.

In Germany too one thinks of this kind of collection. Because of the above mentioned possible savings we think it worth while to stimulate research in this direction.

3.4. Frequency of collection.

One of the questions put in the context of this study is if there is any relation between the frequency of collection and the quantities collected. As we have said before house to house collection of certain components generally takes place once a month mainly at dates when bulky waste is collected.
In several studies one has made variations in frequency. Except from the Danish studies one could not say that a higher frequency of collection results in larger quantities of collected materials. As we have said in the Danish experiment in Birkerød, however, the contrary was true. Changing the frequency from 14 days collection to a month and from a month to a bimonthly collection, a decrease was observed of at least 20%. For apartment houses the decrease was even greater (44%).
Though the other experiments did not show a significant relation between collected quantity and frequency of collection we dare say that a relation like this exists. Especially where collection at apartment houses is concerned one could imagine that lack of available space prevents storing of reclaimable materials for longer periods. In that case the materials are more likely to be disposed of together with the ordinary household refuse.

3.5. Type of residence, collection means and social level.

It will be clear that the influence of the type of residence on the efficiency of the collection in principle is the same as on the collection of domestic waste as such. A report made by the Stichting Verwijdering Afvalstoffen on the efficiency of the collection of domestic waste made it very clear that the efficiency of the collection is much better in the case of apartment houses.

However, speaking about the amount of separate collected materials we see the contrary. In principle the efficiency of collection in the case of apartment houses is better than collection on single-family houses, however, in the case of collection of reclaimable materials the collected quantity from single-family houses is larger.

Probably this is caused by a lack of available space in the apartment which prevents storing of reclaimable materials for longer periods. So we see once again that the frequency of collection is very important.

Another question which is asked for in several studies was if there is any relation between the social level of the population and the collected amount of materials. Although some positive relation was found, that is to say that in general the amount is larger when the social level is "higher", it is not yet fully clear if the difference in amount is a result of either a greater cooperation (motivation) or a quantitive difference in the consumption of certain components by the households.
Furthermore one must be aware of the fact that it is possible that just people with a "lower" social level live in apartment houses where, as we have seen, storage possibilities are not always available.

Finally the question was put if there is any relation between the collected amount and special collection arrangements that is to say special dustbins or plastic bags on behalf of certain components. Though we have only two references (Denmark en Germany) we believe that it is justified to say that this relation exists. When special bags are used the amount tendsto be larger.
One can imagine that special arrangements of this kind work like a reminder.

3.6. Cost-Benefit.

3.6.1. General remarks.

Studying the various experiments it turned out to be very difficult to compare the results and the efficiency especially the economics. In the first place we are confronted with the problem that the economic situation in the countries is quite different (level of wages, taxes etc.). Another problem that faced us is the simultaneous collection of more components (glass and paper or paper and PVC etc.). In these cases it is impossible to calculate the costs for a single component. The same applies to experiments which include more than only collection (f.i. paper is already sorted or pressed into bales). Real collection costs cannot be deduced from the calculations.

However, not only costs comparing is very difficult, the same applies to profits. In principle we can say that the price of secondary raw materials depends on the price of primary materials. In general the quality of secondary raw materials is some what lower so prices will be lower. But even when the quality is quite the same we often see lower prices probably because of the fact that one is not quite sure that the supply will be stable and regularly.
Knowing this it will be clear that there is a great difference between the countries. In the first place it is important if a country has primary raw materials of her own. If not sorting at source can be more succesful economically spoken, because of the fact that prices are relatively higher as a result of transport. Besides it can be advantageous to use home materials. At the other side the economic possibilities of sorting at source can be influenced in a detrimental way if in the country there is no industry to use the collected secondary raw materials. It will be clear that in principle this even applies to one (large) country.

Apart from the above mentioned difficulties in comparing the economic results of sorting at source activities we finally faced another problem.
In principle we are dealing with domestic waste. However, in various experiments the term domestic waste has been defined in rather a broad sense. Often waste from shops and offices is included. So the collected materials do not fully originate from households.

3.6.2. Cost-Benefit analysis.

In this report the economic results of sorting at source have been compared on the basis of costs and revenues of reclaimed materials, that is to say a cost-benefit analysis in traditional sense. In modern literature on environment and economics it is emphasized more and more that the cost-benefit analysis has to take into account the economic impact of indirect consequences of a certain activity. We quite agree with the Danish report which says (page 5) that too limits of materials and energy are important in order to make a well balanced evaluation. But too environmental aspects are connected to sorting at source activities and the same applies to the problem of employment.
In principle sorting at source has two main consequences.
Firstly sorting at source results in smaller quantities of waste to be disposed of. Through this the environmental impact of the disposal of waste can be reduced for instance the emission of incinerators or in the case of landfill soil pollution. Besides it is possible that there will be savings in the field of disposal costs or in landfill capacity.
Secondly sorting at source (secondary raw materials) results in a relatively smaller demand for primary raw materials which is very welcome in this time of exhaustion of virgin materials.

As we have said in principle these consequences should be part of the evaluation of sorting at source projects. However, in practice it turns out to be very difficult to quantify these impacts. Not only because of the fact that we are not quite able to translate them into money but too because of the problem that it is very hard to compare the environmental impacts of an activity in different places. However, one consequence in this context is worth mentioning which is the possibility of savings on disposal costs.

3.6.3. Savings on collection and disposal costs.

In several studies concerning cost-benefit analysis of separate collection systems one has taken into account savings as a result of the fact that a smaller quantity of waste has to be treated or incinerated. Concerning this saving we can make the following remarks.

The question has to be put as to how far it is right to claim the integral collection and disposal costs as a saving. The Institute for Waste Disposal has made a more detailed study on this which shows that two points are essential.
a. long run or short run approach,
b. the organization of the disposal system.

In general the collection of domestic waste is carried out by the municipality. When a municipality has its own public cleansing service the savings will be not more than the variable costs in the short run. The greater part of the costs can be considered fixed. Only in the long run when the public cleansing service has been adjusted to the new situation the integral costs can be considered a saving. Another situation exists when a private firm does the collection. When the municipality pays per ton the saving is as high as the integral costs.

The same can be said of the disposal. Here too when the municipality pays per ton the saving is equal to the integral costs. However, there is one remark to be made. When collection and disposal organizations are confronted with less waste the result can be an undercapacity.
In that case price increase is not unthinkable.

Finally a striking example. When it is decided in the Netherlands to collect paper, glass and tin cans separately on the short run there will be no saving at all. In the Netherlands a considerable part of domestic waste is incinerated in four installations which generate energy. Due to a lower waste supply and a lower caloric value the revenue received on the sale of electricity will decrease so much that the expected saving on the variable costs in reality will be a loss.
In other words when speaking of savings on collection and disposal costs as a result of the fact that the quantity of waste decreases we have to be very careful. In our opinion these savings can only be part of the revenues when they are actually converted.

3.6.4. General remarks on the economic results.

Comparing the costs and revenues only one conclusion can be drawn. With the exception of the voluntary collection system all activities show a loss. However, there is one exception. In some municipalities in Belgium domestic waste is collected by a private firm. This collector does not only collect normal domestic waste but too paper en glass from this kind of waste. Not only collection but also disposal of this waste (composting) is one of his activities. This collector declares that his separate collection does not give extra costs because of the fact that the collection unit has costs too when he does not collect separately. The question can be put if this is the right way to calculate. However, when the collection unit is able to collect both the components and the remainder of the waste the costs are almost nil.

Almost all the other activities show a loss. Which justifies the question if these activities have to be continued. Answering this question it will be clear that costs only are not sufficient to make a decision. In the first place one will have less waste to dispose of. Especically when this waste is landfilled some saving of space is the result or in other words landfill places can be used for a longer time.
Secondly one has to take into account the future raw material supply. It is to be expected that prices raise in future so that recycling can be more profitable. However, in that case one must be aware of the fact that a certain raise of prices can transform certain waste components into raw materials.
Private (volunteers or trade) collection will take their chance especially where delivery of the components to the regular collection-organization is not dictated.
Finally it is possible that separate keeping and separate collection results in a certain awakening of the consumption pattern which can be of no harm in our throw away society.
It will be clear that quantifying this consideration is hardly possible. Nevertheless this factor cannot be missed in the decision making.

4. Paper.

4.1. General remarks.

Thinking of recycling components of domestic waste one firstly thinks of paper. Already for a long time paper is recycled. Technically it is rather easy to use waste paper as raw material for the production of certain paper and cardboard products.
In the context of sorting at source it is important to know the share of paper in domestic waste.

Share of paper in domestic waste.

Belgium	23 per cent
France	30 " "
Italy	-- " "
W-Germany	28 " "
Netherlands	23 " "
Luxemburg	22 - 25 " "
Ireland	25 - 30 " "
U.K.	25 " "
Denmark	-- " "

As one can see there seems to be no great difference in these figures. However, before calculating with these figures it would of sense to relate them to the amount of waste per head of the population per year.

In general the material input of the paper industry consists of rather a high percentage of waste paper. The OECD-report "Prospects and Policies for Waste Paper Recycling" (1976) (page 31) gives the following figures:

Table 2: Actual Utilisation of Waste Paper.

Belgium/Luxemburg	18,4 per cent
France	36,0 " "
Italy	40,6 " "
W-Germany	45,2 " "
Netherlands	42,6 " "
United Kingdom	45,8 " "
Denmark	46,6 " "
Ireland	66 " "

However, not all the waste paper originates from the countries which use it. In these figures import is included. So we have to consider the actual recovery rate:

Table 3: Actual Recovery Rate.

Belgium/Luxemburg	29,9 per cent
France	30,6 " "
Italy	27,9 " "
W-Germany	31,9 " "
Netherlands	46,1 " "
United Kingdom	27,6 " "
Denmark	27,7 " "
Ireland	21 " "

Especially the figure of the Netherlands is important, because of the fact that this amount is collected for rather a great part at the household by predominantly voluntary organizations.

In order to see what is still possible in paper collection by means of separate collection it is important to know what part of the recovered paper originates from households. In this context we would like to use two figures one from the already mentioned OECD report and the other mentioned in the questionnaire.

Table 4: Household contribution to total waste paper recovery.

	Questionn.	OECD
Belgium	5	5
France	2	5
Italy	-	15
W-Germany	2,8	8
Netherlands	40	45
Luxemburg	56-60	-
United Kingdom	-	-
Denmark	-	21
Ireland	2	

Though we can see some remarkable differences between these figures, two figures are worth mentioning i.e. Luxemburg and the Netherlands. In both countries the collection system is predominantly based on volunteers.

4.2. Technics and Organization.

As we have seen the collection of paper from households is predominantly a voluntary matter in Luxembourg and the Netherlands. In general the collection is carried out by schools, boyscouts, etc. in order to earn some additional income. That does not mean that in the other countries there is no voluntary collection at all. However, in most cases there is no continuity and the quantities collected are rather small.

In the other countries the opinion is gaining ground that in the long run a voluntary system will be no acceptable solution. That is why one tries to set up a waste paper collection system, carried out by the public cleansing service or at least organized in the way this service normally operates (at regular times house to house collection). Experiments in the way are running in a great number of towns. The most important ones are:

Belgium	: Luik, Bergen, Brussels, Charleroi
France	: La Rochelle, Lyon, Le Havre
W-Germany	: Konstanz, Dusseldorf
Netherlands	: Rijsenhout
Denmark	: Birkenrød, Bogense, Ballerup, Herler, Alborg.
U.K.	: Oxfam.

One of the most important results is the quantity of collected waste paper during these experiments. Studying the activities it turned to be not possible to give some average. There is a great difference in quantities collected per head of the population. Comparing fourteen experiments we got the following range: 8,2 - 40 kg p.h. p.y.
When we relate the parameters and general conclusions mentioned in chapter 3 to the component paper we can see the same pattern. However, there is one question which is very important in the view of future paper supply. That is the question about the quality of the collected paper.
If only paper from households is collected we roughly got the following composition:

80 per cent newspapers and magazines,
20 per cent cardboard and other papers.

It will be clear that the composition fully depends on the way the collection is organized that is to say whether only households cooperate or the collection is also directed to shops, offices etc. An experiment of this kind has been carried out in La Rochelle (France) with the following result:

11 per cent paper,
89 per cent card board.

Another question about the quality of the collection is to what extent polluted matter (plastics etc) can be expected. Studying the experiments we can say that in general this will be not more than 2 per cent.

We already mentioned that it is very important to know the composition of paper used in households and offices. A recent study about waste paper in the Netherlands indicates that in the near future the input of waste paper in the paper production can be expected to increase considerably as a result of new technics (de-inking, disperging etc.) and improvement of existing technics. The question is in what way this amount can be made available. Is it possible to stimulate the present situation of voluntary collection (in the Netherlands) or do we expect that collection by the municipality is necessary to attain the desirable amount. Even when prices of waste paper will rise in future collection by the municipality will show a loss. Especially when the municipality is not the only collector (volunteers collect as well) the costs will be remarkable. That is why it is believed that the two systems cannot exist together, whether the collection is carried out by the municipality or by volunteers.

Another question which can be asked for in this context is if it possible to issue a prohibition to put waste paper in the normal domestic waste. In that case the collected amount can be much higher. Answering this question one has to know one thing.
The results of all activities depend on the voluntary cooperation of the public.
We do not have enough information to answer this question.
However, for the Netherlands we can say that it will be very hard to introduce a measure like this.

4.3. Economics.

We already indicated that it is very hard to compare the economic results of the experiments. Next to the problem mentioned before some other problems faced us:

1. In many cases during the experiments not only paper is collected.
2. Sometimes the experiment does include more than only collection f.i. sorting etc. while this is not deducible from the cost accounting.

Nevertheless we will give some figures. In order to be able to compare these figures the European Unit of Account of 1-1-1977 is used.

4.3.1. The revenues.

Due to differences in the economic situation in the countries it does not have sense to use absolute figures of costs and revenues. It has more sense to indicate the ratio between costs and revenues. Another important factor is the period in which sorting at source activities took place, because of the fact that especially paper prices show strong fluctuations. Furthermore one must be aware of the fact that the revenue received from the old paper trade or from the paper industry depends on the way of supply. In some cases paper is already sorted or even pressed into bales.

European Unit of Account of 1-1-1977:

West-Germany	1 UoA =	2,68045	DM
France	=	5,57233	Fr.Fr.
Italy	=	985,151	Lire
Netherlands	=	2,80409	Hfl.
Belgium/Luxemburg	=	41,1509	Fr.
UK/Ireland	=	0,654430	£
Denmark	=	6,60115	D.kr.

Revenue per ton (1000 kg) in E.U.A.:

Belgium	41,3	paper industry old paper trade
	10,9	old paper trade volunteers municipalities mixed paper
France (paper)	26,9	paper industry municipalities
(cardboard)		" " sorted and baled
Netherlands	32,1	paper industry old paper trade
	10,7	old paper trade volunteers mixed paper
Luxemburg	12,2	old paper trade volunteers municipalities

Ireland	18,3	old paper trade mixed paper	volunteers
West Germany	10,3	old paper trade mixed paper	municipalities
Denmark (aver.)	11	old paper trade	municipalities volunteers
U.K. (Oxfam)	38	paper industry -	volunteers (paper is sorted etc.)

As you can see the compensation from the old paper trade to the municipalities or the voluntary organizations lies in general in the same range. An exception has to be made for France. The activities in this country of which economic data are available cover more actions than just collecting. In fact in these cases the municipalities have taken over the function of the old paper trade i.e. sorting and baling. Therefore the revenue received from the paper industry is much higher. However, when we see the revenues of the old paper trade from the industry in Belgium and the Netherlands the French prices are in the same range.

4.3.2. Costs.

Speaking about the costs of a separate collection system we are mainly interested in the costs of a separate collection activity carried out by the municipalities. When paper is collected separately by volunteers there are no costs that is to say volunteers do not charge any collection costs.
As we have said it is very difficult to compare the results of the activities. Nevertheless we will give some figures, however without drawing any conclusions. In our opinion the first step to be taken is to develop a uniform accounting system. The U.K. final report has given an example in this context.

Costs per ton (1000 kg) in E.U.A.:

Netherlands		120	
France	La Rochelle	80	with separation
	Le Havre	34	
	Bruay	39	with separation
Germany	Konstanz A	32,3	
	B	25,2	
	C	24,2	
	D	37,9	driver + 2 loaders with
	E	24,0	distribution costs of bags
	F	38,3	
	G	42,7	
	Düsseldorf	23	
Luxemburg		24	
Belgium	Liège	48	
	Bergen	--	
Denmark		26,72	Research figure; Monthly collection. Combined paper/glass/(non) ferrous metals
U.K. (Oxfam)		106	

When costs and revenues are related one can conclude that only in a few cases one can speak of an equation. However, one must be aware of the fact that this equation was found in 1974, the period of very high prices of waste paper.
However, there is one exception. In some municipalities in Belgium domestic waste is collected by a private firm.
This collector does not only collect normal domestic waste but too paper en glass from this kind of waste. Not only collection but also disposal of this waste (composting) is one of his activities. As we have said this collector declares that his separate collection does not give extra costs because of the fact that the collection unit has costs too when he does not collect separately.

In general, however, all the activities show a loss.
In this context the main question will be whether other aspects (environment etc) are considered important enough to justify the loss.

5. Glass.

5.1. General remarks.

The second material which interests us in the context of recycling is glass, mainly because of her share in domestic waste.

Share of glass in domestic waste

Belgium	:	6 to 8 per cent
Luxemburg	:	10,1 " "
France	:	2 to 8 " "
Italy	:	- " "
Ireland	:	8 " "
W-Germany	:	15 " "
Netherlands	:	13 " "
U.K.	:	- " "
Denmark	:	- " "

Already for a long time the glassindustry uses cullet on behalf of the production of glass. This cullet, however mainly originates from bottlers (old bottles) and industries. The glassindustry knows the composition of the glass. However, separate collection of glass of domestic waste gives cullet from all kinds of bottles. In other words in the first place the glass industry has to find out if this cullet is suitable. Experiments of the United Glassworks in the Netherlands showed that it is possible to use mixed cullet from domestic waste up to 60 per cent of the total material input of the production of green glass.

In other words from a technical point of view there is no problem to use "domestic" cullet. Furthermore it is expected that using this cullet energy savings will be possible. These two factors - share in domestic waste and no technical problem is using domestic cullet - have resulted in experiments on separate collection of non-returnable glass.

5.2. Technics and organization.

In contradistinction to separate collection of paper the collection of glass is not predominantly house to house. The following experiments are studied:

Denmark

Birkerød - house to house
Bogense - "
Ballerup - "
Herler - "
Alborg - container in the area.

Netherlands

About 250 communities - container in the area
1 community - house to house

West-Germany

Various communities - container in the area
Konstanz - container in the area
- and house to house
München - container in the area

Belgium

Various communities - container in the area
Bergen - house to house

Ireland

Hardly any glass collection of domestic waste.

Italy

No information available.

France

Marseille	- container in the area
Aix en Provence	- "
St.Foy - Les Lyon	- house to house
Le Havre	- house to house

U.K.

Oxfam	- house to house

It must be noted that the activities mentioned above are not the only glass collection projects within the Community. However, from these projects some information is available. When we analyse the results of these separate collections the main conclusion can be that especially the collected quantities are somewhat disappointing.
One of the main questions in this context is if there is any significant difference in quantities collected between a house to house collection system and a system of container collection.

In general we can say that as far as the collected quantity concerns the results are better when using a house to house collection system.
In this context, however, we have to say that the container collection system can be much improved. One of the main causes of diminishing cooperation of the people in a container system is the fact that one has to take more pains to make recycling possible. We have said already that all activities depend on the voluntary cooperation of the people. They are willing to cooperate when things are made easy for them. That is why one has to try -when a container system will be chosen- to make it as easy as possible. Which means that the distance to the container has to be as short as possible.

In other words the container density is of influence on the results of the collection which is shown on the basis of some experiences in the Netherlands.
Shortly in the Netherlands an experiment will start with 2200 l. containers in an area of 1,100.000 inhabitants. On the basis of a result of 30 per cent (that means that 30 percent of the population cooperates) in this area 500 containers will be placed which means one container on 2100 inhabitants. If the calculations turn out to be right these containers will be full and emptied every week.
Describing the results in the Netherlands one uses the cooperation rate. The consumption of non-returnable glass is about 27 kilogrammes per head per year. On this basis we are able to measure the results of an experiment.

Some results:

Netherlands	number of population	collected quantity	coop. rate	containers	container density [x]
Utrecht	250.000	1260 ton	19 %	10	1:25.000
Apeldoorn	125.000	720 ton	21 %	14	1: 9.000
Papendrecht	21.800	250 ton	42 %	12	1: 1.800
Woerden	22.000	110 ton	18,5%	4	1: 5.500

In the description of the experiments in other countries one does not use the consumption of non-returnable glass but simply the amount of glass in domestic waste assuming that this glass is all non-returnable.

[x] On the basis of these figures one might say that a positive relation exists between container-density and cooperation rate.

Denmark:	number of population	collected quantity	coop. rate	house to house
Birkerød	21.000	318 ton	--	601 paper bag
Bogense	2.700	45,6 "	--	paper bag
Ballerup	5.080	42 "	--	bags
Herler	9.500	25 "	--	bags
Alborg	2.700	19 "	--	containers

Because of the fact that we do not know the yearly consumption of non-returnable glass it is very hard to give a cooperation rate. Comparing these figures with the Dutch results we can conclude that in principle house to house collection gives better results. However, one must be aware of the fact that the collection areas in the Netherlands are much larger than in Denmark. In general the motivation in smaller towns or areas is greater. For instance Rijsenhout a little village in the Netherlands. Glass is collected house to house; number of inhabitants 4500. Collected quantity 94 tons: cooperation rate 75%.

West Germany:	inhabitants	quantity	
Konstanz A	271	5,2 ton	house to house
B	680	12,5 "	house to house
C	865	6,5 "	house to house
D	796	26 "	house to house
E	989	21 "	container 4400
F	782	7,6 "	container 1100 l
G	520	5,5 "	container 1100 l
München		3000 "	46 containers

For these experiments too it is not easy to find a cooperation rate because of the fact that we do not know the annual consumption of non-returnable glass. Further more it is not clear if the glass all originates from households.

Despite of all this it can be concluded that the results (quantities) are better in a house to house collection system. In Luxemburg a system of container collection exists carried out by the glass trade. The containers are emptied when they are full. No details are known about the quantities collected. In Ireland separate collection of glass from households is negligible. There is a form of separate collection at bars and restaurants carried out mainly by the glass trade. Details about quantities are not known.
In Belgium in some communities a container system is used to collect non-returnable glass. A house to house system is applied in about 50 communities. In these towns the collection is carried out by a privat firm. In some communities this firm uses a two compartment car. The area in which he is operating counts 240.000 inhabitants. For next year the expectation is 5000 tons of glass. On an annual glass consumption of 40 kg. This means a cooperation rate of 52 per cent.

Lyon:	-cooperation rate	45 per cent	
-St. Foy	-	39 "	"
-Duchere		15 "	"
-Passin		38 "	" house to
-Oullin		37 "	" house
-Pierre Bénite		34 "	"
Montceau	53.000 inhabitants		
Aix en Provence	- container system	10 à 15 per cent	
Marseille	- container system	10 à 15 per cent.	

In France too it can be concluded that a house to house collection system gives better results. As in the study of Konstanz one has asked in the experiments in St. Foy and Duchere if there is any relationship between social level and collected quantity. As one can see the difference in the results of the two areas is quite remarkable.

Though in the U.K. varous actions on glass are carried out, it is not quite possible to give a cooperation rate. However, the figures of Oxfam show that the average weekly quantities collected and the cooperation are rather good.
Summarizing the results of activities mentioned we can conclude that without some exceptions house to house collection of non-returnable glass gives better results than container collection. In the Netherlans, however, one believes that a container system is most suitable. In principle we can see the Dutch system with small containers as an intermediate form between house to house collection and collection with big containers that is to say one container on a great number of inhabitants. In principle the economics and the environmental aspects must answer the question what system is most suitable in a particular situation.

5.3. Economics.

5.3.1. The revenues.

In general what has been said about paper revenues applies to the component glass. The price of glass, however, does not show fluctuations as strong as in the case of paper.
The price which can be obtained by the collector depends on the way the cullet is supplied to the glass industry.
The consumption of glass concerns three kinds of glass i.c. white, green and amber. When mixed glass is collected separately and in this form delivered to the glassindustry the cullet only can be used to produce green glass. When the cullet is sorted on colour the price which the glass industry is willing to pay will be higher. Up until now, however, in no country separate collection of sorted glass exists.
Under the same conditions as in the case of paper we will give some revenues. Here too the European Unit of Account will be money of account.

	Revenues per ton (1000 kg) glass
Netherlands	26,7 UA glass industry glass trade
	3,6 UA glass trade municipalities mixed glass
Ireland	23,7 UA glass industry glass trade sorted
Germany	11,2 UA glass trade municipality transport costs for municipality
France	25,1 UA glass industry trade or municipality which has sorted
	3,6 UA glass trade collector or initiator
Denmark	5 UA glass trade municipality mixed glass
U.K.	9,1 UA glass trade mixed glass

As one can see the prices do not differ very much.
The compensation from the glass industry to trade or municipality which has taken over the functions of the trade lies in the same range (from 23,7 to 26,7). The same applies to the compensation from trade to municipality. Only in Germany a difference exists because of the fact that the expenses of transport are for the account of the municipality.

5.3.2. The costs.

It will be clear that what has been said about the collection costs of paper applies to glass. In most activities we see a combined separate collection of certain components. Only for the German study of Konstanz and some Dutch activities it is possible to give the collection costs for glass only.

Germany Konstanz	A 37,3	house to house; dustbins 50 l, once a month
	B 37,9	house to house; dustbins 30 l, once a month
	C 47,2	house to house; box , once a month
	D 38,3	house to house; dustbins 50 l, once a month
	E 11,1	container in area 4,4 m^3 , when full
	F 19,7	container in area 1,1 m^3 , when full
	G 25,4	container in area 1,1 m^3 , when full

Netherlands	Various actions between in the area	24,6 and 41	UoA container
	Rijsenhout	50,6	house to house dustbins every week
Luxemburg	Luxemburg	19,4	container in area
U.K.	Oxfam	99,6	house to house (woven bags)

Finally a Belgium activity. In 50 communities in Belgium glass is collected separately by a privat household collector. Glass is collected simultaneously with the other domestic waste (see 4.2.4.). As in the case of paper this collector declares that he does not have any extra costs.

5.3.3. Cost-Benefit.

Comparing the revenues and the costs we have to consider the fact that the collection costs and the revenues received from the glass industry do not answer the question if the activity is profitable. The collected glass can only be used by the industry when it is broken and cleaned. That is why the compensation from glass trade to collector is much lower than the price which pays the glass industry to the glass trade.
In general we can say that separate collection of glass is economically not profitable. Only in one case in Konstanz a small profit was realized. In this particular case glass is collected by means of a big container (4,4 m^3) which is emptied when it is full. The question can be put if this system can be part of an integrated waste disposal system.
In the Netherlands in various towns separate collection of glass takes place by means of a big container predominantly situated near supermarkets. In these cases the collector only collects the attractive quantities.

As we have said before we do not think that this must be the leading principle in recycling. With the already mentioned intended action in the Netherlands one thinks to prove that by means of a rather high container density and an efficient collection pattern the greater part of the population can cooperate at acceptable costs.

6. Iron and non-ferrous metals.

6.1. Introduction.

Another material which is recyclable is iron. In our society an extensive scrap trade exists. Non-ferrous metals too are are recycled especially in the industry. In other words there are no insuperable technical problems to recycle these materials. In this report we have put the question if there is any possibility to collect ferrous and non-ferrous metals from domestic waste by separate collection.

6.2. Technics and Organization.

A lot of ferrous and non-ferrous metals from domestic waste are not collected in general with the normal collection of domestic waste because of their size (refrigerators, old bikes, etc.). Normally these objects are collected by a special bulky waste collection. Beside this collection we often see in bigger towns little scrap traders driving in front of the normal collection to pick out valuable things (especially iron). In the UK, however, this practice is illegal.
Nevertheless in several towns in the countries there are experiments on separate collection of ferrous and non-ferrous metals. It will be clear that the collected quantity predominantly exists of tin cans.
Experiments are done in:
Netherlands: Zeist.

Ferrous and non-ferrous	Coop. rate	
2,8 per cent	5 per cent	container system

Denmark: Ferrous and non-ferrous		Coop. rate	
Birkerød	3,3 per cent	32 per cent	house to house
Bogense	3,3 per cent	60 per cent	house to house
Ballerup	3,3 per cent	70 per cent	house to house
Herler	3,3 per cent	--	house to house
Alborg	3,3 per cent	--	containersystem
U.K.:			
Oxfam	in woven bags together with glass and plastics.		house to house

Here too we can see that the cooperation rate is higher in the case of house to house collection.
In the Netherlands where an experiment is done with container collection we believe that ferrous and non-ferrous metals only can be collected house to house. However, because of the fact that this share in domestic waste is rather small only a combined collection (with glass f.i.) can be successfull.

6.2.1. Revenues and costs.

In the case of ferrous and non-ferrous metals we have seen hardly any separate collection. Only in Denmark and in the Netherlands these materials are collected regularly.
The Oxfam experiment in the UK does not yet give sufficient information. In the Dutch experiment only tin cans are collected which are detinned. It is assumed that on every 1000 kilogrammes of tin cans one can reclaim 2,75 kilogrammes of tin.
In the long run it is expected that the price of this detinned material will be about 62,4 UA (1000 kg).
The price of tin will be 7,85 UA (1 kg).
In other words the market price which can be expected on the long term will be about 84 UA per ton tin cans.

The collection costs are based on a collection by means of containers of 0,75 m^3 which are emptied once a week. Because of the voluminous character of tin cans these containers have a maximal capacity of 90 kilogrammes; in view of the transportcosts it is possible to reduce this volume to 200 kilogrammes. Further reducing is not desirable. In order to be able to detin the cans have to be cleaned, which will be much easier when the cans are not fully compressed. When we expect that 20% of the population will join the action the collection costs will be 54,6 UA. Detinning costs will be 35,7 UA. When we translate this to a nation-wide action we get the following scheme:

Tin cans in tons a year by 20% cooperation rate:	16.973
Number of containers (0,75 m^3)	3.626
Number of collection cars	24
Number of 20 m^3 containers	56
Number of truc combinations	4

Costs per ton.

Collection	54,6 UA
Transhipment	8,4
Transport	11,5
Cleaning and Detinning	35,7
Other costs (publicity, overhead etc.)	19,4
	129,6 UA

Revenues.

Iron	62,4 UA		
Tin	21,6 UA		
	84 UA	84	UA
	Net loss	45,6	per ton

As we can see the results are not very encouraging.
In the Netherlands the cans are detinned. In the last few weeks prices of tin have increased. One could say that in future detinning can be profitable. However, when tin is scarce there is a possibility that tin is substituted by other materials.
As we have said the collection of ferrous and non-ferrous metals (predominantly tin cans) is organized in the Netherlands by means of a container system.
Referring to the Oxfam experiment we believe that only a combined collection system (with other components) has some chance to be successful because of the fact that overhead costs are shared with other materials (see the U.K. report p. 27).

6.3. Economics.

It will be clear that there is no economic profitability in the Dutch experiments. The collection costs and transportation costs are too high to make a profit.

7. Plastics.

7.1. Introduction.

One of the components the share of which in domestic waste steadily increases is plastic. One of the main technical questions at this moment is if plastic can be recycled.
In industry plastic waste is re-used, however, in that case that the composition of this plastic is homogeneous.
When plastic of domestic waste is collected separately, one has plastic of a very different composition. The Institute for Waste Disposal has made an analysis of this kind of plastic with the following result:
Total share of plastic in domestic waste 5,3 per cent (weight).

Pe + PP	77,5	per cent
PVC	7,5	" "
P.S	14,2	" "
rest	0,8	" "
	100	per cent

In Japan (Mitsubitshi) a machine is developed to treat mixed plastics. In the EEC, however, plastics from domestic waste are not yet re-used.
In France an experiment is running on separate collection of PVC. In the UK plastics are collected separately into the Oxfam experiment. On this collection, however, the information is not sufficient to make an analysis.

7.2. Technics and Organization.

In relation to the other countries in the common market the French use rather a lot of PVC bottles (eau minerale). The annual consumption of PVC bottles lies about 3 kg per inhabitant which means 160.000 tons a year. In La Rochelle once a week separate collection was carried out on paper and PVC.
In 1975 60 tons of PVC were collected. On the basis of an annual consumption of 360 tons (120.000 inh. and 3 kg. p.i. p.y.) the cooperation rate is about 17 per cent.
In La Rochelle paper and PVC are collected in combination which means that it is necessary to separate these two components. This separation is done by hand on a conveyor belt.
Another French town where PVC is collected separately is Lyon. In this town, however, the cooperation rate was very disappointing i.e. 10 per cent in the first phase. After 5 months of experimentation a permanent collection system was introduced. Using the experiences of the first phase it turned out to be possible to increase the cooperation rate up to 31 per cent. Perhaps this rate is higher in reality because of the fact that there is some discussion on the question if the consumption of PVC really amounts to 3 kg.

Other statistics show a figure of 2 kg., which automatically means a higher cooperation rate. Once again we see that it is necessary to analyze the composition of domestic waste in a certain area before starting separate collection.
Another experiment was done in Le Havre. In this town a cooperation rate of 50 per cent was attained.
The collection of PVC in the towns mentioned is organized house to house. It will be clear that a containersystem is not suitable. PVC bottles are very light, but voluminous (20.000 bottles in a ton). That means that containers are quickly full, however, with a rather small quantity (in weight). So revenues will be rather small and costs (transport and emptying) are rather high.

7.3. Economics.

7.3.1. Benefits and costs.

As we have said large scale separate collection of plastics only takes place in France. In this country a rather extensive consumption of PVC bottles exists. In the other countries the consumption of plastics does not show one plastic product which easily can be kept separate. The composition of plastics is rather heterogeneous.

It is considered (UK report p. 23) that the householder cannot be expected to separate plastics into its many different grades.
The UK knew its own experiment on plastics at Oxfam. "The results, however, were thougt to be hardly worth while".
So the only figures we can give originate from French experiments. The revenues are quite different, from 179,5 UA per ton to 53,8 UA per ton taking into account that the price of 179,5 UA is a price for treated PVC that is to say PVC which is already broken and granulated. Concerning the costs of collection it is very hard to give figures because of the fact that PVC is always collected in a combined system. The only figure we can give originates from "La Récupération" no. 3 23-1-1976 in which the authors estimate that the collection costs of PVC only probably lie between 269,2 UA and 358,9 UA.

The conclusion can be drawn that sorting at source of PVC too only has a chance to be successful if it is combined with the collection of other materials.
When only PVC is collected separately the costs will be too high.

8. Textiles.

On textile we can be very short. Already for many years textile originating from households is recycled. In former days collected textile was mainly used in the paperindustry. However, after the introduction of the artificial fibre this application became less important.
Nowadays rag dealers have to sorte textile into various categories. Analyzing domestic waste it is clear that textile is hardly important. Nevertheless an extensive rag trade exists. This means that on textile there is already a form of separate collection. Studying the information from various countries it became clear that the collection pattern in the EEC is almost the same. Apart from some ragmen the bulk of textile originating from households is collected by volunteers expecially charitable organizations. The average collection frequency is about one time a year. In the Netherlands this organization distributes plastic bags which are collected some time afterwards.
However, in the Oxfam experiment in the UK and in Denmark textiles or rag collection is integrated in a separate collection system. Partly this textile is used as second hand clothes and partly this textile is sold to rag dealers.
The few data available, however, do not make it possible to draw any conclusions on efficiency and economic result.

9. Literature and information.

In this report we have used the following information:

a. Information originating from the questionnaire which has been send to the various departments of environment in the member-states.

b. Information originating from visits to several experts in the member-countries in particular Germany, France, Belgium and Ireland.

c. Information from reports published on specific sorting at source activities in the countries.

d. General information concerning waste disposal.

Literature:

1. Sorting at Source of Consumer Waste in Denmark: Enviroplan, Copenhagen nov. 1977.

2. Technico-Economic Study on Sorting at Source of Consumer Waste in the U.K.: Department of the Environment, London nov. 1977

3. Getrennte Hausmüllsammlung: Darnier System GmbH, Friederichshafen. Untersuchung über die Trennung und Verwertung von Papier und Glass aus Hausmüll, dargestellt zum Beispiel der Stads Konstanz.

4. Analyse de quelques cas concrets cas concrets de mise en oeuvre d'une collecte sélective: Ministère de la Qualité de la Vie, France.

5. La Collecte Sélective des Ordures Ménagères: Ministère de la Qualité de la Vie, France.

6. Hergebruik Verpakkingsglas (SVA/506C): Institute for Waste Disposal, Netherlands.

7. Inzameling van huisvuil (SVA/1317): Institute for Waste Disposal, Netherlands.

COMMISSION OF THE EUROPEAN COMMUNITIES

(Directorate General XII - Research, Science, Education)

SORTING AT SOURCE OF CONSUMER WASTE IN DENMARK

Report by

J.D. Petersen and N.J. Hahn

November 1977

ENVIRONPLAN A/S
Consulting Engineers in
Environmental Technology
Krogshøjvej 31
2880- Bagsvaerd
Copenhagen
(Denmark)

PREFACE

This technico-economic study on Sorting of Consumer Wastes in Denmark has been prepared for the Working Party Research and Development on Consumer Wastes, set up by the Sub-Committee Research and Development on Raw Materials, set up by CREST, (Comité de la Recherche, Scientifique et Technique), European Economic Community.

The study has been carried out in conjunction with the Department of the Environment, United Kingdom, and Stichting Verwijdering Afvalstoffen, Holland, which covers the United Kingdom and the remaining seven member countries of the EEC respectively.

Collaboration has taken place through meeting and communication with the Stichting Verwijdering Afvalstoffen and the Department of Environment.

In connection with retrieval of information about collection of reclaimed household waste materials, numerous contacts have been made with municipalities, Gendan Ltd., and the reclamation industry. Data have been assembled from reports and through personal communication with the administration staff involved in the collections.

Continuous communication has taken place with the Danish National Agency of Environmental Protection.

Detailed descriptions about specific collections are found in the annexes numbers 2 to 14, and in Annex 1 references are

listed. A map of Denmark with indication of municipalities in which the described field trials and permanent collections have taken place or are going on, is found between Annex Index and Annex 1. In Annex 1 a vocabulary is found with explanation of specific terms.

CONTENTS

CONTENTS (continued)

SECTION 1 ABSTRACT

In this report Danish collections of reclaimed sorted waste materials from households are described.

Related to quantity, the materials mostly collected are paper and glass, but also iron, non-ferrous metals and rags are comprised in the collections.

Although only a few of the collections have been officially reported on, much information has been assembled through direct communication with the individuals involved. Both field trials and permanent collections are reported on. All collections except one have been managed by municipalities. As an example of a widespread type of collection in Denmark, a collection organized by voluntary organizations has been described. These collections are often of an accidental and inconsistent nature, and detailed information about them is not available. The one described covers a complete municipality with a regular collection frequency, which makes comparison with the municipally managed collections possible.

Section 2 is an introduction to reclamation of sorted waste materials from households in Denmark, and Sections 3 and 4 discuss collecting methods and specification of the collected materials respectively.

Section 5 comprises the recording of amounts collected and an evaluation of varying parameters that possibly influence the amounts collected from a household. For the sake of comparison a calculated specific monthly amount per household is used. As the specific amount is based on the known amounts collected per month, the value depends on the number of households in

the collections reckoned with. It has been chosen to calculate with all households in the collection area, notwithstanding the fact that in some cases the number of households is only known with an uncertainty. When choosing to calculate with all households and not only the actively participating ones, a degree of 'area efficiency' is represented by the value of the specific amount.

The true specific amounts are of course higher. The known parameters influencing the specific amounts are discussed, but due to lack of sufficient data, unknown and therefore unmeasured parameters may to a certain extent alter some of the conclusions.

In Section 6 an economic evaluation is found. Only in few of the collections detailed economic information is available. The costs per ton of collecting reclaimed materials from households are quoted.

Proposals for necessary research studies and development work are found in Section 7.

The motivation for initiating field trials has primarily been viewed as a reclamation concept, whereas the municipally managed permanent collections rather have been introduced as part of a necessary waste removal arrangement. Moreover, the municipalities wishing to sort bulky and garden wastes into combustible wastes for the sake of producing a better efficiency of incineration plants hereby see a possible way to include reclamation with little extra costs.

Because of the demand/supply situation, the reclaimed waste materials from households cannot be collected profitably, seen from a local economic point of view.

Conclusively, it can be judged as probable that the inclusion of reclamation of waste materials from households as a supple-

ment to a combined collection arrangement of other types of wastes gives the lowest costs in contrast to separate rounds of collection.

The reclamation as a concept must be evaluated on a larger scale with the inclusion of environmental considerations and an evaluation of national and international available resources.

SECTION 2 SORTING AT SOURCE IN DENMARK

2.1 Introduction

Recycling of waste materials has existed at all times in the communities. According to period and place the motives behind recycling have been different. Until the ecological conscience appeared in the industrial societies economic evaluations have dominated to a great extent. If it paid its own way, recycling of waste materials was established. After a possibly necessary refining the materials have been used as secondary raw materials together with primary raw materials. Also direct reuse of materials such as bottles has been applied.

Based on the economical evaluation of recycling the different industries have developed methods of their own through the ages in collecting, sorting, and refining their waste materials. The recycling took place inside the factory and was as a consequence applied to the special processes of the factory. It became a primary aim to prevent contamination of the waste materials and therefore methods were used to minimize the costs of sorting and refining.

Recycling can be effected outside the factory as well because collection, sorting, and refining become more economical when dealing with greater quantities. The waste material industry receiving wastes from many different sources acts as supplier of secondary raw materials.

These types of recycling have always been part of the community and are still, even after the intensified collections of sorted waste materials from the households, the most important.

When the understanding of the concept of limited resources was perceived, also recycling of reclaimable waste materials from

households was being focused on. Limitation on consumption by introducing mandatory recycling is a possiblity, which is and will be used as a mean to help limiting the spill of resources and stretching those left. It is important to realize that recycling of materials is connected to energy consumption. The limits of materials and energy and the interdependence of primary raw materials, recycling and energy resources lead to the conclusion that considerations and evaluations can no longer be based on local experiences and traditions but that parametres such as national and international necessity must be included.

2.2 Collection from the Household

The increase in Denmark of the number of collections of reclaimed waste materials from households reflects a popular and widespread sentiment that has grown in the population through the last five years.

The purpose of this report is to inform on reclamation of waste materials sorted by the households. Materials attractive for reclamation either because of quality or amount can be reclaimed by sorting in the household or by a central sorting of the collected and mixed household waste. Only sorting at source is discussed and commented on. Waste materials from offices and services are in a few cases included in the description of Danish collections, but because of lack of data it has been impossible to report on quantities from this source.

2.2.1 Voluntary Organizations

Collection of reclaimable waste materials from households is today executed by both voluntary organizations and the municipalities. The economic gain was earlier the most important motive when the voluntary organization collected and only newspapers and magazines were chosen because these materials in sorted and bundled form represented a high and therefore well-paid quality. With the growing interest in the society for the

the necessity of increase of recycling the collection by the voluntary organization is given a wider perspective. Consequently, the organizations have to a certain extent expanded their collections to include other reclaimable waste materials besides newspapers and magazines. Also bottles, glass, and textiles are collected.

2.2.2 Municipalities

The legislation demands the municipalities to arrange mandatory collection of household refuse in areas with a population of more than 1,000 inhabitants. In other areas collection can be arranged. Collection of other types of wastes from households is not included in the legislation, but the responsibility of keeping control with unhygienic conditions and unwanted pollution of the environment lies with the municipalities. This has led to an expansion of the collections to include other types of wastes besides ordinary household refuse, thereby enabling the municipalities to keep a better control.

In the weekly collection of household refuse carried out by the municipality either steel container or an approximately 100 litre paper or plastic bag is used. The bag is disposed of whereas the container is emptied into the collecting vehicle and returned to the household/owner. The type of waste collected weekly is limited to household refuse. The household produces other types of wastes, and the municipality advises the citizen about disposal of these at the local or regional incineration plant or sanitary landfill. Disposal through private waste collection interprises is also possible but of course at one's own expense. The collection and transport of the household waste types outside the weekly collected refuse have given problems to a certain extent when the wastes were dumped illegally and thereby producing an environmental nuisance. Because of this and the wish to offer a better service to the citizens various municipalities have introduced arrangements with collection and disposal of these waste types. The wastes in question can be termed

as:

Bulky Wastes (Big pieces of household wastes such as furniture, bicycles, refrigerators, etc)

Garden Waste

Earth, Stones, etc

Oil and Chemicals

Oil and chemicals are disposed of through separate channels and are not included in this report. Earth and stones are not collected by the municipality because of weight and because of irregular production.

An arrangement introduced by the municipality to collect bulky and garden wastes is a great advantage for the citizen. The different municipalities have introduced various collection methods. These are described at length in Section 3, Collection Methods in Denmark.

2.3 Collecting of Reclaimed Waste Materials

When the municipalities in 1974 introduced municipally managed collections of reclaimed waste materials from households, it was only natural that the collection was regarded as a supplement to already established waste collection arrangements or as part of a total waste collection arrangement which took care of all types of household waste.

When a municipality introduces collection of reclaimed materials, the citizens are urged to continue to support the collections managed by the voluntary organizations. Further, it is emphasized that the municipally managed collection primarily should be seen as waste removal.

In some cases municipalities have combined collection of reclaimed materials with initiatives to create jobs for unemployed

or as a help for rehabilitees. See Annex 12, Silkeborg.

The materials collected are sold to the reclamation industry and the profits deducted from the costs of collecting (administration, driving, and possible sorting). It must be stressed, though, that the profits gained from selling the materials in no way can pay the costs of the collections with the current price levels of reclaimed waste materials.

In contrast to the majority of collections arranged by voluntary organizations the municipal collections also comprise glass, iron and non-ferrous metals, and textiles. In the municipality of Silkeborg, where rehabilitees are employed, only paper and cardboard are collected. Collection of materials besides paper and cardboard have been found only natural by the municipalities and in some cases seen as a way of preventing their entry into the incineration plant where glass, iron, and metal only take up room.

Plastic is not collected from households in Denmark.

2.4 Collections

All the most important collections of reclaimed waste in Denmark have been analyzed. Both field trials and permanent collections are described in detail in the annexes.

Municipal field trials in five municipalities are described and in one three different trials have taken place. They are Annex 3, Ballerup, Annex 5, Birkerød, three trials, Annex 6, Bogense, Annex 7, Greve, and Annex 13, Aalborg.

Six permanent collection arrangements managed by the municipalities are described. They are Annex 4, Ballerup, Annex 8, Helsingør, Annex 9, Herlev, Annex 10, Randers, Annex 11, Rødovre, and Annex 14, Aalborg. Two of these, Ballerup and Aalborg, were the result of field trials whereas the remaining four introduced

their collections directly without field trials, but based on the experience gained from other collections.

In Annex 2 a permanent collection organized in the municipality of Allerød by voluntary organizations is described, and in Annex 12, Silkeborg, a collection employing rehabilitees is described.

In Table 2.1 the collections are presented, and in Table 2.2 detailed data are found about the municipalities, their populations, areas, collection periods, extension of collection in part of or in the whole of the municipality, population, and number of households living in single-family and apartment houses respectively.

Collections have been described in 11 municipalities with 520,000 inhabitants out of a total of 275 municipalities with 5 million inhabitants. 42,000 citizens have been involved in field trials, and 395,000 are served by a permanent collection arrangement.

Besides the 10 collections arranged by the municipalities many collections managed by voluntary organizations take place in various towns and municipalities in Denmark. One of these, Annex 2, Allerød, has been included in this report because the collection covers the whole of the municipality and because information about amounts etc was available, thus making comparisons with the other collections possible. It has not been possible to analyze other collections by voluntary organizations due to lack of data. There exists statistical information obtained from the reclamation industry about the total amount of paper and cardboard collected from households in Denmark in 1976. The amount was 36 tons (see R 1 in Annex 1) representing 20% of the combined collected amounts from the industry, offices and households. If the total amounts from collections managed by the municipalities are calculated on the basis of data from the annexes in this report, the comparable amount is 1,530 tons per year of paper and cardboard representing 4% of the total

COLLECTION BY VOLUNTARY ORGANIZATIONS

Allerød	(Annex 2)	

COLLECTION BY REHABILITEES

Silkeborg	(Annex 12)	Only paper and cardboard are collected

FIELD TRIALS

Ballerup	(Annex 3)	
Birkerød	(Annex 5)	
Bogense	(Annex 6)	
Greve	(Annex 7)	Only paper and cardboard are collected
Aalborg	(Annex 13)	

PERMANENT, MUNICIPAL COLLECTIONS

Ballerup	(Annex 4)
Helsingør	(Annex 8)
Herlev	(Annex 9)
Randers	(Annex 10)
Rødovre	(Annex 11)
Aalborg	(Annex 14)

Table 2.1: Collections of Reclaimed Waste Materials Sorted by Households and Described in Annex 2 till 14.

Table 2.2: Data about Municipalities in Which Collections of Reclaimed Waste Materials Sorted by Households Have Taken Place and Are Analyzed in the Report

Annex	Municipality	Category[1]	Population	Area Hectares	Population of Principal Town	Collection Period	Months	Field Trial (F) / Permanent Collection (P)	Collection in Whole or Part Only of Municipality	Number of Households & Citizens Involved in Collection			
										Single-family Houses	Apartments	Total No of Households	Citizens
2	Allerød	b	20,700	7,800	-	- 74 -	-	P	Whole M	5,500	1,300	6,800	20,700
3	Ballerup	b	51,300	3,260	-	Jan75-Dec75	12	F	Part of M	1,650	0	1,650	5,080
4	Ballerup	b	51,300	3,260	-	Feb76-	-	P	Part of M	6,600	0	6,600	20,000
5	Birkerød	b	22,000	3,500	-	Sep74-Dec76	28	F	Whole M	5,000	2,000	7,000	22,000
6	Bogense	a	6,200	10,200	2,900	Sep74-Aug75	12	F	Part of M	800	265	1,065	2,800
7	Greve	b	29,000	8,000	-	Sep74-Jan75	5	F	Part of M	1,912	1,143	3,055	9,500
8	Helsingør	a	56,700	12,160	43,000	Oct74-	-	P	Whole M	10,000	11,000	21,000	56,700
9	Herlev	b	24,700	1,202	-	Apr76-	-	P	Part of M	3,200	0	3,200	9,500
10	Randers	a	64,000	15,400	58,000	Apr77-	-	P	Whole M	10,400	16,600	27,000	64,000
11	Rødovre	b	41,500	1,150	-	Jan77-	-	P	Whole M	8,300	8,300	16,600	41,500
12	Silkeborg	a	45,500	25,300	29,000	- 66 -	-	P	Part of M	2)	2)	9,000	28,000
13	Aalborg	a	155,000	56,700	100,000	Apr74-Mar75	12	F	Part of M	920	0	920	2,700
14	Aalborg	a	155,000	56,700	100,000	Apr77-	-	P	Whole M	31,000	34,200	65,200	155,000

1) a: Town in the provinces, b: Suburban area near Copenhagen
2) Data not available

collected amount from households.

Because of available information from the municipalities about number of single-family and apartment houses, respectively, collected amounts of reclaimed materials and in some cases collection economy it has been possible to deduce conclusions about efficiency of collections and to compare the different collections. In Annex 1, Documentation, the sources of information are listed.

The information available is too inadequate to obtain a sure knowledge about the sensitivity of a collection (management, method, etc) to the variation of parametres such as geographical positioning of households in Denmark, household income, etc. Further no exact information is available about maximum reclaimable amounts of materials in the household waste and the composition of the materials. In Annex 5, Birkerød, paragraph 2.5.1 and 2.5.2, a study of household waste composition and a study of composition of the reclaimed materials are reported on. The data obtained by these studies are based on too small a quantity seen from a statistical point of view.

In some cases - Birkerød and Aalborg - research studies have taken place to find out the citizens' attitudes towards different collection methods and to record their views on collection of reclaimed materials.

It has been possible to a certain extent to analyze the influens on amounts collected in relation to type of residence as information has been available. In three reported collections only single-family houses are involved, and in two municipalities during field trials careful registration was performed.

2.5 Evolution of the Danish Collections

Of the described collections, Silkeborg, Annex 12, is the oldest and was begun in 1966. All the others were started in 1974

and later. See Table 2.2. It was especially in the later part of the sixties that the ecological conscience emerged throughout the country. In 1973 the oil crisis influenced to a high degree the urge to begin collections of reclaimed waste from the households. In Figure 2.1 the collection periods of the collections described in this report are illustrated.

2.6 Calculations

Because of inadequate, detailed information the calculations made to compare the different collections are uncertain. The magnitude of the uncertainty is unknown and as a consequence conclusions must be taken with reservation. The influence of anticipated and wholly unknown - and therefore unmeasured parametres - on amounts reclaimed adds to the uncertainty.

The following amounts have been calculated for: Paper and cardboard, glass, iron and non-ferrous metals, and textiles:

A Specific amount in kilogrammes per household per month

B Monthly amount collected in collection area

The calculated amounts are found in Section 5.

MUNICIPALITY

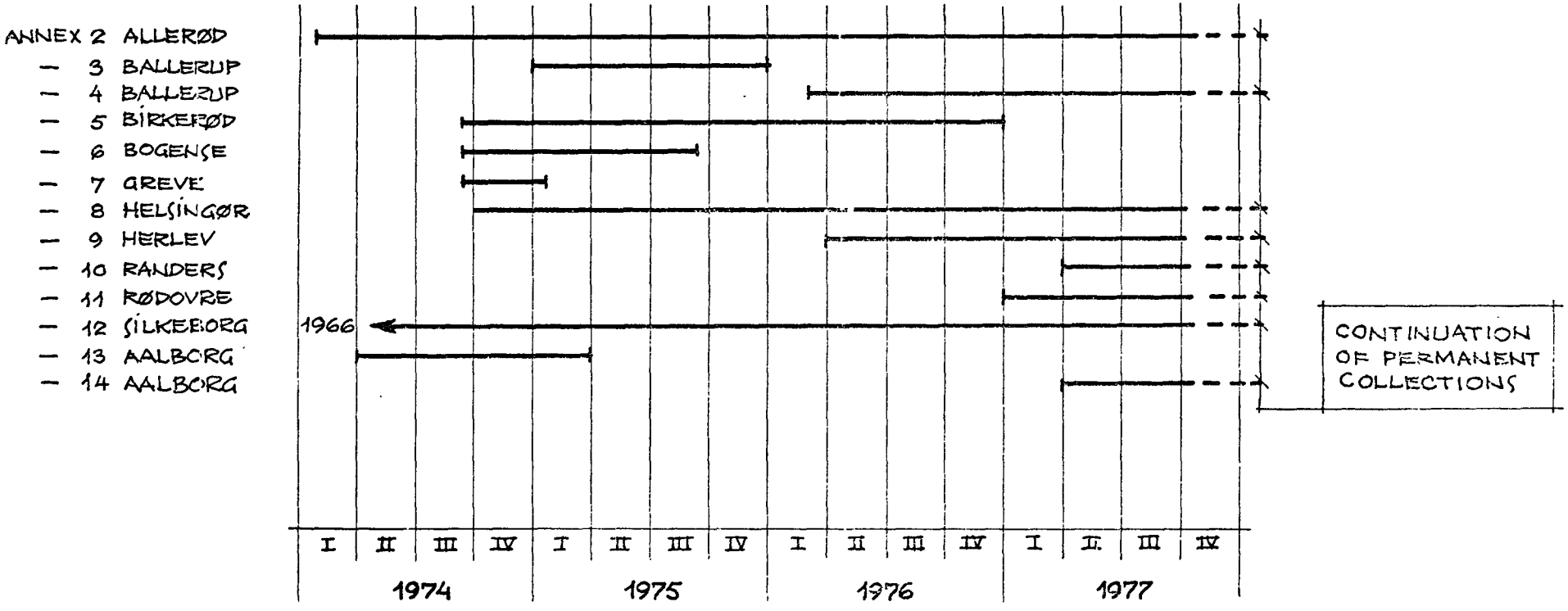


FIG. 2.1 : ILLUSTRATION OF COLLECTION PERIODS OF THE DIFFERENT COLLECTIONS DESCRIBED.

SECTION 3 COLLECTING METHODS

The collection in Denmark of reclaimable waste materials sorted at source in the household covers all types, from a private occasional collection managed by voluntary organizations or by the reclamation industry, to a municipal arrangement with regular collection of the separated materials. Consequently, the type of management and collection method varies accordingly.

Sale of collected materials as a rule takes place via the reclamation industry which refines the materials before sale to the producing industry or before exportation. Examples of sale directly to the producing industry are also found.

The reclamation industry and trade dealing in waste paper and scrap iron and steel, represents an established organization which chiefly receives its supply of secondary raw materials from the producing industries. Also the voluntary organizations deliver a substantial continuous supply of waste materials - primarily paper originating from the households.

The supply - mostly newspapers and magazines - from the voluntary organizations (scouts, sport clubs, schools, etc.) furnishes the recycling of paper with approx. 26% of the total amount recycled. This equals approx. 34,500 tons per year or, if averaged on the total number of households in Denmark, approx. 1.8 kg per household per month. The mean value is based on widely varied amounts from 0 kg to calculated specific amounts of 4.5 kg per household per month.

The motivation of the municipalities to introduce field trials of collection of reclaimed materials has been many-sided, but limitation of resources, better service offered to the citizens and economic considerations have been the primary aims.

Some of the first collections managed by the municipalities were started in 1974 when the energy crisis was heavily felt, and because of the extremely high prices of waste materials. The high prices were to a certain extent a consequence of the crisis. Because of a widespread sentiment in the population and because of an anticipation of economically feasible collection arrangements, field trials were initiated interdependently in different municipalities.

Only to a certain extent did the field trials take place under fully controlled conditions, which has made comparisons of trial results difficult. Further, the trials have not all in detail been officially reported on.

As a rule the collections were dominated by individuals' wishes to try out in practice their ideas and theories.

As a consequence the different field trials were started uncorrelatedly throughout the country. Differences in social, sociological and methodical conditions have decreased the possibilities of estimating the influence of the individual parametres on degree of participation, collected amounts, material quality etc.

The first field trials in Denmark were limited to areas of single-family houses only. From the field trials in Birkerød, Annex 5, and Greve, Annex 7, information became available from other types of sources as well (Birkerød: apartment houses and industrial enterprises, Greve: apartment houses).

Different collection methods have been applied, which has lead to various degrees of service level for the citizens. In Annexes 2 to 14 detailed descriptions of different collections are found.

In areas with single-family houses the following collection methods have been applied:

a) Centrally placed containers in the local area into which the citizens could deposit separated paper and cardboard, glass material and iron and non-ferrous metals. Either a number of containers for the different materials or a container divided into different spaces were used. The container area without continuous supervision.

b) Containers placed centrally in the area. Open for depositing, for instance once a week for approximately two hours with supervision.

c) Collection of bundled newspapers and cardboard at the households. The materials were either placed beside the household refuse or by the pavement. Various collection frequencies in the different collections were used: fortnightly, monthly or bimonthly. As collection vehicle both ordinary lorries and back-loaders have been used.

d) Collection at regular intervals of waste material sorted in two 60 litre paper bags - one for paper and cardboard and one for mixed glass, iron and non-ferrous metals. The paper bags are collected by a lorry with two compartments so the collected materials can be kept apart.

e) Regarding collection of reclaimable glass materials trials have taken place where the glass was collected in centrally placed containers. In some cases all types and sorts of glass materials were collected, and in other cases the primary aim was to collect unbroken reusable bottles (wine and spirits). These specially designed bottle containers are placed near shopping centres within easy reach for the customers. The amounts of bottles collected with this method have been great and as a consequence of the success they have been introduced in a number of municipalities as a permanent collection arrangement.

Field trials in which methods adaptable for apartment houses have been tested, show that for this type of residence special

problems are encountered. The experience obtained from methods applied to single-family houses cannot be used directly.

Generally less space to accumulate waste materials is found in apartments making an easy day-to-day depositing a necessity. During the trials other problems, such as lack of areas available for depositing the waste materials between collection dates, accessibility for collection vehicles and the janitors' willingness to cooperate, were experienced. These factors appear to be of great importance for the success of a collection. In both field trials and in permanent collection arrangements for the different apartment houses have been arranged to try to encourage collection of household amounts comparable with single-family houses.

It has been disclosed that various reasons and motives dictate the household to participate in collections of reclaimed waste materials. In connection with the field trials in the municipality of Birkerød in 1974-75 a series of interviews were made before and during the trials so the motives in the population could be monitored. Approximately 90% of the 7,000 households participated actively in the collection. The majority motivated their participation with considerations on limits of resources. But pollution abatement, expectation of a reduction of refuse tax or more room in the regular weekly collected refuse bag were mentioned by many.

Uniformly for all field trials and permanent collections is the fact that it has not been possible to obtain profitability. The costs of collection and transport exceed the proceeds from the sale of the reclaimed materials to the reclamation industry. Consequently, removal of reclaimed materials imposes an increase in taxes or rates for the collections arranged by the municipality. Because the reclaimed materials as seen from a consumer's point of view are wastes, the citizen should be indifferent as long as the costs per ton of removed reclaimed wastes do not exceed the costs per ton of removal of the ordinary household refuse.

The interviews after the first Field Trial A in Birkerød - 12 months - showed at willingness to accept extra costs.

It is the experience from collections of bulky and garden wastes that the willingness to accept extra costs is related to degree of service in the collection arrangement.

In many municipalities arrangements have been introduced to collect regularly and remove bulky wastes and garden waste from the households. The motivation has been a wish to reduce the amount of household refuse which requires a more cost-demanding treatment than bulky and garden wastes. The increased centralization of waste treatment has made it more difficult for the individual household to dispose of the wastes that are not accepted in the refuse collection. Further, the increase of wastes as a consequence of increase of standard of living and changes in consumer behaviour have all added to the general recognized necessity of introducing new and supplementary ways of collecting the extra amounts of wastes.

The collection arrangements usually introduced comprise monthly collections from the household. Another type of collection arrangement is with containers placed locally in the neighbourhood.

When collection from the household is favoured in contrast to the container arrangement, one of the reasons is the equal costs producing at the same time a high level of service to the households. Containers must be supervised to prevent the area from becoming untidy, and this adds to the costs. Further, the container arrangement does not service all households equally because of differences in distance to the containers, differences in type of residence (garden waste from single-family houses and not from apartments) etc.

Research with interviews in connection with trials testing different collection and container arrangements has disclosed that the willingness to pay for a container arrangement was less or

equal to the actual costs, whereas the willingness to pay for collection from the household was 25-50% above the actual costs. (The actual costs were equal for the two alternative collection methods.)

Experience from different bulky and garden waste collection arrangements and from collections of reclaimable materials has been identical in showing that the collection from the household is a better way of collecting. During the collection a higher quality of reclaimed waste materials is ensured in the monitoring by the collection men of the correct sorting of the materials.

The container is used when establishing individually applied arrangements for apartment houses and for collection from industrial enterprises.

The introduction of the specially designed bottle (glass) containers (for collection of wine and spirits bottles) has shown the way to a new concept of collecting which seems to indicate a usable solution to an increased recycling of bottles. It is not known to what degree the introduction in the autumn 1977 of a series of standardized wine bottles specially produced for supermarket chains to increase recycling (fixed deposit is included in bottle price when sold) will affect the bottle container collection arrangement.

The field trials of collection of reclaimed waste materials and the testing of different collection arrangements for bulky and garden wastes have produced information enabling several municipalities to introduce Total Waste Collection Arrangements combining collection of bulky and garden wastes with collection of reclaimed waste materials.

Contributory to introducing a Total Waste Collection has been:

a) The sum of costs of collection by separate rounds for the different waste types are higher than of the combined type

of collection.

b) Experience has shown that when separation of bulky and garden wastes into combustible and non-combustible wastes takes place, the substantial part of the non-combustible share consists of glass, iron and non-ferrous metals.

Of the eight described permanent collections managed by municipalities the five comprise Total Waste Collection Arrangements combining the collection of bulky and garden wastes with reclamation.

The specific costs of the reclamation activity part of a Total Waste Collection Arrangement is difficult to assess with exactitude because they are directly influenced by both the proportionate amounts of the reclaimable wastes and the other waste types and by the quantities in question. In Section 6, Economy, an approximate specific price has been quoted enabling a comparison with separate rounds collection arrangements.

Beside the above discussed collection methods of bulky and garden wastes and reclaimed waste materials - paper, cardboard, iron, non-ferrous metals and rags - the regular weekly collection of household refuse takes place, but separately. Three vehicles are employed: two for bulky, garden and reclaimed wastes (usually a back-loader for the combustible part and a lorry with compartments for the reclaimed wastes) and one for household refuse. It seems to be worthwhile to contemplate the usage of two vehicles only by dividing the collection as follows:

a) One vehicle collects weekly household refuse and separated reclaimed paper and cardboard,

b) The other vehicle collects monthly bulky and garden wastes and separated glass, iron, non-ferrous metal and rags.

This collection arrangement would consider the varying amounts

of material types and if identical designed vehicles were used, a high degree of standardization could be introduced.

SECTION 4 COLLECTED MATERIALS

Collection of reclaimable waste materials from households and sorted by the households will produce waste qualities according to the publicized specifications. But if the material specifications are too complex, the result will be an uneven quality because of faultily sorted waste. As a general rule, the specifications are stated in simple terms which ensures the minimum of faults in sorting. Further sorting takes place when the specified materials are taken over by the reclamation industry. The collected reclaimed materials are in a few cases delivered directly to the producing industry, by-passing the reclamation industry. There is, of course, a feed-back on material specifications both from the industry using the reclaimed waste materials and from the reclamation industry which sorts and blends the collected household waste into higher priced qualities. Consequently, the material specifications used in collecting from households and the specifications demanded by the producing industry are economically related. A higher degree of quality meaning a more uniform material characterization demands a higher sorting effort with an increase in price as in result. As the material specifications can be influenced by the choice of collection method, a great deal of experiments have taken place - in most cases primarily motivated by the increase in the economical gain in collecting a more refined waste material.

The price structure interrelates the national and to a certain extent the international supply and demand situation, and the mentioned related parameters, such as grade of sorting and collection method efficiency, are only valid in a stabilized market.

As commented upon in Section 2 the municipalities that introduce collection of reclaimed waste, e.g. in connection with a

Total Waste Collection Arrangement, primarily see the collection as a means of solving a waste problem and offering a higher degree of service.

The following specifications are used in the majority of collections:

Paper and Cardboard:

Clean and dry materials. Newspapers, magazines, printed paper, other paper, and cardboard.

Contaminated paper, such as plastic coated paper, is not accepted.

Glass:

Bottles, jars, scrap glass.

Covers and caps are not accepted.

When using the specially designed glass/bottle container (capable of containing 300 wine bottles) in a collection, only unbroken reusable bottles are accepted.

Iron and Non-ferrous Metals:

Tins, cans, scrap iron, and non-ferrous metals.

Textiles:

All types of rags and clothing.

Wood and plastic materials are not collected. Not all types of plastic can be recycled, and collection of plastic materials is anticipated to produce very low qualities because of the difficulty for the household in recognizing the different types. Sorting of already mixed plastic materials is complicated, and the usage of mixed types as secondary raw material is not attractive due to reduced strength of the finished product.

SECTION 5 AMOUNTS OF COLLECTED RECLAIMED MATERIALS

5.1 Introduction

In Annexes 2 to 14 the different collections are described in detail. Amounts of reclaimed materials are given, and both specific amounts per household per month and the total monthly collected amounts in the collection areas are quoted. When calculating the specific amounts the quantities collected have been averaged on all households in the area whether or not they actively participated in the voluntary collection. Because not all citizens participate, the true specific amount is higher than the calculated one. It was chosen to average on all households in the collection areas wherefore a factor of motivation is included. The factor varies according to collection and is further related to the period when the collection takes place and thereby is influenced by current events.

The total amounts of collected reclaimed materials have been averaged to a monthly value for each collection. Comparisons between these values and national key figures quoted by the reclamation industry have been made to a certain extent to enable an evaluation of a possible increase of collected amounts in the future.

In connection with the field trial A in Birkerød, Annex 5, a quantity of household refuse was examined before and during the trial. Based on the results from the examination maximum possible extractable waste materials are calculated and commented upon.

In the following paragraphs waste materials typically chosen for collection from households are analyzed:

Paper and Cardboard

Glass

Iron and Non-ferrous Metals

Textiles (Rags)

Glass, iron and non-ferrous metals only take up room in an incineration plant, and are also for this reason included in collections. Only small quantities of glass materials out of the total waste glass amount in Denmark are collected. In recent years the reclamation of unbroken bottles (wine and spirits) for reusage has been concentrated on in some of the collections. Besides energy saving, when bottles are reused, it is because the specialized glass products produced by the industry and the sensitivity to impurities in the glass production process makes the sorting of scrap glass expensive.

Iron and non-ferrous metals collected from households represent only small amounts compared with other sources.

Plastic materials and wood are not included in the collections.

When introducing reclamation, decreases in the ordinary weekly collected household refuse have been observed. At the same time an increase in the total amounts of refuse and reclaimed waste materials combined have been recorded indicating that introduction of reclamation attracts waste that earlier was disposed of through other channels.

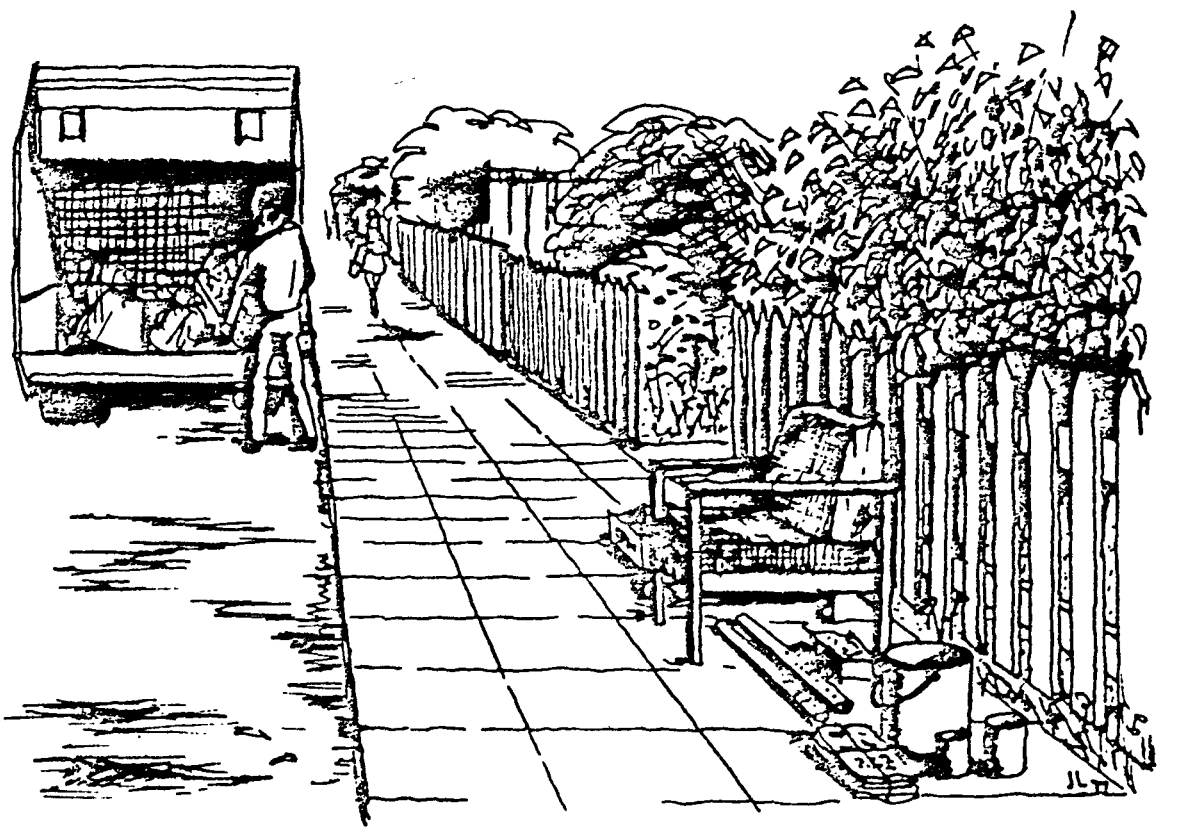
5.2 Commentary on Recorded Results

The comments on the recorded collected amounts are chiefly valid for paper and cardboard, but analogous tendencies can be observed for glass materials. It is more difficult, though, to make conclusive evaluations by comparing specific amounts of glass materials because the type of material is differently defined according to specification of collection. In some cases the glass materials are collected in mixed form without special consideration towards unbroken glass containers. In other cases

the collection method has been adapted specially to the reclamation of unbroken bottles. Therefore the scrap glass is not collected and consequently excluded from the calculated specific amount.

In Figure 5.1 is shown the relationship between sorting of materials by the households and the collection methods. There is a limitation to the degree of sorting that can take place by the household. If too fine a sorting is requested of the household, the collection will produce unacceptable errors and thereby produce a lower quality of reclaimed material.

Iron and non-ferrous metals and rags respectively are usually sorted by the reclamation industry.



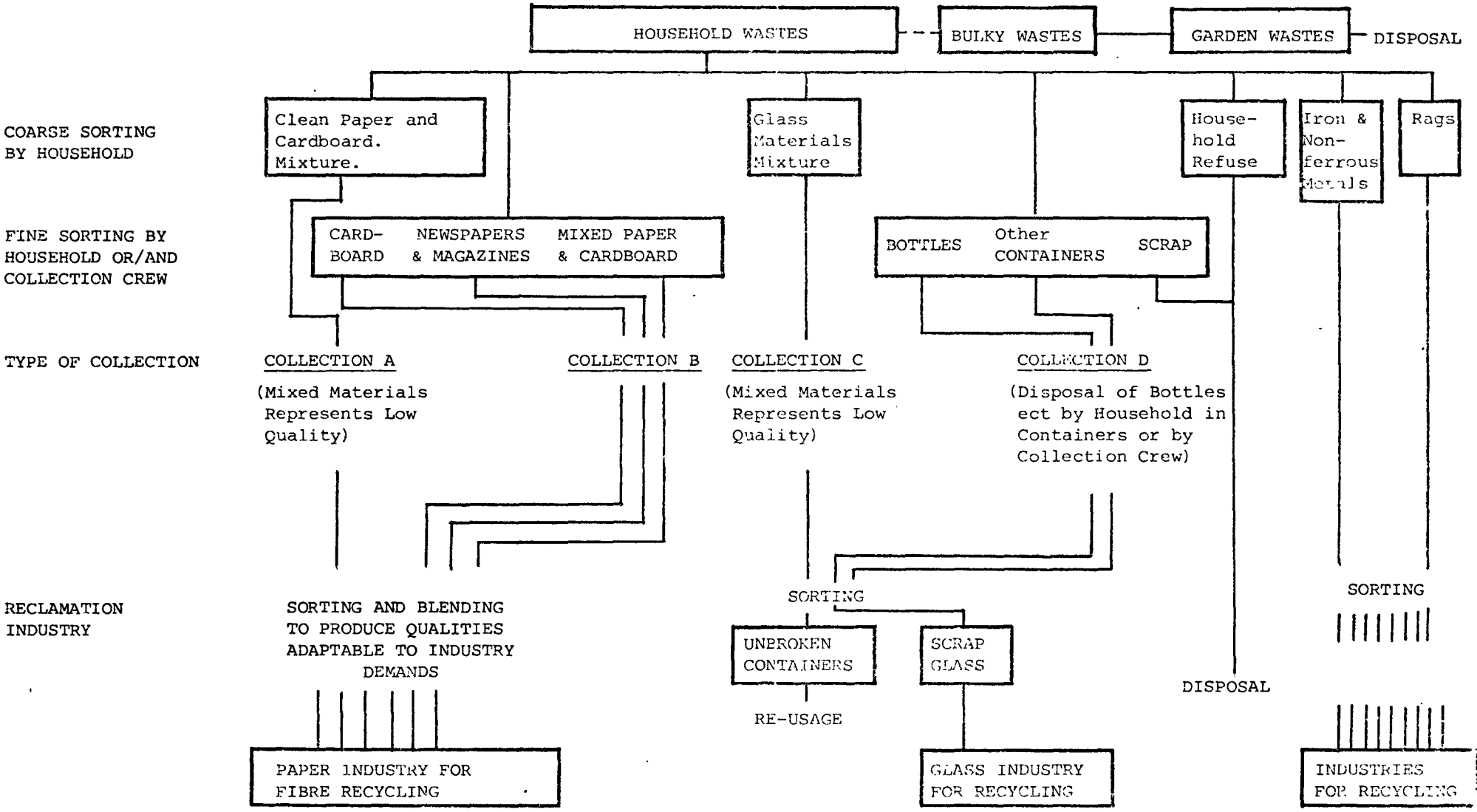


Figure 5.1: Relationship Between Sorting and Collection Method.

5.2.1 Relative Amounts of Materials Collected

The percentage of types of materials collected varies from collection to collection. But as an average approximately 60% (weight) paper and cardboard, 20% glass, 20% iron and non-ferrous metals and a few percent rags are collected. In Table 5.1 the apportionment of materials collected in the described collections is shown.

5.2.2 Specific Amounts as a Function of Collection Frequency

The collection frequency of the different collections is shown in Table 5.2. The influence of collection frequency on collected specific amounts can be evaluated with a fair amount of certainty in two collection areas where the frequency was changed. In the collection in Birkerød, Annex 5, a decrease (16%) in paper and cardboard was recorded for single-family houses when the frequency was changed from 14 days to a month and again a further decrease (20%) when collection took place bimonthly. For apartment houses a greater decrease (44%) was observed by changing from 14 days to a month. Because of this observation a bimonthly collection frequency in apartment houses was not tested when going from trial B to C. As a remedy against low specific amounts specially adapted collection methods were applied to the apartment houses.

In Bogense, Annex 6, a decrease (27%) was recorded when the frequency was changed from 14 days to a month.

5.2.3 Specific Amount as a Function of Type of Residence

It can be concluded from the collections that the specific amounts collected from single-family houses are greater than the amount collected from households in apartments. Lack of available space in the apartment prevents storing of reclaimable materials for longer periods. If special arrangements for easy

Table 5.1: Collections of Reclaimed Waste Materials from Households. Material Percentages (Weight) of Total Amount Collected.

Annex	Municipality	Field Trial or Permanent Collection	Paper and Cardboard	Glass Bottles	Glass Scrap	Iron and Non-ferrous Metals	Rags
2	Allerød	P	72%	23%	4%	0 3)	3%
3	Ballerup	F	36%	38%		22%	4%
4	Ballerup	P	57%	17%		26%	-2)
5	Birkerød	F (Trial A)	55%	34%		11%	0
	Birkerød	F (Trial B)	55%	45%		0	0
	Birkerød	F (Trial C)	54%	46%		0	0
6	Bogense	F (First 6 months)	73%	22%		5%	0
	Bogense	F (Last 6 months)	69%	24%		7%	0
7	Greve	F	100%	0		0	0
8	Helsingør	P	74%	26%	0	0	0
9	Herlev	P	59%	13%		27%	1%
10	Randers	P	59%	11%	-	22%	8%
11	Rødovre[1)]	P	49%	8%	8%	35%	0
12	Silkeborg	P	100%	0		0	0
13	Aalborg	F	65%	—— 35% ——			0
14	Aalborg	P	29%	13%	-	58%	0

1) Amounts are mean of collections in Ballerup, Herlev and Rødovre combined.
2) No data available (-)
3) Zero indicates that material is not collected.

Table 5.2: Collection Frequency for Collections, Annex 2 to 14.

Annex	Municipality	Field Trial (F) or Permanent Collection (P)	Collection Frequency
2	Allerød	P	Monthly
3	Ballerup	F	14 days
4	Ballerup	P	14 days
5	Birkerød Birkerød Birkerød	Field Trial A Field Trial B Field Trial C	14 days Monthly Bimonthly*
6	Bogense First 6 months Bogense Last 6 months	F	14 days Monthly
7	Greve	F	Monthly
8	Helsingør	P	Monthly
9	Herlev	P	14 days
10	Randers	P	Monthly
11	Rødovre	P	Weekly
12	Silkeborg	P	Bimonthly
13	Aalborg	F	Containers emptied when full
14	Aalborg	P	Monthly

*) For single-family houses only.

day-to-day disposal are not available for the apartments, the materials are more likely to be disposed of together with the ordinary household refuse.

Specially adapted collection arrangements have been observed to yield higher specific amounts from apartments. See Annex 5, Birkerød, Trial C.

5.2.4 Specific Amounts Related to Type of Collection

In the annexes both Field Trials and Permanent Collections have been described. It can be observed that Field Trials yield higher specific amounts than the permanent collections managed by the municipalities. An exception is the municipally managed Silkeborg-collection (Annex 12) where rehabilitees are engaged in collecting. The specific amount of collected paper and cardboard in Silkeborg is the highest among the described permanent collections.

The greater amount collected during Field Trials is possibly caused by the fact that more publicity is given a Field Trial. Active promotion by the municipalities and coverage by the medias throughout the trial probably increase the amount collected. The permanent collection probably creates less interest after the initial phase.

Voluntary organizations collect in Allerød and large specific amounts are observed. The degree of motivation of the voluntary organizations are, no doubt, the main cause of producing larger amounts.

The permanent municipally managed collections yield small specific amounts when these are calculated on amounts collected from areas with mixed residences - single-family houses and apartment houses. In areas with single-family houses only - Annex 3, Ballerup, and Annex 9, Herlev - the specific amounts are

larger equaling Allerød, but still smaller than amounts obtained in Field Trials.

5.2.5 Specific Amounts Related to Collection Method

Because of too few data it is not possible to conclude whether collection method for single-family houses as a sole varying parameter influences the specific amounts collected. For apartment houses it was observed that specially adapted collection arrangements yielded greater specific amounts. See Annex 5, Birkerød, Trial C.

In Table 5.3 the collection method for the different collections described is shown.

In Birkerød Trial C an evaluation was made of the different collection methods in apartment houses with the aim of trying to correlate with specific amounts. In Annex 5 details will be found, but the evaluation did not lead to reliable conclusions. General conclusions can not be drawn with certainty about how a specific amount is related to collection method because of few data.

In the Birkerød Field Trial B and C a complete change in collection method of glass materials was introduced. Instead of the municipality collecting glass in distributed paper bags, specially designed glass containers were positioned throughout the municipality near shops. The citizens were requested to dispose of their bottles etc in the glass containers. When the citizens were shopping locally, the glass containers were within easy reach.

It was observed that the total amounts collected by means of the glass containers were the same as the amounts collected at the households. Further a higher quality of materials was obtained with a greater number of unbroken reusable bottles.

Table 5.3: Collection Method for Different Collections.

	Collection in Distributed Paper Bags	Materials Deposited at Pavement or at Ground Level for Apartments	Disposal in Container in Local Area	Glass (Bottles etc) Collected Separately in Container Near Shop in Local Area
FIELD TRIALS				
Annex 3 Ballerup		x		
Annex 5 Birkerød A	x			
Annex 5 Birkerød B	x (paper and cardboard only)		------ plus ------	x
Annex 5 Birkerød C	x (paper and cardboard only)		------ plus ------	x
Annex 6 Bogense	x			
Annex 7 Greve	x[1)]			
Annex 13 Aalborg			x	
PERMANENT COLLECTION				
Annex 2 Allerød		x		
Annex 4 Ballerup		x		
Annex 8 Helsingør			x	
Annex 9 Herlev		x		
Annex 10 Randers		x		
Annex 11 Rødovre		x		
Annex 12 Silkeborg		x		
Annex 14 Aalborg		x	------ plus -----	x

1) For apartment houses containers placed at ground level were used.

Although the amounts are the same, the difference in collection method may very well have canalized into the containers materials that were earlier disposed of outside the collection. The types and amounts earlier collected at the household are not necessarily identical with the amounts collected with the altered collection method. Comparisons can not be drawn with certainty until more information becomes available.

5.3 Paper and Cardboard

In Table 5.4 are shown the calculated specific amounts per household per month of reclaimed waste materials in the different collections described in Annex 2 to 14.

The recorded amounts for single-family and apartment houses respectively are specified. To make comparisons possible with collections from which there exists no information about separate amounts collected from the two types of residences, a mean amount has been calculated.

In Figures 5.2 to 5.4 the specific amounts are illustrated with indication of periods in which Field Trial collections were performed. Regarding the permanent collections the periods from which data have been available are indicated. In Figure 5.2 is shown the specific amounts - both recorded and calculated - from areas with mixed single-family and apartment houses. In Figure 5.3 and 5.4 are shown specific amounts collected from single-family and apartment houses respectively.

From the permanent collection, Annex 2, Allerød, information is available about paper qualities collected. Only the sold amounts of the qualities "Newspapers", "Magazines" and "Cardboard" have been recorded. During the two field trials, Birkerød, Field Trial A, (Annex 5) and Greve (Annex 7) reclaimed waste paper has been analyzed.

Table 5.4: Specific Amounts of Paper and Cardboard Collected in Different Collections.

PAPER & CARDBOARD				Specific Amounts per Household per Month, Kilogrammes			
Annex	Municipality	Field Trial or Permanent Collection	Collection Period	Single-family Houses (Mixed Paper & Cardboard)	Apartment Houses (Mixed Paper & Cardboard)	Calculated Mean of Amounts from Single-family and Apartment Houses	Average for Mixed Residences: Mixed Paper and Cardboard
2	Allerød	P	1974-	-	-	-	2.9
3	Ballerup	F	12 months	2.1	0	-	-
4	Ballerup[1]	P	Feb 74-	2.5	0	-	-
5	Birkerød	F (Trial A)	14 months	5.5	1.8	4.4	-
	Birkerød	F (Trial B)	6 months	4.6	1.0	3.6	-
	Birkerød	F (Trial C)	8 months	3.5	3.5	3.5	-
6	Bogense	F	First 6 months	-	-	-	7.0
	Bogense	F	Last 6 months	-	-	-	5.1
7	Greve	F	First 3 months	8.2-8.6	4.5	6.9	-
	Greve	F	Last 2 months	5.8		5.3	
8	Helsingør	P	Oct 74-	-	-	-	0.57
9	Herlev[2]	P	Apr 76-	2.9	0	-	-
10	Randers	P	Apr 77-	-	-	-	0.8
11	Rødovre[3]	P	Jan 77-	-	-	-	1.4
12	Silkeborg	P	1966-	-	-	-	4.6
13	Aalborg	F	12 months	3.4	0	-	-
14	Aalborg	P	Apr 77-	-	-	-	0.28

1) Specific amount averaged on period of 8 months, Feb-Sep 76.
2) Specific amount averaged on period of 6 months, Apr-Sep 76.
3) Specific amount is mean of the municipalities of Ballerup, Herlev and Rødovre. Information from Regional Incineration Plant where reclaimed wastes from the three municipalities are handled as a whole. Only collection from single-family houses takes place in Ballerup and Herlev.

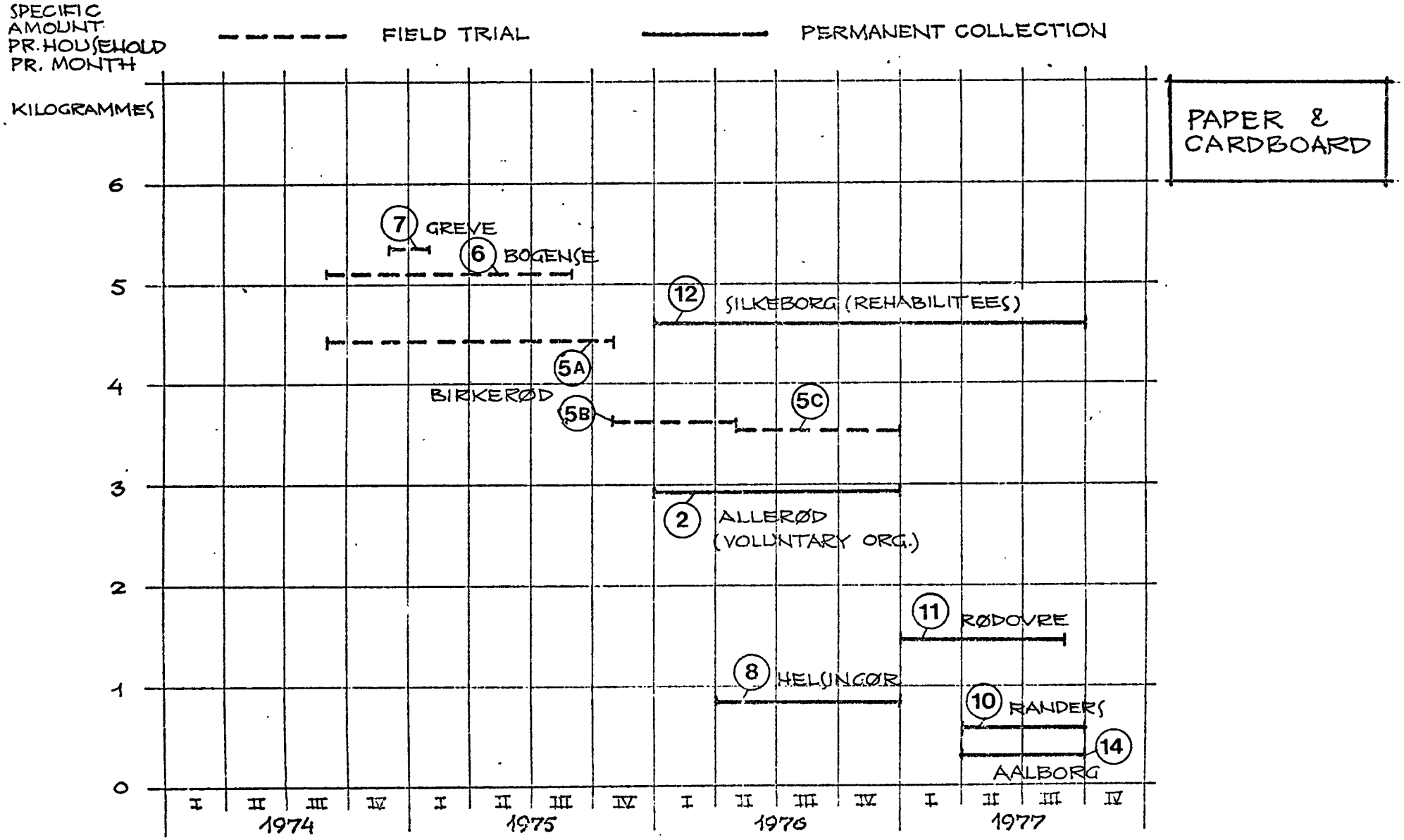


FIG. 5.2 : SPECIFIC AMOUNTS AVERAGED ON ALL SINGLE-FAMILY AND APARTMENT HOUSES TOGETHER. PERIODS WITHIN WHICH DATA ARE AVAILABLE

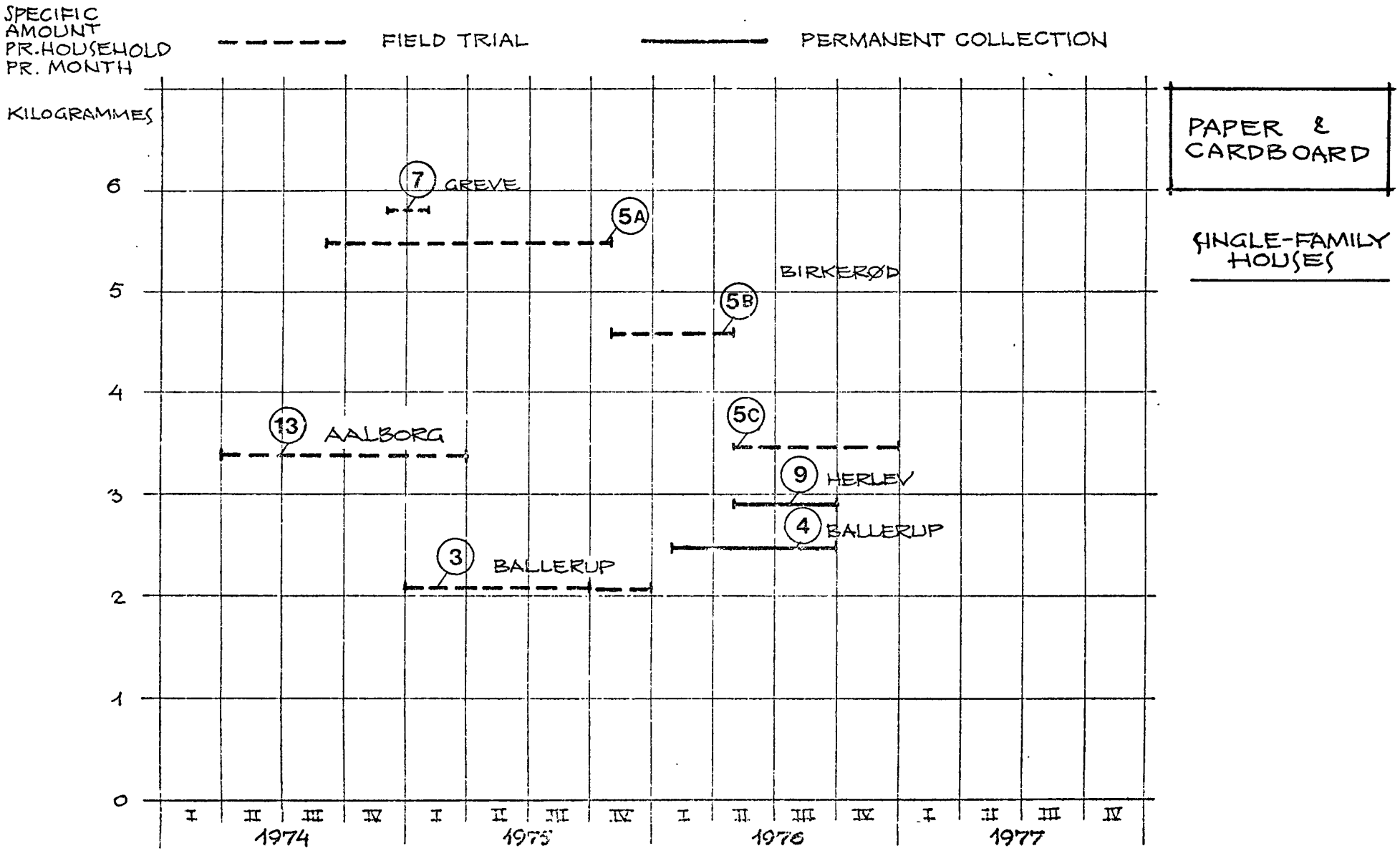


FIG. 5.3: SPECIFIC AMOUNT FROM SINGLE-FAMILY HOUSES. PERIODS WITHIN WHICH DATA ARE AVAILABLE

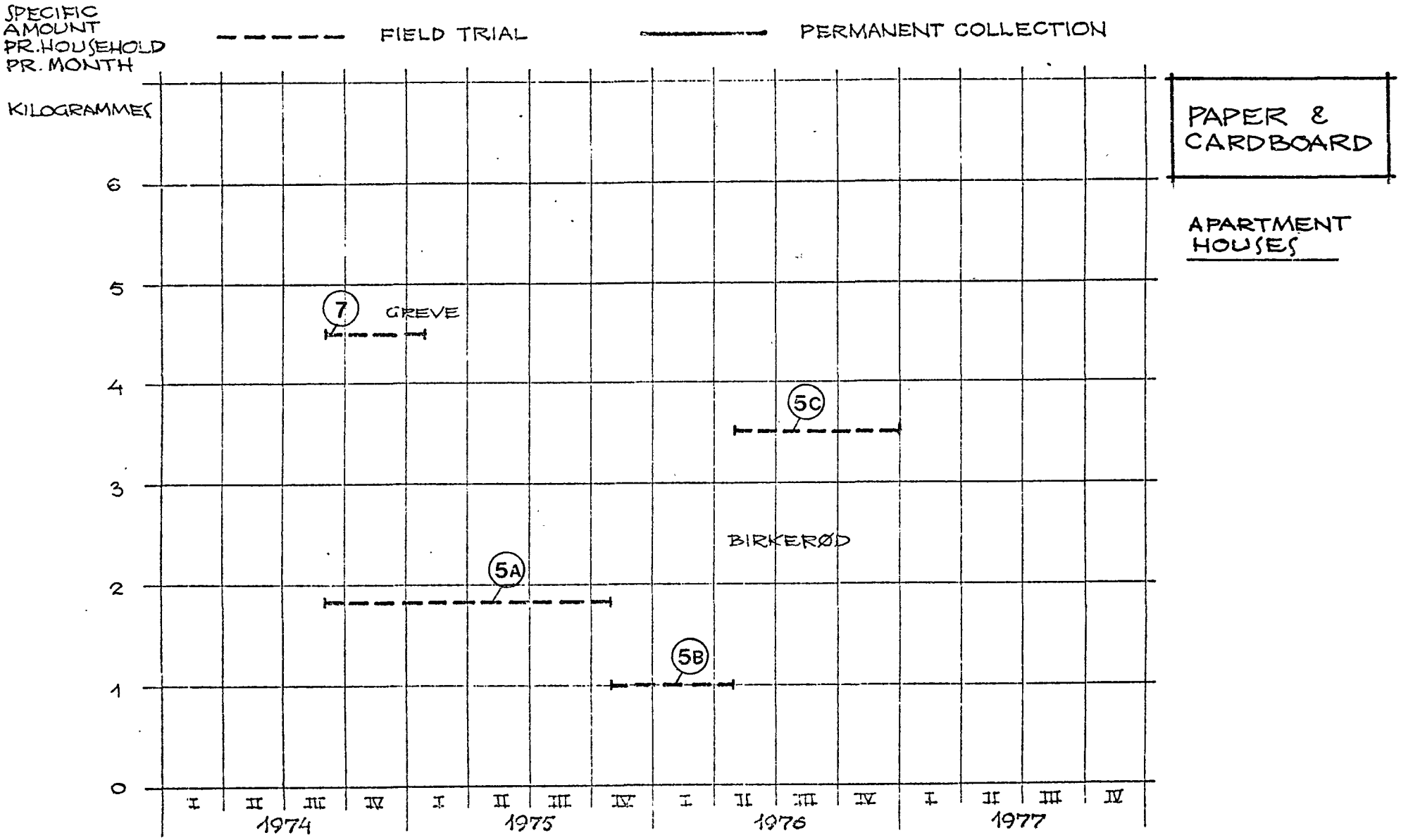


FIG. 5.4: SPECIFIC AMOUNT FROM APARTMENT HOUSES. PERIODS WITHIN WHICH DATA ARE AVAILABLE

In Table 5.5 the specific amounts of qualities are listed. Because of low quality only few magazines are sold from Allerød to the reclamation industry, and the percentage quoted does therefore not represent the amount collected.

In Birkerød Field Trial A, Annex 5, a research study was performed to obtain information about composition of household refuse before and during the field trial. From the results of this study the maximum reclaimable amount of clean paper and cardboard can be deducted:

	Specific Amount per Household per Month*	
	Before Trial	During Trial
Clean Paper and Cardboard in Household Refuse	4.4 kg	2.1 kg

Theoretically the extracted amount from household refuse is 2.5 kg equaling 52%.

The specific amount collected as reclaimed waste material was 4.4 kg wherefore it can be concluded that a greater amount of wastes has been canalized into the controlled collection. As the composition has been analyzed on the basis of only 1,000 kg before the trial and 1,900 kg after the trial, the averaged specific amounts used for estimation of possible yields of reclaimed materials from households must be used with discretion.

In this connection it must be realized that the results of research studies in selected collections are probably influenced by parametres specially related to the individual collection arrangements. The results, therefore, cannot be transmitted directly for usage in other areas.

---

*) Calculated on a 0.8 participation factor. See also paragraph 2.5.1 in Annex 5.

Table 5.5: Specific Amounts of Reclaimed Paper and Cardboard Specified According to Paper Qualities. Percentages of Recorded Total.

Reclaimed Waste Paper Quality	SPECIFIC AMOUNTS PER HOUSEHOLD PER MONTH				
	Newspapers	Magazines	Printed Matter	Cardboard	Other
ANNEX 2 Allerød. Permanent monthly collection. Voluntary organizations. Sold paper qualities recorded continously.	2.0 kg (70%)	0.08 kg (2%)	? 1)	0.82 kg (28%)	?
ANNEX 5 Birkerød. Field Trial A. Collected fortnightly. Organized by municipality. Research study based on 172 weekly collected bags of reclaimed waste paper (approximately 1,700 kg). 2)	3.4 kg (42%)	1.80 kg (23%)	0.7 kg (8%)	?	2.2 kg (27%)
ANNEX 7 Greve. Field Trial. Collected monthly. Organized by municipality. Paper and cardboard are only collected. Study based on 605 kg reclaimed paper.	3.2 kg (52%)	2.10 kg (34%)	?	0.90 kg (14%)	?

1) ?: Means not recorded
2) Specific amounts calculated as mean of total number of households. See also Table 5.3 in Annex 5.

Amounts of reclaimed paper and cardboard collected in the permanent collections arranged by the municipalities are per year approximately 1,500 tons*. The total number of inhabitants in the collection areas are 375,000 or 8% of the total population in Denmark.

The total amount of collected reclaimed paper and cardboard from households was in 1976 36,000 tons (information from R 1, see Annex 1). The permanent municipal collections yield 1,500 tons (4% of the total), and the remaining 34,500 tons are collected by voluntary organizations (96%).

To what degree the amounts collected by the voluntary organizations will be influenced if more collections managed by the municipalities are introduced is not known. But from the collection in Birkerød (Annex 5) it is known that during the field trial the amount collected by a voluntary organization was unaltered.

If amounts of collected reclaimed paper and cardboard are increased and if the demand from the industry does not increase as well, the price structure will be affected with a probable decrease in amounts from voluntary collections.

Key figures of reclaimed waste paper and cardboard are shown in Table 5.6. Collected amounts from households represent 20% of the total amount collected.

Assessment of possible extractable amounts of paper from households can only be made with uncertainty because of lacking information. But a calculation of amount of newspapers and magazines - constituting a substantial part of waste paper in a household - can give an indication of magnitude.

---

*) Calculated on the basis of the monthly recorded averaged amounts from collections in Ballerup, Herlev, Rødovre, Helsingør, Randers, Aalborg and Silkeborg.

Table 5.6: Amounts of Reclaimed Paper Collected in Denmark in 1976.

Reclaimed Paper Collected:	
Industry (Shavings)	94,000 tons (52%)
Trade, Offices and Other Industry	51,000 tons (28%)
Households	36,000 tons (20%)
Total	181,000 tons
Reclaimed Paper Imported	16,000 tons
Total Amount of Reclaimed Paper in 1976	197,000 tons* (100%)

*) 24.2% of total paper consumption, 812,000 tons. Of 225,000 tons produced paper in Denmark, 135,000 tons or 60% is reclaimed waste paper.

If the yearly amount of approximately 130,000 tons of newspapers and magazines distributed in the households in Denmark is averaged on the population (375,000) in the permanent municipally arranged collections, the maximum extractable amount is 9,750 tons. The permanent collections yield 1,125 tons (12%) and the amount collected by voluntary organizations is 2,200 tons (23%)*. The remaining 6,200 tons (65%) per year are not collected.

The calculation is based on the assumption of equal consumption of newspaper etc throughout Denmark although it is known that there is a +10% to - 77% variation around the mean value according to geographical position.

---

*) 130,000 tons newspapers and magazines distributed to 5 million people equal:

$$\frac{130{,}000 \cdot 375{,}000}{5 \cdot 10^6} = 9{,}750 \text{ tons}$$

Collected by permanent municipal collections:

$$0.75 \cdot 1{,}500 \text{ tons} = 1{,}125 \text{ tons}$$

Collected by voluntary organizations:

$$0.85 \frac{34{,}500 \cdot 375{,}000}{5 \cdot 10^6} = 2{,}200 \text{ tons}$$

5.4 Glass

In Table 5.7 are shown the calculated specific amounts of collected glass materials in the different collections described in Annex 2 to 14.

According to method of collection amounts have either been recorded as mixed glass materials or bottles and scrap glass respectively. Where information has been available, amounts have been specified for single-family houses and for apartment houses. To make comparisons possible between individual collections the specific amount in Birkerød Field Trial A has been averaged on the total of both types of residences.

In paragraph 5.2.5 the influence of collection method on types of glass materials collected has been commented on. Comparisons of specific amounts between the described collections cannot be used as a measure of collection efficiency unless collection method is the same. The collection method is closely interrelated with the types of waste glass material produced.

When the specially designed glass containers are used, the primary object is to attract unbroken reusable bottles into a collection. The collected contents of a container will include other glass containers and scrap glass as well, but a substantial portion is bottles. Beer and lemonade are in Denmark primarily distributed in glass bottles mandatorily recirculated. As a consequence the bottles collected from households are mainly wine and spirits bottles.

In collections where the materials are fetched directly from the households, the paper bag collection method yields a mixture of all sorts of glass material.

In collections where the households deposit sorted waste materials at the pavement or for apartment houses at ground level, a higher glass quality with a greater amount of unbroken bottles is obtained.

Table 5.7: Specific Amounts of Glass Collected in Different Collections.

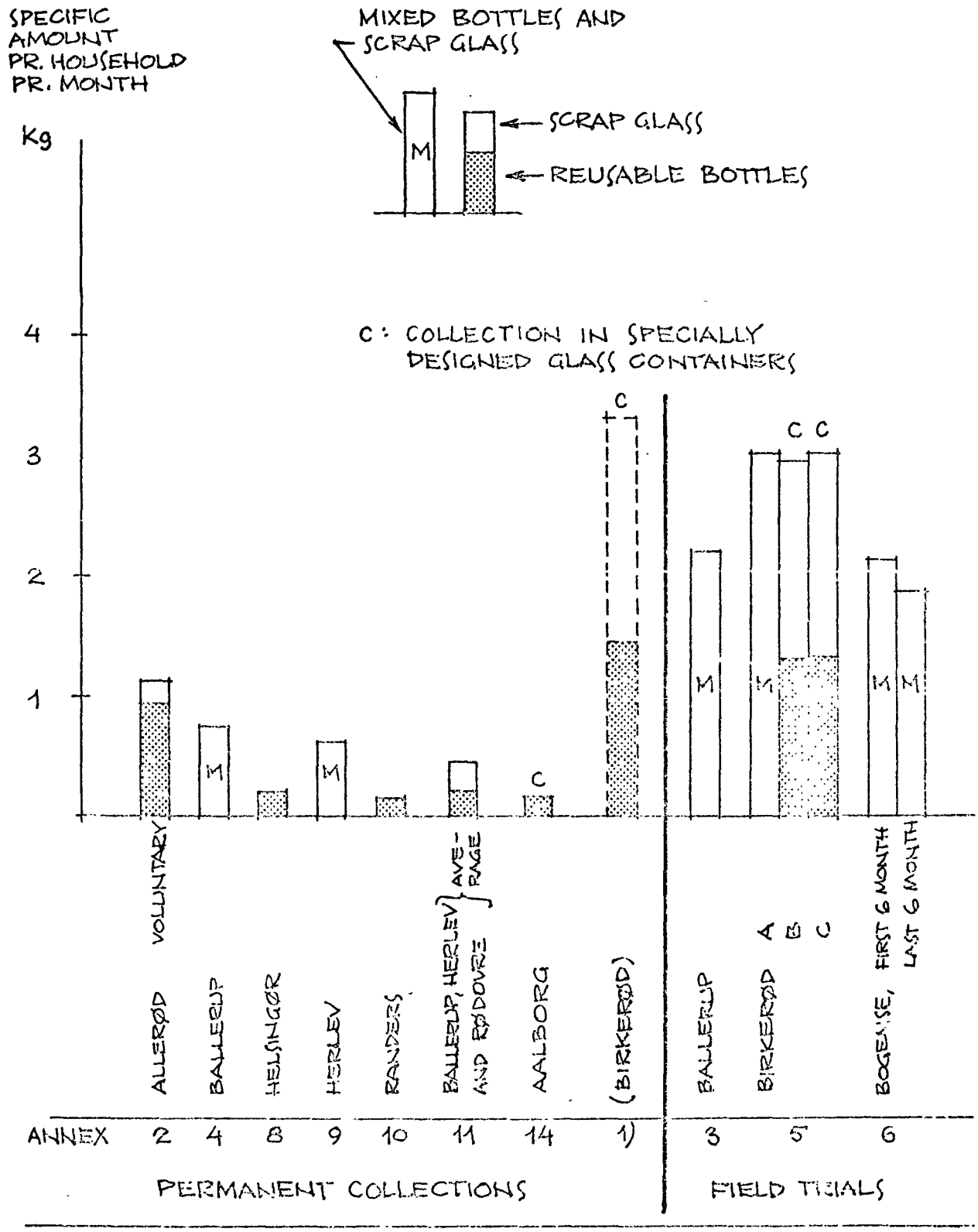
GLASS				Specific Amounts per Household per Month, Kilogrammes						
Annex	Municipality	Field Trial or Permanent Collection	Collection Period	Mixed Glass Materials		Specific Amounts Averaged on Total of Single-family Houses & Apartment Houses	Average f/All Households			
				Single-family Houses	Apartment Houses		Bottles	Scrap Glass	Mixed Glass Mat	Total Glass Mat
2	Allerød	P	1974-		-	-	0.94	0.17	-	1.11
3	Ballerup	F	12 months	2.2	0	-	-	-	-	-
4	Ballerup[1]	P	Feb 74-	0.75	0	-	-	-	-	-
5	Birkerød	F (Trial A)	14 months	3.7	2.0	3.0	-	-	-	
	Birkerød	F (Trial B)	6 months	-	-	-	1.4	1.5	-	2.9
	Birkerød	F (Trial C)	8 months	-	-	-	1.4	1.6	-	3.0
6	Bogense	F	First 6 months	-	-	-	-	-	2.1	2.1
	Bogense	F	Last 6 months	-	-	-	-	-	1.8	1.8
7	Greve	F	First 3 months	---------- No Glass Collected ----------						
	Greve	F	Last 2 months							
8	Helsingør	P	Oct 74-	-	-	-	0.2	?	-	-
9	Herlev[2]	P	Apr 76-	0.66	0	-	-	-	-	-
10	Randers	P	Apr 77-	-	-	-	0.14	-	-	-
11	Rødovre[3]	P	Jan 77-	-	-	-	0.22	0.21	-	0.43
12	Silkeborg	P	1966-	---------- No Glass Collected ----------						
13	Aalborg	F	12 months	No Data Available. Glass, Iron & Metals Weighed Mixed						
14	Aalborg	P	Apr 77-	-	-	-	0.13	-	-	-

1) Specific amount averaged on period of 8 months, Feb-Sep 76.
2) Specific amount averaged on period of 6 months, Apr-Sep 76.
3) Specific amount is mean of municipalities of Ballerup, Herlev and Rødovre. Information from Regional Incineration Plant where reclaimed wastes from the three municipalities are handled as a whole. Only collection from single-family houses takes place in Ballerup and Herlev.

Introducing glass (bottle) containers and positioning them within easy reach near shops, yields by far the highest glass quality of the methods described. In consequence of altering the collection method to attract a greater number of unbroken bottles for reusage, the other class containers and scrap glass from the household are prone to be deposited together with the other types of household waste and are thereby exempted from recording. Therefore, the specific amounts calculated for different collections are to a certain extent based on different types of glass waste materials.

In Figure 5.5 the specific amounts of the different collections are illustrated. The collected amounts are high in the field trials and considerably lower in the permanent collections. Allerød (collection by voluntary organizations), Ballerup and Herlev (collection from single-family houses only) yield higher amounts than Helsingør (containers in local area), Randers and Aalborg. The amounts recorded in Randers and Aalborg are for the initial six months of the collections and may therefore not be representative of the areas. In Birkerød the collection of bottles in the specially designed glass containers has become a permanent arrangement. The specific amount averaged for the first five months in 1977 shows a value comparable with earlier results in Birkerød and the other field trials described. The difference between other permanent collections and Birkerød is remarkable, but cannot be explained in full on the basis of the information and data available. The continuation of over two years of reclamation in the municipality and a collection widely publicized in the media may have added to the collection efficiency. Other parameters may very well have an influence on the specific amounts, but uncovering of these through research studies has not taken place.

From a research study on the composition of household refuse, see Annex 5, Birkerød Field Trial A, the amount of glass materials before and during the field trial was measured. Before



1) COLLECTION OF GLASS IN CONTAINERS HAVE BECOME A PERMANENT ARRANGEMENT IN BIRKERØD.
AMOUNT IS AVERAGE OF FIRST FIVE MONTHS IN 1977

FIG. 5.5 SPECIFIC AMOUNTS OF RECLAIMED GLASS IN DIFFERENT COLLECTIONS.

the trial the amount of glass in the ordinary weekly collected household refuse was 2.1 kg* per household per month, and during the trial 1.1 kg. The collected specific amount is recorded at 3 kg, which indicates that more material is attracted to the 'controlled' combined collection of refuse and reclamation materials than before initiating the trial.

Averaged on a yearly basis, the number of collected reusable bottles accounted for in the described collections and including the Birkerød permanent arrangement ab January 1977 (totalling approx. 390,000 inhabitants or 8% of population in Denmark) will be approx. 0.9 million wine and spirits bottles**, equalling 500 tons. The number of reusable wine and spirits bottles cleansed in Denmark is approximately $25 \cdot 10^6$ bottles (14,000 tons) per year, and the total number of circulating wine and spirits bottles is 180 million. The amount of glass bottles and other glass containers consumed in Denmark is estimated to be 160,000 tons.

5.5 Iron and Non-ferrous Metals

The specific amounts of iron and non-ferrous metals collected from households are specified in Table 5.8 for the different collections. The amounts are of the same magnitude in both field trials and permanent collections. In Table 5.1 the percentages of iron and non-ferrous metals out of the total collected waste materials are found.

The total monthly collected amounts are 71 tons or 850 tons a year for the permanent collections in Ballerup, Herlev, Rødovre, Randers and Aalborg. The population involved in collections in these five municipalities amounts to 290,000.

---

*) Calculated on a 0.8 participation factor. See also Table 5.2 in Annex 5.

**) Average monthly collected reusable bottles in Allerød, Ballerup, Herlev, Rødovre, Helsingør, Randers, Aalborg, and Birkerød: 74,000, equalling 41 tons.

Table 5.8: Specific Amounts of Iron and Non-ferrous Metals Collected in Different Collections.

	Municipality	Specific amount per household per month	
		Field Trial	Permanent Collection
Annex 2	Allerød		- 1)
Annex 3	Ballerup	1.3 kg	
Annex 4	Ballerup		1.15 kg
Annex 5	Birkerød Trial A	1.0 kg	
Annex 5	Birkerød Trial B	-	
Annex 5	Birkerød Trial C	-	
Annex 6	Bogense	0.5 kg	
Annex 7	Greve	-	
Annex 8	Helsingør		-
Annex 9	Herlev		1.34 kg
Annex 10	Randers		0.3 kg
Annex 11	Rødovre		0.97 kg 2)
Annex 12	Silkeborg	-	
Annex 13	Aalborg	0.97	
Annex 14	Aalborg		0.58 kg

1) - : Not collected.

2) Mean value of Ballerup, Herlev and Rødovre collections in 1977.

According to the research study on composition of household refuse performed during the Birkerød Trial A Collection, Annex 5, the amount of iron, aluminium and other non-ferrous metals constituted 1.22 kg* per household per month before the trial and 1.15 kg during the trial. The comparable calculated specific amount of collected material is 1.0 kg, indicating that materials earlier disposed of in other ways are attracted into the collection.

The majority of the collected iron and non-ferrous metals is iron (approx. 90% weight).

The amounts recorded are insignificant when compared with for example the yearly amount of 450,000 tons of iron and steel scrap delivered to the Danish mills and foundaries.

*) Calculated on a 0.8 participation factor. See also Table 5.2 in Annex 5.

5.6 Textiles

The specific amounts of rags collected from households are specified in Table 5.9 for the different collections.

The few data available give no indication of any comparable relationship between collections. The calculated averaged amounts collected per year from the permanent collections are only 37 tons.

Table 5.9: Specific Amounts of Rags Collected in Different Collections.

	Municipality	Specific amount per household per month	
		Field Trial	Permanent Collection
Annex 2	Allerød		0.09 kg[1)]
Annex 3	Ballerup	0.2 kg	
Annex 4	Ballerup		0.02 kg
Annex 5	Birkerød Trial A	- 2)	
Annex 5	Birkerød Trial B	-	
Annex 5	Birkerød Trial C	-	
Annex 6	Bogense	-	
Annex 7	Greve	-	
Annex 8	Helsingør	-	
Annex 9	Herlev		0.01 kg
Annex 10	Randers		0.1 kg
Annex 11	Rødovre		-
Annex 12	Silkeborg		-
Annex 13	Aalborg	-	
Annex 14	Aalborg		-

1) Old clothing collected as well, but not included in specific amount.

2) - : Not collected or no data available.

SECTION 6 ECONOMY

No collection of reclaimed waste material arranged by municipalities has been or is profitable because the prices offered by the reclamation industry do not cover the costs of collecting.

After the period in 1974 with the extremely high price level for reclaimed paper and cardboard - mixed quality fetched around DKr 250.00, September 1974 (January 1977: DKr 328.00, EUA 50.00)* - the prices have decreased to DKr 50.00, January 1977, EUA 7.63.

The prices paid by the reclamation industry for reclaimed wastes are related to parametres influenced by the national and international supply/demand situation and fluctuate accordingly to time. The proceeds from sale of the collected reclaimed waste materials in the different collections are therefore accidental seen in relation to type of collection, collection method, etc.

Beside the proceeds from sale of waste materials the reduced volume in ordinary household wastes represents a proceed as well because of the consequent decrease in capacity, in transport and in ultimate disposal.

*) Quoted prices are dated. According to documentation available the prices, for the sake of comparison, have been converted to a reference date: January 1977. Calculation is based on official Danish price index. Conversion to European Units of Account. EUA: January 1977: 100 EUA = 655 DKr. November 1977: 100 EUA = 716 DKr.

Current prices* paid by the reclamation industry can be quoted as:

(Autumn 1977)

Corrugated Paper	DKr 150.00 per ton	(EUA 21.00, Nov 77)
Newspapers	DKr 100.00 per ton	(EUA 14.00, Nov 77)
Mixture of Paper and Cardboard	DKr 50.00 per ton	(EUA 7.00, Nov 77)
Magazines	DKr 20.00 per ton	(EUA 2.80, Nov 77)
Glass, Scrap, Mixed Colours	DKr 36.00 per ton	(EUA 5.00, Nov 77)
Glass, Scrap, Colour-sorted		
Green	DKr 80.00 per ton	(EUA 11.20, Nov 77)
White & Brown	DKr 150.00 per ton	(EUA 21.00, Nov 77)

Documentation of costs for collection of reclaimed materials is available for four of the collections described.

Allerød	(Annex 2)	Managed by voluntary organizations.
Birkerød	(Annex 5)	Arranged by the municipality of Birkerød. Three different Field Trials.
Bogense	(Annex 6)	Field Trial arranged by the municipality.
Greve	(Annex 7)	Field Trial arranged by the municipality, the county and the paper industry.

For the permanently arranged collections economic data about the reclamation have not been available, mainly because the collection of reclaimed wastes is a part of the collection of other types of household waste and is administered technically and economically as a whole. As a rule all the wastes are collected by the same collection enterprise, and costs are not

*) The quoted prices are indications only and vary according to quantity, quality and specific gravity. Glass prices are specially subject to variations because of the sensitivity to impurities of the processes.

specified especially for the reclamation activity.

From research study undertaken by Enviroplan A/S a price for the cost of the additional collection of reclaimed waste materials from households is available. The price is based on a simultaneously performed monthly collection of garden and bulky wastes and reclaimed materials with two collection vehicles.

In Table 6.1 the costs of collecting reclaimed materials in different collections are found. The costs are unspecified, but cover: Paper bags, container hiring, wages and transportation costs but are exclusive of administration.

The prices for Birkerød, Bogense and Greve comprise separate collection rounds outside other collection activities of refuse and waste in the municipality. The price for Bogense has been calculated for the complete trial period in which collection took place every fortnight the first six months and monthly the last six months.

The price quoted for the Allerød collection organized by voluntary organizations is, of course, exclusive of wages.

The lowest cost per ton of reclaimed waste materials collected seems to be obtained when the reclamation collection becomes part of a combined collection activity where the different types of waste are collected. The weekly collected household refuse is outside of this activity. The low cost quoted remains to be verified.

Table 6.1: Costs per Ton of Collecting Reclaimed Materials from Households. Except for Allerød and Enviroplan Research the Materials are Collected in Paper Bags and Containers. In Allerød the Materials are Deposited by the Pavement. A Combined Collection with two Vehicles Collecting Garden and Bulky Wastes and Reclaimed Waste Materials is the Basis of the Price Quoted for Enviroplan Research.

Annex	Collection	Collection Frequency	Paper & Cardboard	Glass & Iron and Non-ferrous Metals	Price Converted to January 1977	
					DKr	EUA
5	Birkerød. Field Trial A	14 days [1]	--------	474.00 --------	547.00	83.51
5	Birkerød. Field Trial B	Monthly [1]	665.00	Glass in Containers	714.00	109.00
5	Birkerød. Field Trial C	Single-family H.: Bimonthly Apartment H.: 14 days	466.00 430.00	Glass in Containers Glass in Containers	473.00 437.00	72.21 66.72
6	Bogense. Field Trial	First 6 months: 14 days Last 6 months: Monthly	--------	600.00 --------	692.00	105.65
7	Greve. Field Trial	Monthly[1]	308.00	Not Collected	360.00	54.96
2	Allerød. Permanent Collection by Voluntary Organizations	Monthly[1]	--------	175.00 --------	183.00	29.62
			Glass/Bottle Container Near Shops			
5 5	Birkerød. Field Trial B Birkerød. Field Trial C	Twice Weekly or When Full	243.00		254.00	38.78
			Part of Total Waste Collection Arrangement. All Types of Materials			
Enviroplan A/S. Research		Monthly Together with Garden and Bulky Wastes	Approx. 175.00		175.00	26.72

1) Single-family and apartment houses in same area.

SECTION 7 RESEARCH AND DEVELOPMENT. PROPOSALS

The knowledge of reclamation of waste materials from households is to a great extent based on accidental information from the collections. In some cases a great effort has been made to obtain information of the possible relationship between different parametres influencing the amounts yielded. But it is probable that not all parametres have been disclosed, and it is obvious that those focused on in the past and at present are not measured with the degree of exactitude which is necessary to make correct conclusions.

To increase the knowledge of reclamation of waste materials from households research studies must be undertaken.

In this section research is proposed on subjects on which lack of sufficient knowledge has been found. Recording of fundamental data as well as detailed studies of already developed processes are proposed.

During the preparation of this study exchange of views on needed research and development has taken place with Stichting Verwijdering Afvalstoffen, Holland, the Department of the Environment, United Kingdom, and the Danish National Agency of Environmental Protection.

1) Standard definitions of terms, waste components and analyzing should be agreed upon.

   The definition of waste components should be related to both "waste" and to "secondary raw material".

2) Standard definition of costs and benefits in connection with retrieval of "secondary raw materials" from households.

The costs and benefits should be evaluated from a profitability point of view which also includes environmental and resource oriented aspects both locally and nationally.

3) Amounts of waste produced by the household and composition of the wastes should be recorded in detail.

A necessary and sufficient knowledge of amounts and composition of wastes is needed to enable a usage of statistical predictions on a national scale. Influence of social and sociological parametres should be disclosed. The relationship between amounts reclaimed from households and materials from other sources should be established.

4) A more detailed knowledge is needed about when and how products become waste during the flow through the household.

This knowledge is essential in order to establish a relationship between quality of potential reclaimable waste material and the moment at which the waste is retrieved for reclamation.

5) Research should be undertaken on the possible degree of extraction of reclaimable waste materials from the households.

This includes research into possible parametres influencing the motivation for participation in reclamation. The impact on way of life and waste handling traditions in the households according to type of collection (collection by voluntary organization, as part of Total Waste Collection Arrangement by municipality, collection by reclamation industry) should be evaluated. Amounts collected in relationship to collection method, collection frequency, type of residence, etc, should be studied.

Research and development studies are needed especially for apartment houses where the recorded results generally show

smaller collected specific amounts (i.e. per household) than for single-family houses. Specially applied collection methods have indicated during a field trial that increases of specific amounts are possible. Introduction of two or more refuse chutes in apartment houses would possibly yield greater specific amounts.

6) Degree of efficiency in collecting and transporting of reclaimed wastes should be recorded and relationship to methods and techniques established.

Design of collecting vehicle related to types of wastes to be collected from the households should be studied. Lower costs have been recorded per ton of collected reclaimed waste when collection was part of a Total Waste Collection Arrangement comprising garden and bulky wastes as well. Type, number and design of vehicles used in the collection rounds influences to a great extent the costs of collection because man-hours spent are directly related to these parametres. All handling of reclaimable wastes must be regarded in relation to material quality wherefore a necessary and sufficient degree of sorting is interrelated with the sensitivity of the industrial processes when using secondary raw materials.

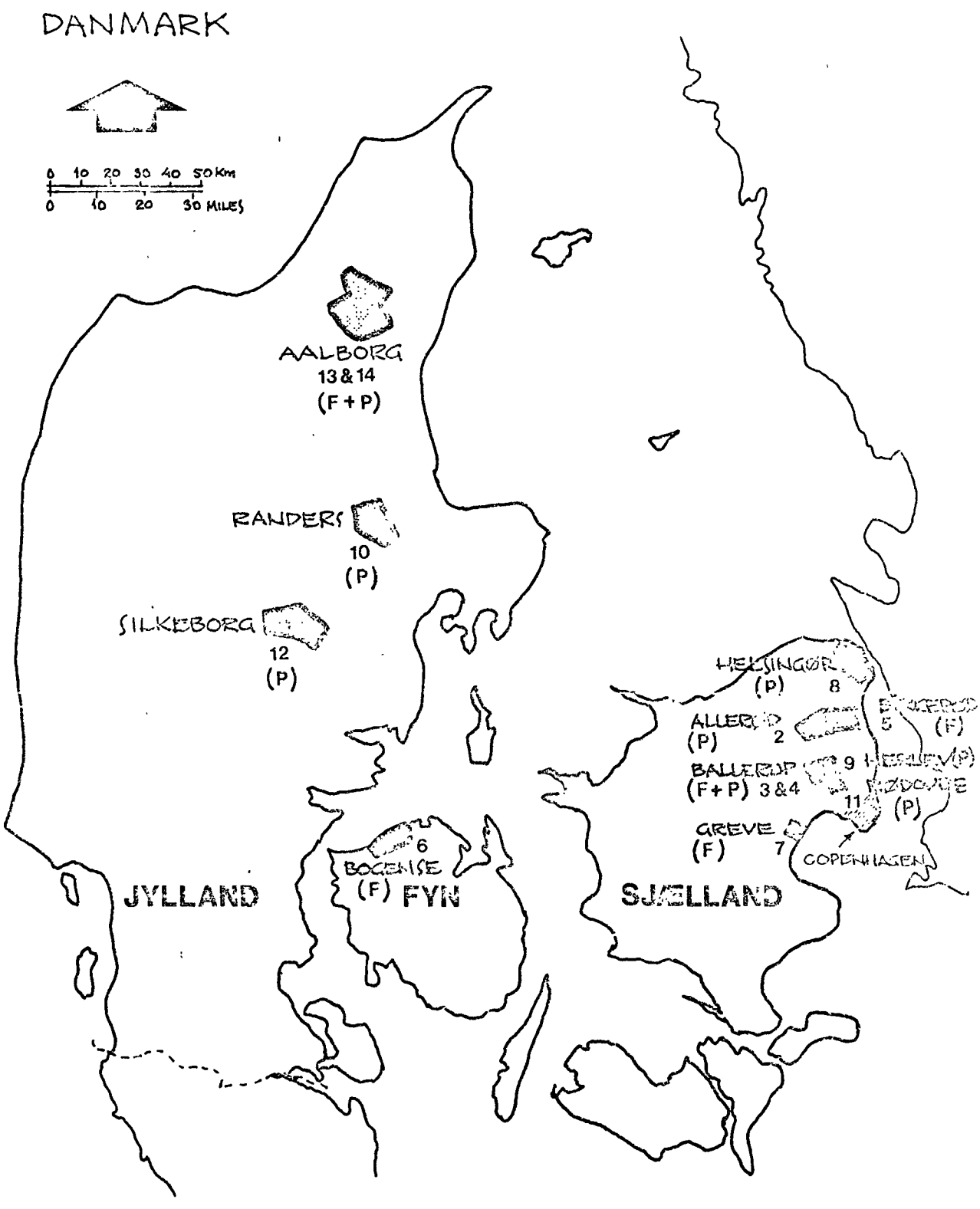
7) Research should be undertaken of the changes in waste production by households and in the flux of the amounts of reclaimable and reclaimed waste materials as a result of introducing intensified or mandatory collections and recycling.

It is important to obtain a knowledge about possible introduction of substitutional materials in the household due to alteration of waste flow. The relationship between proposed changes of collections and the resulting reactions in household behaviour should be known to prevent unnecessary and unwanted changes in amount and quality of reclaimable waste materials.

ANNEXES

INDEX

After Index and before Annex 1, a map of Denmark is found with indication of municipalities in which the collections described have taken place.



NUMBER REFERS TO ANNEX

F : FIELD TRIAL
P : PERMANENT COLLECTION

FIG. A1 : POSITIONING OF MUNICIPALITIES DESCRIBED IN THE ANNEXES 2 TO 14.

ANNEX 1

REFERENCES

R 1: Gendan Ltd. The Society for Encouraging Recycling in Denmark. Members: National Association of Danish Municipalities, the Danish Society for Conservation of Nature, Societies and Limited Companies representing the paper industry, the reclamation industry, the container industry, suppliers of waste handling equipment, refuse bags, etc.

R 2:

Annex 2, Allerød
Annex 3, Ballerup
Annex 4, Ballerup
Annex 9, Herlev
Annex 11, Rødovre
Personal communication with management staff. Personal communication with administration staff of the municipalities and the regional incineration plant, Vestforbrænding.

Annex 5, Birkerød Report by the Danish National Agency of Environmental Protection: "Reclamation Field Trial in the Municipality of Birkerød, September 1, 1974 to December 31, 1976". July 1977. "Reclamation Field Trial 1974-75, Municipality of Birkerød", Enviroplan A/S, February 1976. Personal communication with administration staff.

Annex 6, Bogense Report by Leif Eskelund: "Reclamation Field Trial in Bogense", August 1975. Personal communication with administration staff of the municipality.

Annex 7, Greve	Report, "Field Trial of Reclamation of Used Paper", May 1975, by the municipality of Greve, the county of Roskilde and Forenede Paper Mills Ltd.
Annex 8, Helsingør	Personal communication with administration staff of the municipality of Helsingør.
Annex 10, Randers	Personal communication with administration staff of the municipality of Randers.
Annex 12, Silkeborg	Personal communication with administration staff of the municipality of Silkeborg.
Annex 13, Aalborg Annex 14, Aalborg	Personal communication with administration staff of the municipality of Aalborg.

VOCABULARY

Cardboard	General term used for all varieties such as millboard, pasteboard, etc.
Single-family house	General term used for detached, semi-detached and terrace houses.
Apartment house	A house with more than 2 flats and households living on a first floor. Residence usually without extra space available for accumulated wastes.
Back-loader	Waste collection vehicle where waste is loaded at the back end and supplied with a compression unit to increase amount carried.

Container	General term used for steel boxes with up to e.g. 30 cubicmetres. Usually furnished with lockable lids.

ANNEX 2

THE MUNICIPALITY OF ALLERØD. PERMANENT COLLECTION.

The municipality of Allerød is positioned 25 kilometres from Copenhagen and covers 7,800 ha (19,200 acres). The population is 20,700.

1. Description of Collection

The collection which started in 1974 is solely managed by voluntary organizations. From all households in the municipality the materials are collected monthly. The collection takes place on Saturdays and vehicles collect the materials deposited by the households on the pavements in various disposable plastic and paper bags or in returnable containers.

During and after the collection a sorting of the collected reclaimed materials takes place with the object of producing high qualities of reclaimed wastes. The motivation of the voluntary organizations to obtain the better prices for higher qualities is strong regardless of the extra man-hours necessary - which in this case are without economic consequence. At a central reclamation centre the materials are deposited in containers - one for every quality sorted: loose newspapers, bundled newspapers, cardboard, mixed household paper, etc. Also baling of paper is executed by the voluntary organizations.

The materials are sold sorted to the reclamation industry. It was not earlier possible to sell "Mixed Household Paper", and this grade was therefore disposed of at the regional incineration plant. Recently (summer 1977), though, this grade is sold as well to the industry.

Paper and cardboard, bottles, jars, rags, and old clothes are collected. Iron and non-ferrous metals are not collected.

Besides the regular, weekly collection of household refuse the municipality has established two centres with containers into which all citizens can dispose of their garden and bulky wastes.

2. Reclaimed Waste Materials

The collection comprises the following reclaimable waste materials:

Paper and Cardboard:

Newspaper, magazines, paper, and cardboard. Contaminated materials such as plastic coated paper are not collected.

Glass:

Bottles, jars, and scrap glass. The reusable bottles are sorted out during and after the collection.

Rags and Clothes:

Textiles of all sorts. Also here a sorting takes place.

3. Population

The population is 20,700 and the number of households is 6,800. Of these 81% live in single-family houses.

4. Amounts of Reclaimed Materials

The specific amounts of reclaimed waste materials is averaged on the basis of the total number of households in the municipality.

	Monthly average per household in 1976:	
Newspapers	2.00 kg	(49%)
Magazines	0.08 kg	(3%)
Cardboard	0.82 kg	(20%)
Glass, reusable bottles	0.94 kg	(23%)
Glass, scrap	0.17 kg	(4%)
Rags	0.09 kg	(3%)
Total	4.1 kg	(100%)

Information about specific amounts collected from single-family houses and apartments respectively is not available.

The total monthly amounts collected in 1976 were:

	Monthly average:	
Newspapers	13.8 ton	
Magazines	0.5 ton	
Cardboard	5.5 ton	
Glass, reusable bottles	9.2 ton	(16,700 bottles)
Glass, scrap	1.1 ton	
Rags	0.6 ton	
Total	30.7 ton	

ANNEX 3

THE MUNICIPALITY OF BALLERUP. SKOVLUNDE FIELD TRIAL.

The municipality of Ballerup is situated 14 kilometers from the center of Copenhagen. It covers an area of 3,264 hectares (8,062 acres), and the population is 51,300. Ballerup is a suburb of Copenhagen.

1. Description of Collection

In a residential area in the municipality of Ballerup, a field trial was performed from 1st January 1975 to 31st December 1975. The trial covered 1,650 households in single-family houses. The collection of reclaimed waste materials became an integrated part of the usual collection of household refuse and other household waste. Household refuse and garden waste were collected weekly, and every fortnight reclaimed waste was collected.

The households placed the separated reclaimed waste materials at the pavement. The materials were separated into six categories placed in various bags and sacks. Specially marked containers were returned empty to the household. The materials were collected by a lorry with six compartments in which the reclaimed wastes were placed.

The collected reclaimed waste materials were transported directly by the collection lorries to the regional incineration plant, in which Ballerup shares a partnership with 11 other municipalities. From here the materials were sold to the reclamation industry. Household refuse and garden refuse were as usual disposed of in the incineration plant.

2. Reclaimed Waste Materials

In the field trial the following waste materials were reclaimed:

Paper and Cardboard:

Newspapers, magazines, paper, cardboard, etc. Clean and dry materials only. Contaminated materials such as plastic coated paper were not collected.

Glass:

Bottles, jars and scrap glass. Covers and caps were not collected.

Iron and Non-ferrous Metals:

All types of tins and cans as well as other iron and non-ferrous metal waste.

Rags:

Textiles of all sorts.

Also bulky wastes like furniture, bicycles, etc, and waste oil, were collected. Waste oil was canalized into a specially nation-wide collection system, and the large pieces of household waste were not reclaimed at the point of collection.

The above specifications were the only ones used during the trial. The citizens were carefully informed about the specifications.

3. Population

The population in the field trial area was 5,080 persons. The average percentage of participation was approximately 70%. Number of households in the area: 1,650.

4. Amounts of Reclaimed Materials

The specific amounts of reclaimed materials have been averaged on the basis of the total number of households in the area, and not only on the participating households.

	Monthly average per household:	
Paper and cardboard	2.1 kg	(36%)
Glass	2.2 kg	(38%)
Iron and non-ferrous metals	1.3 kg	(22%)
Rags	0.2 kg	(4%)
Total	5.8 kg	(100%)

The total amounts collected were:

	Monthly average:
Paper and cardboard	3.5 ton
Glass	3.5 ton
Iron and non-ferrous metals	2.2 ton
Rags	0.3 ton
Total	9.5 ton

The reclaimed materials have amounted to 15% of the total collected amount of household refuse, reclaimed waste and garden waste.

ANNEX 4

THE MUNICIPALITY OF BALLERUP. PERMANENT COLLECTION. (See also Annex 3).

1. Description of Collection

Following the Skovlunde field trial and based on the experiences gained, a permanent arrangement for single-family houses only was introduced on 1st February, 1976, with collection of reclaimed waste materials sorted by the households. The collection of the reclaimed materials is an integrated part of a Total Waste Collection Arrangement comprising all forms of waste from household: household refuse, garden waste and bulky waste. Collection of surplus earth and building site waste is not included in the arrangement.

The collection follows the same pattern as in the Skovlunde field trial, with collection every fortnight of the reclaimed waste material sorted by the households in various disposable paper and plastic bags or in permanent returnable containers placed by the pavement. The materials are collected by a lorry with compartments for the sorted waste. Household refuse is collected separately weekly, and garden refuse weekly between 1st April and 30th November.

The reclaimed materials are transported directly to the regional incineration plant, in which Ballerup shares a partnership with 11 other municipalities. From the plant the materials are sold to the reclamation industry. All other refuse is disposed of at the incineration plant.

2. Reclaimed Waste Materials

The collection comprises the same categories of reclaimable

materials as in the Skovlunde field trial.

The categories are:

Paper and cardboard
Glass
Iron and non-ferrous metals
Rags
Large pieces of household refuse
Waste oil

For a more detailed specification, see Annex 3.

3. Population

The population involved in the permanent collection of reclaimed waste materials are 20,000. The number of households is 6,600. This is 40% of the total population in the municipality.

4. Amounts of Reclaimed Materials

The specific amounts of reclaimed materials are averaged on the basis of the total number of households included in the collection, 6,600, and not only on the participating households.

The specific amounts for the period of eight months from February to September, 1976, are:

	Monthly average per household: (mean of 8 months)	
Paper and cardboard	2.51 kg	(57%)
Glass	0.75 kg	(17%)
Iron and non-ferrous metals	1.15 kg	(26%)
Rags	0.02 kg	(-)
Total	4.43 kg	(100%)

The total amounts collected were:

	Monthly average: (mean of 8 months)
Paper and cardboard	16.6 ton
Glass	5.0 ton
Iron and non-ferrous metals	7.6 ton
Rags	0.13 ton
Total	29.3 ton

Data about quantities of materials from the municipality of Ballerup is not available for the period after September 1976. The reclaimed materials are today handled together with those of the municipalities of Herlev and Rødovre. The total amounts of reclaimed materials collected in the three municipalities have stabilized on a constant level in 1977. See Annex 11, Rødovre, paragraph 4, for averaged specific amounts in 1977.

ANNEX 5

THE MUNICIPALITY OF BIRKERØD. FIELD TRIALS.

The municipality of Birkerød is situated 25 kilometres from Copenhagen, and covers an area of 3,500 hectares (8,650 acres). The population is 22,000, whereof 20,000 live in the town of Birkerød.

1. Introduction

Since 1st September, 1974 field trials of collection of reclaimable consumers waste materials have taken place in the municipality of Birkerød in a period of 28 months ending on 31st December, 1976. The collection methods have been altered through the period, and because of the alterations and the extension of the periods of the trials - 14 months, 6 months, and 8 months - the results obtained have ensured reliable information about sorting at source of consumers wastes under different circumstances.

Field Trial A. Period: 14 Months

Paper, glass, iron, and non-ferrous metals were collected every fortnight from the households.

Field Trial B. Period: 6 Months

Paper was collected monthly from the households. Bottles etc were collected separately in containers positioned in 20 different places throughout the municipality. The citizens were supposed to deposit their bottles and jars in the containers. These were within easy reach for everyone near shopping centres.

Field Trial C. Period: 8 Months

Paper was collected every second month from the households.

Paper collection methods specially adapted for the different apartment houses were introduced. Bottles etc were collected separately in containers as in trial B.

In the following paragraphs each field trial is separately described together with results. Research studies conducted during trial A are described in paragraph 2.5. In paragraph 5 comparisons between yielded amounts of reclaimed materials in the three trials are summarized.

The field trials in Birkerød have been the most comprehensive in Denmark. The municipality of Birkerød in collaboration with the reclamation industry managed the trials and the Danish National Agency of Environmental Protection participated with contract studies and funds in general. As a consequence the Birkerød field trials have been analyzed in detail.

2. Field Trial A

2.1 Description of Collection

During a period of 12 months, from 1st September 1974 to 31st October 1975, a field trial of collection of reclaimed consumer waste materials sorted at source was carried through by the municipality of Birkerød. Besides the usual weekly collection of household refuse in paper bags, reclaimed waste materials were collected every fortnight in either paper bags or containers.

Two 60 litre paper bags, one intended for paper, the other for glass, iron, and non-ferrous metals, were placed at every single-family house. Likewise, at apartment houses, at ground level, there were placed either larger paper bags (100 litres) or two containers, the volume of which corresponded to the number of tenants. The household refuse was collected weekly as usual in 100 litre bags. The reclamation paper bags were for the sake of convenience placed beside the refuse paper bags and because of this exposure to open air made of the same high

all-weather quality.

The participation was voluntary, but the field trial was proposed to cover 21,000 of the 22,000 citizens. The remaining 1,000 residing in an area outside the town of Birkerød participated in the collection by means of containers placed centrally in the local area. The reclaimed materials were deposited in one container through a slit to prevent unwanted access to the materials, and in another container non-reclaimable waste could be deposited. Throughout the trial the participation varied around a monthly average of 80% of all the households, with a minimum of 70% and a maximum of 93%.

Also local industrial enterprises participated in the trial, but the following information deals exclusively with consumer waste.

The reclaimed materials were collected by a lorry with two compartments, one for each type of bag with sorted waste. When the filled bags were collected, two new paper bags were delivered. The collection rounds of the reclaimed waste materials were performed outside the usual routine of household refuse collection. The reclaimed waste was collected by the same private collection firm that had a long-term contract of refuse collection with the municipality.

The reclaimed materials were transported directly in the paper bags to the reclamation industry outside the municipality.

Simultaneously, the household refuse was, as usual, transported directly to the regional incineration plant, in which Birkerød shares a partnership with 11 other municipalities. (See also Annexes 4, 9, 11, Ballerup, Herlev, and Rødovre, respectively.)

2.2 Reclaimed Waste Materials

In the field trial the following waste materials were reclaimed.

Paper and Cardboard:

All types of paper, newspapers, magazines, etc. Dry and clean materials only. Contaminated paper, such as plastic coated paper and carbon paper, was not collected. Cardboard was supposed to be bundled and placed beside the reclamation bags.

Glass:

All types of bottles, jars, scrap glass, etc. The instruction stated that covers and caps were not accepted.

Iron and Non-ferrous Metals:

All types of tins and cans as well as other iron and non-ferrous metal waste.

No other specifications of the reclaimed materials were used, and the materials were received by the reclamation industry in the unopened reclamation bags.

The citizens were carefully instructed about the specifications of the reclaimed waste to be collected.

2.3 Population

The total population in the municipality during the field trial was 21,800. The proposed participants were 21,000 (97%) in residential areas, covering 2/3 of the total area of the municipality.

The residences in Birkerød consist of 7,000 households with 71%, 5,000, living in single-family houses, and the remaining in apartment houses.

2.4 Amounts of Reclaimed Materials

The amounts of collected materials were biggest in the beginning of the trial period. Later on smaller amounts were collected, but the monthly amounts stabilized and were nearly constant during the last eight months of the fourteen months field trial.

It is on the basis of the last 8 months that the amounts of reclaimed waste have been calculated. The amounts of reclaimed materials have been averaged on the basis of the total number of households in the municipality, and not only on the participating households.

In Table 5.1 the reclaimed amounts are presented.

	Monthly Average per Household		
	Paper & Cardboard	Glass/Iron & Metals	Total
Single-Family Houses	5.5 kg	4.9 kg	11.4 kg
Apartment Houses	1.8 kg	2.6 kg	5.8 kg
Average for Birkerød	4.4 kg (55 %)	4.0 kg* (45 %)	8.4 kg (100 %)

*) Of the 4.0 kg approximately 3 kg is glass.

Table 5.1: Monthly Average of Reclaimed Waste per Household in Birkerød. Averaged on Total Number of Households. Trial A.

The total amount collected per month was 57.5 tons (average of six months):

Paper & Cardboard	-	31.0 tons per month
Glass	-	22.8 tons per month
Iron & Metals	-	3.7 tons per month

2.5 Research Studies

During the field trial special research studies were made to obtain detailed information, and the Danish National Agency of Environmental Protection participated in the field trial making a study of the average composition of household refuse. Studies were also performed concerning the composition of the reclaimed materials.

The research studies were based on waste materials from a selected number of households. The specific amounts mentioned in the following paragraphs do not correspond with the averaged amounts in Table 5.1, the reason being the different number of waste bags examined for each specific study.

The amounts in Table 5.1 have been averaged on six months of the 14 months trial period and thereby give the most realistic specific amounts. Amounts collected in the beginning of the trial have been influenced by materials from the period before the trial.

2.5.1 Composition of the Household Refuse

Table 5.2 presents the composition of household refuse before and during the field trial.

Table 5.2: Composition of Household Refuse Before and During the Field Trial.

Type of waste	Before trial. Average of 71 paper bags*)			During trial. Average of 154 paper bags*)		
	Mean weight kg	Range kg	%	Mean weight kg	Range kg	%
Organic kitchen refuse	3.790	2.655	33.5	3.846	2.468	39.2
Wet paper	1.276	0.787	11.3	1.290	1.341	13.1
Coated paper	0.480	0.410	4.2	0.547	0.410	5.6
Clean paper	1.053	1.861	9.3	0.518	0.795	5.3
Clean cardboard	0.211	0.265	1.9	0.124	0.184	1.3
Wood	0.519	3.676	4.6	0.086	0.245	0.9
Leather	0.241	1.678	2.1	0.026	0.185	0.3
Rubber	0.315	2.376	2.8	0.030	0.146	0.3
Textiles	0.206	0.370	1.8	0.204	0.452	2.1
Plastics	0.632	0.443	5.6	0.580	0.360	5.9
Iron	0.250	0.306	2.2	0.192	0.302	2.0
Aluminium	0.058	0.068	0.5	0.119	0.153	1.2
Other metals	0.073	0.231	0.6	0.040	0.135	0.4
Glass	0.653	0.707	5.8	0.357	0.693	3.6
Ceramics and pottery	0.059	0.208	0.5	0.091	0.489	0.9
Garden refuse	0.480	1.822	4.2	0.778	3.531	7.9
Other refuse	1.029	1.766	9.1	0.992	1.507	10.1
Average per refuse bag, kg	11.325	8.751	100.0	9.820	5.306	100.0
Specific gravity, ton/m^3	0.180	-	-	0.127	-	-
Reclaimable portion per refuse bag, kg	2.298	-	20.3	1.350	-	13.7

*) One paper bag represents the weekly amount of refuse from one household.

The maximum reclaimable amounts of paper, glass, iron, and non-ferrous metals in the household refuse can be extracted from Table 5.2:

	Before field trial	During field trial
	(monthly amount per household) (i.e. 4 refuse bags)	
Clean paper, cardboard, etc	5.1 kg (11.2%)*	2.6 kg (6.6%)
Glass, iron, non-ferrous metals	4.1 kg (9.1%)	2.8 kg (7.1%)

*) (1.053 + 0.211) x 4 = 5.1 kg

The maximum amounts of reclaimable materials are not separated. Only 49% of the paper is reclaimed, and 32% of the combined amount of glass, iron, and non-ferrous metals.

2.5.2 Composition of the Reclaimed Materials

Table 5.3 and 5.4 show the composition of reclaimed paper and glass based on 172 reclamation bags.

Table 5.3: Composition of Reclaimed Paper.

Newspapers	4.2 kg	42%
Magazines	2.3 kg	23%
Printed paper	0.9 kg	9%
Other	2.7 kg	26%
Average per participating household per month	10.1 kg	100%

Table 5.4: Composition of Reclaimed Glass.

Bottles, jars, etc	8.0 kg	98%
Broken glass	0.2 kg	2%
Colour. White	3.8 kg	46%
Green	3.4 kg	41%
Brown	1.0 kg	13%
Average per participating household per month	8.2 kg	100%

3. Field Trial B

Due to lack of funds and because of the wish to test other methods the collection of reclaimable materials from households was altered in Field Trial B. The trial period was 6 months from 1st November, 1975 till 30th April, 1976.

3.1 Description of Collection

Iron and non-ferrous metals were excluded in the collection. Only paper and cardboard were collected from the households. A 100 litre paper bags were distributed to all single-family houses in the municipality and the bags with the reclaimed paper and cardboard were collected monthly. To apartment houses an appropriate number of paper bags were distributed. Cardboard in greater amounts was asked to be bundled with strings. When the materials were collected, additional paper bags were distributed to replace the filled. The containers put at disposal for the apartment houses in Field Trial A were withdrawn, but privately owned or leased mini-containers were offered emptied fortnightly. The regular household refuse collection continued as during Field Trial A with weekly collections and was not correlated with the reclaimed waste collection. The reclaimed waste paper and cardboard were transported directly in the paper bags to the reclamation industry.

Glass was not collected from the households as in Trial A, but placing of 35 specially constructed glass containers in 20 different positions throughout the municipality was tried as a cheaper collection method and introduced as a collecting method to enable reclamation of a greater amount of reusable bottles - especially wine bottles. Beer, lemonade and sodawater are distributed in Denmark to a very great extent in returnable bottles wherefore the glass in household waste mainly comprises wine bottles and jars of all sorts.

As iron and non-ferrous metals constituted only 16% (weight) of the combined total amounts of glass, iron, and metals collected in Field Trial A, and as, further, it was found that extraction of reusable bottles from the paper bags was a complicated and slow operation, the iron and metals were excluded from the collection and the glass container system was chosen. The specially constructed glass container prevents bottles from being broken when deposited. A more detailed description of the container can be found in Annex 14 in paragraph 1, Description of

Collection.

At a reclamation centre in the municipality the contents of the glass container were sorted by a reclamation enterprise into reusable bottles and jars and into green, brown, and white scrap glass.

The collection from single-family houses was performed as in trial A by separate rounds and did not interfere with the regular weekly household refuse collection. The glass containers which contained approximately 300 wine bottles were emptied twice a week when full. The reclaimed paper and cardboard were transported directly to the reclamation industry outside the municipality.

3.2 Reclaimed Waste Materials

The specification of reclaimed paper and cardboard were the same as in trial A - clean and uncontaminated. All types of class were collected but the design of the special glass containers clearly points towards collection of unbroken and reusable bottles.

3.3 Amounts of Reclaimed Materials

The amounts of collected materials are presented in Table 5.5.

	Monthly Average per Household		
	Paper & Cardboard	Glass	Total
Single-Family Houses	4.6 kg	-	-
Apartment Houses	1.0 kg	-	-
Average for Birkerød	3.6 kg (55 %)	2.9 kg (45 %)	6.5 kg (100 %)

Table 5.5: Monthly Average of Reclaimed Waste per Household in Birkerød. Averaged on Total Number of Households. Field Trial B, Collection Monthly of Paper and Cardboard and Glass in Special Glass Containers.

Of 1,892 emptied glass containers in the twelwe months period from 1st January till 31st December, 1976 (Field Trial B and C) the averaged monthly amount was 22 tons. Of this amount 45% (weight), 17,600 bottles, were unbroken and reusable, and the remaining 55% was scrap glass. The scrap glass was sorted according to green (60%), white (27%), and brown (13%) colours.

The total amount collected during Field Trial B per month was 47 tons (average of six months).

Paper and Cardboard	-	25.0 tons per month
Glass	-	20.1 tons per month

4. Field Trial C

To test the relationship between amounts of collected reclaimed paper and cardboard from households and the period between collection dates Field Trial C was initiated. The period between collection dates was extended to two months. Field Trial B had revealed that the amounts of paper and cardboard collected from apartments had diminished seen in relation to Field Trial A. A further extension of the period between collection dates to two months was foreseen to yield even lesser amounts from apartments. Therefore Field Trial C incorporated in 20 apartment houses individually applied collection arrangements with the intention of extracting maximum amounts of reclaimable paper and cardboard.

The glass container arrangement introduced in Field Trial B was continued without alterations. Field Trial C took place from May 1 to December 31, 1976.

4.1 Description of Collection

From single-family houses 100 litre paper bags were collected every two months, and the extended period was the only difference between trial B and C.

For 20 apartment houses constituting approximately 95% of all residences in this category of habitat special arrangements and individually applied, methods were introduced. This was done in close collaboration with the tenants and the janitors.

Some of the arrangements necessitated extra work by the janitor when collecting the reclaimed paper and cardboard which the households deposited at a central place on the premises. As the collection of reclaimed materials was voluntary, the extra work imposed on the janitors was anticipated, in some cases, to have influenced negatively on the amounts of materials collected.

The following different arrangements were tested in the trial:

		Houses	Apartments
I	Containers placed centrally at ground floor in open air	3	139
II	Containers placed indoors at ground floor in the usual refuse room	2	213
III	Paper bags (100 litres) placed centrally at ground floor in open air	1	36
IV	Paper bags (100 litres) placed indoors at ground floor in the usual refuse room or in another suitable room	8	903
V	Paper bags (100 litres) placed at at ground floor in all staircases	3	325
VI	Paper bags (100 litres) or loose materials placed at ground floor near receiving end of refuse chutes	2	240

		Houses	Apartments
VII	Mini paper bags (50 litres) placed in individual apartments collected weekly by janitor	1	126

Collection of filled paper bags and emptying of containers was performed fortnightly. In one case where a 16 cubicmetres container was used, only emptying took place when full.

The reclaimed paper and cardboard were transported, as in trial A and B, directly to the reclamation industry outside the municipality. The glass containers were emptied and the contents sorted at a central reclamation centre as in trial B.

The household refuse was separately collected and disposed of as during trial A and B.

4.2 Reclaimed Waste Materials

The specification of the reclaimed materials were the same as in trial B.

4.3 Amounts of Reclaimed Materials

The amounts of collected materials are presented in Table 5.6.

	Monthly Average per Household		
	Paper & Cardboard	Glass	Total
Single-Family Houses	3.5 kg	-	-
Apartment Houses	3.5 kg	-	-
Average for Birkerød	3.5 kg (54 %)	3.0 kg (46 %)	6.5 kg (100 %)

Table 5.6: Monthly Average of Reclaimed Waste per Household in Birkerød. Averaged on Total Number of Households. Field Trial C. Collection Every Two Months of Paper and Cardboard from Single-family Houses and Fortnightly from Apartment Houses. Glass Was Collected in Special Glass Containers as in Field Trial B.

The arrangements in the apartment houses were applicated to suit the different circumstances individually. The calculated specific amounts collected under the different circumstances must be regarded with uncertainty due to the varying degree of collaboration at the different apartment houses (janitor plus tenants). Specific amounts vary between 0.2 kg (house with 87 households) and 7.0 kg (house with 36 households) per month per household. According to collection method the specific amounts are:

		Number of Different Houses	Total Number of Households in the Houses	Specific amount per Month per Household
I	Centrally placed containers outside building	2	139	5.4 kg
II	Centrally placed containers in room at ground floor	2	213	3.2 kg
III	Paper bags at usual refuse area. Open air	1	36	7.0 kg
IV	Paper bags in refuse or other room at ground floor	5	903	3.1 kg
V	Paper bags at ground floor in staircases	3	325	4.8 kg
VI	Paper bags at ground floor near refuse chutes	2	240	2.7 kg
VII	Mini paper bags in apartments	1	126	4.5 kg

Extra work for the janitor takes place especially when using method V, VI, and VII, but due to variation in number of tenants and due to a varying degree of motivation, it is not possible to compare the different methods and conclude whether one is more efficient than the other.

The collection of glass in special glass containers was unaltered through Field Trial B and C.

The total amounts collected during Field Trial C per month was 46 tons (average of eight months):

Paper and Cardboard Collected from households	25 tons per month
Glass (17,100 reusable bottles, 9.4 tons)	21 tons per month

5. Reclaimed Materials and Household Refuse

During the field trials a relationship was sought established between the amounts of reclaimed materials and a corresponding decrease in the other categories of waste from the households. The amounts of household refuse, garden and bulky wastes, and reclaimed materials have been compared both on a monthly and a yearly basis. The reclaimed materials during trial A (collection every fortnight) amounted to 17% (weight) of the household refuse as measured before the trial. During trial B (monthly collection of paper and glass collected in containers) it was 10% and during trial C (collection of paper every second month and glass collected in containers) 12%. The observed decrease in household refuse corresponded more or less with the amounts of reclaimed wastes although there was a slight increase of the combined amounts of refuse and reclaimed waste materials.

These observations must be regarded as uncertain as it has been impossible to registrate a uniform tendency, but no doubt the field trials have attracted into the "controlled" collection system - waste that was earlier disposed of in other ways.

6. Summary of the Three Field Trials

In Table 5.7 the results of the three field trials in the municipality of Birkerød are summarized. Iron and non-ferrous metals have only been collected during trial A and have therefore been left out of the table.

The amounts of reclaimed paper and cardboard decreased by 19% when trial B with monthly collection instead of fortnightly was introduced. But a marked difference was observed between single-family houses, where the specific amount was reduced by only 16%, and apartments, where the reduction was 44%. The length of period between collection dates has clearly influenced on the amounts collected. In trial C, where the period between collection dates was extended to two months for single-family houses, the specific amount further decreased by 24% (a 36% decrease of trial A's amount). To prevent a foreseen, further reduction in amounts collected from apartments special arrangements applied individually to the different apartment houses were introduced and resulted in an increase from 1.0 kg per month per house (trial B) to 3.5 kg. The overall average for the municipality was 3.5 kg, 3% less than during trial B, and 20% less than trial A. The average total amounts were the same in trial C and trial B because of better collection efficiency for the 2,000 apartments despite the 24% decrease in amounts from the 5,000 single-family houses.

When first introducing collection of reclaimable waste materials from households it was understood that the ad hoc and regularly reclaimed waste collections performed by voluntary organizations were to continue. In the municipality of Birkerød a boy and girl scouts organization all through the field trials period continued to collect a constant amount of approximately 4.2 tons of newspapers per month. The scouts sold directly to the reclamation industry outside the official collection. The amounts from the scouts equal 13-17% of the officially collected amounts. If this amount is added to the values in Table 5.7, the total reclaimed amount of paper and cardboard collected

	PAPER & CARDBOARD				GLASS	
	Monthly Average of Total Amounts	Specific Amount (Monthly Average per Household)			Monthly Average of Total Amounts	Specific Amount (Monthly Average per Household)
		Single-Family Houses (5,000 ea)	Apartments (2,000 ea)	Overall Average		Overall Average
Field Trial A Collection every fortnight. 14 months*. Sept 74 - Oct 75	31 tons	5.5 kg	1.8 kg	4.4 kg	22.8 tons	3.0 kg
Field Trial B Paper and cardboard collected monthly. Glass collected in containers in public areas. 6 months. Nov 75 - Apr 76	25 tons	4.6 kg	1.0 kg	3.6 kg	20.1 tons	2.9 kg
Field Trial C Paper and cardboard collected bimonthly. Glass collected in containers in public areas. 8 months. May 76 - Dec 76	25 tons	3.5 kg	3.5 kg	3.5 kg	21.0 tons	3.0 kg

*) Amount averaged on last eight months of field trial.

Table 5.7: Amounts of Reclaimed Waste Materials Sorted at Source by Household During Three Field Trials in the Municipality of Birkerød During 28 Months from Sept 74 till Dec 76. The Population in the Municipality is 22,000.

from the households is:

	Specific, reclaimed amount per month per household inclusive of materials collected by voluntary organizations:
Trial A	5.0 kg
Trial B	4.2 kg
Trial C	4.1 kg

Glass waste materials including both reusable bottles, jars, and scrap glass were collected in equal amounts during all the three trial periods. Attention should be paid to the fact that the two entirely different methods of collecting in field trial A and in trial B and C yielded the same amounts of glass. In trial A the glass was collected in a distributed paper bag into which the household deposited both glass, iron, and non-ferrous metals. In trial B and C glass materials - preferably reusable bottles, but all sorts and types of glass were accepted - were collected in 35 glass containers placed in 20 different places in the municipality primarily near shopping centres.

Introduction of glass containers in trial B and C produced a higher quality of reclaimed glass with 50% of the amount as unbroken returnable bottles. Sorting of glass and bottles from the paper bags in trial A was difficult and slow.

No doubt, the voluntary collection of non-returnable bottles in the glass containers have been influenced by the familiarization of the wide-spread system of returnable beer and lemonade bottles existing in Denmark.

ANNEX 6

THE MUNICIPALITY OF BOGENSE. FIELD TRIAL.

The municipality of Bogense is situated on the island of Fyn. It covers an area af 10,200 hectares (25,200 acres), and the population is 6,200, whereof 2,900 live in the town of Bogense.

1. Description of Collection

A field trial was performed from 1st September, 1974 till 31st August, 1975 in a residential area of the town of Bogense. The field trial covered single-family houses as well as apartment houses and supplemented the regular weekly collection of household refuse by collection of reclaimable materials.

Two paper reclamation bags for paper and for glass, iron and non-ferrous metals, were delivered to the households. The reclamation bags were collected every fortnight for the first six months. The last six months of the trial the bags were collected monthly. Bags were only collected when full. The reclaimed materials were separately collected by a vehicle outside the usual round of household refuse collection.

The reclamation bags were transported to two centrally placed 30 m^3 containers - one for paper and cardboard and one for glass, iron, and non-ferrous metals. The filled containers were transported 40 km to a reclamation industry outside the municipality.

2. Reclaimed Waste Materials

The following waste materials were reclaimed:

Paper and Cardboard:

Newspapers, magazines, paper, cardboard, etc. Dry and clean materials only.

Glass:

All types of glass, bottles, jars, and scrap glass.

Iron and Non-Ferrous Metals:

All types of tins and cans as well as other iron and non-ferrous metal waste.

3. Population

The number of households in the trial area was 1,065 and the population was 2,800.

4. Amounts of Reclaimed Materials

The specific amounts of reclaimed materials have been averaged on the total number of households in the trial area. There is no information available about amounts collected from single-family and apartment houses respectively.

	Specific Amount, Monthly Average per Household		
	Collection Every Fortnight (First 6 Months)	Collection Every Month (Last 6 Months)	Mean of 12 Months
Paper and Cardboard	7.0 kg (73%)	5.1 kg (69%)	6.0 kg (71%)
Glass	2.1 kg (22%)	1.8 kg (24%)	1.9 kg (23%)
Iron and Non-Ferrous Metals	0.5 kg (5%)	0.5 kg (7%)	0.5 kg (6%)
Total	9.6 kg (100%)	7.4 kg (100%)	8.4 kg (100%)

The total amounts collected during the trial period were:

	Monthly Average:	
	First 6 Months	Last 6 Months
Paper and Cardboard	7.40 ton	5.40 ton
Glass	2.20 ton	1.90 ton
Iron and Non-ferrous Metals	0.55 ton	0.54 ton
Total	10.20 ton	7.80 ton

The reclaimed materials have amounted to 16% (weight) of the combined, collected amount of household refuse and reclaimed waste.

ANNEX 7

THE MUNICIPALITY OF GREVE. FIELD TRIAL.

The municipality of Greve is situated 20 kilometres from the centre of Copenhagen. It covers an area of 8,000 hectares (20,000 acres) and the population is 29,000. Greve is an outer suburb of Copenhagen.

1. Description of Collection

In selected residential areas in the municipality of Greve a field trial was performed through a period of five months, from 1st September 1974 till 31st January 1975. The field trial only comprised paper and cardboard. Besides the weekly collection of household refuse and the monthly collection of garden waste and bulky waste the reclaimable waste materials from the households were collected monthly. Four different residential areas were selected for the trial.

Single-Family Houses:

1,840 households deposited their paper and cardboard waste in distributed 100 litre paper bags. The bags were collected monthly on the same day as the garden and bulky waste but by a different vehicle. The reclaimed materials were placed by the household at the pavement.

Apartment Houses, Type A:

900 households deposited their paper and cardboard waste at the ground floor in each staircase from where the janitor collected the materials and placed them in centrally placed containers. When full the containers were emptied.

Apartment Houses, Type B:

243 households deposited their paper and cardboard wastes

in centrally placed 10 cubicmetre containers. The containers were unlocked in the day-time between 7.00 a.m. and 8.00 p.m. The containers were emptied when full.

Terrace Houses:

72 households deposited their paper and cardboard wastes in a centrally placed locked 10 cubicmetre container. Every household had a key to the container. When full the container was emptied.

The reclaimed materials were transported to a paper manufacturer who jointly together with the municipality and the county had organized the field trial.

2. Reclaimed Waste Materials

Only paper and cardboard were collected. Newspapers, magazines, paper and cardboard, etc. Clean and dry materials only. Contaminated materials such as plastic coated paper were not collected.

3. Population

The population included in the field trial was approximately 9,500 persons, and the number of households was 3,055. This represented approximately 30% of the total population in the municipality.

4. Amounts of Reclaimed Materials

The specific amounts of reclaimed materials have been averaged on the basis of the total number of households in the field trial area. There are no data available about actually participating number of households.

	Monthly Average of Paper and Cardboard per Household:	
	First 3 Months	Last 2 Months
Single-Family Houses	8.2 kg	5.8 kg
Apartment Houses, Type A	4.5 kg	
Apartment Houses, Type B	4.5 kg	
Terrace Houses	8.6 kg	

During the field trial a batch of 605 kg reclaimed paper and cardboard was examined. The batch consisted of the following types of materials:

Newspapers	310 kg	(51%)
Magazines	200 kg	(33%)
Cardboard	45 kg	(8%)
Corrugated Paper	40 kg	(6%)
Refuse (Plastic, Rags, etc)	10 kg	(2%)
Total	605 kg	(100%)

The total amounts collected during the five months of the field trial were 94,000 kg paper and cardboard.

ANNEX 8

THE MUNICIPALITY OF HELSINGØR. PERMANENT COLLECTION.

The municipality of Helsingør is situated in the eastern part of Denmark to the north of Copenhagen. It covers an area of 12,160 hectares (30,000 acres), and the population is 56,700.

1. Description of Collection

The municipality of Helsingør has arranged a collection of garden and bulky wastes since October 1974 by the placing of containers once a month from Friday evening till Sunday evening in a district area. The municipality is diviced into four districts, and the containers are moved from district to district every week-end.

The collection is for households only. The containers are within easy reach for everyone. In the open country households have to ask for collection as no containers are placed outside residential areas. Building site waste and earth are not accepted in the collection.

Two mini-containers of 800 litres each are placed beside the ordinary containers to collect reclaimable household wastes. One mini-container is for paper and cardboard, and one is for bottles. Although only bottles are encouraged deposited in the containers, other glass materials like jars, etc, and scrap glass are placed there.

The reclaimed materials are collected and forwarded to the reclamation industry outside the municipality. Difficulties have been encountered with the bottle containers. Earlier the contents were sold unsorted to the reclamation industry in neighbouring Sweden (5 kilometres across the Sound of Øresund - 20 minutes by ferry), but this has stopped because the industry

was no longer interested in receiving the materials.

To-day (November 1977) sorting is effected by the local Society of Deafs which buys the bottle containers' contents from the municipality. Scrap glass is deposited on the local sanitary landfill.

2. Reclaimed Waste Materials

The materials reclaimed are paper and cardboard and bottles. Instructions have been issued to the citizens with a request to deposit only bottles and clean paper and cardboard.

3. Population

The population is 57,000 and the number of households is 21,000 with approximately 48% living in single-family houses. 43,000 live in the town of Helsingør.

4. Amounts of Reclaimed Materials

The specific amounts of reclaimed materials have been averaged on the total number of households. Further the amounts have been averaged on nine months of collection in 1976, April till December.

	Monthly Average per Household:
Paper and Cardboard	0.57 kg
Bottles	0.20 kg
Total	0.77 kg

The total monthly amounts collected are:

	Monthly Average:
Paper and Cardboard	11.9 tons
Bottles	4.2 tons
Total	16.1 tons

ANNEX 9

THE MUNICIPALITY OF HERLEV. PERMANENT COLLECTION.

The municipality of Herlev is situated 10 kilometers from the center of Copenhagen. It covers an area of 1,202 hectares (2,969 acres), and the population is 24,700. Herlev is a suburb of Copenhagen.

Herlev is partner in the same regional incineration plant as Ballerup (Annex 3 and 4) and Rødovre (Annex 11).

1. Description of Collection

The municipality of Herlev has introduced a permanent arrangement for single-family houses only from 1st April 1976, with collection of reclaimed waste materials sorted by the households in disposable paper or plastic bags, or in permanent returnable containers placed by the pavement. The collection of reclaimed waste materials is an integrated part of a Total Waste Collection Arrangement including all forms of household waste: household refuse, garden refuse, and large pieces of waste. Collection of surplus earth and building refuse is not included in the arrangement.

Reclaimed waste materials are collected fortnightly by lorries with compartments for the sorted waste. Household refuse is collected separately weekly, and between 1st April and 30th November garden refuse is collected every fortnight.

The reclaimed waste materials are transported directly to the regional incineration plant, from where they are sold to the reclamation industry together with the materials from Ballerup and Rødovre.

2. Reclaimed Waste Materials

The collection comprises the following categories:

Paper and cardboard
Glass
Iron and non-ferrous metals
Rags
Bulky wastes
Waste oil

The specifications of the reclaimed waste are the same as for the municipalities of Ballerup (Annex 3) and Rødovre (Annex 11). For a more detailed specification, see Annex 3.

3. Population

The population involved in the permanent collection of reclaimed waste materials are 9.500. The number of households is 3,200. This is 39% of the total population in the municipality.

4. Amounts of Reclaimed Waste

The specific amounts of reclaimed materials are averaged on the basis of the total number of households included in the collection, 3,200, and not only on the basis of the participating households.

The specific amounts for the period of six months from April to September, 1976, are:

	Monthly average per household: (mean of 6 months)	
Paper and cardboard	2.89 kg	(59%)
Glass	0.66 kg	(13%)
Iron and non-ferrous metals	1.34 kg	(27%)
Rags	0.01 kg	(1%)
Total	4.90 kg	(100%)

The total amounts collected were:

	Monthly average: (mean of 6 months)
Paper and cardboard	9.2 ton
Glass	2.1 ton
Iron and non-ferrous metals	4.3 ton
Rags	0.03 ton
Total	15.6 ton

Information about quantities of materials is not available for the period after September 1976. The reclaimed materials are handled together with materials from the municipalities of Ballerup and Rødovre.

The total amounts of reclaimed materials collected in the three municipalities have stabilized on a constant level in 1977. See Annex 11, Rødovre, paragraph 4, for averaged specific amounts in 1977.

ANNEX 10

THE MUNICIPALITY OF RANDERS. PERMANENT COLLECTION.

The municipality of Randers is situated on the eastern coast of Jylland, 36 kilometres north of Aarhus. It covers an area of 15,400 hectares (38,000 acres) and the population is 64,000 with approximately 58,000 persons living in the town of Randers in the centre of the municipality. Randers is the sixth largest town in Denmark.

1. Description of Collection

In connection with a reorganisation from 1st April 1977 of the collection of household refuse introducing a Total Waste Collection Arrangement in the municipality collection of reclaimable waste materials sorted by the households was established at the same time. The Total Waste Collection Arrangement comprises the usual weekly collection of household refuse and is supplemented with a monthly collection of garden waste, bulky waste and reclaimable waste. Surplus earth and building site waste are not collected. Although offices, shops, and smaller workshops are included in the collection rounds, larger supermarkets and factories are as a whole exempted.

The reclaimable waste materials are sorted by the households and positioned by the pavement outside the single-family houses. The materials can either be bundled or placed in disposable paper and plastic bags or in returnable containers. For apartment houses the tenants place the waste material at ground level at specially marked areas.

Outside the towns in the country households must place their wastes at the nearest public road.

The monthly collection is performed by two vehicles, which collect simultaneously at each address. On one vehicle garden and bulky waste are deposited, and on the other the reclaimable waste materials are placed sorted in compartments.

The reclaimed materials are transported to a special reclamation site which is owned by the municipality but managed by a reclamation company. This company handles all reclaimable materials collected.

2. Reclaimed Waste Materials

The collection comprises the following categoriesof reclaimable waste materials:

Paper and Cardboard:

Newspapers, magazines, paper, cardboard, etc. Clean and dry materials only. Contaminated materials such as plastic coated paper are not collected.

Glass:

Bottles, jars, and scrap glass. Covers and caps are not collected.

Iron and Non-Ferrous Metals:

All types of tins and cans and other iron and non-ferrous metal waste.

Rags:

Textiles of every type.

The above specifications are the only ones used.

3. Population

The population is 64,000 persons and the number of households is 27,000. Approximately 10,400 households (39%) inhabitates single-family houses and 16,600 apartments.

4. Amounts of Reclaimed Materials

The specific amounts of reclaimed materials have been averaged on the basis of the total number of households in the municipality.

The amounts have been calculated on the initial six months of collection and can therefore not be regarded as representative.

	Monthly Average per Household:	
Paper and Cardboard	0.80 kg	(59%)
Glass*	0.14 kg	(11%)
Iron and Non-ferrous metals	0.30 kg	(22%)
Rags	0.10 kg	(8%)
Total	1.34 kg	(100%)

The average monthly total amount collected is for the initial six months' period:

	Monthly Average:
Paper and Cardboard	21.0 tons
Glass (∿ 6,700 bottles)	3.7 tons
Iron and Non-ferrous Metals	8.5 tons
Rags	2.3 tons
Total	35.5 tons

During the collection operation and at the central reclamation site a sorting of paper and cardboard into different quantities

*) There is only information available about unbroken reusable bottles.

is effected. Of the 21 tons monthly collected 18% is cardboard, 77% is newspapers, and the remaining 5% is "mixed household paper"-quality.

Although no accurate information about amounts of reclaimed waste materials collected by voluntary organizations (scouts, Lions, etc) is at hand, the quantity of reclaimed materials collected by the municipality is estimated by the municipality to be approximately 2% of the total amount of household refuse, garden and bulky wastes.

ANNEX 11

THE MUNICIPALITY OF RØDOVRE. PERMANENT COLLECTION.

The municipality of Rødovre is situated 7 kilometres from the centre of Copenhagen. It covers an area of 1,150 hectares (2,840 acres) and the population is 41,500. Rødovre is a suburb of Copenhagen.

Rødovre is partner of the same regional incineration plant as Ballerup and Herlev.

1. Description of Collection

As part of a Total Waste Collection Arrangement the municipality of Rødovre introduced collection of reclaimed waste materials from households starting 1st January, 1977. The Total Waste Collection Arrangement which is offered to all the households in the municipality comprises the usual weekly collection of household refuse. For single-family houses garden and bulky wastes are collected on the same day as the household refuse, but by means of a separate vehicle. Surplus earth and building site waste is as a rule not collected although a small amount of up to 10 litres per household is permitted collected. The reclaimable materials are sorted by the household and placed by the pavement beside the other types of wastes in disposable paper or plastic bags or in returnable containers marked with a specially printed label "Reclaimed Waste". For apartment houses the tenants place the sorted waste materials at appropiate areas pointed out by the janitor and the collection enterprise.

If private containers are used, only combustible materials are deposited in the containers whereas the sorted reclaimed wastes and the bulky waste are placed beside the containers. When full the containers are collected for emptying. The reclaimed waste materials and the other types of waste placed outside the con-

tainers are collected weekly.

The collection vehicle is furnished with compartments for the sorted reclaimed materials as well as for the garden and bulky wastes.

The reclaimed waste materials are transported directly with the collection lorries to the regional incineration plant in which Rødovre shares a partnership with Ballerup and Herlev and nine other municipalities. From here the materials are sold to the reclamation industry. The other types of wastes are disposed of in the incineration plant.

2. Reclaimed Waste Materials

The following categories of waste materials are reclaimed:

Paper and cardboard (Cardboard and newspapers are requested to be bundled with a string)
Glass
Iron and non-ferrous metals
Bulky wastes

The specification of the reclaimed waste is the same as for the municipality of Ballerup (Annex 3) and Herlev (Annex 9).

3. Population

The population of the municipality of Rødovre is 41,500 and the number of households is 16,600. Approximately 50% of the households inhabitate single-family houses.

4. Amounts of Reclaimed Waste

There is no information available about quantities for Rødovre as the reclaimed waste materials from the three municipalities of Ballerup, Herlev, and Rødovre are handled together at the

incineration plant. Through 1977 the monthly amounts of collected, sorted materials have stabilized on a constant level.

When the collected amounts are averaged for all three municipalities, the 25,800 households involved in the collections equalizing 71,000 persons, the specific amounts are:

	Monthly Average per Household: (Mean of Three Municipalities Ballerup, Herlev and Rødovre)	
Paper and Cardboard	1.36 kg	(49%)
Glass (20,000 bottles)	0.43 kg	(16%)
Iron and Non-Ferrous Metals	0.97 kg	(35%)
Total	2.76 kg	(100%)

Of the 20,000 bottles collected approximately 50% are reusable. Jars and scrap glass are not reclaimed.

Compared with the specific amounts in 1976 collected in Ballerup and Herlev the 1977-amounts from Ballerup, Herlev, and Rødovre averaged as a whole are smaller.

This can to a certain extent be explained by the fact that Rødovre also collects from apartments which usually yields smaller specific amounts than single-family houses do. Ballerup and Herlev only collect from single-family houses.

ANNEX 12

THE MUNICIPALITY OF SILKEBORG. PERMANENT COLLECTION.

The municipality of Silkeborg is situated in Jylland in the western part of Denmark. It covers an area of 25,300 hectares (62,500 acres), and the population is 45,500 whereof approximately 37,200 live in towns and villages. Approximately 29,000 live in the town of Silkeborg.

1. Description of Collection

The collection, which only comprises paper and cardboard, was initiated by the social department of the municipality in 1966 with the specific purpose to establish meaningful work and at the same time create easily handled jobs for rehabilitees. The organization consists of a daily manager and two drivers. There are 3 collection vehicles available and 15 rehabilitees are handling the collection.

Paper and cardboard are collected every two months from all households living in towns and villages. Houses and farms in the open country are exempted from the collection. The materials are positioned by the households at the pavement.

The reclaimed paper and cardboard are pressed into bales and sold to the reclamation industry.

2. Reclaimed Waste Materials

Clean paper and cardboard in all forms are collected with the exemption of contaminated materials such as plastic coated paper.

3. Population

The population from which the materials are collected by the municipality amounts to approximately 9,000 households equaling 28,000 persons, 75% of the total population. Some areas, especially groups of apartment buildings, have initiated their own collections together with voluntary organizations, and the reclaimed paper and cardboard thereby collected are sold directly to the reclamation industry and are not included in this analysis.

4. Amounts of Reclaimed Materials

There has not been a registration of amounts collected from households and from other sources (industry) which is why the specific amounts calculated have been appraised. The total yearly amount has stabilized on a constant level through the last few years. Further, the specific amounts have been averaged on all types of habitations as no information is available about the amounts collected separately from single-family houses and from apartments. In the municipality of Silkeborg 63% of the households inhabitate single-family houses.

	Monthly Average per Household:
Paper and Cardboard	4.6 kg

The total amount collected is approximately 500 tons per year.

ANNEX 13

THE MUNICIPALITY OF AALBORG. ROMDRUP-KLARUP FIELD TRIAL.

The municipality of Aalborg is positioned in the northern part of Jylland. It covers an area of 56,700 hectares (140,000 acres), and the population is 155,000, with 100,000 living in the town of Aalborg.

1. Description of Collection

In themunicipality of Aalborg a field trial of collection was performed from 1st April 1974 to 31st March 1975. The trial consisted of collection from 920 households living in single-family houses in a separately sited residential area 9 kilometers from Aalborg.

Steel containers were positioned at various places in the area. The containers were furnished with compartments, in which the citizens placed the sorted reclaimed waste.

At the start of the field trial the containers were open for disposal of waste day and night. But because of theft and disposal of unauthorized refuse, opening hours were introduced, and watch was kept by voluntary organisations.

The filled containers were transported to the reclamation industry in nearby Ålborg and sold.

The existing weekly household refuse collection was continued without alterations.

2. Reclaimed Waste Materials

The collection comprised the following categories:

Paper and Cardboard:

Newspapers, magazines, paper, cardboard, etc. Clean and dry materials only.

Glass:

All types and forms of glass.

Iron and Non-Ferrous Metals:

All types of tins and cans and other iron and non-ferrous metal waste.

3. Population

The population in the trial area was approximately 2,700, and the number of households were 920.

4. Amounts of Reclaimed Waste

The specific amounts of reclaimed materials were averaged on the basis of the total number of households in the trial area, and not only the estimated participating 60%.

	Monthly Average per Household:	
Paper and Cardboard	3.4 kg	(65%)
Glass, Iron and Non-Ferrous Metals	1.8 kg	(35%)
Total	5.2 kg	(100%)

The total amounts collected were:

	Monthly Average:
Paper and Cardboard	3.1 ton
Glass, Iron and Non-Ferrous Metals	1.6 ton
Total	4.7 ton

Of the total amounts of household refuse and reclaimed waste materials the reclaimed waste constituted 9%.

ANNEX 14

THE MUNICIPALITY OF AALBORG. PERMANENT COLLECTION.

The municipality of Aalborg is positioned in the northern part of Jylland. It covers an area of 56,700 hectares (140,000 acres) and the population is 155,000 of which 100,000 live in Aalborg. Aalborg is the fourth largest town in Denmark.

1. Description of Collection

Before introducing a Total Waste Collection Arrangement including collection of reclaimable waste from households the municipality of Aalborg conducted extensive field trials in the period from October 1975 till December 1976. The trials were primarily initiated to provide information on amounts of combustible and non-combustible wastes (garden waste, bulky wastes, etc) from households besides the ordinary household refuse. In Aalborg the wastes are disposed of in an incineration plant.

After experiences in pilot areas with voluntary disposal of garden and bulky wastes in containers placed within a short distance of every citizen another type of collection was arranged with collection of wastes directly from the households. The wastes were placed by the pavement and collected from this point. This collection method yielded 67% combustible and 33% non-combustible waste compared to only 45% combustible waste with the container collection method. Further, the costs per household when collecting directly were found lowest.

Further, the field trials were extended to comprise a collection of garden and bulky wastes from a number of households supplemented with a sorting of reclaimable wastes.

From the experiences of the field trials a permanent Total Waste Collection Arrangement was introduced in the municipality from

1st April, 1977. Besides the weekly collection of household refuse a monthly collection of garden and bulky wastes was effected with sorting of reclaimable materials. The reclaimable materials are sorted by the households and placed by the pavement in disposable paper and plastic bags or in returnable containers. Two collection vehicles collect the wastes. The combustible, non-reclaimable wastes are deposited in a back-loader and the reclaimed materials along with non-combustible wastes are placed in a vehicle provided with compartments for the different types of materials.

The reclaimed materials are transported to a reclamation interprise. The rest of the collected wastes are transported to the incineration plant for further disposal.

Glass materials are not collected at the households, but from 1st June, 1977 glass containers, into which the citizens deposit bottles and other glass products, have been placed throughout the municipality near centres and shops. The containers can contain 300 wine bottles and have been specially designed to prevent bottles from being broken. They are provided with rubber bands suspended across the space on the inside to ensure that bottles deposited through the top are not broken when falling down into the container. They have side walls of iron net for easy control to see if full. The container is emptied vertically by opening of the bottom and in this way ensuring a slow and controlled depositing of the unbroken bottles on the sorting table. Reusable bottles are recycled through bottle washing firms and the scrap glass is sent on to the glass industry.

Collection and emptying of the glass containers and the following sorting operation are done by a reclamation firm in Aalborg.

2. Reclaimed Waste Materials

The collection comprises paper, cardboard, iron, and non-fer-

rous metals.

Paper and Cardboard:

Newspapers, magazines, paper, cardboard, etc. Clean and dry materials only. Contaminated paper such as plastic coated paper is not collected.

Glass:

Only reusable bottles are encouraged collected, but scrap glass as well as jars, etc, can be deposited in the glass containers.

Iron and Non-Ferrous Metals:

All types of tins and cans as well as other iron and non-ferrous metal waste.

3. Population

The population of the municipality of Aalborg is 155,000 and the number of households is 65,200. Approximately 27,300 households inhabitate single-family houses and 34,200 apartments.

4. Amounts of Reclaimed Waste

The collected amounts of reclaimed wastes averaged on the total number of households in the municipality for the period April till September 1977 are:

	Monthly Average per Household:	
Paper and Cardboard	0.28 kg	(29%)
Reusable Bottles*	0.13 kg	(13%)
Iron and Non-Ferrous Metals	0.56 kg	(58%)
Total	0.97 kg	(100%)

*) No information is available about scrap glass.

The total amounts per month collected have been:

	Monthly Average:
Paper and Cardbaord	18.1 ton
Reusable Bottles* (15,300 bottles)	8.4 ton
Iron and Non-Ferrous Metals	36.6 ton
Total	63.1 ton

The amounts collected since the permanent collection was initiated correspond with the field trials. The total amount of bulky and garden waste inclusive of the reclaimable materials is approximately 16 kg per household per month for single-family houses and 2-6 kg for apartments.

*) No information is available about scrap glass.

COMMISSION OF THE EUROPEAN COMMUNITIES

(Directorate General XII - Research, Science, Education)

SORTING AT SOURCE OF CONSUMER WASTE IN THE UK

November 1977

DEPARTMENT OF THE ENVIRONMENT
Becket House
Lambeth Palace Road
London SE1 7ER
(United Kingdom)

INDEX

5. Ferrous Metal.

5.1 - Technical Description.

5.1.1 Types, amount and quality.

5.1.2 Techniques of sorting, collection and transport.

5.1.3 Consequences for existing consumer waste collection and disposal systems.

5.1.4 Processing of recovered ferrous metal.

5.1.5 Specification of recovered ferrous metal.

5.1.6 Other relevant remarks.

5.2 - Economics.

5.2.1 Costs.

5.2.2 Benefits.

5.2.3 Other relevant remarks.

5.3 - Conclusions.

6. Plastics.

7. Textiles.

7.1 - Technical Description.

7.1.1 Types, amount and quality.

7.1.2 Techniques of sorting, collection and transport.

7.1.3 Consequences for existing consumer waste collection and disposal systems.

7.1.4 Processing of recovered textiles.

7.1.5 Specification of recovered textiles.

7.1.6 Other relevant remarks.

7.2 - Economics.

7.3 - Conclusions.

REPORT

1. Terms of Reference:

(P. M.)

2. Introduction

Traditionally waste from private houses is collected once a week and a more frequent collection is provided to hotels, blocks of flats, shops and other commercial premises. Some of this mixed mass of waste is a potential source of secondary raw material and a calculated, non-emotive consideration must be given to the means and costs of recovering it for re-use. Once the waste has been placed into the disposable bag or dustbin manual separation is an unpleasant and expensive task, and mechanical separation is technically difficult.

Often this secondary raw material will be far less attractive to a manufacturer than the virgin material he would otherwise use. It may be contaminated by leachate or food waste, it may even be awkward to store or be toxic, and its quality difficult to specify and maintain. Its redeeming feature must therefore be its cheapness compared with the virgin material, if it is to be acceptable to the industrialist.

Some district councils in the UK seek the co-operation of households in keeping re-usable materials separate from general waste, but this activity is nearly always limited to the recovery of waste paper. The practice is to issue a bag or sack and to collect it at the same time as the ordinary waste and carry it in a towed trailer. Special and separate collection is sometimes arranged for the collection of waste paper from commercial premises and other places where the yield justifies the expenditure. However, when the income to the district council falls below about £30 per tonne, the cost of separate collection and baling will almost certainly exceed the income.

This project studies the extent to which "sorting at source" is used in the UK at present, and assembles information regarding the quantities involved and the financial aspects of the various schemes.

Sorting at source is defined in Annex 1 (Technical Annex) as "...all activities necessary to make certain components available to collecting parties, and to transport those components to recovery industries". Mechanical sorting is excluded since it is being studied by another committee.

With the exception of paper, ferrous metals and textiles, all of which have been a continuing operation over many years but with varying degrees of success, the other materials have only been recovered to a very limited extent, and the economics of the systems are difficult to analyse due to lack of precise information. It has therefore been necessary to accept in such cases that if an operation is financially successful it will continue, and if it is not, it will cease, ie the principle of market forces.

3. Paper

3.1 Technical description.

3.1.1 Types amounts and quality.

Paper represents the largest item which is separated at source, and a very high proportion is collected by Merchants, with only a relatively small proportion collected by Local Authorities and voluntary bodies. Table 1 below lists the total figures for actual mill usage in the UK, subdivided into various categories.

TABLE 1

UK MILL USAGE - METRIC TONNES x 000

YEAR	GROUP						TOTAL
	1-4	5	6	7a	7b	8	
1974	163.3	224.7	541.8	364.0	783.4	44.6	2121.8
1975	137.6	157.1	461.7	249.9	657.8	39.5	1703.5
1976	162.5	173.1	536	363.4	772.2	46.3	2053.5

GROUP NO	GROUP DESCRIPTION
1	Cream shavings, fine shavings, white paper, doyley cuttings, second shavings or white printing shavings, best white shavings.
2	White woody seconds, white coated shavings, white woody shavings, unprinted white card cuttings, egg flats, best one-cuts, woody one-cuts, printed woody one-cuts, white and light toned shavings, white and coloured shavings.
3	Buff manilla shavings, buff tabulating cards, coloured tabulating cards, light browns or buffs.
4	Ledgers, white heavy letter, heavy letter, light letter, light paper, quire, best white pams, continuous stationery.
5	Over-issue news, flat read news, crushed news, wood pams, over-issue white woody pams, over issue coloured woody pams, telephone directories with soft covers.
6	Coloured manilla, kraft browns, coloured kraft, mixed browns, kraft sacks, new KLS, old KLS.

GROUP NO	GROUP DESCRIPTION
7A	Coloured card, container waste, strawboards, chipboards.
7B	Mixed papers.
8	All other types.

(NOTE - pams - pamphlets
KLS - Kraft lined strawboard).

Information regarding the total weight of waste paper recovered by local authorities is rather less precise, and is only known with any degree of certainty in regard to the total figures and those related to groups 7a and 7b. These are listed below in Table 2 the difference being assumed to be in Group 5.

TABLE 2

WASTE PAPER RECOVERED BY LOCAL AUTHORITIES IN THE UK

METRIC TONNES x 000

YEAR	GROUP 5	GROUP 7a & 7b	TOTAL
1974	17.4	264.1	281.5
1975	13.5	230.9	244.4
1976	(6 months) 8.7	105.1	113.8

No accurate figures are available for waste collected by voluntary bodies, and the only figure available is an estimate for 1974 of 250,000 tonnes.

3.1.2 Techniques of Sorting Collection and Transport

The waste paper collection system in the UK consists of a limited number of large merchants with sufficient resources to install equipment and facilities to enable them to handle large tonnages, maintain effective grading operations and thus become the major suppliers to the mills.

In addition, there are considerable numbers of merchants without the necessary resources to provide the facilities available to the larger merchants. These tend to sell to the larger merchants, although in some cases deal with the mills direct.

There are also large numbers of dealers who are collectors of waste paper, who do not have the resources or facilities to grade and bale to a standard normally acceptable to the mills. These usually deal with the smaller merchants.

The sorting techniques employed vary slightly with the level of operation. The large merchants tend to purchase material produced in works where the waste material is of a known quality, ie printing, book binding, box making etc. The works concerned is aware of the value of the scrap produced, and stores the various qualities separately for sale to the merchants, thus obtaining an income from otherwise waste material. At the lower levels of operations, where the waste material has become mixed, skilled staff are used to separate it into the grades listed in para 3.1.1, thus maximising the production of the better quality material which bears the higher value. Further down the scale, the only operation which is carried out is to separate the cardboard boxes from newspapers, magazines etc.

In addition to the above there are two special areas of supplies to the mills, the Local Authorities and Voluntary Organisations. The former has been operating with varying degrees of success for many years, but has always been susceptible to the cyclical changes in price structure brought about by variations in the supply and demand situation. This has been particularly noticeable in recent years, and forced economics due to the current financial situation have considerably reduced the quantity of waste paper recovered from this source. The Voluntary

Organisations are various charities and clubs who use waste paper salvaging as a fund-raising activity. The coverage is very limited, and the operation is that of collection, usually by private individuals, and supply to dealer, merchant or mill. This method also has been in considerable difficulty in recent years due to cyclical changes in price mentioned above. In both of these operations, when collection has ceased due to financial problems, there are considerable difficulties in re-starting if the situation improves.

3.1.3 Consequences for existing consumer waste collection and disposal systems. Although it varies considerably, a recovery figure of 1.5kg (3.3 lbs) per household per week may be taken as a realistic figure: this represents approx 12% of the total weight of waste collected. Thus theoretically it can be argued that if an intensive paper collection scheme is introduced the collection vehicle fleet, and operatives, can be reduced by the same amount. It can also be said that 12% reduction in weight due to a reduction of the paper fraction brings about a much greater reduction in volume of waste to be collected. Since the capacity of the collection vehicle is determined by the volume of waste collected rather than its weight, the reduction in transport costs should be even more significant. In practice however, the effect of a separate collection has only a limited effect on the overall collection schedule, and separate collections are usually limited to commercial premises and offices. Usually, paper from private households, if separation at source is practiced, is loaded into a trailer towed behind the collection vehicle. This does not improve the overall efficiency of the collection vehicle, since it introduces reversing problems and reduces the access to the vehicle by the operatives.

In addition, profits from the sale of recovered paper are sometimes appreciably reduced by bonus payments to operatives for the extra work involved.

3.1.4 Processing of recovered paper

In addition to sorting at various levels, as described previously the waste paper is required to be baled before delivery to the mills. The major merchants, but not the majority in the trade, have invested in costly horizontal baling presses, usually with pre-conditioning equipment. It is economically desirable for this equipment is operated around its capacity level and this sometimes precludes sorting in the feed system: the bulk grades therefore, ie mixed papers, container and news grades must arrive at the merchants plant in a condition suitable for easy segregation and tipping into the machine feed system.

At the lower levels of operation, smaller baling machines are often necessary, again with pre-conditioning equipment, in order to provide waste paper in a form which is the most convenient for easy handling, and also provides an economic load for the transport vehicle. These baling machines are sometimes either provided by the mills, or financial assistance provided: in each case appropriate adjustements are made to the price of the bales so as to recover the investment by the mills.

Transport of waste paper in loose form ie in large sacks, is usually in vehicles with specially large bodies in view of the low density: bales, being more dense, can be transported on platform lorries.

3.1.5 Specification for recovered paper.

The quality of waste paper is difficult to define with any degree of precision, since this varies according to the mill, the equipment it uses, the end product being manufactured at the time the raw material is used and the availability of supplies of waste paper. One of the largest of the UK Mills has quoted the following figures for the maximum permitted contraries as a percentage of the total output

(a) Pernicious contraries 0.25%

(b) Non-pernicious contraries 0.5%.

Higher figures than these have been suggested as being typical ie 0.9% and 2% respectively, but there appears to be no generally accepted figures in common use in the industry.

3.1.6 Other Relevant Remarks.

Many local authorities in the UK collect waste paper, and the total number has fluctuated widely over the years, depending mainly on the profitability of the schemes. In 1976, the Waste Management Advisory Council issued Paper No 3 entitled "Report on Waste Paper Collection by Local Authorities", and this states (para 13) that at least 195 out of 402 collection authorities collected waste paper in 1975. The quantity collected amounted to 203,073 tonnes and it was estimated that they could reasonably collect a further 207,684 tonnes per year. This report, in addition to covering all aspects of a waste paper collection scheme as run by a local authority, deals with the economic aspects, and is referred to in para 3.2 of this report.

Apart from the local authorities, many other paper collection schemes are organised by charities, scouts and guides, clubs and sometimes local people who feel that collection of waste paper, and other materials, is something which should be done for the benefit of the locality and the country to provide a source of income, and also to conserve raw materials. Probably the largest of these is that run by Oxfam at Kirklees, West Yorkshire, and further details of this, and various other schemes, are provided in Appendix A. It should be remembered however that frequently such schemes are operated on a voluntary basis, and the costs of time, transport, fuel and other overheads are not taken into account in assessing their viability. However, they make a significant contribution to the waste paper, and other, collection systems, and it is these who are usually the first to suffer when reduction of demand from the mills involves a reduction in the quantity of waste paper required.

3.2 Economics.

The economic evaluation of any salvage scheme is the main criterion which decides whether a salvage scheme shall operate, and many schemes have failed for this one reason, since few local authorities are prepared to commence, or continue, salvage schemes when the nett result is a loss to the community, even after allowance has been made for reduced waste collection costs.

As mentioned earlier, it has also been a source of concern why certain local authorities claimed that their salvage operations were profitable, while others, apparently of similar size and conditions, could only make a loss. The various factors involved were reviewed in some detail in Waste Management Advisory Council Paper No 2 "Report on Waste Paper Collection by Local Authorities" referred to in para 3.1.6. One of the recommendations was that a working group should be formed to devise a standard accounting procedure for waste paper recovery by local authorities to enable realistic assessments to be made of the costs and benefits involved. This was subsequently carried out, and a Department of the Environment paper issued entitled "Report on Uniform Accounting for Local Authority Waste Paper Salvage Schemes". A copy of this report is attached for information.

The report recommends that local authorities analyse their salvage collection costs separately from those for the salvage sorting and baling operations. This will be particularly helpful if changes in the organisation of the scheme are considered at a later date. The proposed costing system also includes both direct and indirect costs, and, where applicable, any contribution by the County Council to reflect savings in their disposal costs due to the reduced amount of waste to be handled. A cost statement and a feasibility statement are also included, and an economic evaluation carried out of a hypothetical scheme using the Discounted Cash Flow technique.

The headings proposed for Cost and Income (Benefits) in the report are reproduced below for ease of reference, but the report itself should be used for further details.

3.2.1 Costs.

COLLECTION OF WASTE PAPER SALVAGE	1974-75 ACTUAL £	1975-76 EST £	1975-76 TARGET £
Employees -			
Salaries etc Cleansing Department			
Wages, Bonuses of Collectors, Drivers			
Supplies and Services -			
Equipment, tools, materials including sacks			
Transport and Trailers -			
Operating Costs			
Repair and Maintenance			
Loan Charges (or Renewals Fund Contribution)			
Premises			
Establishment Expenses -			
Depot Charges			
Central and Departmental Charges			
Publicity and Education			
Gross Expenditure on Paper Collection			
SORTING AND BALING OF WASTE PAPER SALVAGE			
Employees -			
Salaries etc Cleansing Department			
Wages etc Paper Baling			
Supplies and Services -			
Equipment, tools and materials including baling wire			
Baling Plant -			
Use of Fork lift truck, plant etc			
Electric Power			
Repairs and Maintenance			
Loan Charges (or Renewals Fund Contribution)			
Premises			
Establishment Expenses -			
Depot Charges			
Central and Departmental Charges			
Gross Expenditure on Waste Paper Baling			
GROSS EXPENDITURE			

3.2.2 Income (Benefits)

	1974-75 ACTUAL £	1975-76 EST £	1975-76 TARGET £
Sale of Salvaged Paper			
Associated Salvage Income (Rags, Woollens etc)			
Contribution by County Council to reflect disposal savings			
GROSS INCOME			
NET EXPENDITURE/INCOME			

3.2.3 Other Relevant Remarks.

The report also points out that the above approach may not fully reflect the overall costs and benefits to the local authority, and suggests a further refined approach in the form of a Feasibility Statement. Again the details are given below for ease of reference, but the report should be referred to for details.

FEASIBILITY STATEMENT	1974-75 ACTUAL £	1975-76 EST £	1975-76 TARGET £
Gross Expenditure as per Cost Statement			
INDIRECT COSTS AND SAVINGS			
(i) COSTS			
(1) Additional cost of operation, eg repairs, maintenance of refuse collection vehicles as a result of towing trailers, cost of additional time, labour.			
(2) Loss of income from trade collection.			
(3) Ad hoc provision (where applicable) if debt charges do not accurately reflect current rate of depreciation of plant.			
TOTAL COSTS			

	1974-75 ACTUAL £	1975-76 EST £	1975-76 TARGET £
(ii) SAVINGS			
(1) Savings in refuse collection costs that results from smaller quantity of domestic refuse when waste paper salvage removed.			
(2) Savings in refuse storage costs (where local authority provides free bags or bins) that result from smaller quantity of domestic refuse.			
TOTAL SAVINGS			
NOTIONAL GROSS EXPENDITURE			
GROSS INCOME, as per Cost Statement			
NOTIONAL PROFIT/LOSS			

3.3 CONCLUSIONS

Although there is an increasing demand for waste paper in the UK, with the probability of a shortage of home produced waste in the next few years, it is not easy to forecast that extra quantities can be provided economically. There is little doubt that the easy recovery routes are fully exploited by the commercial organisations, leaving the more difficult routes for local authorities and charities, with the inherent difficulty of carrying out the operation on an economic basis. The Oxfam results are not encouraging in this respect, even though being well organised and with considerable local enthusiasm. It is however in an early stage and definite conclusions cannot yet be drawn from its results.

Many local authorities are still finding paper salvage schemes unprofitable, and in these cases losses must be passed on to the rate-payers. Variations in demand, and hence selling price also cause difficulties particularly to the charitable organisations.

A brochure entitled "A Guide to Voluntary Waste Collection" has also recently been made available, and it is hoped that this encouragement and advice will assist local authorities and voluntary groups to achieve greater profitability. A copy of this document is enclosed for information.

4. Glass

4.1 Technical Description.

4.1.1 Type, amount and quality.

The amount of glass cullet recycled from external suppliers for the years 1974 and 1975 is as shown below. Total glass production is also included for comparison purposes

	Cullet recycled	Total glass produced
1974	92,000 tonnes	2.9 million tonnes
1975	94,000	2.75 " "

The figures for recycled cullet exclude that recycled within the glass industry's own works. The bulk was supplied by cullet merchants, and includes that returned by voluntary collection schemes, although some would have been returned direct to the glass manufacturers' own works.

The following analyses are taken from the document "A Specification for Cullet" developed by a joint working party formed by the Glass Manufacturers Federation and the British Glass Industry Research Association. The figures quoted are the results of the analysis of 5 loads of foreign cullet, and illustrate the variations which can occur. Loads A and B are of above average quality and

might be used, under certain circumstances, in a glass furnace either directly or with a minimum of further cleaning. Loads C, D and E are probably typical of the uncleaned cullet available at present.

VARIATIONS IN QUALITY OF CULLET

	A	B	C	D	E
Glass colour	White	White	White	White	Amber
Screen size	N.D	N.D	N.D	N.D	N.D
Contamination by liquids	Arrived wet	No drainage	N.D	N.D	N.D
Type of glass	S-L-S	S-L-S	S-L-S	S-L-S	S-L-S
Contamination by organic substances	0.03%	0.2%	2.15%	2.87%	6.8%
Contamination by magnetic metals	0.06%	0.05%	0.004%	0.31%	1.5%
Contamination by non-magnetic metals	0.01%	0.1%	2.25%	2.18%	0.7%
Contamination by other solid inorganic substances	combi-ned	0.01%	0.04%	0.04%	0.05%
Contamination by glass of other colours:-					
For White Glass	Negli-gible Amber and Green	Zero	Negli-gible Amber and Green	Negli-gible Amber and Green	-
For Amber Glass	-	-	-	-	3.2% White 4.1% Green
Comments	Above average quality	Above average quality	Cleaned before use	Cleaned before use	Cleaned before use

NOTE: N.D = Not determined.

4.1.2 Techniques of Sorting, Collection and Transport.

Sorting is generally done manually to maintain an acceptable degree of purity, but this is obviously a labour-intensive operation which is preferably kept to a minimum. On a larger scale operation, ferrous metal is removed by magnet.

Collection and transport is by conventional means, unless special collection skips are arranged as in the "Bottle Bank" introduced by the Glass Manufacturers Federation (see para 4.1.6).

4.1.3 Consequences for existing consumer waste collection and disposal systems.

The effect on existing systems is at present minimal in view of the relatively limited recovery rate. Unless this is very appreciably increased nationally, this is likely to remain the case. However, glass containers generally are rather bulky, and any reduction in the volume of waste collected would be welcome in so far that it would increase the carrying capacity of the collection vehicles: these are at present restricted by the volume of the waste they carry, and are under-loaded on a weight basis.

The other effect of an intensive glass recovery system would be on composting of wastes, although this is done on only a very limited scale in the UK at present. One of the undesirable constituents of compost is finely broken glass, which farmers and horticulturalists dislike from the point of view of food production, and also the danger to personnel and livestock. This situation would obviously improve by a reduction in the glass content of domestic waste, although the actual improvement would depend on the increase in the recovery rate for glass.

4.1.4 Processing of recovered glass.

Apart from the activities described in para 4.1.2 no other processing is carried out prior to delivery to glassworks.

4.1.5 Specification of recovered glass.

The following target specification for cullet was included in the document referred to in para 4.1.1.

TARGET SPECIFICATION FOR FOREIGN CULLET

This specification is for foreign cullet for direct use in glass batches without any further treatment. It can be taken as a guideline for the industry's requirement if special processing plants were to be set up. However, individual purchasers may agree to accept cullet with other levels of contamination either because the material is considered suitable for a particular use or because the purchaser is willing to clean the cullet.

	Target specification
1. Screen size	Zero material on a 2" bar sieve, with no dust
2. Contamination by liquids	Sample to show no drainage
3. Type of glass	Typical soda-lime-silica glass
4. Contamination by organic substances	0.05% max. as determined by weighing and ignition loss
5. Contamination by magnetic metals	0.01% max. with a maximum size of ¼"
6. Contamination by non-magnetic metals	0.01% max. with a maximum size of ¼"
7. Contamination by other solid inorganic materials	0.05% max. with a maximum size of ¼". All refractory materials should be absent
8. Contamination by glass of other colours:-	
For White Glass	2% max. amber glass 0.1% max. green glass
For Amber Glass	90% min. amber glass
For Green Glass	90% min. green glass
9. Possible use	Full substitution for in-house cullet in most cases.

4.1.6 Other relevant remarks.

In view of the quantity of glass discarded with domestic waste, various studies and projects have been arranged in recent years. The main object has been to prevent the waste of materials and energy involved, but in many cases the financial aspects of the recovery schemes have not proved satisfactory, except in the case of voluntary schemes where labour, and frequently transport, are provided free of charge. These studies and project reports are reviewed in Appendix B (Glass).

The Glass Manufacturers Federation have recently announced a major recycling scheme under the heading "Bottle Bank". The scheme is now in operation at Oxford, Barnsley and Scunthorpe, and projects in Colwyn Bay and Chelmsford should commence operations before the end of 1977. The "skip" method has been adopted since previous experiments have shown that it is not an economic proposition to collect empty glass containers on a house-to-house basis. It is thought that the "Bottle Bank" stands more chance of success since the costly collection of a few bottles from each household is eliminated. Further details of the scheme are included in Appendix B (Glass).

4.2 Economics

4.2.1 Costs.

Apart from the costs quoted in the reports mentioned in Appendices A and B, little reliable information is available on this subject. The voluntary schemes present a rather distorted picture in that various costings are not taken into account in that time, transport etc are provided free, and even in the Oxfam project certain services are not fully costed.

4.2.2 Benefits. (Income)

There is no agreed price structure for cullet, and prices are negotiated between supplier and merchant according to the state of the market. The income to the "Bottle Bank" project is based on £11.50 per tonne delivered to the works (see Appendix B "Glass").

4.3 Conclusions.

As with paper, the easy collection opportunities are already fully exploited by commercial organisations, and the remainder are correspondingly more difficult to cover economically. In addition, the Oxfam results are not particularly satisfactory from the economic point of view, and glass collection has now been discontinued (see Appendix A - (a) Oxfam).

Under these circumstances the Glass Manufacturers Federation introduction of the "Bottle Bank" project is most useful approach to improving the situation and its impact will be studied with interest.

5. Ferrous Metal

5.1 Technical Description.

5.1.1 Types, Amount and Quality.

The UK Government Green Paper "War on Waste" (Issued 1974) quoted the following in respect of ferrous metals.

"The major "leakage" of steel from the reclamation cycle is in waste collected by local authorities. It has been estimated that of the 20 million tonnes of household and trade waste collected each year, over 1 million tonnes is ferrous, largely in the form of metal containers, mostly tin cans. Of the ¾ million tonnes of tin cans which enter the United Kingdom market each year, almost all is thrown away as domestic refuse."

Approx 50,000 tonnes of ferrous scrap was recovered from incinerators during 1975/6 and a further 18,000 tonnes of unburned ferrous scrap was recovered

by other means ie pulverisers etc. Further amounts are collected by itinerant street collectors and voluntary organisations and although no official figures exist, it is thought that a total of approx 100,000 tons of ferrous metal is recovered per year from domestic sources.

There is therefore considerable scope for improvement in the recovery of ferrous metals, which it is hoped will be achieved as a result of the Government sponsored publicity campaign referred to in Section 3 "Paper".

The recovery at source aspect of this report will undoubtedly hinge on the recovery of tin cans by the housewife, and it is probable that the bulk collection of the results of her efforts is where problems arise, due to the bulky nature of the material.

It is also important that the cans should be cleaned before being handed over, so as to avoid nuisance from putrifying material during storage, although no reports of problems in this respect have been received from existing schemes.

5.1.2 Techniques of sorting, collection and transport.

Where the domestic collection separates out individual materials, no further separation is required. Where several materials are collected in one container however, such as in the Oxfam "dumpy", separation at the central collection depot is required, and this can be done manually, or by magnetic means if the quantities justify the extra expense.

Collection and transport depend largely on quantities and facilities available, but normally no special requirements exist other than to provide vehicles suited for the bulky nature of tin cans: it is, of course likely that they would be collected in conjunction with other materials, for which the same requirements apply.

Larger items of scrap domestic equipment are sometimes collected by local authorities as part of their Civic Amenity service, but this is done by whatever vehicles are available.

5.1.3 Consequences for existing consumer waste collection and disposal systems.
As with other materials, it is unlikely that there would be any noticeable effect on volume unless a highly successful scheme were to be operated. If however the local authority had a magnetic separator included in their system, they could find that the metal recovery quantity would be reduced.

5.1.4 Processing of recovered ferrous metal.
Ferrous metal needs to be baled before sale to the main merchants or to mills. For small schemes the collectors would sell loose to merchants who had baling equipment, but for larger collection schemes it would probably be worth while purchasing or leasing equipment.

5.1.5 Specification of recovered ferrous metal.
Although the British Steel Corporation have a range of 13 specifications for scrap metal with several sub-sections, these all exclude any materials containing tin. Materials recovered without incineration are therefore sold as (a) Bright, or municipal bales, or if after incineration (b) Black, or destructor bundles. Neither have an agreed specification, but the latter are watched for excessive quantities of slag, which is both non-productive and also detrimental to the quality of the finished product.

5.1.6 Other relevant remarks.
The impact of "Sorting at Source" on the ferrous metal industry has been very limited, except in the sense that the itinerant street collector has been a feature of life for many years in the towns of the UK. The amount of material collected per year must be quite appreciable, but no accurate figures are available.

The main collecting operation other than the street trader, as with other materials, has been the Oxfam "Wasteover" project, the results of which are given in Appendix A.

5.2. Economics

5.2.1 Costs)
)
5.2.2 Benefits) The results of this aspect of the Oxfam "Wasteover" project are given in Appendix A, which shows that this is not a profitable operation at present, even under the favourable conditions under which the scheme is operating.

The costs and benefits to the itinerant street trader are not available, but as part of the complete range of his operations, it is thought to be profitable. This must partly be due to his ability to recognise the areas of domestic and other dwellings which provide the best supply of material.

5.2.3 Other relevant remarks.

As with paper, and other materials, this aspect of the recovery industry has been continually beset with troubles due to the cyclical nature of demand and price, and hence profitability. This has naturally had its effect throughout the various levels of the recovery system, which has usually left the lowest level, ie sorting at source, in some difficulty.

5.3 Conclusions.

Unless there are effective measures taken to modify the financial structure of the ferrous metals recovery industry, it seems unlikely than an economically viable case can be made for attempting to improve recovery by more intensive "sorting at source" operations. This statement would probably not be accepted by the conservationist groups, who would undoubtedly argue that all materials should be recovered to preserve natural resources. This emotionally based approach, while being valid from that particular point of view, is not supported by the economic facts.

6. Plastics

There have been no attempts made in the UK to separate plastics at source in the domestic field, and in any case this material forms only a very small proportion of total household waste - under 5% by weight, less than 0.5 kg per house per week. It is considered that the householder cannot be expected to separate plastics into its many different grades, and the results from the Oxfam project were thought to be hardly worth while. A few attempts have been made to recycle works scrap, but these efforts, even with the advantage of a reasonably consistent feedstock of known quality, have not been a success in the long term.

7. Textiles

7.1 Technical Description.

7.1.1 Types, amount and quality.

The main methods of collection for textiles separated in the household are via the itinerant street trader and marine stores where available.

The material collected is separated into the following categories, with the approx % of the total collected

a. Knitted woollen rags for woollen spun cloth (7%)

b. Cloth rags for bedding flock and furniture upholstery (20%-24%)

c. Knitted synthetic garments for export to foreign pullers for blanket manufacture (20%)

d. Roofing rags, consisting of throw-outs from other grades etc (12%)

e. Wiping cloths, consisting of shirts dresses curtains and larger pieces of cotton or cotton/synthetic rags (35%).

There are no accurate figures available for the quantity of textiles recovered, but for 1976 it is estimated that the quantity was between 80 and 85,000 tonnes.

7.1.2 Techniques of Sorting, Collection and Transport.

Although lorries are gradually taking over, the traditional "horse and cart" collection is used, and in fact may now be increasing due to fuel prices. Other materials are collected at the same time, such as scrap metal, old furniture etc, thus improving the economics of the system. The same trader is usually also willing to collect the left-over material from "jumble sales" and also from local authority land reclamation sites where permitted. ("jumble" refers to unwanted clothing, toys, books, shoes etc which are given by householders to various charities, who then hold a "jumble sale" at which the material is sold, usually to those in the lower income group. Since all labour, and the material to be sold, is free, these operations provide a very useful source of income to the charities).

Marine Stores were originally in the dock areas, and used ropes, sails and other material from ships were taken to them. With the departure of sailing ships, the trade reduced, and the marine stores extended their activities to metals etc. The expression is now used for any promise which collect unwanted metal and other material, but the materials are generally taken to the store.

7.1.3 Consequences for existing consumer waste collection and disposal systems.
Since textiles only amount to between 3% and 4% of domestic waste, the effect on collection and disposal services of any increase or reduction in textile segregation is likely to be insignificant.

7.1.4 Processing of recovered textiles.
After collection, the textiles are delivered to a "rag-sorter" who manually sorts the rags into the categories described in para 7.1.1, and stores them until sufficient quantities have been accumulated to justify transport to the next category of merchant.

7.1.5 Specification of recovered textiles.
There are no generally accepted specifications for recovered materials.

7.1.6 Other relevant remarks.
This is a very "fragmented" industry as a whole; the collection and processing from domestic sources is a relatively small part of the more complex recovery industry dealing with new cuttings from textile and clothing manufacture, and from spinning and weaving mills.

7.2 Economics.
There is virtually no reliable information on this subject. A selling price of about £63 per tonne of sorted material has been mentioned, but how the collection and sorting costs relate to this is not known.

7.3 Conclusions.

While this industry is reasonably viable at the moment, reference has been made to the necessity for improvements. There is a substantial amount of material collected which is not suitable for further processing, and has to be disposed of by burning or to local authority landfill sites. This is a loss to the industry and to the nation, and some method of utilising this waste material is required. There is also an awareness that the sorted material is sometimes exported, only to be imported in the form of processed goods.

8. Non Ferrous Metal

Very little information is available regarding recycling from domestic waste. The quantity is quite large, however, and Warren Spring Laboratory made the following assessment of national figures in 1976.

Copper	24,000	tonnes
Aluminium	70,000	"
Zinc	36,000	"
Lead	8,000	"
Tin	7,000	"

These figures should be considered as indicative only, since they are the results of extrapolation of analyses of small quantities to obtain national figures. While indicating potential savings, it must be remembered that it is virtually impossible to achieve anything other than a very small recovery rate, even with modern technology. Aluminium will respond to eddy current extraction, but can only be justified on a large scale and providing that the waste from the area concerned contains sufficient aluminium to cover the extra costs involved. Similarly tin can be recovered from tinplate, mainly tin cans, provided the material is adequately cleaned and in a suitable shape. Other materials can only be recovered by manual means.

Separation at source offers a possible route for economic recovery of non-ferrous metals, and as the Oxfam results analysed in Appendix A indicates, is the only raw material to show a profit. This may of course be due to the fact that overhead costs are shared with other materials, which operate at a loss. It cannot be assumed therefore that to recover non-ferrous metals only would be a profitable operation, and further results from Oxfam, and similar projects, are awaited before definite conclusions can be made. The modifications to the "Oxfam"

system referred to in Appendix A (a) Oxfam indicate that they are proposing to continue collection of aluminium, but only as a central processing plant for materials collected as described: some of this could, of course, be collected as a result of "separation at source" operations.

In general terms an appreciable, but unknown quantity of non-ferrous metal must already be separated at home by car owners who carry out their own repairs and maintenance, and by other "do-it-yourself" activities. The resulting collection is then disposed of to either itinerant collectors or local scrap metal merchants as convenient.

9. Oil

This is also an area where little or no information is available on domestic activities, but with large potential return.

The Waste Management Advisory Council have issued a report on this subject entitled "An Economic Study of Waste Oil" (Paper No 3). This quotes the total waste oil arising in the UK for 1975 as 440,000 tonnes per year, excluding 31,000 tonnes per year which is already recovered by "laundering" of customers own used oil. Of this amount, 46,000 tonnes per year is recovered for lubrication purposes 264,000 tonnes per year is used as a fuel, and the balance of 130,000 tonnes per year is disposed of in various other ways but is a complete loss to the system.

The report concludes that the recovery rate of approximately 70% is reasonably good, but estimate that some 65,000 tonnes per annum of reasonably high quality waste oil are not currently recovered. The net national resource saving to be gained from this tonnage is estimated to be of the order of £1m to £2.3m per annum at 1975 prices.

The report analyses the problems and imperfections of the present system, and in the case of "do-it-yourself" arisings suggests the provision of suitable

storage facilities at convenient collection centres such as Civic Amenity sites or local garages, together with extensive publicity. These recommendations have already been implemented in certain areas, but no results or costs are as yet available.

A Code of Practice for the recovery of mineral oils has been issued by the Chemical Recovery Association. This proposes various methods to be adopted, mainly applicable to industry, but also including proposals for the collection of oil from the "Do-it-yourself" motorist.

10. Combined collection systems

These have been referred to in the report, and details quoted in Appendices A and B.

11. Conclusions

Sorting of materials at source is considerably influenced by local conditions and market potential. In these circumstances Research and Development, it is suggested, must be operated on a local scheme rather than a Community basis.

APPENDIX A

VOLUNTARY COLLECTION SCHEMES

It should be noted that some of the schemes referred to below recycle more than one material. Cross-references in other sections of the report are included where necessary.

(a) Oxfam, Kirklees, West Yorkshire.

This scheme, known as the "Wastesover" Project, was devised by the internationally known Oxford Committee for Famine Relief, or Oxfam, whose prime object is the alleviation of poverty in underdeveloped countries. Their objective therefore was to obtain funds for this purpose, and in doing so to reduce waste and re-cycle raw materials.

The scheme involves the separation at source by householders of their domestic waste. This is done by supplying to each household a special container known as a "dumpy", which consists of a stand which holds 4 bags (3 coloured plastic and 1 woven). These are used as follows:-

i. Blue - for jumble (clothes, toys, books etc)

ii. Red - for newspapers

iii. Yellow - for mixed paper

iv. Woven - for glass, plastic and tins

The contents of the bags are collected and taken to a central depot for sorting: initially these operations were carried out on a voluntary basis, but at a later stage some paid employees were taken on under the Government "job-creation programme".

This project received considerable assistance initially, both financial and in form of equipment, from the Government and local businesses, which considerably improves the apparent effectiveness of the scheme.

Because of the time lag in providing equipment to all the houses involved in the 1st place, it was decided to monitor the response and drop-out rate on a long term basis a group of 48 houses consisting of 16 large detached houses, 12 semi-detached houses and 20 terraced houses. The results from this group have been monitored, and the results statistically analysed in some depth (1), together with subsequent results as they have become available.

The main conclusions of the report on the first 3 months of operation are as follows:-

i. Drop out rates are quite low- 10 per cent when allowance is made for the length of time households stayed in the scheme. Households in the large detached houses had double the average drop out rate, while for households in terraced houses the drop out rate was only 4 per cent.

ii. After the initial impact the average weekly quantities collected by households were approximately:

newspaper	- 1.1kgs
glass	- 0.8kgs
mixed paper	- 0.5kgs
tins	- 0.2kgs
plastic	- 0.03kgs
jumble	- 0.3kgs
bottles	- 0.2 (ie 1 bottle over 5 weeks)

iii. There is no evidence of any decline in the average quantities collected by co-operating households, but amounts tended to be smaller than usual over the summer holiday period and at Christmas time.

iv. Excluding bottles and jumble the amount collected by Oxfam represents about 20 per cent of the total waste produced by the average household.

---

(1) DOE Report - Wastesover Project - Analysis of the 1st years results.

v. The collection of plastic and the separation of bottles seems to have been hardly worthwhile in view of the small quantities obtained.

vi. On the whole larger quantities were collected from households in large detached houses, though the quantities tended to vary more from week to week. Tins were a major exception with largest quantities coming from households in the terraced houses.

Economic Results (for the whole project):-

These were analysed in some detail by a DOE Economist attached to Oxfam, the periods covered being March, April and May 1976, and a second period covering November and December 1976, and January 1977.(1) The results of the various sections have been shown in Table A1 in financial terms only, and Table A2 relates these to tonnages processed.

Subsequent to the collection of the results shown in Tables A1 and A2, the following statement(2) has been received from Oxfam WASTESAVER describing the scope of their activities, and recent changes introduced as a result of the economic results

"Oxfam Wastesaver is in its third year of operation with an annual turnover of nearly a quarter of million pounds per annum.

The main element is the textile sorting operation. Textiles are collected from 580 shops around Britain and despatched under a national transport arrangement with NCL. Approximately 1,500 tons of material per annum are involved. Sorting is into garments which are being re-used and nine different grades of rags. Textiles are collected by house-to-house collection in the locality and are also purchased from other charitable organisations. This operation puts Oxfam among the dozen largest rag sorting firms in the UK.

(1) DOE reports (Leeds Office) Oxfam Wastesaver - An analysis of operating costs.

(2) Letter - Oxfam to DOE 26 October 1977.

Associated with this operation is the collection of aluminium foil and all aluminium beverage cans via the same shops network with, in addition, a further 300 collection points, including a chain of establishments run by a national brewery and two motorway service station chains.

Collection of wastepaper has extended to a total of 15,000 houses in the Kirklees area but increasing transport and collection costs, coupled with static wastepaper prices has lead to a decision to cut this back to only a few, low cost, collection methods.

Among these is a new collection point situated in the car park of a large local supermarket and a collection point for cartons in the local covered market.

Earlier operations involving furniture, tin-cans, glass and plastics proved to be uneconomic and have been discontinued.

TABLE A.1

BREAKDOWN OF RUNNING COSTS AND SALES (£)

Month	Paper	Glass and Tin	Aluminium and Scrap	Textiles	Clothing Shop	Furniture Shop	Total
March 76							
Costs	2557	1251	-	5723	987	2856	13,374
Sales	987	288	173	2968	1361	3283	9,060
Profit/loss	-1570	-963	+173	-2755	+374	+427	-4,314
April 76							
Costs	2870	1370	-	6090	1102	2915	14,347
Sales	930	251	620	3543	1501	4220	11,065
Profit/loss	-1940	-1119	+620	-2547	+399	+1305	-3,282
May 76							
Costs	3478	1750	-	8880	1585	3959	19,652
Sales	820	422	267	5147	1773	3247	11,676
Profit/loss	-2658	-1328	+267	-3733	+188	-712	-7,976
Nov 76							
Costs	5709	2080	112	10499	1653	4562	24,615
Sales	1861	653	128	10423	1628	2365	17,895(3)
Profit/loss	-3848	-1427	+16	-76	-25	-2197	-6,720
Dec 76							
Costs	6120	2131	118	12249	2485	5681	28,784
Sales	2239	232	850	9887	2443	2463	18,161(3)
Profit/loss	-3881	-1899	+732	-2362	-42	-3218	-10,623
Jan 1977							
Costs	4987	1633	120	8779	1771	4882	22,172
Sales	2487	651	732	8775	2069	2420	17,239(3)
Profit/loss	-2500	-982	+612	-4	+298	-2462	-4,933
TOTAL							
Costs	25721	10,215	350	52,220	9583	24855	122,944
Sales	9324	2497	2770	40,743	10,775	17998	85,096(3)
Profit/loss	-16397	-7718	+2420	-11,477	+1192	-6857	-37,848(3)

NOTES

1) Costs include their proportion of maintenance, transport, administration and general costs

2) The May sales for paper have been adjusted to allow for the fact that due to plant problems only 21 tonnes were sold against 40 tonnes processed.

3) The following miscellaneous donations have been included in total sales:- Nov £837. Dec £47. January £105.

TABLE A2

BREAKDOWN OF PROFIT/LOSS PER TONNE

Period	Paper	Glass and Tins	Textiles
March 76			
Profit/loss	-£ 1570	-£ 963	-£ 2755
Tonnes	48	Glass 16 Tins 6 22	27
Profit/loss per tonne	-£ 32.80	-£ 43.8	-£ 102
April 76			
Profit/loss	-£ 1940	-£1119	-£ 2547
Tonnes	43	Glass 25 Tins 3 28	32
Profit/loss per tonne	-£ 45.2	-£ 40	-£ 79.8
May 76			
Profit/loss	-£ 2658	-£1328	-£ 3733
Tonnes	40	Glass 40 Tins 3 43	40
Profit/loss per tonne	-£ 66.5	-£ 30.9	-£ 93.2
Nov 76			
Profit/loss	-£ 3848	-£1427	-£ 76
Tonnes	95	39	101
Profit/loss per tonnes	-£ 40.5	-£ 36.6	-£ 0.75
Dec 76			
Profit/loss	-£ 3881	-£1899	-£ 2362
Tonnes	61	6	59
Profit/loss per tonne	-£ 63.6	-£ 316.5	-£ 40
Jan 77			
Profit/loss	-£ 2500	-£ 982	-£ 4
Tonnes	81	22	71
Profit/loss per tonne	-£ 30.9	-£ 44.6	-£ 0.05
TOTAL			
Profit/loss per	-£16397	-£7718	-£11477
Tonnes	368	160	330
Profit/loss	-£ 44.6	-£ 48.2	-£ 34.8

NOTES: 1) Profit/loss figures from Table A1.

2) No weights available for Aluminium and Scrap, Clothing Shop and Furniture Shop (as listed in Table A1).

(b) Other Schemes.

Apart from the 195 local authorities and Oxfam mentioned earlier, there are many smaller projects too numerous to list in detail and generally concentrating on paper. A few are mentioned below as an example of the work being carried out, together with a brief description.

(c) Oxfordshire County Council.

"Save Oil" campaign.

This was initiated in the City of Oxford and then extended to other towns. The object was to save used engine oil, usually changed by the "Do-it-yourself" motorist. This would save a material which could be re-cycled, or burned. The scheme involved the setting up of storage tanks at garages throughout the county, and some garages were found to be unwilling to co-operate, since it would encourage motorists to carry out their own servicing.

Shredded Waste Paper For Farm Use.

This was an attempt to find an alternative market for low grade waste paper. The paper was shredded by a local scout group and supplied to a farmer. The shredded paper was found to be suitable in some cases, but in others caused problems. The farmer was charged £18 per ton, which was rather higher than he would have had to pay for straw. However the economic viability would be improved in the event of straw being diverted to other purposes.

Help To Voluntary Bodies.

This covers assistance and advice to various voluntary bodies, whose activities included collection of rags (textiles), aluminium containers from the "Meals-on-Wheels" service and paper. Problems recorded in this area were in regard to organisation, and continued effort and enthusiasm over the length of time required to justify recycling operations.

(d) Waste Reclamation Scheme, Bradford.

This scheme was initiated jointly by the National Consumer Council, the National Housewives Association and West Yorkshire Metropolitan County Council, and has been organised and run by Mrs Cynthia Stein.

The following materials have been collected during a 4 month period

Paper and board	2 tons
Glass	10 tons
Tins	2 tons

No reliable information is available regarding income and costs, although the income from glass is £10 per ton less the cost of transport. The scheme is operated by housewives, with more emphasis on re-cycling materials than economics.

(e) The Survival Project.

This is a scheme run by Cambridge University branch of the Conservation Society and the Friends of the Earth.

Paper and glass is recovered during the 26 weeks of the academic year, and the following figures for quantity and income have been quoted

Glass	Hocks	180 dozen	£43
	Other reusable	400 dozen	£24
	Deposits		£92
	Cullet	2½ tonnes	£15
Paper	Newspaper		£70
	Waste paper		£ 4
	(Newspaper price varies between £12 and £15 per tonne)		
	Total income for 1976		£260
	Expenses		52
		Profit	£208

APPENDIX B (GLASS)

The following studies and project reports have been prepared during recent years. The information on glass recovery from the Oxfam project should also be noted.

"The Glass Container Industry and the Environmental Debate" - issued by the Glass Manufacturers Federation.

This document reviewed the industry generally, but mainly from the point of view of the glass bottle in all its forms, including the re-usable bottle, and the recovery and re-use of glass containers.

"Glass Re-cycling in the UK, 1973-1976" issued by the Glass Manufacturers Federation.

The report examines the glass container industry from the recycling aspect, and reviews other uses for waste glass, voluntary recycling schemes, Government action in recycling and recycling within the glass industry.

Other uses for waste glass include the following

a. Fillers used with other materials
b. Glass-polymer composites
c. Building materials
d. Insulation material
e. Road surfaces.

"Glass container recovery: its viability"

A report of a glass container recovery experiment carried out in York by Redfearn National Glass Ltd and the City of York District Council.

The report describes the background to the decision to carry out this project, which was done under very favourable circumstances since the glass works was situated in York. The collection period was May and June 1974, and produced 11 tonnes of glass, consisting of 8.25 tonnes clear and 2.75 tonnes coloured. The costs involved were as follows

Skip hire and emptying	£ 3.80
Labour, transport, printing etc	£31.50
Total	£35.30

The income from Redfearn National Glass Co was the prevailing price of £5 per tonne for coloured glass and £7 per tonne for clear glass, which left a deficit of £30.30 per tonne. This takes no account of the fact that Redfearn National provided 10,000 paper sacks at £37 per 1000, which would have been a major item of extra expenditure if the scheme had been adopted as a permanent one. In addition, had the glass factory not been within the city, labour and transport charges would have been much higher.

"Wine and Spirit Bottle Recovery Pilot Feasibility Study" - carried out by P E Consulting Group Ltd on behalf of the following trade associations:

Brewers Society

Gin Rectifiers and Distillers Association (also representing the Vodka Trade Association)

Scotch Whisky Association

Wine and Spirit Association (also representing the Rum Importers Association)

Glass Manufacturers Federation.

The report evaluates a hypothetical recovery scheme based on a network of collection points, a network of regional marshalling depots, a transport organisation and four bottle processing factories for washing and packing recovered bottles prior to delivering them to the bottlers. The overall range of costs produced by this pilot study was 4p to 7p per bottle with a total capital requirement of between £16 and £20 million (Note - from other sources the cost of a new bottle has been put at 3 to 4p).

"St Anne's Beat the Bottle Campaign", otherwise known as "The Buxton Glass Project".

The project was sponsored by the "Keep Britain Tidy Group" with support from the Co-operative Wholesale Society, the Paper Sack Information Bureau, and many others. It was carried out by St Anne's School, Buxton, and was mainly an exercise in litter reduction rather than an exercise in the cost-effectiveness of glass recovery.

The exercise ran from 4.29 March 1974, and during this period the children of the school collected a total of 42,700 glass containers, which included 14,700 jam jars and 14,600 "pop" bottles, the balance being in miscellaneous domestic glass containers. The collections were not only from homes, but also in a local conservation area. In addition the staff of a Manchester Hospital, who heard of the project, collected 4000 non-returnable drip-feed bottles, although these have not been included in the figures listed above. No costing was carried out for this project.

Other projects involving the collection of glass are the Waste Reclamation Scheme, Bradford, and the Survival Project at Cambridge University, both of which are included in Appendix A.

"Bottle Bank" - Glass Manufacturers Federation.

This system uses covered skips, with 3 holes in the cover, colour-coded to indicate the colour of glass bottle to be put into it. It is similar to the system used on the Continent for several years, where it has been found to be very successful.

Literature has been issued by the Glass Manufacturers Federation describing how the scheme works, and including a formula for calculating the income and costs involved. This formula is based on a purchasing price by the glassworks of £11.50 per tonne delivered to the factory.

An example is given of typical figures for a town of, say, 100,000 population, located 150 miles from a glassworks. The calculation showed that the break-even figure would be 611.8 tonnes per year or 11.8 tonnes per week. The skip would need emptying 15.3 times per year or once every 3.4 weeks. The literature suggests that these figures should be readily attainable.

Since the scheme only commenced in Oxford and Barnsley on 24 August 1977 and in Scunthorpe on 7 September 1977, results are very limited. In Oxford the 5 cubic yard "Bottle Banks", each holding about 1½ tonnes, were initially filled in just over a week but this has now reduced to 4 to 5 days. The first container to be filled in Barnsley took 10 days and held nearly 4 tonnes.