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Waste flows in frameworks of physical input-output tables and material flow accounting

Contents

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Preface

This final report summarises the results of a pilot project 'Compilation and presentation of data and statistics on waste in the frameworks of physical input-output tables, material flow accounting and material balances'. The work was benefited from financial support by the European Commission, and it was accomplished by Statistics Finland and Thule-institute of University of Oulu. Development and description of the methods and calculations on waste flows combined with physical input-output tables for Finland 1999 were done by Ilmo Mäenpää from the Thule Institute, with Mika Pirneskoski as an assisting researcher. Expertise –input for the work were given by Juha Espo, Simo Vahvelainen and Keijo Asunmaa from Statistics Finland.

The final report was compiled by Ilmo Mäenpää from the Thule Institute and by Jukka Muukkonen from Statistics Finland, Environment and energy statistics.
As this report is a result of a pilot study, it should be noted that tables presented in it are not official statistics of Statistics Finland or other organisations mentioned as data sources.

1. Introduction

The objective of the project was to develop the compilation and presentation of data and statistics on waste in frameworks of physical input-output tables, material flow accounting and material balances. This objective included creation and improvement of links between waste classification presented in European Waste Catalogue EWC and detailed physical input-output tables. The other objective was to create appropriate links between data and statistics on recycled waste and industrial statistics on production and raw material use, including packages and packaging waste (CN, CPA and PRODCOM classifications).

The project was based on basic data and statistics on waste, raw material and commodity use, production of commodities, and packages. These data and statistics are available from waste statistics and industrial statistics of Statistics Finland, register on waste by Regional Environmental Centres and Finnish Environment Institute, statistics on mining and quarrying, and the Ministry of the Environment.

Material flow accounting offers a practical framework for statistical data on waste to be treated and presented in the form of waste accounting as integrated part of material flow accounting and material balances. The meaning of waste generation and recovery of waste for the economy is shown more clearly than in traditional waste statistics. Also, estimation and treatment of waste flows as a part of general material flows of the economy makes it possible to estimate such waste flows, from which direct basic or statistical data are not available or it includes remarkable shortcomings or data gaps.

In this pilot study waste accounting has been developed in the framework of physical input-output tables for year 1999 (PIOT99). The report is structured to present the results starting from the whole framework and ending to individual parts, as an 'up to down' presentation.

Chapter *2. Physical Input-Output tables 1999 (PIOT99): General structure and waste flows* describes the structure of PIOT99, and the position of waste flows in it. Table 2. shows the preliminary Material balance of Finland by industry in 1999, and in Table 2.4. economy-wide material balance of Finland 1999 is presented. In chapter *3. Categorisation of waste* the European Waste Catalogue EWC and it's applicability for waste accounting is examined, and it is compared to the Classification of Products by Activity (CPA) used in economic statistics of the EU. This is focused especially on CPA categories including recovered waste. Chapter *4. Basic data, statistics and calculation methods for waste flows* describes calculation methods developed and used in the work by waste categories and by data sources. In the final chapter *5. Summary and conclusions*, short summary is presented and some conclusions are drawn on waste statistics, waste accounting, physical input-output tables and material flow accounting as approaches supplementing each other and environmental accounting in general.

2 Physical Input-Output tables 1999 (PIOT99): General structure and waste flows

2.1 General structure of the PIOT99

Classifications used in the PIOT99 are based on branches of industry (activities) and product classifications used in monetary input-output balances in national accounting. For this report branches of industry are aggregated into 30 groups, as shown in the Annex 1. Calculations are made on the level of 149 branches, which can be aggregated in various ways according to reporting purpose in case. Basicly, in the classification according to activity, services –activities have been aggregated, but disaggregation have been made for 'environmental' activities. Thus the activities of wholesale and retail trade are aggregated, but the wholesale of waste have been separated from this aggregate. Also, activities such as collection and treatment of sewage, collection and treatment of other waste, and other environmental activities have been separated.

Product classification used in national accounting is based on Classification of Products by Activity CPA, (Commission Regulation (EC) No 1232/98 of 17 June 1998), which have been to some extent supplemented by PRODCOM classification (Council of the European Communities, Regulation No 3924/91). In PIOT99, only those products have been taken into account, which consists clearly of physical materials, and services including such materials. Two product categories have been separated in order to specific description of waste flows; ferrous scrap and dross from the manufacture of iron and steel (CPA 2710) and cullet of glass and glass waste (CPA 261510). Classification principles of CPA are still taken into account in these separations. In order to include such recoverable waste categories into the supply and demand tables that are not represented in the CPA classification, 6 additional waste categories are added to the product list, coded as 99 as the first two numbers in the code. The total number of products at the calculation level is 713.

Software built for the compilation of PIOT99 is a combination of Excel and APL programmes. Basic data is saved into excel files, in which the data are processed and specific calculations are made. The APL programme combines the data and forms the input-output tables from it, tables which are presented and reported for further use as Excel files.

The PIOT99 is summarised in following Table 2.1. It describes the flow of material into the economy from domestic nature and from foreign countries, stock formation inside the economy and the flow of materials into the nature and foreign countries. Figures in the table are preliminary, and the difference between total input and total output is still relatively high for some branches of industry.

For crop production and waste management the PIOT99 follows the approach presented in SEEA 2000 (System of Integrated Environmental and Economic Accounting) manuscript. Thus the input of agriculture into the economy consist only of difference between earth materials consumed by crop production and materials placed into the fields (e.g. fertilisers). Total output of waste is included to outputs that, in principle, are in the use of the economy, and waste placed into landfills is treated as net addition to material stock, although it is treated separately from changes of stocks of productive capital and durable goods.

Table 2.1. Material balance of Finland by industry 1999, 1000 tonnes (preliminary 25.11.2002)

Industries	INPUTS							OUTPUTS									TOTAL		
	From Domestic Nature				RoW	From Economy		To Economy			RoW	To Domestic Nature							
	Unused extraction	Raw materials	Water	Air (O, N)	Imports	Domestic goods	Waste	Domestic goods	Waste	Net add. to stocks	Exports	Emissions into air	Water vapour	Emissions into water	Dissipative use	Unused extraction	INPUT	OUTPUT	Discr. O - I
1 Agriculture and fishing	0	767	31 358	22 274	970	15 349	22 610	18 288	22 625	0	364	4 297	47 443	184	0	0	93 327	93 200	-127
2 Forestry, logging etc	23 078	50 913	0	356	69	38	0	50 271	1	0	623	336	126	19	0	23 078	74 455	74 455	0
3 Mining and quarrying	21 755	108 424	0	220	130	790	0	96 146	10 847	0	1 914	217	72	6	0	21 755	131 318	130 956	-362
4 Manufacture of food products	0	0	1 044	509	1 406	7 491	260	6 719	337	0	661	501	2 548	1	0	0	10 710	10 768	57
5 Manuf of textiles etc	0	0	0	97	101	48	2	37	5	0	71	88	40	0	0	0	249	242	-7
6 Manuf of wood & wood products	0	0	20	706	2 481	23 259	933	7 238	4 718	0	5 259	890	8 827	1	0	0	27 400	26 933	-467
7 Manuf of pulp, paper, paper prod	0	0	0	14 694	12 688	44 714	3 415	15 338	4 157	0	14 183	19 232	22 632	209	0	0	75 511	75 751	240
8 Publishing, printing etc	0	0	7	35	161	465	0	360	28	0	146	33	29	0	0	0	669	595	-74
9 Manuf of coke and petroleum ref.	0	0	0	3 177	12 880	972	0	6 380	29	0	5 038	3 139	2 689	1	0	0	17 029	17 276	247
10 Manufacture of chemicals etc	0	0	856	1 330	3 294	3 970	142	5 672	1 701	0	3 032	1 039	481	5	0	0	9 592	11 929	2 336
11 Manuf of rubber and plastic prod	0	0	0	67	307	303	5	321	13	0	253	63	36	0	0	0	682	686	4
12 Manuf of non-met mineral prod	905	2 090	555	876	2 155	7 743	182	11 105	244	0	492	1 735	1 012	0	0	905	14 506	15 492	986
13 Manufacture of basic metals	0	0	0	2 850	6 333	8 634	1 049	8 059	2 148	0	3 520	5 214	1 581	1	0	0	18 865	20 523	1 657
14 Manuf of metal products	0	0	0	223		679	0	866	24	0	314	176	113	0	0	0	1 361	1 494	133
15 Manuf of machinery and equipm	0	0	0	106	473	446	3	299	53	0	414	98	56	0	0	0	1 028	919	-109
16 Manuf of electrical equipment	0	0	0	33	249	241	0	172	20	0	237	28	20	0	0	0	523	477	-46
17 Manuf of transport equipment	0	0	0	58	139	175	8	153	34	0	160	56	25	0	0	0	381	427	47
18 Manufacturing n.e.c.	0	0	0	35	67	247	15	170	8	0	83	37	59	0	0	0	365	357	-8
19 Recycling	0	0	0	5	44	1	1 107	1 016	185	0	3	4	2	0	0	0	1 157	1 211	54
20 Electricity, gas & water supply	0	0	0	23 336	5 817	6 750	3 438	0	839	0	2	25 507	13 075	1	0	0	39 342	39 423	81
21 Building	8 500	0	0	720	976	26 468	0	25 977	1 254	0	0	680	254	0	0	8 500	36 664	36 664	0
22 Civil engineering	25 000	13 200	0	706	610	65 225	875	79 699	12	0	0	665	251	0	0	25 000	105 616	105 627	11
23 Wholesale and retail trade etc	0	0	0	1 210	146	516	0	0	301	0	0	1 141	430	0	0	0	1 872	1 872	0
24 Hotels and restaurants	0	0	0	103	103	589	0	555	97	0	0	101	43	0	0	0	796	796	0
25 Transport, storage	0	0	0	11 308	1 481	2 702	0	0	103	0	0	10 748	3 963	0	677	0	15 491	15 491	0
26 Post and telecommunications	0	0	0	39	8	7	0	0	1	0	0	38	15	0	0	0	54	54	0
27 Dwellings	0	0	0	1 486	161	918	0	0	17	0	0	1 740	809	0	0	0	2 566	2 566	0
28 Public administration and services	0	0	0	654	172	291	0	0	171	0	0	674	273	0	0	0	1 117	1 117	0
29 Sewage, refuse disposal; sanitation	0	0	0	83	2	6	2 555	716	1 647	0	91	123	17	53	0	0	2 647	2 647	0
30 Other service activities	0	0	0	277	99	161	0	0	146	0	0	279	113	0	0	0	538	538	0
Production activities total	**79 237**	**175 394**	**33 840**	**87 574**	**53 985**	**219 199**	**36 600**	**335 555**	**51 762**	**0**	**36 862**	**78 878**	**107 031**	**480**	**677**	**79 237**	**685 830**	**690 482**	**4 652**
1 Household consumption	0	0	1 900	13 024	1 936	8 674	0	0	1 613	85	0	13 666	10 156	13	0	0	25 534	25 534	0
2 *- other goods*	*0*	*0*	*1 900*	*13 024*	*1 764*	*8 589*	*0*	*0*	*1 442*	*0*	*0*	*13 666*	*10 156*	*13*	*0*	*0*	*25 277*	*25 277*	*0*
3 *- durable goods*	*0*	*0*	*0*	*0*	*172*	*85*	*0*	*0*	*172*	*85*	*0*	*0*	*0*	*0*	*0*	*0*	*257*	*257*	*0*
4 Fixed capital formation	0	0	0	0	230	105 321	0	0	1 440	104 111	0	0	0	0	0	0	105 551	105 551	0
5 *- buildings*	*0*	*0*	*0*	*0*	*0*	*25 977*	*0*	*0*	*1 070*	*24 907*	*0*	*0*	*0*	*0*	*0*	*0*	*25 977*	*25 977*	*0*
6 *- infrastructures*	*0*	*0*	*0*	*0*	*0*	*79 022*	*0*	*0*	*0*	*79 022*	*0*	*0*	*0*	*0*	*0*	*0*	*79 022*	*79 022*	*0*
7 *- machinery and equipment*	*0*	*0*	*0*	*0*	*230*	*322*	*0*	*0*	*370*	*182*	*0*	*0*	*0*	*0*	*0*	*0*	*552*	*552*	*0*
8 Changes in inventories	0	0	0	0	-1 937	1 894	0	0	0	-42	0	0	0	0	0	0	-42	-42	0
9 Landfills	0	0	0	0	0	0	18 215	0	0	18 141	0	74	0	0	0	0	18 215	18 215	0
Domestic final use total	**0**	**0**	**1 900**	**13 024**	**230**	**115 889**	**18 215**	**0**	**3 053**	**122 295**	**0**	**13 740**	**10 156**	**13**	**0**	**0**	**149 257**	**149 257**	**0**
Exports of imports	**0**	**0**	**0**	**0**	**861**	**0**	**0**	**0**	**0**	**0**	**861**	**0**	**0**	**0**	**0**	**0**	**861**	**861**	**0**
Total	**79 237**	**175 394**	**35 740**	**100 598**	**55 076**	**335 088**	**54 815**	**335 555**	**54 815**	**122 295**	**37 723**	**92 618**	**117 187**	**492**	**677**	**79 237**	**835 948**	**840 600**	**4 652**
Net balance	**79 237**	**175 394**	**35 740**	**100 598**	**55 076**					**122 295**	**37 723**	**92 618**	**117 187**	**492**	**677**	**79 237**	**446 045**	**450 229**	**4 184**

Some flows are balanced automatically due to the calculation method. For flows of materials in combustion, input of oxygen and nitrogen included into air consumption in combustion process plus mass of fuel equals the total output of ash, emissions into air and water vapour. In agriculture material flows of livestock and material flows of households' human nourishment are produced by metabolic model (Mäenpää & Vanhala 2002). In this model, total mass of food, drinking water and oxygen equals to total mass of livestock products, excrement, and carbon dioxide, methane and water vapour of expiration.

Services –activities are balanced based on the assumption, that other intermediate inputs than fuels finally end up as waste. Inputs (excluding fuels and households' human nourishment) of construction activities, service activities, household consumption and capital formation are estimated preliminary by 'supply surplus' principle. According to this principle, for each product,

supply in domestic markets =
+domestic production
+ imports
- exports, and
'supply surplus' =
supply in domestic markets
- estimated intermediate consumption of industry and agriculture.

Supply surplus is then divided to typical users of each product. These estimations will be improved when monetary input-output tables of national accounts are finalised.

For industrial activities, material flows (other than flows of fuels) are combined and estimated from various data sources. This is a major reason for relatively high difference between total input and output in some branches of industry. One reason is water content of different raw materials and products: although co-efficients for changes in water content between inputs and outputs have been identified and developed, some information on them is still missing especially on products of chemical industry. Also, in chemical industry and in the manufacturing of basic metals, high amounts of water and oxygen is tied in the products during production processes. Only partial estimations have been made for the oxygen. For products for which data on physical amounts is missing, or it is reported as number of pieces etc., the amounts as mass is estimated based on prices per tonne, which are available from statistics on foreign trade (statistics of custom). This method includes some uncertainties, especially when the content of some individual product group is different from the content of the same product group in import and export. Product flows of industries are based on industrial statistics on products, raw materials and fuels, and full coverage of these statistics have been obtained only for some individual product flows.

2.2 Waste flows

Waste flows are described in the Table 2.1. as follows: Column 'Unused extraction' includes those material from the nature, which are transferred in extraction of natural resources. These include silvicultural waste of forestry and logging, side stone of mining and earth movements in construction. A part of side stone is recorded in the branch of manufacturing of mineral products. Unused extraction is recorded in both input and output parts of the table. In input side column 'Waste' includes domestic recovery of waste as raw materials or fuels. Imported waste are included into column 'Import'. In the output side, waste includes both recovered

waste and waste landfilled. Exported waste is recorded in the Export –column. Landfilled waste is calculated as difference between generation and recovery of waste. Detailed description of waste flows by branches of industry are presented in Table 2.2.

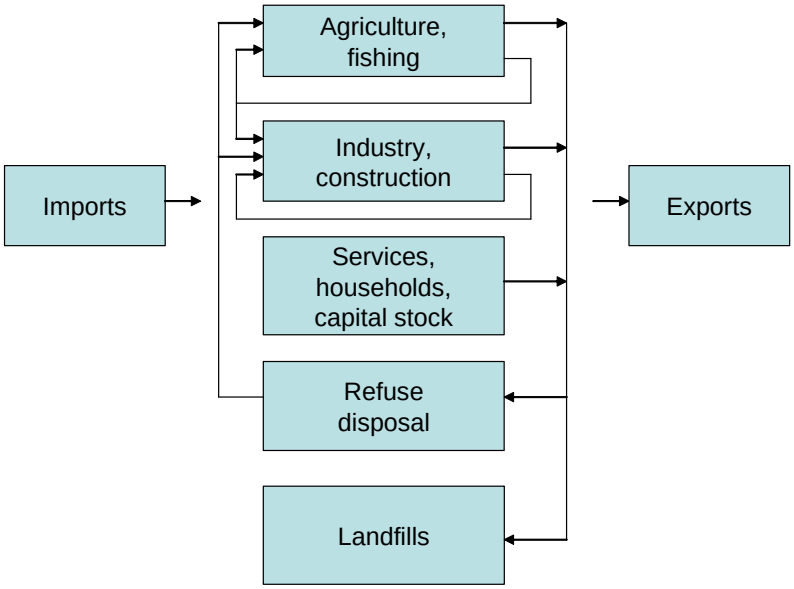
Table 2.2. Waste flows by branches of industry and by end use 1999, 1000 tonnes.

		Use of waste			Waste generated			
		Imports	Domestic		Domestic disposal			Exports
			Use as material	Use as energy	Recovered waste	Packaging waste	Final waste	
1	Agriculture and fishing	0	22 610	0	22 601	11	13	1
2	Forestry, logging etc	0	0	0	0	0	1	0
3	Mining and quarrying	0	0	0	0	1	10 846	0
4	Manufacture of food products	70	250	10	257	61	19	4
5	Manuf of textiles etc	0	2	0	0	2	3	0
6	Manuf of wood & wood products	51	46	887	4 664	7	47	5
7	Manuf of pulp, paper, paper prod	187	575	2 840	2 762	39	1 356	5
8	Publishing, printing etc	0	0	0	8	7	12	1
9	Manuf of coke and petroleum ref.	0	0	0	0	4	24	0
10	Manufacture of chemicals etc	7	27	116	115	34	1 551	11
11	Manuf of rubber and plastic prod	1	5	0	1	6	6	1
12	Manuf of non-met mineral prod	18	171	11	80	20	143	2
13	Manufacture of basic metals	196	1 049	0	1 065	14	1 069	68
14	Manuf of metal products	1	0	0	-2	14	12	18
15	Manuf of machinery and equipm	1	3	0	10	23	20	0
16	Manuf of electrical equipment	0	0	0	0	16	4	0
17	Manuf of transport equipment	0	8	0	12	10	12	0
18	Manufacturing n.e.c.	1	2	13	2	3	3	0
19	Recycling	43	1 107	0	100	0	85	0
20	Electricity, gas & water supply	164	0	3 438	495	0	343	2
21	Building	0	0	0	0	53	1 201	0
22	Civil engineering	0	875	0	0	10	2	0
23	Wholesale and retail trade etc	0	0	0	0	105	196	0
24	Hotels and restaurants	0	0	0	0	27	70	0
25	Transport, storage	0	0	0	0	3	100	0
26	Post and telecommunications	0	0	0	0	0	1	0
27	Dwellings	0	0	0	0	0	17	0
28	Public administration and services	0	0	0	0	7	163	0
29	Sewage, refuse disposal; sanitation	0	2 555	0	1 637	0	9	91
30	Other service activities	0	0	0	0	6	139	0
	Industries total	**740**	**29 284**	**7 316**	**33 809**	**483**	**17 470**	**208**
	Households	0	0	0	0	99	1 514	0
	Capital formation	0	0	0	0	19	1 421	0
	Exports of imports	212	0	0	0	0	0	212
Total		**952**	**29 284**	**7 316**	**33 809**	**601**	**20 405**	**420**

The row ‘Exports of imports’ in the table includes iron –based scrap. It has been assumed, that export of that scrap includes mainly scrap that is only trespassing Finland by intermediate suppliers.

The structure of waste accounting is presented in Figure 2.1.

Figure 2.1. The logical structure of waste flows



Amounts of waste have been estimated and calculated on following basis:

Agricultural waste: based on metabolic model (Mäenpää & Vanhala 2002) including manure and carcases of animals of fur production. manure is recovered for crop production, and carcases for feed production. Also some waste from fishing are used in feed production.

Waste on mining and quarrying: based on statistics on mining. Part of dressing sand is recorded in the manufacturing of mineral products.

In industry both recovery of waste and generation of recoverable waste are based on industrial statistics on raw materials, products and fuels, that are included into CPA/PRODCOM product classifications. For other recovered waste, mainly waste that are re-used in construction VAHTI register (data system of environmental control and load, maintained by environmental administration) have been used, as well as for final waste. Waste generation of construction activities is taken from estimation of waste generation in 1999 (Annex 2).

In services activities, the amounts of waste are calculated based on balancing of inputs and outputs. Thus those materials used as inputs but are not included into material content of outputs are recorded as waste, as well as ashes from combusted fuels.

Of materials used in households, 4 million tonnes are food stuffs and 5 million tonnes are fuels. Food, excrement and ashes -wastes originated from them are calculated by metabolic model and mass balances of fuel combustion. Other short term and semi-durable goods are assumed to end up as waste. For durable goods it has been estimated, that 2/3 of those are used to renew the product stocks and 1/3 to increase the stock. Durable goods that are no longer in use end up as waste.

A separate estimate have been done for durable goods in productive use. No estimation is available for buildings. For machinery and equipment preliminary assumption is, that 2/3 of investments are made to renew the stock, and amount equal to this end up as waste.

Generation of packaging waste: Data on supply of packaging materials by branches of industry are available from industrial statistics. Preliminary packaging material co-efficients by products (kg/kg) have been deduced from this data. Packages end up as wastes of the users of the products in those packages. 50 % of packages of consumable goods of household are recorded as packaging waste of trade activities.

Recoverable parts of packaging waste, waste from services activities, waste from households and waste from fixed capital formation are not separated from total amounts of these wastes, and the are thus recorded in the flows of final waste. Recoverable parts of those wastes are separated in the branches of environmental management and recycling.

2.3 Comparison

Figures on waste in the PIOT99 table are not directly comparable with figures on waste presented in waste statistics 1999 (Annex 2). In PIOT99 waste of mining are divided into two parts, side stone as unused extraction and dressing sand as waste remaining inside the economy. Also, from combustion of waste only ashes are recorded as waste remaining in the economy. On the other hand, in PIOT99 the total amount of waste includes some double counting, as the branches of waste management and recycling are producing 'waste from waste'.

A summary of comparison between PIOT99 and waste statistics 1999 are presented in Table 2.3. Items included are defined and summarised in order to reach as comparable items as possible.

Table 2.3. Waste generation in PIOT99 and in waste statistics

	PIOT99	Waste statistics
Waste generated	52 983	55 116
Recovery as raw materials	29 182	27 942
Recovery as energy	7 316	4 818
Combusted		77
Landfilled	18 215	17 558
Other treatment		3 611

For generated waste, side stone of mining industry have been subtracted from amounts in waste statistics, and waste produced in branches of environmental management and recycling have been subtracted from amounts of PIOT99. The amounts of waste generated and amounts recovered as raw materials are relatively close to each other in PIOT99 and in waste statistics, but the difference for waste recovered as energy is a good 50 percent.

One reason for differences is, that waste statistics registers only the use of waste, that are generated in the same year. Part of waste is recorded as intermediate stocks (included into row 'Other treatment'). PIOT99 in turn, includes all recovery of waste in the preference year, even if the waste is generated during previous years. Still, this does not explain the high difference in waste recovered as energy. In PIOT99, the most of that waste is wood waste from forest industry. Basic data on wood waste comes from industrial fuel statistics as cubic metres, and conversion factors from cubic metres to tonnes explain the difference to some extent.

Dressing sand from mining industry is in the table 2.3. included into landfilled waste. PIOT99 shows to some extent higher amounts of waste landfilled than waste statistics. One reason for this difference is again, that waste statistics registers only the use of waste, that are generated in the same year. On the other hand, in PIOT99 it has been assumed, that all waste that is not recovered, ends up to landfills. Actually there are exceptions against this assumption, e.g. some organic waste from households that is composted inside the household activity, and part of machinery and equipment in agriculture, which finally end up to the farm area.

2.4 Economy-wide material balance

According to one approach of material flow accounting, economy wide material balance is compiled by estimating total material flows of the economy as inputs, outputs and stocks (European Commission 2001). Most of the items included in this balance can be directly summarised from PIOT99, in which it is presented as 'Net balance' in the Table 2.1.

In the Net balance material flows inside the economy (domestic goods and waste from the economy as inputs, and domestic goods and waste as outputs to the economy) are subtracted from the totals of inputs and outputs. What is remained to the economy-wide material balance are direct material inputs from the nature and imported inputs, outputs to nature as emissions, water vapour, dissipative use of materials and net additions to material stocks, and unused extraction in both input and output side of the balance.

Although the elements of the economy-wide material balance can basicly be seen in the Net balance –row of PIOT99, some definitions and balance boundaries are different from it. In the framework of economy wide balance, growth of crop and earth materials bound into the growth belong to the nature instead of the economy, and thus the crop yield is an input from nature to economy, and inputs such as seeds, fertilisers and land improvement materials are recorded as dissipative use of products. Also landfills are defined to be part of the nature, and waste that ends up to the landfills are emissions to nature, and not additions to stocks inside the economy, as in the PIOT framework.

The economy-wide material balance of Finland 1999 is presented in Table 2.4. The balance is based on PIOT99, but it is adapted to the framework and definitions presented by Eurostat (European Commission 2001.

Table 2.4. Economy-wide material balance of Finland 1999, million tons

INPUTS (origin)		OUTPUTS (destination)	
Domestic extraction	**190.0**	**Emissions and wastes**	**120.9**
Fossil fuels	8.1	Emissions to air	76.9
Minerals	115.6	Waste landfilled	18.2
Biomass	66.3	Emissions to water	0.3
Imports	**55.1**	Dissipative use of products and losses	25.4
Balancing items	**123.6**	**Balancing items**	**106.0**
Oxygen, nitrogen from the air	83.6	Water vapour	106.0
Water embodied into the products	40.0		
DMI - direct material inputs	**368.7**	**DPO - domestic processed output to nature**	**226.9**
Unused domestic extraction	**79.2**	**Disposal of unused domestic extraction**	79.2
From mining/quarrying	22.7	From mining/quarrying	22.7
From biomass harvest	23.1	From biomass harvest	23.1
Soil excavation	33.5	Soil excavation	33.5
TMI – total material input	**447.9**	**TDO - total domestic output to nature**	**306.1**
		Exports	**37.7**
		TMO – total material output	**343.9**
		Net Additions to Stock	**104.1**
			447.9

3. Classification of waste

3.1 EWC – European Waste Catalogue

In EWC classification starting points for classification hierarchy are activity and process types of classification. This study is based on 'old' EWC 1994, but basicly a key between EWC1994 and 2001 is available. In head categories (at 2-digit level) of the EWC only some categories are based on classification according to waste type (Table 3.1.). At 4-digit level, processes and activities are more detailed (Table 3.2.), but only at 6-digit level the waste type can be seen (Table 3.3.). At this level, quite often an additional '99' class is needed, in order to find a category to a waste type, that is not typical for the activity concerned. Because of the structure of the EWC classification, same individual waste type that can be placed into certain category of the EWC in some branches of industry, can only be placed on '99' category in some other branches, and information on the waste type is thus lost.

Reason for the approach and structure of the EWC classification may be, that expertise on waste generation is based more on activities and processes than waste types. Also, waste producing processes are in environmental government in more close monitoring than waste types. For waste and material flow approach, especially on information on recovery of waste, information by waste type and by branches of industry are of more importance.

Table 3.1. Main categories of EWC classification (EWC 1994)

01	Waste resulting from exploration, mining, dressing and further treatment of minerals and quarry
02	Waste from agricultural, horticultural, hunting, fishing and aquaculture primary production, food preparation and processing
03	Wastes from wood processing and the production of paper, cardboard, pulp, panels and furniture
04	Wastes from the leather and textile industries
05	Wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal
06	Wastes from inorganic chemical processes
07	Wastes from organic chemical processes
08	Wastes from the manufacture, formulation, supply and use (mfsu) of coatings (paints, varnishes and vitreous enamels), adhesive, sealants and printing inks
09	Wastes from the photographic industry
10	Inorganic wastes from thermal processes
11	Inorganic waste with metals from metal treatment and the coating of metals; non-ferrous hydro-metallurgy
12	Wastes from shaping and surface treatment of metals and plastics
13	Oil wastes (except edible oils, 05 and 12)
14	Wastes from organic substances employed as solvents (except 07 and 08)
15	Packaging; absorbents, wiping cloths, filter materials and protective clothing not otherwise specified
16	Waste not otherwise specified in the catalogue
17	Construction and demolition waste (including road construction)
18	Wastes from human or animal health care and/or related research (excluding kitchen and restaurant wastes which do not arise from immediate health care)
19	Wastes from waste treatment facilities, off-site waste water treatment plants and the water industry
20	Municipal wastes and similar commercial, industrial and institutional wastes including separately collected fractions

Table 3.2. Sub-categories for main category 02

0201	Primary production waste
0202	Wastes from the preparation and processing of meat, fish and other foods of animal origin
0203	Wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee and tobacco preparation, processing; conserve production; tobacco processing
0204	Wastes from sugar processing
0205	Wastes from the dairy products industry
0206	Wastes from the baking and confectionery industry
0207	Wastes from the production of alcoholic and non-alcoholic beverages (excluding coffee, tea and cocoa)

Table 3.3. Basic categories of sub-category 0203

020301	Sludges from washing, cleaning, peeling, centrifuging and separation
020302	Wastes from preserving agents
020303	Wastes from solvent extraction
020304	Materials unsuitable for consumption or processing
020305	Sludges from on-site effluent treatment
020399	Wastes not otherwise specified

3.2. CPA – Classification of Products by Activity

CPA (CPA 1998) is a general product classification in the EU. Like in EWC, the starting points are activities and processes as branches of industry. In the CPA, four first numbers of an individual class define that branch of industry according to NACE classification, for which a certain product is typical. Two last number after the first four ones are used for more detailed separation of the products produced.

For industrial products, even 8-digit level is in use in the CPA, as PRODCOM classification (PRODCOM 1991). The CPA differs from the EWC, because an individual product always falls in same CPA category, even if it is produced in many different branches of industry. This, in turn, takes place because the CPA and NACE are closely connected: branch of industry of the producing unit is based on the CPA class of the main product of the unit in case.

CPA product classes are also connected with CN classification used in foreign trade statistics of the EU. Data according to CN classification can be transformed into data according to CPA classification, with the exception of only few products.

The CPA classification is focused on products, which have monetary value in the economy. For most of recovered waste the monetary value also exists, and so most of recovered waste have been classified according to the CPA. CPA categories that include recoverable waste are presented in Table 3.4. In the table some product groups are presented as 5-number classes, and some as 6-number classes, because the 6-digit basic level includes several sub-groups that are all wastes. Group 26151110 is presented at the level of PRODCOM classification, because CPA 6-number groups include glass products in addition to waste.

Table 3.4. Waste classes in the CPA.

Code	Description
151140	Raw offal, inedible
152018	Other inedible products of fish, crustaceans, molluscs or other aquatic invertebrates
153330	Vegetable materials and vegetable waste, vegetable residues and by-products
158320	Beet-pulp, bagasse and other waste of sugar manufacture
159620	Brewing or distilling dregs
160020	Tobacco refuse
17106	Silk waste; waste of wool or of fine or coarse animal hair; cotton waste
182240	Worn clothing and other worn articles
201040	Sawdust and wood waste and scrap
211260	Waste and scrap of paper and paperboard
241660	Waste, parings and scrap, of plastics
247030	Waste of man-made fibres
251380	Waste, parings and scrap of rubber (except hard rubber) and powders and granules
26151110	Cullet and other waste and scrap of glass; glass in the mass (excl. glass in the form of powder; granules or flakes)
265310	Plaster (consisting of calcined gypsum or calcium sulphate)
271091	Slag, dross, scalings and other waste from the manufacture of iron or steel
271092	Ferrous waste and scrap
27416	Waste and scrap of precious metal
27423	Waste and scrap of aluminium; ash and residues containing mainly aluminium
27433	Waste and scrap of lead, zinc and tin; ash and residues containing mainly zinc or lead
27443	Waste and scrap of copper; ash and residues containing mainly copper
27454	Waste and scrap of nickel; ash and residues containing other metals and metal compounds
314030	Waste and scrap of primary cells, primary batteries and electric accumulators; spent primary cells, primary batteries and electric accumulators
351160	Vessels and other floating structures for breaking up
371010	Metal secondary raw materials
372010	Non-metal secondary raw materials
401020	Spent (irradiated) fuel elements (cartridges) of nuclear reactors

CPA 2002, an updated version of the CPA includes some important additions to waste products. These additions are presented in Table 3.5.

Table 3.5. Product additions of CPA 2002

Code	Description
232040	Waste oil
244225	Waste pharmaceuticals
900120	Sewage sludge
900220	Municipal waste

The CPA also includes classes that are quite close to waste, such as re-used products and products made of waste, for which the value added is very small. This kind of product groups are presented in Table 3.6. The first four products of food manufacturing industry are wastes that are turned into products for transportation and stocks, products which end up mainly for feed production. Without this possibility they would end up as waste. Second hand clothes and cars that are exported are removed from domestic use, but they do not end up as waste.

Table 3.6. CPA classes close to waste

151313	Flours, meals and pellets of meat unfit for human consumption; greaves
152017	Flours, meals and pellets of fish, crustaceans, molluscs or other aquatic invertebrates, inedible
154131	Oil-cake and other solid residues, of vegetable fats or oils
156150	Bran, sharps and other residues from the working of cereals
182240	Worn clothing and other worn articles
201023	Wood in chips or particles
241480	Residual lyes from the manufacture of wood pulp, excluding tall oil
251120	Used pneumatic tyres, of rubber
341025	Motor cars for the transport of persons, used
341043	Motor vehicles for the transport of goods, used
351160	Vessels and other floating structures for breaking up

Data on recovered waste used as raw materials are available from industrial statistics as supply of materials and equipment. Fuel statistics of industrial statistics includes data on waste recovery for energy production. Wastes used as fuel with their CPA codes are presented in Table 3.7. , as well as fuel types produced from waste. For some fuels CPA class can not be found, and a code beginning with '99' has been given to them for further use.

Table 3.7. Waste fuels and fuels produced from waste

CPA	Fuel classes	
201040	3121	Bark
201040	3122	Saw dust
201040	3123	Wood waste fuel ships
201040	3129	Other wood waste
999010	3140	Other wastes and by-products from wood processing industry
201040	3150	Construction and demolition wood
999999	4910	Other by-products and wastes
201040	3160	Patent wood fuels
999020	3210	Gases derived from biomass and wastes
999020	3230	Recovered/recycled fuel
999020	3210	Gases derived frombiomass and wastes

4. Basic data, statistics and calculation methods for waste flows

4.1 Wastes in industrial statistics and in foreign trade statistics

Supply and use of recoverable waste as presented in Table 4.1. are available from industrial statistics and statistics on foreign trade. Coding used in the table follows the coding used in PIOT99: First six numbers refer to CPA code and the seventh number is used when needed to separate products at PRODCOM level. Such waste that are included into the CPA, but are not presented in commodity statistics of Statistics Finland and/or are very small in their volumes are not included into product list of PIOT99 are left out from the table.

Table 4.1. Supply and use of recoverable waste according to industrial statistics and statistics on foreign trade. 1000 tonnes

		Industry		Foreign trade		Total	
		Supply	Use	Imports	Exports	Supply	Use
1511400	Raw offal, inedible	69.7	184.5	8.5	4.4	78.2	188.9
1520170	Other inedible products of fish, crustaceans, molluscs or other aquatic invertebrates	15.6	19.0	17.6	0.4	33.2	19.4
1533300	Vegetable materials and vegetable waste, vegetable residues and by-products	4.4	2.1	0.2	0.0	4.6	2.1
1583200	Beet-pulp, bagasse and other waste of sugar manufacture	56.0	59.1	15.3	0.0	71.3	59.1
1596200	Brewing or distilling dregs	3.4	2.3	0.1	0.1	3.5	2.4
1600200	Tobacco refuse	0.0	0.7	1.2	1.1	1.2	1.8
1710600	Silk waste; waste of wool or of fine or coarse animal hair; cotton waste	0.3	0.0	0.3	0.1	0.6	0.1
2010400	Sawdust and wood waste and scrap	6 794.5	7 149.9	369.5	7.6	7 164.0	7 157.4
2112600	Waste and scrap of paper and paperboard	29.5	614.4	39.4	93.4	68.9	707.7
2416600	Waste, parings and scrap, of plastics	0.9	6.9	0.6	2.3	1.4	9.2
2513800	Waste, parings and scrap of rubber (except hard rubber) and powders and granules	0.5	0.0	0.6	0.7	1.0	0.7
2615111	Cullet and other waste and scrap of glass; glass in the mass (excl. glass in the form of powder; granules or flakes)	6.4	71.5	0.0	0.0	6.4	71.5
2653100	Plaster (consisting of calcined gypsum or calcium sulphate)	101.5	98.4	19.9	3.4	121.4	101.8
2710910	Slag, dross, scalings and other waste from the manufacture of iron or steel	973.7	226.5	23.4	56.4	997.1	282.9
2710920	Ferrous waste and scrap	116.6	1 053.4	345.7	211.6	462.3	1 265.0
2742300	Waste and scrap of aluminium; ash and residues containing mainly aluminium	0.5	47.0	49.9	6.9	50.4	53.8
2743300	Waste and scrap of lead, zinc and tin; ash and residues containing mainly zinc or lead	11.4	1.1	3.9	21.9	15.3	23.1
2744300	Waste and scrap of copper; ash and residues containing mainly copper	41.9	15.2	11.3	17.4	53.2	32.6
2745400	Waste and scrap of nickel; ash and residues containing other metals and metal compounds	28.6	0.9	3.3	0.1	31.9	1.0

Remarkable unbalance between supply and use of some recoverable waste shows a need to seek missing supply or use outside industry. Based on the unbalance of paper waste (211260), cullet of glass (26151110) and iron scrap (271092), it can be estimated the amounts of collection of those wastes from municipal waste flows.

On the other hand, main use of slag from iron manufacturing takes place outside manufacturing industry, in construction activities.

In industrial statistics' data on delivery of commodities and supply of materials only such waste are included, that have recorded monetary value. Waste that are potentially recoverable but still end up to landfills, and waste that end up to recovery but do not have recorded monetary value are missing from industrial statistics.

4.2. Industrial waste in VAHTI register

Industrial sites in VAHTI register in 1999 were compiled into a file, that included waste generated in those sites. Branch of industry (NACE) of site, EWC class of waste, type of waste treatment (re-use as raw material, combustion for energy production, recovery by unidentified way, final treatment), and specific description of waste type by the reporting unit were connected to each individual waste item. From these waste items, such EWC classes were identified, that could be directly or by using specific descriptions of waste type given by the reporting units be connected with CPA classes.

It turned out, that from general '99'-ending EWC classes remarkable amounts of waste belonging clearly to some CPA class were found (e.g. CPA 271091, slag, dross and scaling from manufacture of iron and steel). Also some waste that are not included into CPA, such as e.g. manure, ash, slag, and waste water sludge were recovered waste. In order to calculate flows of these wastes in the PIOT99 system, classes beginning with '99' code were added to the CPA (last rows in the table 4.2.)

Packaging, construction and demolition wastes were separated from the data in VAHTI register, in order to identify the amounts of clearly process- and municipal wastes. Summary on waste generation and treatment in industry is presented in Table 4.2.

Table 4.2. Process and municipal waste in industry included in VAHTI register according to CPA classification. Generation and treatment.
K = use as raw material, E = used for energy production,
H = Unknown type of use, L = final treatment. 1000 tonnes

		K	E	H	M	Total
1511400	Raw offal, inedible	2.2	0.0	0.0	0.3	2.5
1520170	Other inedible products of fish, crustaceans, molluscs or other aquatic invertebrates	0.0	0.0	0.0	0.0	0.0
1533300	Vegetable materials and vegetable waste, vegetable residues and by-products	22.7	0.0	0.0	2.3	25.0
1583200	Beet-pulp, bagasse and other waste of sugar manufacture	0.0	0.0	0.0	0.0	0.0
1596200	Brewing or distilling dregs	0.0	0.0	0.0	0.0	0.0
1600200	Tobacco refuse	0.0	0.0	0.0	0.0	0.0
1710600	Silk waste; waste of wool or of fine or coarse animal hair; cotton waste	0.0	0.0	0.0	0.3	0.3
2010400	Sawdust and wood waste and scrap	568.9	1377.1	25.2	119.0	2090.3
2112600	Waste and scrap of paper and paperboard	83.5	25.5	9.2	5.8	124.0
2416600	Waste, parings and scrap, of plastics	2.4	5.4	0.0	5.6	13.4
2513800	Waste, parings and scrap of rubber (except hard rubber) and powders and granules	0.2	8.5	0.0	0.0	8.7
2615111	Cullet and other waste and scrap of glass; glass in the mass (excl. glass in the form of powder; granules or flakes)	7.4	0.0	0.0	0.1	7.4
2653100	Plaster (consisting of calcined gypsum or calcium sulphate)	65.1	0.0	0.0	104.7	169.8
2710910	Slag, dross, scalings and other waste from the manufacture of iron or steel	410.2	0.0	0.0	20.6	430.8
2710920	Ferrous waste and scrap	107.0	0.0	0.5	3.7	111.2
2742300	Waste and scrap of aluminium; ash and residues containing mainly aluminium	9.2	0.0	0.0	0.0	9.2
2743300	Waste and scrap of lead, zinc and tin; ash and residues containing mainly zinc or lead	1.4	0.0	0.0	0.0	1.4
2744300	Waste and scrap of copper; ash and residues containing mainly copper	6.2	0.0	0.1	0.1	6.3
2745400	Waste and scrap of nickel; ash and residues containing other metals and metal compounds	0.0	0.0	0.0	0.0	0.0
9901201	Manure	0.0	0.0	0.0	2.1	2.1
9914201	Soil and stone waste	225.1	0.0	0.0	451.9	676.9
9927002	Other slag	28.6	0.0	0.0	145.2	173.8
9940101	Ash	483.3	0.0	12.4	587.0	1082.7
9990102	Sewage sludge	294.4	763.6	41.5	957.9	2057.3
9990201	Mixed waste	248.1	88.8	4.1	974.1	1315.1
	Total	2565.6	2268.9	93.1	3380.6	8308.2

Comparison of generation of recoverable waste included in VAHTI register and produced recoverable waste in industrial statistics by CPA classes is presented in Table 4.3. Total amount of recoverable waste is in industrial statistics more than three times higher than in VAHTI register. Main reason for the difference is CPA class 2010400 ‘sawdust, wood waste and scrap’, for which industrial statistics show much higher amounts than VAHTI register. For some waste categories, such as paper waste 2112600, vegetable waste 1533300, aluminium scrap 2742300, waste of rubber 2513800 and waste of plastics 2416600 VAHTI register gives higher amounts.

In 1999 VAHTI register covered 530 industrial sites, and product inquiry of industrial statistics covered 5300 sites. Still, it is obvious that VAHTI register covered sites producing the main waste flows. On the other hand, industrial statistics does

not include data on deliveries of materials that have no monetary value directly connected to them. Thus all recovered waste is not recorded in industrial statistics.

PIOT99 procedure combines data from both above mentioned systems. The main source used for supply of recovered waste is industrial statistics, but in branches of industry where VAHTI register gives higher amounts of waste this register is used. VAHTI data is also used for types of waste not included in the CPA classification, and for final waste (waste not in recovery use).

Table 4.3. Generation of recovered CPA classified waste in VAHTI register and in industrial statistics 1999. 1000 tonnes

		VAHTI	Industry statistics
1511400	Raw offal, inedible	2.2	69.7
1520170	Other inedible products of fish, crustaceans, molluscs or other aquatic invertebrates	0.0	15.6
1533300	Vegetable materials and vegetable waste, vegetable residues and by-products	22.7	4.4
1583200	Beet-pulp, bagasse and other waste of sugar manufacture	0.0	56.0
1596200	Brewing or distilling dregs	0.0	3.4
1600200	Tobacco refuse	0.0	0.0
1710600	Silk waste; waste of wool or of fine or coarse animal hair; cotton waste	0.0	0.3
2010400	Sawdust and wood waste and scrap	1946.0	6794.5
2112600	Waste and scrap of paper and paperboard	109.1	29.5
2416600	Waste, parings and scrap, of plastics	7.8	0.9
2513800	Waste, parings and scrap of rubber (except hard rubber) and powders and granules	8.7	0.5
2615110	Cullet and other waste and scrap of glass; glass in the mass (excl. glass in the form of powder; granules or flakes)	7.4	6.4
2653100	Plaster (consisting of calcined gypsum or calcium sulphate)	65.1	101.5
2710910	Slag, dross, scalings and other waste from the manufacture of iron or steel	410.2	973.7
2710920	Ferrous waste and scrap	107.0	116.6
2742300	Waste and scrap of aluminium; ash and residues containing mainly aluminium	9.2	0.5
2743300	Waste and scrap of lead, zinc and tin; ash and residues containing mainly zinc or lead	1.4	11.4
2744300	Waste and scrap of copper; ash and residues containing mainly copper	6.2	41.9
2745400	Waste and scrap of nickel; ash and residues containing other metals and metal compounds	0.0	28.6
	Total	**2702.9**	**8255.4**

4.3. Packaging waste

Statistics on packages and packaging waste are in Finland compiled by Finnish Environment Institute, according to European Union directive (97/138/EY). These statistics do not separate the use of packages by branches of industry, and flow of packages ending up to waste of the users of products inside the packages. Table 4.4. shows total use, re-use, new packages (entering the markets) in Finland in 1999. The amount of new packages also describes the amount of packages taken away from use, and is thus an estimate for the amount of packaging waste.

Table 4.4. Packages in Finland 1999. 1000 tonnes

Packaging material	Total use	Re-use	New packages	Rate of re-use (%)
Glass	347	289	58	83.2
Plastic	293	201	92	68.6
Paper and paperboard	266	10	256	3.8
Metals	324	287	37	88.7
Total	**1 230**	**787**	**443**	

Recovery rate of packages is quite high in Finland. However, it should be noted that during one year many packages are re-used several times, and total use of packages is much higher than the amount of packages that are in use. Also, new packages taken into use are re-used, and are thus recorded as higher total use and re-use than their total amount.

Industrial statistics on packaging materials include packages bought by branches of industry in both monetary values and physical amounts. In practice physical amounts are often recorded as pieces of packages, and are often lacking from the statistics. Classification of packages is relatively detailed (47 types), and the amounts can usually by estimated with help of prices and values recorded. Statistics mainly include only new packages, and data are thus directly linked with generation of packaging waste of the products inside the packages.

Industrial statistics on packaging materials include same groups of materials than in Table 4.4., plus wooden packages. In Table 4.5. a comparison between new packages according to statistics of Finnish Environment Institute and industrial statistics is presented. The amounts are relatively close to each other, although industrial statistics do not cover packages in agriculture and in wholesale and retail trade activities. Branch of manufacture of food products and beverage (NACE 15 and 16) forms approximately one third of industrial use of packages.

Table 4.5. Use of new packages. Industrial statistics of Statistics Finland and package statistics of Finnish Environment Institute (FEI) 1999. 1000 tonnes

	Industrial statistics	Statistics of FEI
Wooden packages	254	
Glass	46	58
Plastics	96	92
Paper	266	256
Metals	43	37
Total	705	443

So far only packages used by industry have been taken into account in PIOT99. A separate calculation method has been developed for packages that end up to the users of products inside the packages. In this method, from 721 products included into PIOT99 products that are packaged and products not packaged are defined. Bulk materials and products are usually transported without packages. Number of product groups that are packaged is 525.

PIOT99 method calculates package-coefficient for each industrial activity at 3-digit level of PIOT classification of branches of industry. This coefficient is calculated as a amount of packages / amount of packaged products in each activity group. After this stage, coefficients by product groups are calculated by using supply matrices. It is assumed, that coefficient for all products in individual branch of industry is the same one. It is also assumed, that coefficients do not differ between imported and domestic products.

Finally, by using use matrix of products and package-coefficient, the method produces amounts of packages for each branch of industry and product group, that end up to the users of the products, that finally end up as packaging waste. However, half of packages ending up to households in consumable goods, are in PIOT99 transferred to packaging waste of retail trade activities.

The method presented above is still quite rough, but it can be improved e.g. by connecting most relevant packaging materials to more specific products, and by estimating package waste of trade activities on the basis of data directly from enterprises of wholesale and retail trade.

Balance of flows of packaging materials is presented in Table 4.6. More packaging material is leaving the country in exports, than enter the country in imports. Thus the amount of packaging waste that remains in domestic economy (930 – 329 = 601 thousand tonnes) is smaller than the amount of new packages used (705 t.t.).

Table 4.6. Amounts of packages by origin and destination 1999, 1000 tonnes

Origin of packages	**930**
Packages of domestic products	705
Packages of imported products	225
Destination of packages	**930**
Industry	261
Construction and investments	82
Trade	105
Other services	54
Households	99
Export	329

4.4. Wastes of energy production

In PIOT99, ashes of fuel combustion are calculated in a system of material balances of fuel combustion. This system includes data on fuel use by branches of industry and material contents of fuels, including ash content. It is also assumed, that in combustion of solid fuels, one percent of the fuel is not burnt because of incomplete combustion processes. Material balances, including ash formation, are calculated separately for each branch of industry.

Ashes (mainly from big power plants) are also delivered to recovery in construction activities. Data on this share of ash are taken from VAHTI register, rest of ash is recorded as final waste. Data on gypsum generation (in purification processes of carbon combustion) and recovery is taken from VAHTI register as well.

4.5. Wastes of agriculture, fishing and forestry

The main amounts of agricultural waste are manure and carcases of animals of fur production. Data on them are calculated by metabolic model. All manure is recorded to be used in land improvement and all carcases in feed production.

Silvicultural waste of forestry and logging industry is mainly recorded as unused extraction. Amounts of this material is calculated by tree species –specified coefficients from data on logging included in forest statistics. Lubricant and hydraulic oils of forestry and logging machinery are not accounted at this stage of PIOT99.

From fishing activities approximately 10 percent of the weight of fish catch turns into waste, and part of that waste is re-used in feed production. So far this is not accounted in PIOT99. Amounts of other waste from agriculture and fishing, e.g. oil and plastic waste are not yet estimated.

4.6. Waste of mineral quarrying and construction

Data on main material flows of mining industry is taken from mining statistics (Tilastoja Vuoriteollisuudesta 1999 ,2000), which is based on register of mines. Mining of soft construction stone is included in mining statistics. Data on other extraction of stone, gravel, sand and other earth materials are available from statistics on extraction of earth materials based on registers of Finnish Environment Institute (Rintala 2002). Use of other materials in mining and quarrying activities is included in industrial statistics. Definitions of material flows according to mining statistics and their connection to definitions of material balance approach is presented in table 4.7.

Table 4.7. Material flows of mining 1999, 1000 tonnes

MIning	Material balance	Amount
Total extraction	Total input	36 558
- Overburden	- Unused extraction	18 717
= Gross ore	= Raw material input	17 841
- Concentration sand	- Produced waste	10 674
=Produced concentrates	= Produced products	7 167

By dissaggregating the total flows of mining according to mining statistics, the flows can be placed to branches of mining according to NACE 3-digit level. Material flows of mining of soft stone are transferred to branch of manufacture of mineral products, which is included in industrial statistics. Also a part of gravel and sand extraction recorded in extraction statistics is transferred to manufacture of mineral products.

Earth materials and rock which are removed by construction activities are not included in registers of extraction of earth materials. These ‘surplus’ earth materials are recorded as unused extraction of construction activities. Rough estimates of these materials are based on case study made in 1998. Gravel crushed from rock in road construction, and used in road construction, is recorded as input of materials in construction activities.

Remarkable amounts of waste, such as slag, dross, ash and sludge are used in construction. Direct data on amounts are not available, and in PIOT99 they are estimated from supply of recoverable waste. Amounts of wastes from civil engineering, e.g. packaging waste are not yet estimated. Estimates on waste from building construction are available. Total output of construction is calculated as 'material output = raw materials and intermediate goods – waste'. Material balances of fuel combustion are not included in this calculation.

4.7. Wastes of services and households

For those services activities, where output does not consist of materials, it is assumed that used intermediate products and packages end up as wastes. Together with balances for fuel combustion this leads automatically to material balances in these activities.

In branch of hotels and restaurants (NACE 55) output have also material content, as mass of served food and drinks. The mass of output is calculated by subtracting losses of food preparation from mass of inputs, used foodstuff. Thus waste of food preparation forms a balancing item.

In branch of Sewage and refuse disposal (NACE 90), sub-branch Collection and treatment of other waste (NACE 9002) is in PIOT99 treated as an activity, that also separates and transfers wastes from general flow to recovery. This branch also destroys part of waste by incinerating (in fact turning waste into ash, slag and emissions to air). Waste transferred to landfills is treated as intermediary action of this sub-branch, and this transferred waste is not recorded into material balance of it. Recoverable waste separated by collection and treatment of other waste is calculated as a difference, that takes place when use of recovered waste (mainly waste paper, metal scrap and cullet of glass) is higher than total supply industry and imports.

An other possibility would be to focus the separation of recovery waste from general waste flow to branch of Wholesale of waste and scrap (NACE5157). However, this could lead to more complicated balances, when branch of trade would no longer be treated purely as intermediary of products.

Waste generation of households is deducted by groups of consumable goods. Acquisition of consumable goods of households is presented in Table 4.8. More than half of the acquisition is fuels and approximately 40 % is foodstuff. Solid waste from fuel combustion is ash, amount of which is one percent of the mass of fuels. Half of the mass of fuels is wood. Foodstuff includes also food and drinks taken in restaurants and places comparable to them. Waste includes waste from food preparation and solid metabolic excrata. Most of the mass of fuels combusted and foodstuffs ends up as carbon dioxide into air.

Table 4.8. Acquisition and wastes of consumable goods of households 1999, 1000 tonnes

	Acquisition	Wastes	
Fuels	5 327	53	Ash
Foodstuffs	4 076	452	Bio waste
Durable goods	274	183	Scrap
Other goods	833	833	Mixed waste
Packages	99	99	Packaging waste
Total	10 610	1 620	Total

For acquisition of durable goods it is estimated, that 2/3 replaces old durable goods, and 1/3 ends up as increase of stocks. Short-term goods and packages end up as waste. As a whole, solid wastes of households are only 15 % of total amount of goods acquisition.

4.8. 'Capital waste'

Estimates on capital waste consisting of scrap withdrawn from material capital stock are very preliminary. There is a clear need to improve estimates and develop calculation methods in this area in the future.

Demolition waste of building construction is an estimate made in Statistics Finland. Demolition and other capital waste from civil engineering are at present not estimated at all. Withdrawn from stock of machinery and equipment is estimated to be 2/3 of physical mass of investments on machinery and equipment.

5. Summary and conclusions

In this pilot study, methods have been developed to identify and combine necessary data and statistics on waste generation, recovery and other treatment of waste by branches of industry, and to adapt this information on waste flows in frameworks of physical input-output tables and material flow accounting. Main results of the work are presented as summaries in physical input-output balance by branches of industry (Table 2.1.), and economy- wide material balance (Table 2.4.).

Data and statistics on waste generation, treatment of waste and use of waste are collected and presented in several statistical systems, systems which are based on different needs and different definitions and classifications. In this study, links were created between waste statistics that follow EWC classification, industrial statistics following CPA and PRODCOM classifications, and foreign trade statistics following CN classification. Also, methods were developed in order to adapt data and statistics on packaging waste, wastes of services and households, wastes of agriculture, fishing and forestry, wastes of energy production, wastes of mineral quarrying and construction, and capital waste into the input-output balances.

Input-Output balance and economy-wide material balance show clearly, that waste flows form remarkable share of total physical input and output in both national economy and in many individual branches of industry. Tracing these waste flows by material groups and by branches of industry is essential for comprehensive compilation and presentation of material flows in frameworks of material flow accounting.

On the other hand, Material flow accounting offers a practical framework for statistical data on waste to be treated and presented in the form of waste accounting as integrated part of material flow accounting and material balances. The meaning of waste generation and recovery of waste for the economy is shown more clearly than in traditional waste statistics. Also, estimation and treatment of waste flows as a part of general material flows of the economy makes it possible to estimate such waste flows, from which direct and adequate basic data and/or statistics are not available.

In addition to their essential meaning to physical input-output balance and economy wide-material balance, methods developed in this study offer a practical and useful basis for separate waste accounting, that would remarkably broaden and supplement traditional waste statistics. Although waste statistics in Finland are well developed and rather workable tool in environmental accounting (including NAMEA approach) and in environmental policy in general, a need to combine and present data and statistics on waste flows in forms of accounting and balances is apparent. This could also be done on annual basis, which is necessarily not the case for input-output balance by branch of industry, because of rather heavy resource requirement of this approach.

In waste accounting, generation and treatment of hazardous waste should be presented separately from other waste. Waste should also be dissaggregated into material groups, such as e.g. minerals, metals, wood, other biotic material etc. as the main components, in order to link the amounts of waste with their environmental impacts, and the impacts of their recovery use to need of extraction of virgin natural resources. These disaggregations by hazardous/non hazardous and material

groups are to some extent already included in classifications used in basic data and statistics on waste, but some work in this field is still needed.

Additional costs of annual extending of statistics on waste to waste accounting and balances can be estimated to be approximately 15.000 – 20.000 Euro per year. These costs would rise mainly from improved dissaggregations of waste types, maintaining and updating the links between classifications and statistical systems involved, and improving of estimation and calculation methods especially on water content of products, co-efficients for packages, and flows of capital waste.

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Annex 1. Branches of industry in PIOT99

Industries		NACE
1	Agriculture and fishing	01,05
2	Forestry, logging etc	02
3	Mining and quarrying	C
4	Manufacture of food products	15, 16
5	Manuf of textiles etc	17,18,19
6	Manuf of wood & wood products	20
7	Manuf of pulp, paper, paper prod	21
8	Publishing, printing etc	22
9	Manuf of coke and petroleum ref.	23
10	Manufacture of chemicals etc	DG
11	Manuf of rubber and plastic prod	DH
12	Manuf of non-met mineral prod	26
13	Manufacture of basic metals	27
14	Manuf of metal products	28
15	Manuf of machinery and equipm	29
16	Manuf of electrical equipment	DL
17	Manuf of transport equipment	DM
18	Manufacturing n.e.c.	36
19	Recycling	37
20	Electricity, gas & water supply	E
21	Building	F
22	Civil engineering	F
23	Wholesale and retail trade etc	G
24	Hotels and restaurants	H
25	Transport, storage	IA
26	Post and telecommunications	IB
27	Dwellings	7021
28	Public administration and services	L, M, N
29	Sewage, refuse disposal; sanitation	900
30	Other service activities	701,7022,703, KB, O,P

Annex 2. Generation of waste in Finland 1999. Thousand tonnes.
Sources: Statistics Finland and Finnish Environment Institute

	Solid municipal waste	Sewage sludges from municipal waste water treatment plants*	Hazardous waste	Industrial waste	Waste from energy and water supply	Waste from mining and quarrying*	Waste from agriculture	Construction and demolition waste**
Total amount	2 400	160	638	19 123	921	29 600	20 000	1 200
Recovered as materials	700	144	32	7 625	561		18 800	
Recovered as energy	200	2	52	4 555	9			
Incinerated			69	6	2			
Landfilled	1 500	14	388	4 657	315			
Other treatment			97	2 280	34		1 200	

* Dry weight

** In addition to this, 8 500 thousand tonnes earth materials from building construction and 25 000 thousand tonnes from civil engineering