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THULE INSTITUTE
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Compilation and analysis of complete waste accounts in conjunction with general material flow accounts

Contents

1. Foreword

This report includes results and conclusions achieved in compiling complete waste accounts of the Finnish economy, and in integrating those accounts with physical input-output tables of Finland. This work was done in a pilot project that received funding from the European Commission. The project also benefited from experiences and expertise gained in previous pilot projects on material flow accounting made for Eurostat by Finland.

The work was conducted as a joint effort of the Thule Institute of University of Oulu and Statistics Finland. Ilmo Mäenpää from the Thule Institute, and his assistant Tiina Härmä provided the waste accounts and physical input-output tables by branches of industry, and produced part of the indicators derived from the waste accounts. Tero Tyni from Statistics Finland calculated weights in tonnes for commodities included into Industrial Statistics of Statistics Finland. Conversion factors calculated by Ilmo Mäenpää were used in these calculations. Marianne Kaplas and Juha Espo from Statistics Finland gave valuable expertise for the waste accounts. Jukka Muukkonen and Simo Vahvelainen from Statistics Finland compiled this final report to Eurostat.

Detailed description of calculation methods and concepts for physical input-output tables of Finland are presented in publication *Ilmo Mäenpää 2005: Physical Flow Accounts. Calculation Methods and Concepts. Material Balances in Finland 1999. Statistics Finland and Thule Institute, University of Oulu*. Only the methodology of calculation of waste accounts and indicators are described in this report of the pilot study to Eurostat. Waste accounts, indicators and physical input-output tables of Finland for the year 2002 are preliminary, and they are not presented as official statistics of Statistics Finland.

2. General description of the pilot study

The objectives of the study were to construct supply and use tables for the year 2002 for Finnish waste accounts. Both the compilation of the accounts and the derivation of analytical results, or waste indicators, were performed by exploiting the data and the results of the 2002 physical input-output tables, PIOTs, in other words general material flow accounting.

The classifications of the waste accounts comply with the classifications of the Regulation of the European Community on waste statistics (2151/2002), the EWC-Stat classification and division of activities in which waste industries (37, 5157 and 9002) were separately identified. Waste supply and use tables were initially compiled by utilising basic sources of data on waste, especially the VAHTI, the compliance Monitoring Data System of Environmental Government of Finland. Following this, the PIOT data were used to verify waste data for the activities that are incomprehensively covered by the basic data sources and to estimate completely missing waste flows.

Comparing indicators of NAMEA and MFA type with each other concluded the project. Conclusions were drawn from the results to serve discussion about waste indicators that could be applied at the total economy level, especially in approaches of the waste generation/TMR (or DMI) ratio type, in particular as indicators of prevention of waste generation.

3. Waste accounts

The basic source of data on the waste generation of manufacturing industries were the waste data for the year 2002 in VAHTI, the information system of the Finnish Environmental Administration. The waste data 2002 in VAHTI are classified in accordance with the European List of Waste (LoW). The recyclable waste substances were converted into the CPA classification and added to the product flows of industrial statistics if those flows were smaller or lacking altogether in them. The wastes of mining and quarrying were obtained from the mining register of the Ministry of Trade and Industry. Additional data on special wastes were obtained from the monitoring reports required by the Waste Directives of the EU and compiled by the Finnish Environment Institute.

In physical flow accounts, package waste is obtained from package flows and ashes from the material balances of fuel combustion. Therefore, package and ash wastes were removed from the waste data of VAHTI. Some large waste items were also added basing on the special studies made during the compilation physical flow accounts.

The wastes of service industries were derived by assuming that material inputs other than fuels and foodstuffs end up as final waste. Fixed capital wastes include the demolition waste of buildings and machinery, appliances and vehicle scrap. These are equivalent to the physical withdrawal of fixed capital.

Foreign trade statistics include the imports and exports of recyclable waste. Besides these, there are also transfers of hazardous waste for waste treatment in other countries. The monitoring data for these waste flows were obtained from the Finnish Environment Institute.

In the application of waste legislation and in the waste statistics of Finland, a wide interpretation of waste is followed where production residues going direct to further use are also accounted as waste. Even the residues used - mostly as energy sources - by the producing unit itself are included in waste if they are not circulated in continuously working closed processes such as is the case with the use of black liquor in pulp processing.

In the general tables of physical flow accounting, only the final waste going to landfills or to waste treatment is shown separately. The generation and use of recovered waste is included in the product flows, but from the detailed product classification of the calculation level supply and use tables, the recovered waste flows can be classified by means of the waste list presented in table 1.

Table 1. *Waste list by the CPA classification*

CPA	Description
1511400	Raw offal, inedible
1520180	Other inedible products of fish, crustaceans, molluscs or other aquatic invertebrates
1533300	Vegetable materials and vegetable waste, vegetable residues and by-products
1583200	Beet-pulp, bagasse and other waste of sugar manufacture
1596200	Brewing or distilling dregs
1600200	Tobacco refuse
1710600	Silk waste; waste of wool or of fine or coarse animal hair; cotton waste
1822400	Worn clothing and other worn articles
2010400	Sawdust and wood waste and scrap
2112600	Waste and scrap of paper and paperboard
2416600	Waste, parings and scrap, of plastics
2513800	Waste, parings and scrap of rubber (except hard rubber) and powders and granules
2615110	Cullet and other waste and scrap of glass; glass in the mass
2653100	Plaster (consisting of calcified gypsum or calcium sulphate)
2710910	Slag, dross, scalings and other waste from the manufacture of iron or steel
2710920	Ferrous waste and scrap
2742300	Waste and scrap of aluminium; ash and residues containing mainly aluminium
2743300	Waste and scrap of lead, zinc and tin; ash and residues containing mainly zinc or lead
2744300	Waste and scrap of copper; ash and residues containing mainly copper
2745300	Waste and scrap of nickel; ash and residues containing other metals and metal compounds
9901201	Manure
9914201	Soil and stone material waste
9923201	Waste oil
9940101	Ash
9990101	Sewage sludge, municipal
9990102	Sewage sludge, industrial
9990202	Recovered fuels

Table 2 presents waste flows according to the wide waste definition. The total domestic waste generation is shown in the bottom row of the generation side. The total waste generation is obtained when the imports of waste and the double accounting of the waste produced by the waste of the recycling and sewage and refuse disposal industries are subtracted from the total supply of waste.

In the table 2, the use of final waste (1) includes all wastes converted to useful waste by branches of recycling and waste management (sewage, refuse disposal; sanitation) and all final waste ending up to landfills. Landfills in this context also include pools for dressing sands and areas for the placement of waste soil and stone (as recommended in the SEEA 2003 manual). Final waste (2) includes all waste that end up to waste management activities or directly to landfills. Also municipal waste is recorded as final waste, because even after assorting they end up to waste management activities or wholesale trade of waste.

Unused extraction (3) consist of logging waste (wood, needless and leaves), side stone from mining and quarrying, and unused soil and stone from construction activities. If unused extraction –materials are recovered, they turn to useful waste and are subtracted from the original amount of unused extraction. The recovery of waste from civil engineering includes also the use of this waste in filling mines and in landfill structures. Wastes from capital formation are demolition waste and machinery that are removed from use. The exports of imports are mainly metal scrap, which Finnish companies import and then export to some other country. It has to be recorded as import and export, because the ownership of scrap is temporarily transferred to Finnish companies.

As a result of the wide interpretation of waste, in the waste accounts and in the PIOT waste are divided into two categories: 1) Recovered waste and 2) Final waste. Differences between terminology used in waste directives, Waste statistics regulation, waste accounts and PIOT are clarified below:

1) Recovered waste includes production residues and internal recycling of waste, which are not accounted in waste statistics according to the Waste statistics regulation. Recovered waste is further divided according to the CPA classification, as presented in Table 1 in page 4.

2) Final waste includes all waste that end up to waste management activities or directly to landfills. In the Finnish case the generation of final waste is practically equal to waste generation according to the Waste statistics regulation. Treatment of final waste includes both material and energy recovery, disposal to landfills and waste incineration without energy recovery. The treatment covers all recovery and disposal operations included into the Waste statistics regulation.

In order to avoid confusing terminology between the wide interpretation of waste and waste definitions in waste directives and Waste statistic regulation, the term ‘recovered waste’ could be replaced by term ‘recovered materials’, and the term ‘final waste’ could be replaced by term ‘waste’. It is also possible, that the wide interpretation of waste followed in the Finnish waste accounts could be narrowed to equal the interpretation of waste followed in directives and regulation. However, internal recycling of production residues and waste is a very important factor of waste prevention and effective use of materials, and it has to be clearly recorded in the PIOT –framework. The amounts of internal recycling should also be presented together with information provided by waste statistics.

Table 2. *Waste flows by industry 2002, million kg*

Waste generation, recovery and use		Waste recovery				Waste generation			
Finland 2002, 1000 tonns		Imports	Domestic		Use of	Domestic			Exports
			as material	as energy	final waste[1)]	Rocovered waste	Final waste[2)]	Unused extraction[3)]	
1	Agriculture and fishing	0	23 845	332	0	23 521	197	0	2
2	Forestry, logging etc	0	12	0	0	1 439	0	21 227	0
3	Mining of energy minerals	0	1	0	0	0	0	436	1
4	Other mining and quarrying	0	0	0	0	4 935	11 196	8 437	8
5	Manufacture of food products	134	606	8	0	775	110	0	113
6	Manuf of textiles etc	0	0	4	0	7	10	0	3
7	Manuf of wood & wood products	23	3	1 267	0	4 888	73	0	82
8	Manuf of pulp, paper, paper prod	83	1 582	3 109	0	4 548	1 289	0	122
9	Publishing, printing etc	0	0	0	0	17	58	0	5
10	Manuf of coke and petroleum ref.	0	17	2	0	19	30	0	2
11	Manufacture of chemicals etc	4	104	54	0	189	2 354	0	32
12	Manuf of rubber and plastic prod	0	9	0	0	18	23	0	13
13	Manuf of non-met mineral prod	9	448	9	0	318	176	2 308	20
14	Manufacture of basic metals	123	1 203	0	0	1 313	1 219	0	33
15	Manuf of metal products	4	6	0	0	12	54	0	20
16	Manuf of machinery and equipm	0	12	1	0	6	105	0	32
17	Manuf of electrical equipment	0	0	0	0	2	57	0	10
18	Manuf of transport equipment	0	2	0	0	13	46	0	2
19	Manufacturing n.e.c.	0	0	14	0	14	7	0	5
20	Recycling	18	1 392	0	211	315	222	0	7
21	Electricity, gas & water supply	72	272	5 273	0	576	581	0	2
22	Building	0	0	0	0	146	1 932	6 000	0
23	Civil engineering	2	8 824	0	0	0	3 862	18 000	0
24	Wholesale and retail trade etc	0	0	0	0	0	359	0	0
25	Hotels and restaurants	0	0	0	0	0	104	0	0
26	Transport and communication	0	0	0	0	0	52	0	0
27	Dwellings	0	0	0	0	0	2	0	0
28	Public administration and services	0	0	0	0	0	202	0	0
29	Sewage, refuse disposal; sanitation	0	0	0	6 025	5 053	755	0	134
30	Other service activities	0	0	0	0	0	208	0	0
	Production activities, total	**473**	**38 338**	**10 074**	**6 236**	**48 124**	**25 283**	**56 408**	**647**
	Households	0	0	0	0	0	1 974	0	0
	Fixed capital formation	0	0	0	0	0	20 519	0	0
	Landfills	0	0	0	41 540	0	0	0	0
	Exports of imports	250	0	0	0	0	0	0	250
Total		**723**	**38 338**	**10 074**	**47 776**	**48 124**	**47 776**	**56 408**	**897**

Notes 1), 2) and 3) are explained in the previous page

Domestic waste generation amounts to 152 million tonnes. In the waste statistics of Statistics Finland, the waste generation in 2002 is slightly less than 120 million tonnes. The difference is mainly due to two factors. The waste statistics include wall rock and tailings as waste from mining and quarrying. In physical flow accounts, unused extraction also includes the excavated overburden. Second, in the waste statistics, energy recovery amounts to 5,4 million tonnes, while in physical flow accounts it rises to over 10 million tonnes. Mainly industrial wood residues cause the difference in the energy recovery. In physical flow accounts the quantities are derived from energy statistics while in waste statistics they are based on the amounts reported by industries to the VAHTI register.

In physical flow accounts, in addition to the landfills of manufacturing and municipalities, landfills also include tailings reservoirs. Subtracting the tailings, pools for dressing sands and areas for the placement of waste soil and stone from the total accumulation of landfills, the total generation of manufacturing

and municipal landfill waste becomes 9 million tonnes. In waste statistics, manufacturing and municipal landfill waste generation is 8.1 million tonnes.

In physical flow accounts, the waste generation of service industries and households is derived from input use. When the household waste treated in backyards is subtracted from this waste, 2.4 million tonnes of waste are left. This is equal to the generation of municipal waste in waste statistics. However, the statistical concept of municipal waste includes the manufacturing waste which comes to municipal waste treatment plants and, on the other hand, apparently excludes e.g. household car scrap, which in physical flow accounts is defined as household waste.

The sewage and refuse disposal industry could also be divided into two subindustries, treatment of liquid waste and treatment of solid waste. In physical flow accounts, to simplify the account structure, the waste placed in municipal sewerage, which mainly comes from service industries and households, is also accounted as final waste. 1999 data divided into treatment of liquid and solid waste showed, that liquid waste treatment has used 263 thousand tonnes (solid waste amounted to 3,1 million tonnes) of final waste, measured at 15% moisture content. From this, 183 thousand tonnes are retrieved as sewage sludge, of which 179 tonnes are recycled. From the waste input of liquid waste treatment, 53 thousand tonnes are lost as discharges into water and the remainder is converted in sewage treatment plants and in the composting of sewage sludge into gases of which some are processed into biogas for energy use.

In addition to the unused inputs, one of the largest waste items is the recovered waste generated by agriculture amounting to 23.8 million tonnes. Almost all of these are comprised of manure. Furthermore, most of the manure is liquid manure with a moisture content of over 90%. The dry matter content of the manure is only 2.4 million tonnes. The final waste of manufacturing also contains sludge items with high moisture contents. Thus, the average moisture content of the waste of the pulp and paper industry slightly exceeds 50%. The notable share of water in some waste items creates problems in the comparability of different waste flows. Anther problematic fact is that some large manufacturing sludge items are reported to the VAHTI register as dry matter.

When comparing industries, the moisture problem should always be kept in mind. In agriculture, manure produces the result that the ratio of waste to ordinary products is boosted, even when the share of recovered waste inputs is also high on the use side. For total production activities, the waste-product ratio becomes 15% and the waste-input share is 13%.

Table 3 shows the supply-use balance of useful waste in Finland by detailed waste classes according to the CPA classification and by main economic user categories. From that table it can be clearly seen, which waste categories are the most important ones with respect to the total amount of useful waste. The manure alone covers almost half, wood almost one fifth, soil and stone material waste 16 %, metal based waste more than 6 %, and sewage sludge 5 % of the total amount of useful waste. Agriculture, forest industries, metal industries, construction and waste management activities are the main players in the supply and use of these materials.

Table 3. *Supply-use balance of Recovered waste. Finland 2002, million kg*

		Use by main categories					Supply			
Waste classes		Agricult. Forestry Fishing	Manufact. industries	Const-ruction	Exports	**Total**	Domestic production	Imports	**Total**	
CPA	**Description**									S (-) U
212141	Forest chips	332	1 110	0	0	**1 442**	1 439	0	**1 439**	-3
1511400	Raw offal, inedible	0	90	0	3	**93**	68	36	**104**	11
1513130	Flours, meals and pellets of meat unfit fo	0	38	0	0	**38**	6	7	**13**	-25
1520180	Other inedible products of fish, crustacea	0	34	0	0	**34**	3	28	**32**	-2
1533300	Vegetable materials and vegetable wast	3	47	1	0	**51**	39	2	**41**	-9
1583200	Beet-pulp, bagasse and other waste of s	0	78	0	0	**78**	17	30	**47**	-30
1596200	Brewing or distilling dregs	105	316	0	0	**421**	421	1	**422**	0
1600200	Tobacco refuse	0	0	0	0	**0**	0	0	**0**	0
1710600	Silk waste; waste of wool or of fine or co	0	0	0	0	**0**	0	0	**1**	0
1822400	Worn clothing and other worn articles	0	0	0	0	**0**	0	0	**0**	0
2010400	Sawdust and wood waste and scrap	3	7 930	8	105	**8 046**	7 894	142	**8 037**	-9
2112600	Waste and scrap of paper and paperboa	0	646	0	128	**774**	738	36	**774**	0
2416600	Waste, parings and scrap, of plastics	0	20	0	7	**27**	22	1	**22**	-4
2513800	Waste, parings and scrap of rubber (exc	0	0	17	4	**21**	17	1	**19**	-2
2615110	Cullet and other waste and scrap of glas	0	81	1	9	**91**	91	0	**91**	0
2653100	Plaster (consisting of calcified gypsum o	0	224	1	5	**230**	165	8	**172**	-57
2710910	Slag, dross, scalings and other waste fro	0	1 186	0	0	**1 186**	1 198	0	**1 198**	12
2710920	Ferrous waste and scrap	0	1 296	0	403	**1 699**	1 208	491	**1 699**	0
2742300	Waste and scrap of aluminium; ash and	0	23	0	17	**40**	12	31	**43**	3
2743300	Waste and scrap of lead, zinc and tin; as	0	13	0	10	**23**	5	3	**7**	-16
2744300	Waste and scrap of copper; ash and res	0	20	0	18	**38**	43	3	**46**	9
2745300	Other non-ferrous metals and articles th	0	74	0	5	**80**	30	15	**44**	-35
2745400	Waste and scrap of nickel; ash and resid	0	20	0	0	**20**	1	1	**2**	-18
9901201	Manure	23 497	14	0	0	**23 511**	23 511	0	**23 511**	0
9914201	Soil and stone material waste	111	177	7 668	0	**7 956**	7 956	0	**7 956**	0
9923201	Waste oil	0	18	0	0	**18**	58	0	**58**	39
9940101	Ash	11	70	466	0	**547**	547	0	**547**	0
9990101	Sewage sludge, municipal	77	0	571	0	**648**	648	0	**648**	0
9990102	Sewage sludge, industrial	51	1 412	91	0	**1 554**	1 578	0	**1 578**	24
9990202	Recovered fuels	0	463	0	0	**463**	408	0	**408**	-55
	Total	**24 189**	**15 400**	**8 824**	**715**	**49 127**	**48 124**	**835**	**48 959**	**-168**

4. Comparison between MFA, PIOT and waste statistics at nation-wide level

Complete physical input-output tables make it possible to calculate complete output table in the economy-wide MFA framework, and to construct an 'origin-destination' balance of the MFA. When waste accounts are included into the PIOT, it gives further possibilities to compare waste as an element of the PIOT and traditional waste statistics.

Table 4 shows the summary tables at economy-wide MFA, PIOT including waste accounts and waste statistics of Finland 2002. The PIOT, economy-wide MFA, waste accounts and waste statistics all include partly same waste and waste-related materials, that are defined and recorded differently from angles of four different, but clearly related frameworks.

Table 4. *PIOT, MFA and waste statistics at nation-wide level Finland 2002, million kg*

MFA: ORIGIN		PIOT: INPUT		PIOT: OUTPUT		MFA: DESTINATION	
Domestic extraction	**327 119**	**Domestic extraction**	**327 119**				
Raw materials	172 571	Raw materials	172 571				
Water	38 138	Water	38 138				
Air (O,N)	116 410	Air (O,N)	116 410				
Imports	**66 897**	**Imports**	**66 897**				
		Domestic products	**363 619**	**Products for domestic use**	**367 432**		
		Commodities	315 207	Commodities	**319 308**		
		Recovered waste	48 412	Recovered waste	48 124		
		Final waste	**47 776**	**Final waste**	**47 776**		
				Exports	**41 593**	**Exports**	**41 593**
				Net accumulation	**120 885**	**Net addition to stock (NAS)**	**79 717**
				Household consumption	101	Household consumption	101
				Fixed capital formation	79 138	Fixed capital formation	79 138
				Changes in inventories	478	Changes in inventories	478
				Landfills	41 168		
						Domestic processed output	
				To domestic nature	**229 061**	**to nature**	**270 229**
				Emissions into air	123 736	Emissions into air	123 736
				Water vapour	103 938	Water vapour	103 938
				Discharges into water	492	Discharges into water	492
				Dissipative use	895	Dissipative use	895
						Landfills	41 168
Unused extraction	**56 408**	**Unused extraction**	**56 408**	**Unused extraction**	**56 408**	**Unused extraction**	**56 408**
TOTAL	**450 424**	**TOTAL**	**861 819**	**TOTAL**	**863 155**	**TOTAL**	**447 947**

WASTE STATISTICS OF FINLAND 2002: GENERATION AND TREATMENT OF WASTE						
Waste statistics	**Total waste produced**	**18 606**		Direct material inputs **DMI**		
reported to EU according to	**Waste treatment**	**18 606**		= Raw materials + Imports		239 468
directives on waste	recovery	9 916				
	landfilled	8 100		Total material input **TMI**		
	other disposal	590		= DMI + Unused extraxtion		295 876
Materials related to waste,						
but not included into directive reporting				Domestic material consumption **DMC**		
Agriculture: manure	Generation	21 400		= DMI - Exports		197 875
	Recovery	21 200				
	Disposal	200		Physical trade balance **PTB**		
Mining and quarrying:	Generation	25 244		= Imports - Exports		25 304
wall rock, dressing sand,	Recovery	4 965				
surplus soil	Disposal	20 279		Domestic processed output to nature		
Construction: surplus soil	Generation	32 000		**DPO**		270 229
	Recovery	8 000				
	Disposal	24 000		Total domestic output to nature **TDO**		
Forestry: logging residuals	Generation	22 400		= DPO + Unused extraction		326 637
	Recovery	1 200				
	Disposal	21 200				
Grand Total	**Generation**	**119 650**				
from directive reporting	**Recovery**	**45 281**				
and other statistics	**Disposal 1)**	**74 369**				
1) Disposal includes materials, that are recorded as unused extraction						
in MFA and PIOT frameworks (logging residuals, soil, stone)						

The main difference between the MFA and PIOT framework is, that in 'origin' and 'destination' columns of the MFA, all flows are clearly recorded only once. In the PIOT 'input' column, domestic extraction and domestic products are to some extent overlapping items; materials processed from extracted materials are again recorded in domestic products. In the 'output' column, e.g. products for domestic use and net accumulation are overlapped, as well as final waste and landfills as a part of net accumulation.

An other difference is, that usually only raw materials are presented in MFA 'origin'. The PIOT also includes those parts of air and water, that are tied up to products or residues of the economy. In the MFA, air has to be recorded only, if emissions to air are recorded in MFA 'destination' side as carbon dioxide etc. including the oxygen and nitrogen included into these emissions. In this case, air is an input to combustion processes. Water as raw material can be recorded in MFA 'origin' only as additional information, because it is not included into indicators 'Direct material input' and 'Total material output'.

In PIOT calculations, inputs to agricultural crop production consist mainly of nutrients, water and air that have been calculated separately by detailed biological balance of crop production. This method differs from the Eurostat framework of MFA, where input includes production of crop yield. Also, dissipative use of products in the PIOT does not include use of seeds and fertilisers.

In the PIOT 'output', materials disposed to controlled landfills are recorded as part of net accumulation according to recommendations of the SEEA 2003 handbook. In the MFA 'destination' side, landfills belong to domestic processed output (DPO) to nature, and not into net additions to stock (NAS).

Waste accounts included into the PIOT introduce two concepts: Recovered waste and Final waste. These concepts do not have exact counterparts in MFA or in waste statistics. Recovered waste in the PIOT context includes also internal recycling of waste, which is not accounted in waste statistics according to the Waste statistics regulation. Therefore, if Recovered waste and Final waste are used as indicators or component of indicators, they should be presented in the context of the PIOT, and ratios should not be directly calculated between components of PIOT, waste statistics and MFA.

It should also be noted, that unused extraction presented in PIOT and MFA is overlapping with materials, which are regarded as waste in the Finnish waste statistics. Some overlapping also exists with waste statistics according to EU directives and waste statistics regulation. This overlapping is mainly focused on materials such as wall rock, surplus soil and logging residuals. In PIOT the distinction between unused extraction, useful waste and final waste is clear, but some future work is required to exactly show relations between unused extraction and waste statistics by material groups.

MFA, waste accounts and waste statistics in Finland 2002 at economy-wide level are further summarised in table 5. In this summary, an attempt has been made to present waste in these contexts in a way, that makes it possible to relatively directly compare waste figures recorded in MFA, waste accounts and waste statistics.

Table 5. *Summary of MFA, waste accounts and waste statistics at economy-wide level. Finland 2002, million kg*

MFA: ORIGIN		**MFA: DESTINATION**		**MFA indicators:**	
Domestic extraction	**327 119**	**Net addition to stock (NAS)**	**79 717**	**DMI** = Raw materials + Imports	**239 468**
Raw materials	172 571	**Exports**	**41 593**	**TMI** = DMI + Unused extraxtion	**295 876**
Water	38 138	**Domestic processed output to nature**	**270 229**	**DMC** = DMI - Exports	**197 875**
Air (O,N)	116 410	Emissions into air	123 736	**DPO**	**270 229**
Imports	**66 897**	Discharges into water	492	**TDO** = DPO + Unused extraction	**326 637**
		Disposal	41 168	**NAS**	**79 717**
		Landfills	8 100	**PTB** = Imports - Exports	**25 304**
		Other disposal of solid materials	33 068	**Ratios:**	
		Dissipative use	895	**Disposal / DMI**	**0,17**
		Water vapour	103 938	**Disposal / TMI**	**0,14**
Unused extraction	**56 408**	**Unused extraction**	**56 408**	**Disposal / DPO**	**0,15**
TOTAL	**450 424**	**TOTAL**	**447 947**	**Disposal / TDO**	**0,13**
				Disposal / NAS	**0,52**
				Disposal / DESTINATION TOT.	**0,09**
WASTE ACCOUNTS: GENERATION		**WASTE ACCOUNTS: USE**			
Domestic generation	**95 900**	**Recovery**	**48 412**	**Ratios:**	
Recovered waste	48 124	as material	38 338	**Landfills (disposal) / Total use**	**0,43**
Final waste	47 776	as energy	10 074	**Recovery / Total use**	**0,57**
Exported waste	**897**	**Use of imports**	**723**	(Recovery includes items	
		To Recovered waste	**6 236**	'use of imports' and	
		Landfills (disposal)	**41 168**	'to Recovered waste')	
Total generation	**96 797**	**Total use**	**96 539**		
WASTE STATISTICS / EU FORM					
Generation	**18 606**	**Treatment**	**18 606**	**Ratios:**	
		Recovery	9 916	**Disposal / Treatment**	**0,47**
		as material	4 539	**Recovery / Treatment**	**0,53**
		as energy	5 376	**Landfills / Treatment**	**0,44**
		Disposal	8 690		
		Landfills	8 100		
		Other disposal	590		
WASTE STATISTICS / FINLAND					
Generation	**119 650**	**Treatment**	**119 650**	**Ratios:**	
		Recovery	45 281	**Disposal / Treatment**	**0,62**
		as material	40 445	**Recovery / Treatment**	**0,38**
		as energy	5 376	**Landfills / Treatment**	**0,07**
		Disposal	74 369		
		Landfills	8 100		
		Other disposal 1)	66 269		
1) Other disposal includes some materials, that are recorded as unused extraction					
in MFA and PIOT frameworks (logging residuals, soil, stone)					

In the summary, an item ‘disposal’ is added to MFA, waste accounts and waste statistics. In the MFA destination side, this disposal consists of waste to landfills according to *WASTE STATISTICS / EU FORM* (directives on waste), and other disposal of solid materials. The total amount of disposal equals to ‘landfills’ in *WASTE ACCOUNTS* and in PIOT, in which landfills also include pools for dressing sands and areas for the placement of waste soil and stone.

Disposal in *WASTE STATISTICS / FINLAND* also include landfills equal to waste statistics according to EU directives on waste. Other disposal is expanded to cover materials that are recorded as unused extraction in MFA and in PIOT (e.g. surplus soil, logging residuals). The advantage of this expansion is, that it takes into account both waste according to waste accounts and EU waste statistics, and materials that are extracted from the nature but disposed back to it without any economic use (and without any significant treatment methods).

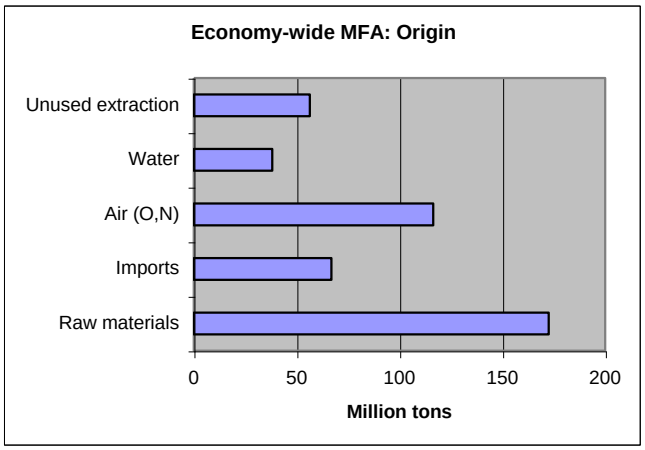
For MFA origin-destination balances, it is of importance to disaggregate recovery into material use and energy use. This is due to avoid double counting, if emissions to air are recorded in destination side. Emissions to air from waste incineration as disposal process should also be noted in the balance.

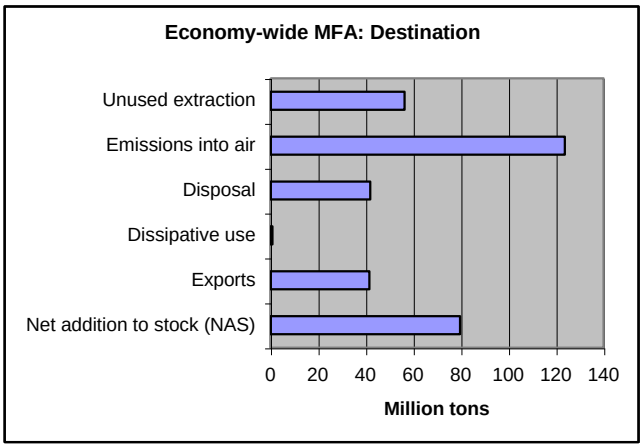
In this project report, hazardous waste is included into total amounts of waste generation and treatment (or input and output). In *WASTE STATISTICS / EU FORM*, the generation of hazardous waste is 1,3 million kg, 7 percent of the total generation. Four fifths of hazardous waste is generated in the branch of manufacture of basic metals. Of hazardous waste 15 percent is recovered as material and as energy, 70 landfilled, 6 incinerated without energy recovery and 9 percent treated by other disposal methods. The ratio of hazardous waste to MFA indicators is very small, and as such not very informative at economy-wide level.

Ratios that are calculated from MFA indicators and disposal of materials can be used to describe economy-wide physical efficiency of material use. Ratios calculated from waste accounts and waste statistics are focused on generation, use and disposal of waste and waste-related materials, and they can be used in monitoring the successfulness of waste prevention policies.

In general, the economy wide MFA balance (Figure 1.) indicates the material structure of the economy. In the Finnish case disposal and unused extraction together form a very remarkable flow of materials when compared to net additions to stock and to exports. Comparison of ratios of waste recovery and disposal to total use/treatment of waste (Figure 2.) shows, that if unused extraction of materials is seen as disposal of materials, the recovery ratio is smaller than the ratio of disposal. By both waste accounts and waste statistics according to the EU form, the result is just the opposite.

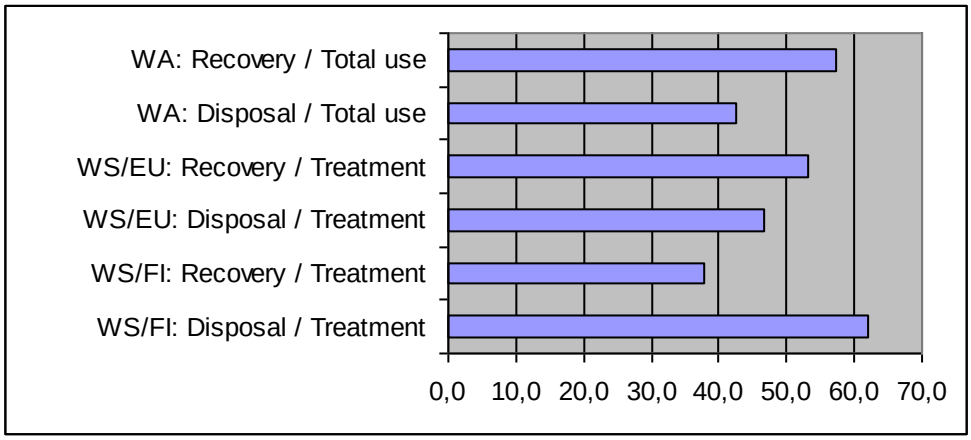
Figure 1. *Origin/Destination balance of the economy-wide MFA. Finland 2002.*





Destination excluding water vapour
Disposal includes discharges into water bodies

Figure 2. *Share (per cent) of recovery and disposal of waste total waste treatment/use. Finland 2002.*



WA refers to waste accounts, WS/EU to waste statistics/EU form, and WS/FI to Finnish waste statistics.

From purely physical point of view, the basis of waste prevention consists of five elements: extraction and use of natural resources (including unused extraction), generation of waste, recovery of waste, disposal of waste and net accumulation of materials into structures and durable goods. Information on generation, recovery and disposal of waste is not alone sufficient for waste prevention policies, and this information should be examined and presented in relation to information on extraction of natural resources, unused extraction and net accumulation of materials. Waste accounts and PIOT at economy wide level are useful tools for extending information provided by MFA and waste statistics, and at branch of industry level they make it possible to focus waste prevention policies and measures to branches, where the most significant material flows and possibilities for waste prevention exist.

5. Indicators derived from waste accounts

Especially when waste accounts are integrated into full PIOT by branches of industry, and connected to main economic variables of those industries, information base for the construction of indicators becomes very large. The PIOT itself, when calculated and structured in a way that is described in *Ilmo Mäenpää 2005: Physical Flow Accounts. Calculation Methods and Concepts. Material Balances in Finland 1999* makes it possible to derive directly the key indicators of economy wide material flow accounting (DMI, DMI/GDP, DMC, PTB etc.). The PIOT and waste accounts make it possible to examine the material efficiency at level of branch of industry.

As shown in table 6a and 6b, the PIOT records all major material flows of the economy. Waste accounts go even deeper into those flows, by showing at detailed level foreign trade, recycling and disposal of materials. This in turn can be examined together with other material flows and monetary flows of the economy as a whole and by branches of industry, as summarised in table 7.

Table 6a. *Physical input table by branches of industry*
Finland 2002, million kg (also presented in ANNEX)

Summary of the		**INPUTS**									**TOTAL**
physical flow accounts		**From domestic nature**				**From RoW**		**Domestic**			
including waste accounts		Unused	Raw	Water	Air	Import	of which	Domestic	of which	Final	**INPUT**
Million kg		extrac-	mater-		(O, N)		waste	products	Recovered	waste	
	Industries	tion	ials						waste		
1	Agriculture and fishing	0	477	33 316	25 423	1 102	0	39 460	24 176	0	99 777
2	Forestry, logging etc	21 227	50 191	0	348	102	0	31	12	0	71 900
3	Mining of energy minerals	436	9 448	0	329	4	0	176	1	0	10 393
4	Other mining and quarrying	8 437	90 760	0	199	62	0	28	0	0	99 486
5	Manufacture of food products	0	0	904	479	1 421	134	8 207	614	0	11 010
6	Manuf of textiles etc	0	0	4	108	92	0	51	5	0	255
7	Manuf of wood & wood products	0	0	0	2 522	5 137	23	24 050	1 270	0	31 709
8	Manuf of pulp, paper, paper prod	0	0	9	17 612	14 043	83	53 418	4 691	0	85 083
9	Publishing, printing etc	0	0	37	78	60	0	593	0	0	768
10	Manuf of coke and petroleum ref.	0	0	16	2 995	12 774	0	595	20	0	16 380
11	Manufacture of chemicals etc	0	0	1 607	5 420	3 338	4	4 326	158	0	14 690
12	Manuf of rubber and plastic prod	0	0	0	79	300	0	306	10	0	685
13	Manuf of non-met mineral prod	2 308	5 870	485	986	2 177	9	6 366	457	0	18 193
14	Manufacture of basic metals	0	65	56	3 710	8 156	123	8 189	1 203	0	20 175
15	Manuf of metal products	0	0	4	149	470	4	502	6	0	1 125
16	Manuf of machinery and equipm	0	0	1	175	625	0	346	12	0	1 147
17	Manuf of electrical equipment	0	0	9	43	252	0	162	0	0	466
18	Manuf of transport equipment	0	0	0	91	139	0	157	2	0	387
19	Manufacturing n.e.c.	0	0	0	40	94	0	174	14	0	308
20	Recycling	0	0	31	8	20	18	1 434	1 392	211	1 703
21	Electricity, gas & water supply	0	0	2	27 845	7 122	72	12 081	5 544	0	47 049
22	Building	6 000	0	0	934	1 058	0	21 612	0	0	29 603
23	Civil engineering	18 000	15 760	0	708	618	2	67 875	8 824	0	102 961
24	Wholesale and retail trade etc	0	0	0	1 339	191	0	585	0	0	2 114
25	Hotels and restaurants	0	0	0	114	129	0	583	0	0	826
26	Transport and coomunication	0	0	0	11 614	1 378	0	2 775	0	0	15 767
27	Dwellings	0	0	0	683	192	0	21	0	0	896
28	Public administration and services	0	0	0	688	247	0	395	0	0	1 330
29	Sewage, refuse disposal; sanitation	0	0	0	113	4	0	36	0	6 025	6 178
30	Other service activities	0	0	0	350	175	0	195	0	0	721
	Production activities, total	**56 408**	**172 571**	**36 480**	**105 182**	**61 480**	**473**	**254 727**	**48 412**	**6 236**	**693 084**
1	Household consumption	0	0	1 658	12 711	2 209		8 975		0	25 552
2	Fixed capital formation	0	0	0	0	348		99 309		0	99 657
3	Changes in inventories	0	0	0	0	-131		608		0	478
4	Landfills	0	0	0	0	0		0		41 540	41 540
5	**Domestic final use, total**	**0**	**0**	**1 658**	**12 711**	**2 427**		**108 892**		**41 540**	**167 227**
6	**Exports of imports**	**0**	**0**	**0**	**0**	**1 743**	**250**	**0**		**0**	**1 743**
7	**International transfers, net**	**0**	**0**	**0**	**-1 483**	**1 247**		**0**		**0**	**-236**
8	**Total**	**56 408**	**172 571**	**38 138**	**116 410**	**66 897**	**723**	**363 619**	**48 124**	**47 776**	**861 818**

Table 6b. *Physical output table by branches of industry*
Finland 2002, million kg (also presented in ANNEX)

Summary of the		**OUTPUTS**											**TOTAL**
physical flow accounts		**To use of domestic economy**				**To RoW**		**To domestic nature**					
including waste accounts		Products	of which	Final	Net	Exports	of which	Emissions	Water	Dischar-	Dissip-	Unused	**OUTPUT**
Million kg			Recovered	waste	accum-		waste	into air	vapour	ges into	ative	extrac-	
	Industries		waste		ulation					water	use	tion	
1	Agriculture and fishing	41 655	23 521	197	0	652	2	23 600	33 577	184	0	0	99 864
2	Forestry, logging etc	49 785	1 439	0	0	388	0	335	118	19	15	21 227	71 887
3	Mining of energy minerals	9 069	0	0	0	107	1	601	2	5	0	436	10 221
4	Other mining and quarrying	78 269	4 935	11 196	0	1 735	8	188	70	1	0	8 437	99 895
5	Manufacture of food products	7 530	775	110	0	770	113	508	2 196	1	0	0	11 116
6	Manuf of textiles etc	38	7	10	0	73	3	96	48	0	0	0	265
7	Manuf of wood & wood products	15 298	4 888	73	0	5 638	82	2 850	8 163	1	0	0	32 023
8	Manuf of pulp, paper, paper prod	21 202	4 548	1 289	0	14 269	122	22 647	25 657	209	0	0	85 273
9	Publishing, printing etc	461	17	58	0	149	5	78	63	0	0	0	810
10	Manuf of coke and petroleum ref.	7 553	19	30	0	4 964	2	2 800	1 027	1	0	0	16 376
11	Manufacture of chemicals etc	7 029	189	2 354	0	3 327	32	1 291	767	5	0	0	14 773
12	Manuf of rubber and plastic prod	316	18	23	0	269	13	73	52	0	0	0	734
13	Manuf of non-met mineral prod	12 616	318	176	0	560	20	1 979	693	0	0	2 308	18 331
14	Manufacture of basic metals	8 026	1 313	1 219	0	3 999	33	5 627	1 302	1	0	0	20 175
15	Manuf of metal products	542	12	54	0	327	20	150	63	0	0	0	1 136
16	Manuf of machinery and equipm	381	6	105	0	442	32	192	66	0	0	0	1 185
17	Manuf of electrical equipment	161	2	57	0	247	10	46	20	0	0	0	531
18	Manuf of transport equipment	30	13	46	0	250	2	98	33	0	0	0	456
19	Manufacturing n.e.c.	167	14	7	0	96	5	43	47	0	0	0	360
20	Recycling	1 456	315	222	0	16	7	7	3	0	0	0	1 703
21	Electricity, gas & water supply	574	576	581	0	2	2	30 778	14 975	1	0	0	46 911
22	Building	19 969	146	1 932	0	0	0	1 369	332	0	0	6 000	29 603
23	Civil engineering	79 789	0	3 862	0	0	0	1 070	241	0	0	18 000	102 961
24	Wholesale and retail trade etc	0	0	359	0	0	0	1 246	509	0	0	0	2 114
25	Hotels and restaurants	565	0	104	0	0	0	109	48	0	0	0	826
26	Transport and coomunication	0	0	52	0	0	0	10 962	4 076	0	677	0	15 767
27	Dwellings	0	0	2	0	0	0	633	261	0	0	0	896
28	Public administration and services	0	0	202	0	0	0	820	279	0	30	0	1 330
29	Sewage, refuse disposal; sanitation	4 951	5 053	755	0	135	134	250	34	53	0	0	6 178
30	Other service activities	0	0	208	0	0	0	349	134	0	30	0	721
	Production activities, total	**367 432**	**48 124**	**25 283**	**0**	**38 415**	**647**	**110 794**	**94 857**	**480**	**752**	**56 408**	**694 422**
1	Household consumption	0		1 974	101	0	0	13 783	9 538	13	143	0	25 552
2	Fixed capital formation	0		20 519	79 138	0	0	0	0	0	0	0	99 657
3	Changes in inventories	0		0	478	0	0	0	0	0	0	0	478
4	Landfills	0		0	41 168	0	0	372	0	0	0	0	41 540
5	**Domestic final use, total**	**0**		**22 493**	**120 885**	**0**	**0**	**14 155**	**9 538**	**13**	**143**	**0**	**167 227**
6	**Exports of imports**	**0**		**0**	**0**	**1 743**	**250**	**0**	**0**	**0**	**0**	**0**	**1 743**
7	**International transfers, net**	**0**		**0**	**0**	**1 434**		**-1 213**	**-457**	**0**	**0**	**0**	**-236**
8	**Total**	**367 432**	**48 124**	**47 776**	**120 885**	**41 593**	**897**	**123 736**	**103 938**	**492**	**895**	**56 408**	**863 156**

Table 7. *Summary of key economic variables and physical variables from the PIOT and waste accounts by branches of industry. Finland 2002.*

		Monetary flows		Material flows		Waste generation		Recovery	
		Million Euro		Million kg		Million kg		Million kg	
		Output	Value added	Produced goods 1)	Material inputs 2)	Recovered waste	Final waste	as material	as energy
1	Agriculture and fishing	4 647	1 842	41 655	41 038	23 521	197	23 845	332
2	Forestry, logging etc	3 216	2 465	49 785	50 324	1 439	0	12	0
3	Mining of energy minerals	313	118	9 069	9 628	0	0	1	0
4	Other mining and quarrying	724	208	78 269	90 850	4 935	11 196	0	0
5	Manufacture of food products	8 820	2 075	7 530	9 627	775	110	606	8
6	Manuf of textiles etc	1 458	556	38	143	7	10	0	4
7	Manuf of wood & wood products	5 380	1 167	15 298	29 187	4 888	73	3	1 267
8	Manuf of pulp, paper, paper prod	14 130	4 268	21 202	67 461	4 548	1 289	1 582	3 109
9	Publishing, printing etc	4 376	1 670	461	653	17	58	0	0
10	Manuf of coke and petroleum ref.	3 825	406	7 553	13 369	19	30	17	2
11	Manufacture of chemicals etc	5 492	1 564	7 029	7 664	189	2 354	104	54
12	Manuf of rubber and plastic prod	2 479	992	316	606	18	23	9	0
13	Manuf of non-met mineral prod	2 289	900	12 616	14 414	318	176	448	9
14	Manufacture of basic metals	5 538	1 040	8 026	16 409	1 313	1 219	1 203	0
15	Manuf of metal products	5 180	1 910	542	972	12	54	6	0
16	Manuf of machinery and equipm	10 934	3 143	381	971	6	105	12	1
17	Manuf of electrical equipment	20 411	7 073	161	413	2	57	0	0
18	Manuf of transport equipment	3 561	1 135	30	296	13	46	2	0
19	Manufacturing n.e.c.	1 651	594	167	268	14	7	0	14
20	Recycling	109	20	1 456	1 454	315	222	1 392	0
21	Electricity, gas & water supply	5 096	2 551	574	19 203	576	581	272	5 273
22	Building	13 395	5 018	19 969	22 669	146	1 932	0	0
23	Civil engineering	4 075	1 434	79 789	84 253	0	3 862	8 824	0
24	Wholesale and retail trade etc	23 107	12 884	0	775	0	359	0	0
25	Hotels and restaurants	4 703	1 778	565	712	0	104	0	0
26	Transport and coomunication	22 093	13 273	0	4 152	0	52	0	0
27	Dwellings	15 629	10 391	0	212	0	2	0	0
28	Public administration and services	33 658	22 333	0	642	0	202	0	0
29	Sewage, refuse disposal; sanitation	1 038	536	4 951	40	5 053	755	0	0
30	Other service activities	34 568	19 250	0	371	0	208	0	0
	Total	261 895	122 594	367 432	488 777	48 124	25 283	38 338	10 074
1)	Including also Recovered waste								
2)	Including also Recovered waste, fuels and raw materials from the nature								

For an analysis of waste generation and its recovery by production, activity indicators can be developed both for the supply and use sides of production. On the supply side, the indicator could be the ratio of generated waste to primary products (= produced products without recovered waste generated) and, on the use side, the share of recovered waste in material inputs (= recovered waste included). Ratios can be calculated as well for final waste to primary products and material inputs. These ratios are presented in table 8.

Table 8. *Waste indicators by industry. Finland 2002*

		Ratio of generated waste to primary products	Ratio of recovered waste to material inputs	Ratio of final waste to primary products	Ratio of Final waste to material inputs
1	Agriculture and fishing	0,57	0,57	0,00	0,00
2	Forestry, logging etc	0,03	0,03	0,00	0,00
3	Mining of energy minerals	0,00	0,00	0,00	0,00
4	Other mining and quarrying	0,21	0,05	0,14	0,12
5	Manufacture of food products	0,12	0,08	0,01	0,01
6	Manuf of textiles etc	0,43	0,05	0,26	0,07
7	Manuf of wood & wood products	0,32	0,17	0,00	0,00
8	Manuf of pulp, paper, paper prod	0,28	0,07	0,06	0,02
9	Publishing, printing etc	0,16	0,03	0,13	0,09
10	Manuf of coke and petroleum ref.	0,01	0,00	0,00	0,00
11	Manufacture of chemicals etc	0,36	0,02	0,33	0,31
12	Manuf of rubber and plastic prod	0,13	0,03	0,07	0,04
13	Manuf of non-met mineral prod	0,04	0,02	0,01	0,01
14	Manufacture of basic metals	0,32	0,08	0,15	0,07
15	Manuf of metal products	0,12	0,01	0,10	0,06
16	Manuf of machinery and equipm	0,29	0,01	0,28	0,11
17	Manuf of electrical equipment	0,37	0,00	0,36	0,14
18	Manuf of transport equipment	1,97	0,04	1,54	0,15
19	Manufacturing n.e.c.	0,12	0,05	0,04	0,03
20	Recycling	0,37	0,22	0,15	0,15
21	Electricity, gas & water supply		0,03	1,01	0,03
22	Building	0,10	0,01	0,10	0,09
23	Civil engineering	0,05	0,00	0,05	0,05
24	Wholesale and retail trade etc		0,00		0,46
25	Hotels and restaurants	0,18	0,00	0,18	0,15
26	Transport and coomunication		0,00		0,01
27	Dwellings		0,00		0,01
28	Public administration and services		0,00		0,31
29	Sewage, refuse disposal; sanitation	1,17	126,77	0,15	18,95
30	Other service activities		0,00		0,56
	Total	0,20	0,10	0,07	0,05

Variations of these ratios between branches of industry are very high, depending partly on material intensity of branches and specific features of their production processes. Recovery inside the branch of industry of waste is not even possible for all branches, and their wastes are recovered by other branches of manufacturing industries or by branches of recycling and sewage, refuse disposal and sanitation. These ratios are not very usable for comparisons between branches, but can still be used to follow the development inside individual branches.

A high variety of different ratios could be calculated on the basis of PIOT and waste accounts. In this pilot project, a new indicator in addition to ratio of generated waste to primary products and the share of recovered waste in product inputs is proposed. This indicator is aimed to describe the use ability of material inputs of the economy, as a whole and by branches of industry.

The use ability of material input in the economy reflects the relation between the amount of used material inputs and amount of produced commodities. This

kind of indicator does not tell, whether the amount of produced materials or the material input is necessary of acceptable from environmental point of view, but it reflects only the relation of used materials and produced goods. Generation and use of waste are included in the calculation of this indicator.

In this context the material inputs consist of materials extracted from the nature, materials from production processes and waste generated in these processes. Waste covers both recovered waste and other waste. Material inputs describe the total input of materials into production. From this total input part of the material ends up to produced goods, part ends up to recovery in the same economic activity or in some other economic activity, and part ends up to final waste e.g. in landfills. From this total input, recycled or recovered materials are subtracted, because in the recovery the amount of material taken into use in the national economy is not increased, but is transferred to production of goods. This subtraction is made from that branch of industry, where the recovery has taken place, and not from the producer of the Recovered waste. For example, municipal waste separately collected for recovery is not recovered by households, but by those branches of industry, which finally convert it to new goods.

The formula for calculation of total material input is as follows:

+ Material inputs to production processes (exclud. produced recovered waste)

+ Produced waste
Recovered waste
Final waste

- Recovery
as material
as energy

= Total material input

The indicator describing the use ability of material input is calculated by dividing the Total material input by the amount of goods, that have been produced by the Total material input

Use ability of material inputs = Total material input / Produced goods

This indicator is usually positive and the figure is more than one. If a branch of industry is recovering remarkable amounts of waste produced in some other branch of industry, the indicator can also be less than one. It means that waste inputs have been relatively high in the production process. A negative value for the indicator is possible, if production of goods is negative due to high production of e.g. useful waste. The indicator is infinite, when material goods are not produced, as often takes place in production of services or in final consumption.

The value of the indicator increases, when more material inputs ends up to something else than produced material goods. All final waste is lost material inputs. So are also useful waste when it is not recovered in own production of branch of industry, meaning that the use capacity for material taken as inputs does not exist for useful waste in that particular branch of industry. For indicator calculated at the nation wide level this has no meaning, because all recovery is summed up.

It should be noted, that domestic unused extraction is not included into this calculation, although they are an important part of waste flows presented in the table 2, and also the PIOT table (Tables 6a and 6b).

Use capacity of material inputs –indicator calculated by branch of industry is presented in table 9. At nation wide level, the indicator shows that the total use of material inputs in Finland in 2002 was close to 1,5 with respect to the weight of produced goods.

Table 9. *Calculation for Use ability of material inputs. Finland 2002*

	Produced goods 1)	Material inputs 2)	Recov-waste	Final waste	Recovery	Total material inputs	Indicator
	Mill.kg						
1 Agriculture and fishing	18 134	17 517	23 521	197	24 176	17 058	0,94
2 Forestry, logging etc	48 345	48 885	1 439	0	12	50 312	1,04
3 Mining of energy minerals	9 069	9 628	0	0	1	9 627	1,06
4 Other mining and quarrying	73 334	85 915	4 935	11 196	0	102 046	1,39
5 Manufacture of food products	6 755	8 852	775	110	614	9 124	1,35
6 Manuf of textiles etc	31	137	7	10	5	148	4,76
7 Manuf of wood & wood products	10 410	24 299	4 888	73	1 270	27 991	2,69
8 Manuf of pulp, paper, paper prod	16 654	62 913	4 548	1 289	4 691	64 059	3,85
9 Publishing, printing etc	444	636	17	58	0	711	1,60
10 Manuf of coke and petroleum ref.	7 535	13 350	19	30	20	13 379	1,78
11 Manufacture of chemicals etc	6 840	7 475	189	2 354	158	9 860	1,44
12 Manuf of rubber and plastic prod	298	588	18	23	10	619	2,08
13 Manuf of non-met mineral prod	12 298	14 096	318	176	457	14 132	1,15
14 Manufacture of basic metals	6 713	15 096	1 313	1 219	1 203	16 426	2,45
15 Manuf of metal products	530	960	12	54	6	1 020	1,92
16 Manuf of machinery and equipm	374	965	6	105	12	1 064	2,84
17 Manuf of electrical equipment	159	412	2	57	0	471	2,96
18 Manuf of transport equipment	17	283	13	46	2	339	19,98
19 Manufacturing n.e.c.	153	255	14	7	14	261	1,70
20 Recycling	1 141	1 139	315	222	1 392	284	0,25
21 Electricity, gas & water supply	-2	18 627	576	581	5 544	14 239	0,00
22 Building	19 824	22 524	146	1 932	0	24 602	1,24
23 Civil engineering	79 789	84 253	0	3 862	8 824	79 291	0,99
24 Wholesale and retail trade etc	0	775	0	359	0	1 134	∞
25 Hotels and restaurants	565	712	0	104	0	816	1,44
26 Transport and coomunication	0	4 152	0	52	0	4 204	∞
27 Dwellings	0	212	0	2	0	215	∞
28 Public administration and services	0	642	0	202	0	844	∞
29 Sewage, refuse disposal; sanitation	-103	-5 013	5 053	755	0	795	-7,75
30 Other service activities	0	371	0	208	0	578	∞
Total	319 308	440 653	48 124	25 283	48 412	465 648	1,46

1) Excluding Rec. waste
2) Excluding Rec. waste

With waste accounts, the volume index for the relative change for material use can be further calculated as time series. This kind of index can be calculated by using variable presented above, and by using monetary data from production values. At nation wide level, the volume index can be calculated by weighting with value shares by branches of industry.

6. Conclusions and recommendations

The physical input-output tables (PIOT) records all major material flows of the economy. Waste accounts go even deeper into those flows, by showing at detailed level the recycling and disposal of materials. This in turn can be examined together with other material flows and monetary flows of the economy as a whole and by branches of industry.

In this study, a wide interpretation of waste, as presented in chapter 3, is followed. This is done according to the waste legislation and to waste statistics of Finland. Differences between terminology used in waste directives, Waste statistics regulation, waste accounts and PIOT are also presented in chapter 3.

The suggested indicator 'use ability of material inputs' as calculated in this pilot study is a new one. Some further examination and explanation of terminology used in this indicator may be needed, in order to avoid confusing interpretations with respect to economy wide material flow accounting framework presented by Eurostat and in the SEEA 2003 manual, and with waste statistics.

The meaning of domestic unused extraction as material flow is one issue that should be closely considered. These significant amounts of material are at present not very well taken into account with respect to possibilities of waste prevention and efficient use of materials, even though they can be clearly recorded in material flow and waste accounts. They should also be included into indicators derived from the accounts. An other issue of remarkable amounts of materials is the treatment of waste from mining industry. When this waste are used for filling mine shafts, it is not very clear whether this should be recorded as recovery of waste in the mining industry or in the branch of civil engineering. The third issue is separate recording of hazardous and non-hazardous waste, which is not very informative at economy-wide level, but could be useful in the few branches, which produce the major amounts of hazardous waste of the economy.

One general feature of indicators derived from material flows by branches of industry is, that they should not be directly used to compare different branches of industry with each other. It is more useful to follow the trends shown by indicators and variables behind those indicators, than to try to place branches of industry in any kind of order of e.g. material efficiency.

The share of waste from all materials used as inputs in production processes is significant. In Finland this share is even more than one fourth. Waste accounts in fact show, that difference between material inputs and outputs equals relatively well the total amount of waste generated. By following the relationship between total material inputs and outputs, the prevention of waste generation is followed as well. This makes the waste accounting a remarkable tool in producing information on the development of waste prevention at both economy wide level and at branch of industry level. Waste accounts and the PIOT are also useful in checking consistency and coverage of waste statistics, which are recording one very important part of total material flows of the economy. Internal recycling of production residues and waste is a very important factor of waste prevention and effective use of materials, and it has to be clearly recorded in the PIOT –framework. The amounts of internal recycling should also be presented together with information provided by waste statistics

Ratios that are calculated from MFA indicators and disposal of materials can be used to describe economy-wide physical efficiency of material use. Ratios calculated from waste accounts and waste statistics are focused on generation, use and disposal of

waste and waste-related materials, and they can be used in monitoring the successfulness of waste prevention policies.

From purely physical point of view, the basis of waste prevention consists of five elements: extraction and use of natural resources including unused extraction, generation of waste, recovery of waste including internal recycling, disposal of waste and net accumulation of materials into structures and durable goods. Information on generation, recovery and disposal of waste is not alone sufficient for waste prevention policies, and this information should be examined and presented in relation to information on extraction of natural resources, unused extraction and net accumulation of materials. Waste accounts and PIOT at economy wide level extend and improve information provided by MFA and waste statistics, and at branch of industry level they make it possible to focus waste prevention policies and measures to branches, where the most significant material flows and possibilities for waste prevention exist.