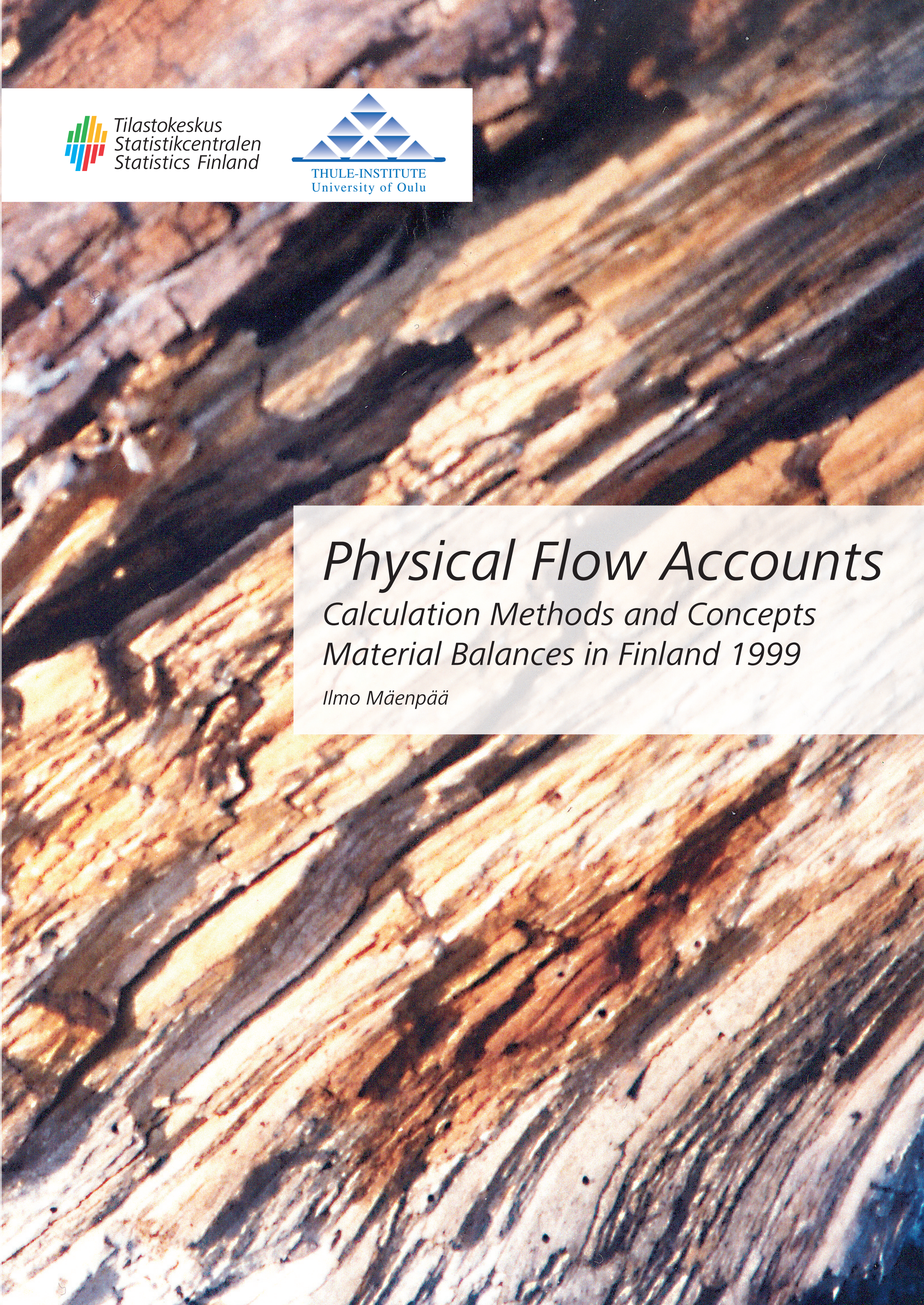

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Physical Flow Accounts

Calculation Methods and Concepts
Material Balances in Finland 1999

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Preface

Statistics Finland publishes this volume mindful of new trends in the demand for statistical data, the strongest among them the need to describe the material basis for interaction between the environment and economy. These physical flow accounts are an excellent response to this challenge.

At the same time this publication is good evidence of the fertility of co-operation between research institutes and various authorities, as well as an example of how the diversity of databases combined with a systematic descriptive method produces entirely new and superb information about our society.

Importance of the availability of physical flow accounts has been emphasised by the OECD and tools for their practical compilation have been developed by the United Nations, Eurostat and certain research organisations, such and the Wuppertal and Thule Institutes. Statistics Finland has also contributed to this work.

Like everything new and rewarding, this volume does not make easy reading. With the precision of a text book, it helps and guides the reader to understand physical flow accounts and their compilation. The accounts themselves are presented as balances calculated with Finnish data concerning the year 1999.

Statistics Finland wishes to express its gratitude to all organisations and people having contributed to this work, especially the Thule Institute and the author of this publication, Dr. Ilmo Mäenpää.

Helsinki, November 2005
Kaija Hovi
Director, Business Structures

Physical Flow Accounts of Finland, and the methods used in their compilation have been developed as a result of several projects.

In the year 2000, preliminary physical input-output tables of the year 1995 were compiled at the Thule Institute in a pilot project funded by the Environment Cluster Research Programme of the Ministry of the Environment. In 2001–2002, methods for material balances of biological metabolism were developed in the project *Material flows of agriculture and eco-efficiency* carried out in collaboration between Agrifood Research Finland and the Thule Institute and funded by the Ministry of Agriculture and Forestry. In 2002, in a common project between Statistics Finland and the Thule Institute, funded by Eurostat, data on waste statistics were incorporated into the accounts and, at the same time, the year of the accounts was changed to 1999.

For this work, where the physical input-output tables are completed and, at the same time, the frame of reference enlarged to general physical flow accounting of the economy, the Thule Institute has received funding from the European Commission from the funding programmes of DG Environment and DG Eurostat.

The development and compilation of the Finnish physical flow accounts were carried out at the Thule Institute, University of Oulu. However, the work was done, in close contact with Statistics Finland, who supplied the greater part of the often very detailed statistical data needed in the compilation work. Discussions about problems concealed in data have also been important.

Dr. Ilmo Mäenpää was the leader of the project. M.Sc. Tiina Härmä worked as research assistant at the last stages of the project.

This work has received funding from the European Commission.

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Contents

1 Introduction

Physical flow accounting describes flows of matter from the environment to the economy, inside the economy, between the economy and foreign economies and from the economy back to the environment, arranged into a systematic and integrated whole. Flows of matter is the basis upon which almost all the environmental effects of an economy are tied: extraction of natural resources; utilization of free environmental goods, air and water; waste; emissions into the air and discharges into water. Through foreign trade – imports and exports – the economy is coupled with the global economy and global environment. By the principle of conservation of matter, all these flows can be collected together into a uniform, consistent description system: all the flows are only different sides of the same flow.

When physical flow accounting has been compiled according to the same boundaries, classifications and description structures as the national accounting of the economy, the environmental effects which have occurred are coupled with the functioning of economic activities.

Material flows, as any other measurement system, do not tell all environmental effects: the effects of forestry on the biodiversity of forest environments not only depend on the volume of fellings but also on the manner in which the fellings are realised; a kilogram of a variety of emissions into the air has different effects on the atmosphere; extremely toxic substances may be hidden in minor material flows. The assessment of complex qualitative effects can, however, be applied only to a relatively narrow field of phenomena at a time. When qualitative assessment is desired for generalising in order to cover wider phenomena fields (e.g. green house effects, acid deposition), the often used method is to tie up the qualitative effect by an estimated specific coefficient with a measurable quantity. The mass of material flows is just this kind of a measurable quantity. Thus, physical flow accounting provides a firm base for generalising qualitative assessments. That is to say, generalising qualitative assessments are one field of application of physical flow accounting, provided that physical flow accounts themselves are first completed.

Environmental policies are often criticised for their fragmentation, in that separate individual problems are only grasped one at a time without seeing the wider contex behind the different problems and thus, the ability to solve interconnected problems more efficiently. This is connected with the struggle to change environmental policies from command policies going into details to general economic and other steering instruments.

Environmental policies are, however, coupled with their information bases, the grounds of which goals and measures are planned. A fragmented environmental policy is coupled with fragmented environmental statistics, where different qualities of the state of the environment and different environmental loads are described as isolated, non-comparable entities and where even the classifications of human and economic activities differ.

Physical flow accounting provides an integrated information base conditioned by an all-inclusive environmental policy, where all the sub-fields of environmental loads are described uniformly, coupled with the activities of humans and the economy by common classifications.

At present, the most important general framework for physical flow accounting is presented in the United Nations handbook *Integrated Environmental and Economic Accounting 2003* (UN et al. 2003), especially in Chapter 3, *Physical flow accounts*. In the handbook, the abbreviations SEEA 2003 or SEEA are used.

The structures of the physical flow accounts of Finland are based on the SEEA framework. However, the SEEA is more of a recommendation about the principles on how environmental accounting integrated with national accounting should be developed than a final set of exact instructions based on a synthesis of experiences from realized accounting works – the level of which national accounting has reached.

Thus, even though the Finnish physical flow accounts follow the SEEA in their main structures, some practical changes have been made. Impulses for these changes have come from the experiences in material flow accounting (MFA), presented in the handbook *Economy-wide material flow accounting – A guide* (EC 2001).

Integrating physical flow accounts with the Finnish national accounts has also meant that special solutions – such as the accounting boundary of forestry – are followed in the Finnish accounts instead of general international recommendations.

The structure of the report is as follows.

In Chapter 2, the main content, used notions, general features of measurement methods and accounting structures are presented.

In Chapter 3, the results of the physical flow accounts are analysed more closely.

In Chapter 4, the key economic figures of environmental loads are derived from physical flow accounts and analysed combined with the monetary quantities used in national accounts. Chapter 4 thus goes to the area that the SEEA 2003 discusses in Chapter 4 under Hybrid flow accounts. Within the EU such combining of physical environmental loads of the economy to national accounts is also known as the NAMEA (National Accounting Matrix including Environmental Accounts). Physical flow accounts can thus be considered the basic accounts from which figures for environmental loads can be collected as an overall description.

The main tables of the physical flow accounts of Finland are presented in the Tables section and the classifications used in the presented tables are given in Annex 1.

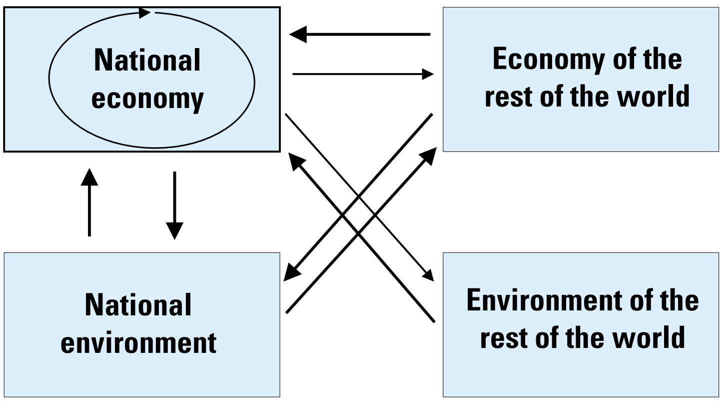
The main data sources of the accounts can be found in Annex 2. Annex 3 contains a more detailed description of the calculation methods used for unobservable flows. Special attention is given to the material balances of fuel combustion and biological metabolism.

2 Structure and content of physical flow accounting

2.1 Accounting boundaries

The focus of physical flow accounting is the physical functioning of a national economy. Besides the inner material flows of the economy, flows between the economy and the environment and between the economy and economies of the rest of the world (RoW) are important description objects. The environment should also be divided between the national environment and the environment of the rest of the world. Sub-systems and material flow relations between them are shown in Figure 2.1.

Figure 2.1. Partition of the world in physical flow accounting



The national economy extracts natural resources, water and air from the national environment and receives products from the RoW economies, processes and uses them, and exports processed products to the RoW economies. The material flow of emissions is fed back into the local national environment. By transboundary pollution and fuel emissions of international transport, the national economy generates direct material flows into the environment of the RoW and, on the other hand, the RoW economies have direct flows into the national environment.

The flows between the national and RoW environments and between the RoW economies and RoW environments are left outside physical flow accounting. However, at the analytical level the picture may be completed by assessing the indirect effects of the national economy on the RoW environment realised through the foreign trade effects of the national economy on the material flows of the RoW economies.

The boundaries of national accounting are followed in setting the exact boundaries of the national economy against the RoW economies and the national environment.

Especially important are differences in the definitions of a national economy and a national environment. The national environment of a country can be defined geographically as the territory inside the borders of the national state, including the sea area and the air space above. The national economy, however, is defined in national accounting as the activities of economic actors – enterprises, institutions and households – whose centre of economic interest is within the national territory of the country, most often meaning that they have the nationality of that country. This definition of national economy means that the activities of the economy may cross territorial borders. Thus, the definition of the borders of a national economy is based on the actors, whereas the borders of the national environment are based on the geographical territory.

The most important activities in national accounting crossing territorial borders are international transport and tourism (and business travel). Thus, the economic output of national shipping and aviation companies also includes the transport services produced, and their intermediate inputs include the fuels bought from outside the home territory. In national accounting, transport services produced outside the territory of a country are registered as exports of the economy, and the fuels bought are registered as imports. In same way, the fuel purchases of foreign ships or aircraft inside the national territory are registered as exports. The consumption expenditure of foreign tourists in the national territory are registered as exports and the consumption expenditure of national households outside the territory as imports.

Environmental statistics are generally based on the geographic borders of the national territory. However, sometimes international transport is totally excluded and sometimes both domestic and foreign transport inside the territory are included.

The arrows between the national economy and the RoW environment and between the RoW economies and the national environment are important in specifying the exact relations of the two kinds of borders. For emissions, we thus have:

	Emissions of the Finnish national economy
–	emissions of Finnish international transports outside the Finnish territory
+	emissions of foreign vehicles inside the Finnish territory
–	transboundary movements of Finnish emissions to RoW
+	transboundary movements of emissions from RoW to the Finnish territory
=	Emissions into the national environment of Finland

The delimitations of national accounts can also be used in specifying the accounting borders between the national economy and the national environment. Problems are found among the activities that are directly connected with nature: primary industries, vital functions of human population and landfills.

Agriculture with land cultivation and the metabolism of growing plants are included totally in the economy. Thus, the main environmental inputs of plant cultivation are carbon dioxide and water tied up by the cultivated plants and soil minerals consumed from fertilisers, manure and other substances spread onto the cultivated land. According to the general recommendations of the European System of Accounts (ESA 1995), commercial forests should also be included in the economy, in which case the growth of the tree stock would be the main output of forestry. In Finnish national accounts, all forests are defined as belonging to the sphere of the environment and, thus, roundwood removals are the main output of the industry and, at the same time, material input from the environment to the economy. This practice of Finnish national accounts has been followed in physical flow accounting.

The human population with its vital functions is included altogether in the economy. Thus, the oxygen tied up by human metabolism is input from the environment to the economy and the carbon dioxide emitted by expiration is an output from the economy to the environment. Landfills as accumulated stocks are included in the economy, too. Thus, the methane and carbon dioxide emissions released by the combustion of organic materials in landfills are flows from the economy to the environment and at the same time, removals out of the stocks.

2.2 Main economic activities and material flows

The main economic activities of national accounting are given in Table 2.1. There are four most aggregate categories: production, consumption, capital formation and rest of the world.

In physical flow accounts, some changes to the list are reasonable but do not, however, break the conformity of accounting systems. In the following, these changes are looked at according to main activity.

Production is divided into industries, which again can be re-grouped into three broad classes: primary production, secondary production and services. In national accounts, it has become a custom to include mining and quarrying into secondary, instead of primary production. This habit deviates from the traditional grouping in social sciences and contradicts the notion of primary production as a first stage in the utilization of natural resources. In physical flow accounts, the place of mining and quarrying becomes especially significant, and thus, mining and quarrying is repositioned under primary production.

The products from services are generally immaterial, thus, they are not seen in physical flow accounts. However, there are two major exceptions. In the hotel and restaurant industry, the service of serving meals and beverages also includes the material content of the meals and beverages. The main economic outputs from sewage and refuse disposal are the services of waste treatment. However, in physical flow accounts, the counterpart of selling these services is considerable material flow on the input side.

Table 2.1. Main activities in national accounts

1.	Production – primary production (agriculture, hunting, forestry and fishing) – secondary production (mining and quarrying, manufacturing, energy supply,construction) – services (private and public services)
2.	Consumption – consumption expenditure of households – consumption expenditure of private non-profit institutions – general government final consumption expenditure
3.	Capital formation – gross fixed capital formation – changes in inventories
4.	Rest of the world – export – import

Consumption is divided into the consumption expenditure of households, private non-profit institutions and government. The actual real activities of non-profit institutions and government lie in service industries, and their consumption expenditure consists only of immaterial budget expenditure. Thus, in physical flow accounts, these categories can be left out and the main category of consumption only includes household consumption. However, as monitoring of accumulation of material stock is important in physical flow accounting, it is useful to divide the consumption into consumption of non-durable and durable goods.

Capital formation consists of fixed capital formation or productive investments (buildings, civil engineering structures, machines and appliances, vehicles) and of changes in inventories. In physical flow accounts, it is reasonable to add landfill accumulation of final waste as a separate category of capital formation.

The activities of the rest of the world category are imports and exports. In physical flow accounts, an additional activity of international transfers is needed for the emissions of international transport and the transboundary movements of emissions.

The resulting main economic activities in physical flow accounts are presented in Table 2.2.

Material flows are divided by SEEA into four main groups as listed in Table 2.3.

Natural resources are mineral and biotic substances extracted from the environment for the use of the economy. Ecosystem inputs are substances from air and water that are mostly free – in a more or less clean form.

Table 2.2. Main economic activities in physical flow accounts

1.	Production – primary production (agriculture, hunting, forestry, fishing, mining and quarrying,) – secondary production (manufacturing, energy supply, construction) – services (private and public services)
2.	Consumption – households, non-durable consumption goods – households, durable consumption goods
3.	Capital formation – gross fixed capital formation – changes in inventories – landfill accumulation
4.	Rest of the world – exports – imports – international transfers

Table 2.3. Main groups of material flows by SEEA

From environment to economy – natural resources – ecosystem inputs
Outputs of the economy – products – residuals

Products are materials produced intentionally in the economy that have economic value and are exchanged inside the economy and between economies. Residues are material residuals from the production and consumption of products which have no economic value. Residues include solid (final) waste and emissions into air and into water. Residues end in landfills or in the environment. However, some of the final waste is recovered back to the product flows of the economy through waste treatment.

In this work, the four material flow groups of the SEEA have been divided further into eight because of analytical differences between them. Experiences in the field of the MFA (European Commission 2001) have been utilised especially in the additional division. The new grouping is presented in Table 2.4.

The group of natural resources of the SEEA is divided into unused extraction and raw materials basing on the practice of the MFA. Examples of unused extraction are the felling residues of forestry, wall-rock from mining and surplus soil from overburden movements in construction. It is characteristic of unused extractions that they are generated by the economy in association with the extraction of useful natural resources but they never enter the economy as inputs and are left direct in the environment. Thus, their inclusion in the physical flow balances is not necessary. They are, however, important factors in assessing the total environmental load of the economy and are included in e.g. Finnish waste statistics. Raw materials are then the part of total extraction which enters the economy as material input for further processing.

Ecosystem inputs as a term is difficult to understand direct, thus, only its constituents, air and water, are used as material flow categories. Physical flow accounts only include the parts of air and water that are tied up in the products or residues of the economy. Only some of the air flowing through the combustion process in power plants or circulating in the lungs of humans and domestic animals is tied up into these processes. Similarly, most water flows through the economy without changes in its characteristics. Discharges into water are, of course, an essential part of material flows.

The material flows produced by the economy and staying in the economic sphere are products, final waste and net accumulation of stocks. The border between products and waste is especially difficult for the production residues of primary production and manufacturing. In the Finnish physical flow accounts, waste taken direct to landfills or waste treatment by the sewage and refuse disposal industry are defined as final waste. All solid or liquid residues from product use of services and households are classified as final waste. The definition of final waste used in Finnish waste statistics and also by the EC is much wider than this and also includes the production residuals which go direct to be used as raw materials or fuel. In physical flow accounts, this recovered waste is included in general product flows. An important reason for this is that it is also included in the CPA classification of products of the EU, and thus included in the product flows of economic statistics and na-

Table 2.4.
Main groups of the material flows in physical flow accounts of Finland

From environment to environment – unused extraction
From environment to economy – raw materials – air – water
From economy to economy – products – residuals – net accumulation
From economy to environment – emissions into air – water vapour – discharges into water – dissipative use
– indirect inputs of imports

tional accounts. However, at the detailed classification level of physical flow accounts, recovered waste items have separate classes so that they can be singled out and presented in a separate waste account table.

Thus, the group of products could be divided into two further sub-groups: a) ordinary products produced intentionally for certain uses and b) recovered wastes generated as residuals from the production of ordinary products but with direct economic uses in the economy.

Net accumulation of stocks is the group of material flows which stays in the economy for a long time.

Emissions into the air include all gaseous flows to the atmosphere except for water vapour. The emissions are divided into ten types that can be chosen for special studies, e.g. greenhouse gases or acidic emissions.

Water vapour consists mostly of the water evaporation released by production, combustion and metabolism.

Discharges into water include the residual material flows ending up in waters. The oxygen demand item of waste water statistics has been transformed into the mass of organic material (or carbohydrate) that generates the measured oxygen demand.

Dissipative use is the dispersal of products or residuals into the environment. It may derive from an intentional activity useful for the environment, such as fertiliser or ash spreading onto forest soil, planting of fry (young fish) into natural waters or spreading of household ash and compost onto backyards. It may also be an unintentional effect from a useful intentional activity, such as the spreading of highway sand and salt into the environment.

Indirect inputs of imports are presented as separate items from other material flows because they are not included in the ordinary physical flow accounts and also contain fairly uncertain estimates. However, they provide useful additional information for analytical purposes. Indirect inputs of imports are assessments of the total material mass used to produce the imported products but not included in the mass of the products itself. The sum of imported products and indirect imports gives an estimate of the natural resource content of imports, and thus makes them comparable with the raw material and unused extraction content of domestic products.

2.3 Measurement unit

The basic physical property of a material body is mass, of which the agreed measurement unit is a kilogram (kg). In the sphere of gravity, mass can be measured as weight; in zero gravity mass can be measured by the inertia of the body. Mass is one of the seven physical basic quantities of the international measurement unit system SI.

For physical flow accounts, the notion of mass is central because of the law of the conservation of matter first formulated by the founder of modern chemistry, Antoine Lavoisier (d. 1794): the mass of matter cannot be created or destroyed by any physical or chemical process.

The theory of relativity by Einstein, however, widened the notion of matter to the uniformity of matter and energy so that mass m is related with energy E by equation $E = mc^2$, where c is the velocity of light (300,000 km/s). Besides being a famous philosophical principle, the formulation of Einstein is an exact calculation formula with which the consequences of the principle can be tested. According to the formula, the energy equivalent of 1 kg mass of matter is:

$$1 \text{ kg } (3 \times 10^8 \text{ m/s})^2 = 9 \times 10^{16} \text{ (kg m/s}^2\text{)}$$
$$m = 9 \times 10^{16} \text{ J} = 90\,000 \text{ TJ}$$

Thus, 1 kg matter is equivalent to 90,000 terajoules of energy. By this relationship, we can inversely calculate how much matter is changed to energy in energy - e.g. heat - generating processes, or what the mass loss effect is in the process.

The energy consumption of the Finnish economy (without international transport) was about 1,331,000 TJ in 1999. Then, the equivalent mass loss is (1,331,000/90,000) kg = 14.8 kg. At the same time, the fuel consumption of the Finnish economy was 56 million tonnes. The net heat content of one tonne of hard coal is 0.026 TJ. Thus, the mass loss in the combustion of one tonne of hard coal is 0.28 milligrams. In a nuclear power plant, one kilogram of nuclear fuel generates about 3 TJ of energy. Even in the nuclear power plant, the mass loss is only 0.003% of fuel mass.

These calculations show that the transformation of mass into energy in the human technosphere is so minor that it stays outside of practical measurement precision. Thus, the law of the conservation of mass is a firm basis for physical flow accounting.

Although the mass of a material body is measured as weight on the surface of the earth, the law of the conservation of matter only holds with mass and not with weight. The weight of a body can be destroyed easily by launching the body into space.

In physical flow accounting, the law of the conservation of mass can be formulated into a very important principle of mass balance:

The mass of the material input of a system = the mass of the material output of the system + the change of the mass of material stock inside the system.

The law of the conservation of mass makes different kinds of materials commensurable.

The criticism often presented against physical flow accounting is that apples and oranges cannot be counted together. Let us study the argument in more detail. We take one apple and one orange and weigh them separately. We then enclose them in an airtight vacuum vessel and shake it so violently that the apple and orange are crushed and mixed into a uniform sauce. Then we heat the vessel to 1,000 °C so that the sauce is transformed into ash and gases. We then launch the vessel into space and measure the mass of its contents by means of inertia. We find that the measured mass is the same as the sum of the separately weighed masses of the original apple and orange. The conclusion of our study is: surely we can count the masses of apples and oranges together.

The measured quantity in physical flow accounting is the mass of materials, and the base measurement unit is one kilogram (kg). In total statistics, a suitable presentation precision is generally one Million kilograms, abbreviated as Mkg.

Mkg is the same measurement unit a the often used 1,000 tonnes or gigagrams (Gg), used especially in green house gas inventories.

At the calculation level, the measurement precision of 1000 kg (tonne) is usually suitable.

Products are measured at their fresh moisture level, or at such moisture content at which they enter the economy or are exchanged in the economy. The moisture content of organic materials at the beginning of a refining processes is high and often diminishes as refining proceeds. Therefore, getting the material balances into order requires estimates of the moisture content of the material flows so that the water released or added during processes can be assessed.

By means of moisture content parameters, material flows may be converted into dry-matter mass, which would also be useful for the compilation of flow balances for some individual substances such as wood, carbon and nitrogen. In general, physical flow accounts of material flows are, however, reasonable for measuring them as they are moving.

Most products are transported from producers to users in various types of packages. In most product statistics, such as those on manufacturing and foreign trade, products are usually measured in net amounts without packages. In Finland, packages mostly remain in re-use circulation for a long time, whereby they can be interpreted as being part of the capital stock of the transportation and storing system. However, disposable packages and loss of re-usable packages occur as acquisitions of packaging materials by producers and as packaging waste of users of packaged products. In physical flow accounts, individual product flows are measured as the net of packages. The flows of disposable packages and the loss of re-usable packages are first accounted as parallel flows of the packaged product from the producer to the user and in the end added into the total material flows at the industry level.

2.4 Classifications

The industrial and product classifications applied in the Finnish physical flow accounts are based on the classifications of Finnish national accounts (Statistics Finland 2003a, 2003b) at the detailed compilation level. In the Finnish national accounts, the compilation level industrial classification mainly follows the NACE classification at the 3-digit level and has 180 industries altogether. In the physical flow accounts, the classification of the national accounts is otherwise followed but a less detailed classification is used for service industries where the total number of industries is 151.

The compilation level product classification of national accounts is based on the CPA classification of the EU (CPA 1998). In the CPA classification, products are classified according to the producing industry so that the first four digits of the CPA code define the producing industry by NACE code, and the last two differentiate products within the industry. The compilation level product classification, as well as the more detailed PRODCOM classification are used here. The CPA classification also includes service products. The compilation level product classification of national accounts contains about 960 products.

The compilation level product classification of physical flow accounts is based on the classification of national accounts. Naturally, service products with no material content are left out. On the other hand, a more detailed product division is applied in certain cases. Mostly the reason for a more detailed division is that recovered wastes are divided into separate classes. Moreover, ten new classes have been added to the end of the classification list for the types of recovered waste not found in the CPA. Altogether, the classification contains 718 types of products.

For the presenting of physical flow accounting results, tables on 151 industries and 718 products are, of course, too detailed. Therefore, the compilation software of the accounts contain a changeable aggregation key according to which products and industries are aggregated into presentation tables.

In the presentation tables of this report both products and industries are aggregated into 30 categories. The presentation categories and their contents in the CPA and NACE classifications are shown in Tables 1 and 2 of Annex 1.

Because analysis of waste flows is an important area of application of physical flow accounts, the categories of recovered and final waste have been classified by means of a separate waste list with which they can be identified from product flows. The waste classification is also presented in Table 3 of Annex 1.

Materials used for energy production, i.e. fuels, also deserve separate examining. The problem here is that many products that are primarily used as fuel also have their uses as raw materials. However, use of fuel by economic activity is included in the accounting system as a separate sub-item, in which emissions to air and other material flows from the combustion of fuels are calculated first before the fuels are added to the general physical flow accounts. Data on fuels are entered into the system according to the classification of fuels used in Statistics Finland's statistics on manufacturing, which is more detailed than the general product classification and thereby also allows more accurate calculations of emissions from their combustion. However, certain additional groupings have been formed in order to facilitate more accurate calculations of different emission from different uses of fuel. Fuel categories and their correlation with the CPA classification are presented in Table 4 of Annex 1.

Emissions into air have been grouped so that environmentally loading equivalents of greenhouse gas emissions and acidifying emission can be calculated from them as weighted values. The classification of emission is presented in Table 5 of Annex 1.

2.5 Supply and use tables and input-output table

Supply and use tables provide a means for organising the extensive data on the economy into a uniform whole. Today, they are the central tools for national accounts (see e.g. Statistics Finland 2003). Defects and contradictions in basic statistics can be revealed and corrected by means of these tables. Completed supply and use tables are a clear, well organised framework for presenting information on the structures of the economy. Integration of the supply and use tables produces an input-output table, which is an important tool for analysing the structural properties of an economy.

Supply and use tables are also central tools in physical flow accounting. All the material flows can be collected into a framework organised with them. They are truly indispensable in locating and correcting gaps and errors in the basic data.

In national accounts, the money unit is the common quantity by means of which the consistency tests of double-entry bookkeeping can be performed: total supply and total use have to be the same for every product and the total output and total input have to match for every industry. In physical flow accounts, the mass unit will do the same work by the law of the conservation of mass.

Table 2.5. Physical use table

	Industries (NACE)	Domestic final use				RoW		Total use
	123 151	Household consumption	Fixed capital formation	Changes in inventories	Landfills	Exports	Transfers from RoW	
Products (CPA) 1								
2								
3								
...								
718								
Products, total								
Final waste								
Raw materials								
Air								
Water								
From nature, total								
Total use								

Unused extraction								
Indirect inputs of imports								

Table 2.6. Physical supply table

	Industries 123 151	Domestic final use Household consumption	 Fixed capital formation	 Changes in inventories	 Landfills	RoW Exports	 Transfers from RoW	Total supply
Products 1								
2								
3								
...								
718								
Products, total								
Final waste								
Emissions into air								
Water vapour								
Discharges to water								
Dissipative use								
Into environment, total								
Net accumulation								
Supply, total								

Unused extraction	

Mass flows have, however, one principal difference from monetary flows as a consequence of which some additions have to be made to the supply table as compared to that of national accounts. The monetary and mass flows differ in that used up products lose their monetary value, but their mass is conserved. Thus, in monetary accounts, final use of products, consumption and capital formation have no outputs. In physical flow accounts, however, final use has used up products as outputs of waste. In the monetary supply and use tables, the final use categories appear thus only in the use table side. In the physical flow tables, however, the final use section also has to be added to the supply side.

The supply and use tables of physical flow accounts can be more easily understood when the use table is presented first. The structure of the use table is shown in Table 2.5.

In the use table, as well as in the supply table, the activities of the economy – industries, categories of domestic final use and foreign trade – are in columns and products in rows. Rasterisation shows in which sections of the table material flows appear logically. Few rasters in a section means that only few activities have such a flow in them.

In the use table, the final use columns have been left out for the consumption of private non-profit institutions and government because they do not have any material flows. Instead, a column for landfills has been added to final use for keeping the accumulation of final waste separate from productive capital formation. In the section of the RoW, in addition to exports, a correction column is needed for the imports of emissions by foreign transport and transboundary movements.

Shown first in the rows is the use of products as intermediate inputs of industries, as domestic final use and for exports. Final waste goes mostly into landfills, but the industry of sewage and refuse disposal feed some of the waste back to the product flows. Moreover, some final waste is incinerated by the refuse disposal industry, whereby it is not destroyed but transformed into ash, emissions into air and water vapour. The bottom section of the main table contains material withdrawals from the environment: raw materials, air and water. The extraction of raw materials is concentrated to a few industries.

Beneath the use table are the rows of unused extraction and indirect inputs of imports. They are presented separate from the main table because they do not enter the inner material flow circulation of the economy, and are thus not included in the proper balances of supply and use.

The structure of the supply table is shown in Table 2.6. The most important difference between the physical supply table and the monetary supply table is that the physical table contains columns of domestic final use for accounting for the outgoing waste of used up products.

In the product rows of the supply table, the product outputs of industries are first. This section shows how much industries have produced not only products typical of themselves but also typical of other industries. The product rows of the final use section are empty in the supply table: garden production and the proceeds from the gathering, hunting and fishing of households are included in the products of primary industries as is also done in national accounts. On the right hand side of the supply table, imports are added to the supply.

Final waste is generated as production waste by industries, and consumption waste by households. Moreover, final waste is generated in capital formation as demolition waste and as scrap of machines, appliances and vehicles.

Flows from the economy to the environment are presented after final waste.

The second but last row contains the net accumulation of stocks. The net accumulation of each category is the difference between the total input in the use table and output of residuals in the supply table. For domestic final use categories, the net accumulation has important real physical content as changes in the material stocks of the economy. For foreign trade, the net accumulation as a surplus (positive or negative) of imports over exports is more of an accounting convention for consistency reasons. However, it may be interpreted as a net effect of the Finnish economy on accumulation in RoW economies.

When all parts of supply and use tables are in their right places, the total sums at the bottom right of both tables have to be the same. Thus, supply and use tables form together a consistent, complete description of the physical flows of the economy.

The compiled supply and use tables are presented in Tables 1 and 2 of the Tables section.

In the product flows of the use tables domestic and imported products are together. However, supply and use tables give for every product i its quantities of domestic production q_i, imports m_i and exports e_i. By means of these the share of imports in domestic use can be calculated for each product i as: $m_i/(q_i + m_i - e_i)$. However, for some products there is exports even if there is no domestic production (e.g. exports of bananas to Russia), or exports are greater than domestic production. In these cases the difference $(e_i - q_i)$ is registered as exports of imports and deducted from imports to the domestic market.

Assuming that the import share for a product is the same in all different uses of the product, imported products can be separated from the product flows in the use table and the column sums of the imports can be placed as one additional row at the bottom section of the use table. Thus, we have a use table for domestic products, imports as basic inputs. The matrix of imported product flows can be presented separately.

Table 2.7. Input-output table

	Industries (NACE) 1 2 3 ... 151	Domestic final use: House-holds	Fixed. capital	Inventor.	Landfills	RoW: Exports	Transf. to RoW
Industries (NACE) 1							
2							
3							
. . .							
151							
Industries, total							
Households							
Fixed capital							
Inventories							
Landfills							
Final use, total							
Imports							
Exports							
Final waste							
Raw materials							
Air							
Water							
From environment, total							
Total use							
Unused extraction							
Indir.inputs of imports							

The separated use tables are presented in Tables 3 and 4 of the Tables section.

In the input-output tables, the supply- and domestic use tables are integrated into one symmetric whole. The basic task in the formation of the input-output table is to transform the use of domestic products into the use of producing industries. The transformation is performed by assuming that the market share of each industry in each alternative use of the product is the same for every product. Mathematically then, the transformation proceeds as follows. Let **S** be the product x industry supply matrix of domestic products and **U** be the use matrix of domestic products by industries and domestic final use categories. Then, the market share matrix **D**, which is formed by dividing each row of matrix **S** by row sums, tells the market share of each industry of the markets of each product. Then, the inner product of the supply and use matrices, **Z** = **D'U** is the use matrix where the use of domestic products is now divided according to the producing industries.

The input-output table, presented in Table 2.7, is now formed from the supply and transformed use tables by placing them

Final waste	Into environment				Net Accumu-lation	Total
	Into air	Water-vapour	Into water	Dissi-pative use		

crosswise on top of one an other. In the input-output table, the columns of the transformed use table stay as columns, but the columns of the supply table are now transposed to the rows in the input-output table. Thus, each column of industries and final use shows how many inputs from each industry, imports and the environment each industry or final use category has used. Each row of industries tells how much of the industry's products is used as intermediate inputs in other industries, how much is used in the final use categories and how much is exported, and how much of its total material output has ended up as final waste or entered the environment.

The compiled input-output table is presented in Table 5 of the Tables section.

2.6 Methods for unobservable material flows

In physical flow accounts, the balancing of product rows in the supply and use tables is fairly straightforward because the products stay unchanged when moving from producers to users. However, identification and correction of lacking or erroneous product data in the base statistics is often a laborious task.

Balancing the columns of supply and use tables means balancing the outputs and inputs of each industry which is a considerably more demanding task. Many industrial processes have considerable flows of air and water which are unobservable in the sense that there is no direct empirical data on them. Nevertheless, exact calculation methods can be developed for the handling of these unobservable material flows basing on the chemistry of the processes.

The main areas of unobservable material flows are:

- Moisture changes of materials during the production process
- Combustion of fuels
- Metabolism of cultivated plants, domestic animals and human population
- Chemical processes in industries especially in the manufacture of basic chemicals and metals.

The calculation methods are presented in Annex 3 in detail. However, a brief overview of the methods is presented in the following.

Moisture changes

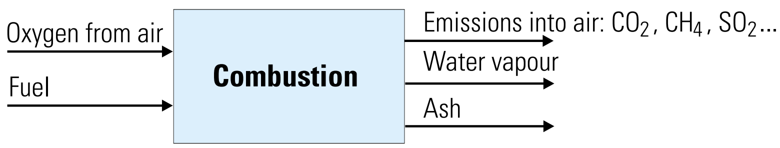
Moisture changes in products are large, especially in the first stages of refining organic materials. For example, the moisture of raw wood going into the forest industry is about 50%, while the moisture of sawn timber is 15% and that of paper 5%. In material balances, the differences between the water contents of inputs and outputs are accounted as produced water vapour when the water content of inputs is greater than that of outputs. When the water content of outputs is higher than that of inputs, the difference is treated as water input. Moisture percentage is evaluated for 236 products in all.

Moisture changes do not, however, cover those processes where water molecules take part in the new molecular structures created by the processes, or are released as residuals of them or are associated in their crystal structures, in which case the question is about the water being chemically embodied in dry matter.

Combustion of fuels

In combustion, fuel is combined with oxygen and the resulting ash, water vapour and emissions are released into the air.

Figure 2.2. Material flows of combustion



For a compilation of the material balance of combustion, data have been collected on the composition of fuels, such as their specific moisture, ash content and shares of combustible elements (C, H, O, N, S), as well as on average specific emissions into air by emission type. The ash residue of combustion is a result of the specific ash content and addition of the residuals of incomplete combustion. The amount of water vapour is calculated by adding moisture content to oxidised hydrogen from which the hydrogen embodied in hydrocarbon emissions is subtracted. The oxygen used in combustion could be established in detail from the mass of oxygen embodied in the molecules of emissions and by subtracting from it the oxygen contained in the fuel itself. The calculation can be performed by counting the input from the air simply as the difference between the mass of combustion outputs and the mass of used fuel. In this case, the nitrogen from the air that is oxidised to some extent in the combustion process, as well as the nitrogen included in the fuel itself are both taken into account.

Biological metabolism

At first glance, the metabolic balances of cultivated plants, domestic animals and human population appear impossible to control. However, in metabolism the question concerns the same processes as in fuel combustion; in the metabolism of plants the process is only reversed. This great insight was already reached by Lavoisier, the founder of the law of the conservation of matter.

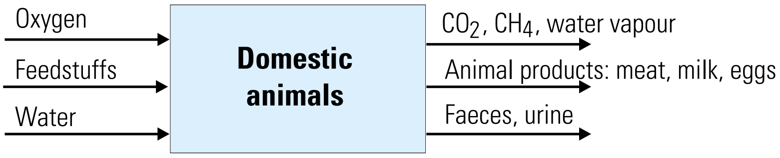
The problem is finding a method simple enough for practical calculations with which all the main physical flows of metabolism can, however, be controlled and which can utilise the empirical knowledge available from the research field. Research into human and domestic animal nutrition has indeed resulted in extensive knowledge on the material content of plant and animal products. Nutrients – carbohydrates, fats and proteins – are the key factors. For each nutrient, knowledge is available about their average material contents: water, ash (or minerals), carbohydrates, fats, proteins. Furthermore, as their average elementary composition (C, H, O, N) is known, exact stoiciometric equations of metabolic flows can be formulated.

Figure 2.3 shows the metabolic flows of cultivated plants.

Data on the amounts of plant products are available from agricultural statistics. The unused biomass of cultivated plants can be estimated by means of by-biomass coefficients. Basing on knowledge of the material contents of plant products, a plant crop can be broken down into its basic components (water, minerals, C, H, O, N). The amounts of the elements C, H and O plants produce are bound through the synthesis of carbon dioxide from air and water. The surplus of oxygen contained in carbon dioxide and water is released into air. Plants take nitrogen and minerals from the ground. Water is bound both in nutrient synthesis and as the moisture of plant products. Although the nutrient synthesis itself happens in complex biochemical processes, the total material flows can thus be controlled clearly and exactly.

Figure 2.3. Metabolic flows of cultivated plants

Figure 2.4. Metabolic flows of domestic animals



The scheme of the metabolism of domestic animals is shown in Figure 2.4.

The amounts of produced animal products and used feedstuffs are preliminary statistical data. With nutrition research knowledge these can be broken down into their material constituents. Nutrition research also provides knowledge on the digestibility of different feedstuffs, or how much of feed is disposed of direct as faeces and how much it the body of an animal can actually utilise. Some of the feed is released as methane into air as a result of incomplete digestion. Methane released by domestic animals, especially cows, is indeed one important source of greenhouse gas emissions.

A large portion of digested feed is bound up in animal products. The remainder is used for energy generation for the vital functions of animals, or combusted and, as a result, carbon dioxide and water are released. In addition to the water contained in feeds and released by combustion, domestic animals require drinking water for the maintenance of their water balance. Water is released partly as water vapour from expiration and perspiration and partly as urine into manure. Manure is a combination of feed losses, disposed bedding and the washing water of liquid manure. This generated manure is a major item of recyclable waste that is fed back into the maintenance of the nutrient balance of cultivated fields.

For the metabolism of the human population, the available statistical database contains information about the amount of food consumed by households, including both their acquired foodstuffs and meals and drinks taken in restaurants and other catering establishments. Calculation of the metabolism of the population can be simplified by assuming a population balance where the biomass of the population is constant. The test calculations also showed that the reproduction rate of the population is so slow in Finland that birth and growth of new members and the withdrawals of the body mass of the deceased remain very low and can thus be omitted from final mass balance calculations. In conditions in the developing countries the case might be different. Thus, the metabolic flows of the human population only contain food digestion and combustion for energy production for vital functions. The share of food remains, or inedible parts and unused meals is, however, also important.

Figure 2.5. Metabolic flows of human population

Chemical processes of manufacturing

In the chemical processes of industries, oxygen, water and other gases are also tied up and released into and from the molecular structures of products. Especially in the manufacture of basic chemicals (NACE 241) when these factors were not yet taken into account the discrepancy between the inputs and outputs of the industry exceeded over 2,000 Mkg. Therefore, commodity data on the manufacture of basic chemicals was acquired from Statistics Finland at a more detailed, or 4-digit, industry level. Information was collected about detailed processes of industries and exact stoiciometric balances were formed for the most important processes. As a result of the study, and with added unobservable flows, the statistical discrepancy was reduced to 0.17 Mkg.

Other types of manufacturing also have important unobservable material flows. Familiar from greenhouse gas inventories is the carbon dioxide released from limestone calcinations. In beverage manufacturing, alcohol fermentation generates about the same amount of carbon dioxide as alcohol (100%), and while some it is preserved for further use, some is released into the air. About 7% of the mass of concrete products is water tied up into the crystalline structures of concrete. In the basic processing of metals oxygen is used in separating metals from concentrates.

A good example of ascertaining the material balances of chemical processes is the manufacture of an important basic chemical, sulphuric acid. Sulphuric acid, or H_2SO_4, is obtained by adding water and oxygen to sulphur dioxide, or expressed as a reaction equation:

$$SO_2 + H_2O + 0.5O_2 \longrightarrow H_2SO_4$$

From the atomic weights of elements S, O and H, it can be calculated that producing one kilogram of sulphuric acid requires 653 grams of sulphur dioxide, 184 grams of water and 163 grams of oxygen.

In practice, sulphuric acid is manufactured in Finland from three different sources: from elementary sulphur (S) obtained as a by-product of oil refining, sulphur dioxide of flue gases from the processing of non-ferrous metals, sulphidic concentrates and ferrous pyrite (FeS_2), produced by metal mines. Table 2.8 synthesises the mass balances calculated with the reaction equations of the manufacturing processes based on the three different raw material sources. The balances calculated

Table 2.8. Mass balance of sulphuric acid manufacturing, Mkg

	Molecule stucture	Mass balance	Elements			
		Mkg	S	O	H	Fe
INPUT						
Sulphur	S	56	56			
Sulphur oxide	SO_2	531	266	266		
Iron pyrite	FeS_2	380	203			177
Oxygen	O_2	597		597		
Water	H_2O	295		262	33	
Total		**1 860**	**525**	**1 125**	**33**	**177**
OUTPUT						
Sulphur acid	H_2SO_4	1 607	525	1 049	33	
Ferrous oxide	Fe_2O_3	253		76		177
Total		**1 860**	**525**	**1 125**	**33**	**177**

separately for each element show the chemical consistency of the general mass balance.

In addition to ordinary raw materials, the manufacturing of sulphuric acid has used 597 million kilograms of oxygen and 295 million kilograms of water, summing up to 48% of the total mass of inputs. The amount of 1,607 Mkg of sulphuric acid is obtained, and 253 Mkg of ferrous oxide, or roasted iron pyrite.

Especially interesting in the mass balance of sulphuric acid manufacturing is that even though originally the main objective was to determine the use of water and oxygen in the process, it revealed two other statistically large unobservable material flows. Flue gas sulphur dioxide is an unobservable material flow of over half a million tonnes from the manufacture of basic metals to chemical manufacturing, and thus also has to be added to the products of the basic metal industry. Second, the ferrous oxide obtained is piled onto the landfill of the factory without further use. Thus, this material flow of over a quarter of a million tonne is an obvious final waste item, even if the factory has not reported it as waste.

2.7 General balancing

In the compilation of the supply and use tables, some parts of the material flows are estimated from the beginning in accordance with the principle of mass balance. Most of the product inputs of construction industries, services and fixed capital formation are estimated by the supply surplus method. In the method, the balance of supply and use elsewhere is first calculated for each of the 718 products and the surplus, if positive, is then distributed to the uses suitable for each product. However, for some products, such as fuels, foodstuffs and vehicles, direct information on the use in these industries was available.

The material content of the product output of the building and civil engineering industries has been accounted as the sum of the material content of the intermediate inputs of these industries, minus the fuel used and the construction waste generated (but without demolition waste).

For service industries, for which no data of waste generation are available, wastes were calculated assuming that all other material inputs besides fuels end up as waste.

Because the material flows of supply and use tables are accounted according to double-entry bookkeeping, from two opposite directions wherever possible, emergence of statistical errors was inevitable in both product and industry oriented balances at the first stages of the compilation process.

Once all the major statistical errors were corrected by more detailed studies, or sometimes with “educated guesses”, the final balancing could be done by mathematical methods.

In product balances, changes of inventories is an item on which data exist for only a few products and, thus, changes of inventories are used in the exact balancing of product flows.

In final balancing, the industry-specific inputs and outputs of balance residuals were allocated to two alternative items. For industries where moisture changes were large the residuals were allocated to water vapour because the moisture estimates of products are rough averages. For industries where moisture changes have a minor role the residual balance was allocated to final waste.

3 Analysis of results

3.1. Summary view of physical flow accounts

The supply and use tables of Finnish physical flow accounts are presented in tables 1– 4 of the tables section and the industry by industry input-output table in Table 5. In the main tables, the emissions into air are presented as total sums, in order to save space. They are shown separately in Table 6.

The physical flow tables become fairly large even when quite aggregated. Table 3.1 presents a summary table where all the main flows are shown on one page by industrial and final use breakdowns. In the rows, the table first shows the material flows of production activities by industry. Beneath them lie the flows of domestic final use categories. At the bottom there are correction factors for direct exports of imported materials and for transfers of emissions.

The column sum of domestic products on the input side and the column sum of products to the domestic economy on the output side are equal. Similarly, the columns of final waste sum up to an equal amount. These columns constitute the inner flows of the economy, and in the final row of column totals of the table they can be eliminated away, in which case the balance of the outer flows of the economy is left: the entrance of materials from nature and the rest of the world and ending up in the stocks of the economy or leaving the economy to the rest of the world or domestic nature. The outer total balance of material flows is shown in Figure 3.1. Indirect inputs of imports are also added into the figure.

Figure 3.1. Total outer material balance of Finland 1999, gigakilograms (million tonnes)

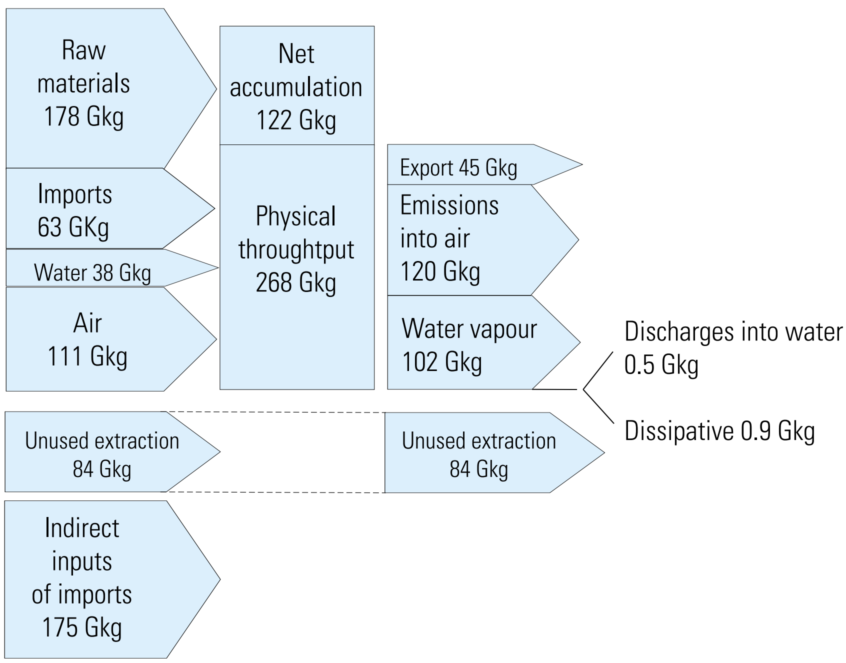


Table 3.1. Summary of the physical flow accounts, Finland 1999, million kilograms

	INPUTS						
	From domestic nature				From RoW	Domestic	
Industries	Unused extrac-tion	Raw materials	Water	Air	Import	Domestic products	Final waste
1 Agriculture, hunting and fishing	0	867	33 122	25 289	989	37 871	0
2 Forestry, logging etc.	23 078	50 032	0	373	77	50	0
3 Mining of energy minerals	436	9 366	0	766	4	6	0
4 Other minig and quarrying	25 164	100 915	0	223	49	73	0
5 Manufacture of food products	0	0	1 024	524	1 471	7 694	0
6 Manufacture of textiles etc.	0	0	0	100	99	51	0
7 Manuf. of wood and wood products	0	0	0	990	2 351	25 994	0
8 Manuf. of pulp, paper, paper prod.	0	0	39	18 905	12 594	51 656	0
9 Publishing, printing etc.	0	0	6	37	172	455	0
10 Manufacture of coke and petroleum	0	0	0	3 264	13 368	876	0
11 Manufacture of chemicals etc.	0	0	1 625	3 504	3 415	4 936	0
12 Manuf. of rubber and plastic prod.	0	0	15	70	306	308	0
13 Manuf. of non-metallic mineral prod.	2 308	3 124	534	939	2 056	8 369	0
14 Manufacture of basic metals	0	65	162	4 056	6 289	7 443	0
15 Manufacture of metal products	0	0	2	228	473	820	0
16 Manuf. of machinery and equipment	0	0	0	109	458	464	0
17 Manufacture of electrical equipment	0	0	8	33	259	251	0
18 Manufacture of transport equipment	0	0	0	61	145	184	0
19 Manufacturing n.e.c.	0	0	0	37	71	267	0
20 Recycling	0	0	6	5	42	1 152	0
21 Electricity, gas & water supply	0	0	1	23 134	5 760	9 396	0
22 Building	8 500	0	0	756	1 409	29 690	0
23 Civil engineering	25 000	13 200	0	740	626	63 374	0
24 Wholesale and retail trade	0	0	0	1 278	148	571	0
25 Hotels and restaurants	0	0	0	113	117	664	0
26 Transport and telecommunication	0	0	0	10 686	1 019	2 848	0
27 Dwellings	0	0	0	1 532	163	834	0
28 Public administration and services	0	0	0	670	202	423	44
29 Sewage and refuse disposal	0	0	0	105	16	29	3 356
30 Other service activities	0	0	0	283	150	197	0
Production activities, total	**84 486**	**177 568**	**36 544**	**98 810**	**54 298**	**256 947**	**3 400**
1 Household consumption	0	0	1 863	13 307	1 779	8 572	0
2 Fixed capital formation	0	0	0	0	271	105 470	0
3 Changes in inventories	0	0	0	0	–1 279	838	0
4 Landfills	0	0	0	0	0	0	18 189
5 Domestic final use, total	**0**	**0**	**1 863**	**13 307**	**771**	**114 880**	**18 189**
6 Exports of imports	**0**	**0**	**0**	**0**	**866**	**0**	**0**
7 International transfers, net	**0**	**0**	**0**	**–1 501**	**7 356**	**0**	**0**
8 Total	**84 486**	**177 568**	**38 407**	**110 616**	**63 290**	**371 827**	**21 589**

OUTPUTS									TOTAL	
To use of domestic economy			**To Row**	**To domestic nature**						
Products	Final waste	Net accu-mulation	Exports	Emissions into air	Water vapour	Dischar-ges into water	Dissi-pative use	Unused extrac-tion	INPUT	OUTPUT
41 003	173	0	365	24 444	31 969	184	0	0	98 137	98 137
49 360	0	0	653	357	128	19	15	23 078	73 609	73 609
8 501	3	0	225	1 406	3	5	0	436	10 579	10 579
88 035	11 207	0	1 728	213	77	1	0	25 164	126 424	126 424
6 970	92	0	660	544	2 447	1	0	0	10 713	10 713
35	8	0	73	89	46	0	0	0	251	251
14 361	58	0	5 176	1 255	8 486	1	0	0	29 335	29 335
17 329	1 372	0	14 187	23 985	26 111	209	0	0	83 195	83 195
439	12	0	146	39	34	0	0	0	669	669
7 606	41	0	5 117	3 436	1 307	1	0	0	17 508	17 508
6 632	1 760	0	2 887	1 391	805	5	0	0	13 479	13 479
321	10	0	254	64	50	0	0	0	700	700
11 366	197	0	499	1 980	979	0	0	2 308	17 328	17 328
7 069	927	0	3 691	5 249	1 077	1	0	0	18 015	18 015
872	16	0	320	200	115	0	0	0	1 523	1 523
398	57	0	407	117	53	0	0	0	1 031	1 031
209	50	0	233	36	23	0	0	0	551	551
116	18	0	161	68	26	0	0	0	390	390
197	9	0	84	40	46	0	0	0	375	375
1 117	79	0	3	4	2	0	0	0	1 205	1 205
509	355	0	1	25 212	12 212	1	0	0	38 290	38 290
29 123	1 258	0	0	1 197	278	0	0	8 500	40 355	40 355
76 579	11	0	0	1 096	254	0	0	25 000	102 940	102 940
0	321	0	0	1 184	492	0	0	0	1 997	1 997
555	185	0	0	107	48	0	0	0	894	894
0	52	0	0	10 092	3 732	0	677	0	14 553	14 553
0	15	0	0	1 751	762	0	0	0	2 528	2 528
0	200	0	44	794	271	0	30	0	1 339	1 339
3 128	16	0	96	183	29	53	0	0	3 506	3 506
0	207	0	0	282	112	0	30	0	631	631
371 827	**18 711**	**0**	**37 009**	**106 816**	**91 972**	**480**	**752**	**84 486**	**712 052**	**712 052**
0	1 438	101	0	13 811	10 016	13	143	0	25 521	25 521
0	1 440	104 302	0	0	0	0	0	0	105 742	105 742
0	0	–442	0	0	0	0	0	0	–442	–442
0	0	17 826	0	362	0	0	0	0	18 189	18 189
0	**2 877**	**121 788**	**0**	**14 173**	**10 016**	**13**	**143**	**0**	**149 010**	**149 010**
0	**0**	**0**	**866**	**0**	**0**	**0**	**0**	**0**	**866**	**866**
0	**0**	**0**	**7 543**	**–1 213**	**–475**	**0**	**0**	**0**	**5 855**	**5 855**
371 827	**21 589**	**121 788**	**45 417**	**119 776**	**101 513**	**492**	**895**	**84 486**	**867 783**	**867 783**

The matter entering the economy amounts to 390 Gkg. The share of raw materials from domestic nature is 36% of the material input, the share of imports 16% and that of air and water 38%. Nearly one third, or 31%, of the entering materials stay in the economy as net accumulation of stocks and over two-thirds flow through the economy into the domestic nature or to the rest of the world. The share of exports of the materials leaving the economy is 13%. The share of emissions into the air is 34% and that of water vapour 29%. Emissions into the air is comprised mostly of carbon dioxide: the share of carbon dioxide of air emissions is about 87%, totalling 104 Gkg. Emissions into air also include oxygen released by cultivated plants. The share of oxygen in air emissions is 12%. Thus, the share of other emissions of the air emissions remains at about one per cent. Discharges into water and dissipative use both stay under one Gkg.

The ratio of unused extractions, 86 Gkg, is less than one third of the used domestic raw materials, whereas indirect inputs of imports, 175 Gkg, are nearly three times direct imports. However, besides unused extractions indirect inputs also include all the materials used direct or indirect in the making of the imported products, excepting the materials contained in the products themselves.

The summary Table 3.1 gives a good opportunity to look over some special items in physical flow accounts.

The extraction of raw materials from domestic nature is placed mainly within the primary industries 1 – 4, but also within the manufacture of mineral products, 13, and in civil engineering, 23. Raw materials of agriculture, collecting, hunting and fishing include products taken direct from nature, such as wild berries, mushrooms, game and fish catches. Reindeer for slaughter are accounted as direct products of nature, too, even though their artificial feeding is a fairly common practice today. The negative material balance of cultivated land has been interpreted as extraction of soil. Raw materials of forestry consist of raw wood and chips from felling residues. The unused inputs of forestry are felling residues, assumed to be 45% of the mass of felled trees.

In the raw materials of mining of energy minerals, peat loss of carbon dioxide emissions and discharges to water are added to the amount of produced fuel and horticultural peat registered in statistical sources. The unused extraction of energy mineral mining includes the clearing of overburden flora and soil of the bog. The raw materials of other mining contain the gross ore of mines and the extraction of gravel, crushed stone, building stone and other soil materials. Unused extraction includes overburden soil and wallrock.

In Finnish industrial statistics, soap stone quarries and some of the extraction of gravel and sand are actually registered in connection with units of mineral product manufacturing. Therefore, the quarried quantities of these and the unused extraction associated with them are moved from the mining industry to the mineral manufacturing industry, even though they are characteristic materials of mining and quarrying.

In civil engineering, excavation generates crushed stone and other soil materials fit for construction use. These are accounted for as direct raw material extraction. However, large movements of soil for which no use is found are also executed in construction. These unused soil movements constitute the unused inputs of construction.

Dissipative use into nature is found in two industries and in households. The dissipative use in forestry includes the fertilising of forests. In the transport and telecommunications industry, dissipative use includes the sanding and salting of highways. For households, backyard composting, ash sprinkling and garden fertilising are accounted as dissipative use.

3.2 Material input and use of natural resources

Material inputs by industry and final use categories are presented in Table 3.2. Material inputs are combined into two summary indicators, direct material inputs and direct contribution to natural resource use.

Direct material input shows the total mass of inputs used direct. However, summing up of the direct material inputs of each industry and the final use category contain double accounting of domestic intermediate goods circulating inside the economy and thus, the totals of the direct material inputs are shown in brackets. The direct material input of the total economy is given as the sum of domestic raw materials and imported goods, which is 233,000 Mkg, a little less than 40% of the sum of the separate direct material inputs. The direct material inputs by industry can be used, however, to measure the material intensities of industries.

Table 3.2. Material inputs by industry and final use category, million kg

	Domestic goods	Raw materials from domestic nature	Domestic unused extraction	Imported goods	Indirect inputs of imports	Direct material input	Direct contribution to nature resource use
Industries	1	2	3	4	5	1+2+4	2+3+4+5
1 Agriculture, hunting and fishing	37 871	867	0	989	630	39 727	2 486
2 Forestry, logging etc.	50	50 032	23 078	77	20	50 158	73 207
3 Mining of energy minerals	6	9 366	436	4	4	9 377	9 811
4 Other minig and quarrying	73	100 915	25 164	49	30	101 037	126 157
5 Manufacture of food products	7 694	0	0	1 471	1 543	9 165	3 014
6 Manufacture of textiles etc.	51	0	0	99	1 027	151	1 127
7 Manufacture of wood and wood prod.	25 994	0	0	2 351	1 910	28 345	4 262
8 Manuf. of pulp, paper, paper prod.	51 656	0	0	12 594	17 908	64 250	30 502
9 Publishing, printing etc.	455	0	0	172	285	627	457
10 Manufacture of coke and petroleum	876	0	0	13 368	4 134	14 245	17 502
11 Manufacture of chemicals etc.	4 936	0	0	3 415	14 590	8 351	18 005
12 Manuf. of rubber and plastic prod.	308	0	0	306	2 065	615	2 371
13 Manuf. of non-metallic mineral prod.	8 369	3 124	2 308	2 056	2 745	13 548	10 232
14 Manufacture of basic metals	7 443	65	0	6 289	55 301	13 796	61 654
15 Manufacture of metal products	820	0	0	473	3 965	1 293	4 438
16 Manuf. of machinery and equipment	464	0	0	458	3 352	922	3 810
17 Manufacture of electrical equipment	251	0	0	259	13 275	510	13 533
18 Manufacture of transport equipment	184	0	0	145	1 243	329	1 388
19 Manufacturing n.e.c.	267	0	0	71	580	338	652
20 Recycling	1 152	0	0	42	1	1 194	43
21 Electricity, gas & water supply	9 396	0	0	5 760	8 078	15 156	13 838
22 Building	29 690	0	8 500	1 409	3 173	31 099	13 082
23 Civil engineering	63 374	13 200	25 000	626	1 146	77 200	39 972
24 Wholesale and retail trade	571	0	0	148	121	719	269
25 Hotels and restaurants	664	0	0	117	176	781	293
26 Transport and telecommunication	2 848	0	0	1 019	360	3 867	1 379
27 Dwellings	834	0	0	163	35	996	198
28 Public administration and services	423	0	0	202	318	625	520
29 Sewage and refuse disposal	29	0	0	16	1	45	16
30 Other service activities	197	0	0	150	410	348	560
Production activities, total	**256 947**	**177 568**	**84 486**	**54 298**	**138 426**	**(488 814)**	**454 777**
Consumption of household	8 572	0	0	1 779	33 586	10 351	35 365
Fixed capital formation	105 470	0	0	271	3 083	105 742	3 355
Changes in inventories	838	0	0	–1 279	–9 160	–442	–10 439
Total	**371 827**	**177 568**	**84 486**	**55 069**	**165 935**	**(604 465)**	**483 058**

Total natural resource use is composed of raw materials from domestic nature, domestic unused extraction, imported goods and indirect inputs of imports which contain natural resources used in the processing of imported goods but not included in their mass. In Table 3.2, the column Direct contribution to natural resource use shows the direct additions of each economic activity to the total natural resource use of the economy so that the column sum is equal to the total natural resource use of the total economy. However, as an indicator of the total use of natural resources of each industry it lacks the indirect natural resource content of the domestic intermediate goods which are revealed by input-output calculations in Chapter 4.

3.3 Waste flows

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 are 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, see Annex 1, Table 3.

Table 3.3 presents waste flows according to the wide waste definition. The total domestic waste generation is shown in the bottom row of the supply 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.

Domestic waste generation amounts to 138 million tonnes. In the waste statistics of Statistics Finland (2002, 20), the waste generation is slightly under 130 million tonnes. The difference is mainly due to two factors. The waste statistics include wallrock 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 5.2 million tonnes, while in physical flow accounts it rises to nearly 9 million tonnes. The difference in the energy recovery is caused mainly by industrial wood residues. 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 amount of 11.2 million tonnes from the total accumulation of landfills, the total generation of manufacturing and municipal landfill waste becomes 7 million tonnes. In waste statistics, manufacturing and municipal landfill waste generation os 6.8 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.

In Table 3.3 the sewage and refuse disposal industry is divided into two sub-industries, 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

Table 3.3. Waste flows by industry 1999, million kg

Industries	Supply: Unused extrac-tion	Supply: Re-covered waste	Supply: Final waste	Use: Material use	Use: Energy use	Use: Final waste	Use: Dissi-pative use	Use: Unused extrac-tion
1 Agriculture, hunting and fishing	0	22 600	173	22 608	0	0	0	0
2 Forestry, logging etc.	23 078	0	0	0	0	0	0	23 078
3 Mining of energy minerals	436	0	3	0	0	0	0	436
4 Other minig and quarrying	25 164	0	11 207	0	0	0	0	25 164
5 Manufacture of food products,	0	272	96	325	7	0	0	0
6 Manufacture of textiles etc.	0	0	8	2	0	0	0	0
7 Manuf. of wood and wood prod.	0	5 406	58	24	936	0	0	0
8 Manuf. of pulp, paper, paper prod.	0	1 978	1 372	614	4 476	0	0	0
9 Publishing, printing etc.	0	9	12	0	0	0	0	0
10 Manufacture of coke and petroleum	0	0	41	0	0	0	0	0
11 Manufacture of chemicals etc.	0	222	1 760	27	86	0	0	0
12 Manuf. of rubber and plastic prod.	0	1	10	6	0	0	0	0
13 Manuf. of non-metallic mineral prod.	2 308	81	197	541	8	0	0	2 308
14 Manufacture of basic metals	0	1 141	927	1 149	0	0	0	0
15 Manufacture of metal products	0	16	16	1	0	0	0	0
16 Manuf. of machinery and equipment	0	14	57	5	0	0	0	0
17 Manufacture of electrical equipment	0	2	50	0	0	0	0	0
18 Manufacture of transport equipment	0	24	18	0	0	0	0	0
19 Manufacturing n.e.c.	0	4	9	2	9	0	0	0
20 Recycling	0	100	79	1 192	0	0	0	0
21 Electricity, gas & water supply	0	510	355	0	3 465	0	0	0
22 Building	8 500	0	1 258	0	0	0	0	8 500
23 Civil engineering	25 000	0	11	744	0	0	0	25 000
24 Wholesale and retail trade	0	0	321	0	0	0	0	0
25 Hotels and restaurants	0	0	185	0	0	0	0	0
26 Transport and telecommunication	0	0	52	0	0	0	0	0
27 Dwellings	0	0	15	0	0	0	0	0
28 Public administration and services	0	0	200	0	0	0	0	0
29a Treatment of liquid waste	0	179	14	0	0	263	0	0
29b Treatment of solid waste	0	3 013	2	0	0	3 105	0	0
30 Other service activities	0	0	207	0	0	0	0	0
Production activities, total	**84 486**	**35 575**	**18 715**	**27 241**	**8 987**	**3 368**	**0**	**84 486**
Imports	0	929	13	0	0	0	0	0
Household consumption	0	103	1 438	0	0	0	103	0
Fixed capital consumption	0	0	1 440	0	0	0	0	0
Changes in inventories	0	0	0	–157	0	0	0	0
Landfills	0	0	0	0	0	18 193	0	0
Exports	0	0	0	433	0	44	0	0
Total	**84 486**	**36 607**	**21 605**	**27 517**	**8 987**	**21 605**	**103**	**84 486**
Correction for international transfers	0	–4 222	–108					
Domestic waste generation	**84 486**	**32 385**	**21 497**					

waste. Thus, liquid waste treatment has used 263 thousand tonnes of final waste, measured at 15% moisture content. From this, 183 thousand tonnes are retrieved as sewage sludge, of which 179 thousand 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 22.6 million tonnes. Almost all of this, or 22.58 million tonnes 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 2.3 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. Drying of wastes before reporting them would indeed be an efficient method of waste minimisation.

Table 3.4. Waste indicators by industry

Industries	Generated waste per primary products, %	Share of recovered waste in inputs, %
1 Agriculture, hunting and fishing	121.3	58.2
2 Forestry, logging etc.	0.0	0.0
3 Mining of energy minerals	0.0	0.0
4 Other minig and quarrying	12.5	0.0
5 Manufacture of food products	5.0	3.6
6 Manufacture of textiles etc.	7.9	1.2
7 Manufacture of wood and wood products	38.7	3.4
8 Manufacture of pulp, paper, paper prod.	18.6	9.7
9 Publishing, printing etc.	3.7	0.0
10 Manufacture of coke and petroleum	0.3	0.0
11 Manufacture of chemicals etc.	21.3	1.4
12 Manufacture of rubber and plastic prod.	2.1	0.9
13 Manufacture of non-metallic mineral prod.	2.4	5.3
14 Manufacture of basic metals	21.5	8.4
15 Manufacture of metal products	2.7	0.1
16 Manufacture of machinery and equipment	9.0	0.6
17 Manufacture of electrical equipment	11.9	0.0
18 Manufacture of transport equipment	16.5	0.0
19 Manufacturing n.e.c.	4.8	3.5
20 Recycling	17.5	99.8
21 Electricity, gas & water supply		22.9
22 Building	4.3	0.0
23 Civil engineering	0.0	1.2
24 Wholesale and retail trade		0.0
25 Hotels and restaurants	33.4	0.0
26 Transport and telecommunication		0.0
27 Dwellings		0.0
28 Public administration and services		0.0
29 Sewage and refuse disposal		100.0
30 Other service activities		0.0
Production activities, total	**15.0**	**13.2**

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 product inputs (= recovered waste included). The indicators are presented in Table 3.4.

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 used side. For total production activities, the waste-product ratio becomes 15% and the waste-input share is 13%.

3.4 Material flows of combustion and energy consumption

The material flows of combustion are presented in Table 3.5. This table keeps to the same structure as the general summary Table 3.1, so that the material flows of combustion can be separated from other flows. In 1999, a total of 46 million tonnes of fuels were used in the territory of Finland. Altogether, 69 million tonnes of oxygen and nitrogen were bound in combustion.

Emissions generated into air totalled 79 million tonnes and water vapour 35 million tonnes. A total of 1.3 million tonnes of ash were produced, of which about half-a-million tonnes were recovered for use in civil engineering.

The total flows of combustion are also demonstrated in Figure 3.2.

The largest user of fuels was the manufacture of pulp and paper with about 18 million tonnes, while the public utilities of gas, electricity and water supply used 15 million tonnes.

The shares of fuels in the product inputs of industries and households are shown in Table 3.6. Fuels comprise almost all product inputs in the electricity, gas and water supply industry and in dwellings. The input share of fuels is also high, over 80%, in transport and in forestry. Nearly half of the material input of household consumption is comprised of fuels. Of household fuels, the share of wood is nearly one half and that of gasoline over one third.

In physical flow accounts, the use of fuels by industries and households was first estimated in energy units (gigajoules) by energy source, for which data were readily available from energy statistics and the material balances of combustion could be calculated uniformly. Using energy units, the fuel consumption could also be extended to cover all energy consumption as the immaterial energy sources – hydro and wind power, reaction heat of industry, imports of electricity and electric and district and process heat – could be included.

Figure 3.2.
Total flows of fuel combustion in 1999

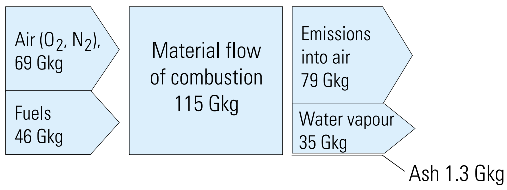


Table 3.5. Material flows of fuel combustion 1999, million kg

Industries	INPUTS: From domestic nature: Unused extraction	From domestic nature: Raw materials	From domestic nature: Water	From domestic nature: Air (O, N)	From RoW: Imports	Domestic economy: Domestic products	Domestic economy: Final waste
1 Agriculture, hunting and fishing	0	0	0	2 495	421	548	0
2 Forestry, logging etc.	0	0	0	371	66	40	0
3 Mining of energy minerals	0	0	0	6	1	2	0
4 Other minig and quarrying	0	0	0	223	40	27	0
5 Manufacture of food products	0	0	0	523	94	129	0
6 Manufacture of textiles etc.	0	0	0	100	19	10	0
7 Manufacture of wood and wood products	0	0	0	988	88	931	0
8 Manufacture of pulp, paper, paper prod.	0	0	0	18 894	1 146	16 821	0
9 Publishing, printing etc.	0	0	0	37	4	7	0
10 Manuf. of coke and petroleum refineries	0	0	0	3 126	489	730	0
11 Manufacture of chemicals etc.	0	0	0	995	184	302	0
12 Manufacture of rubber and plastic prod.	0	0	0	70	13	7	0
13 Manuf. of non-metallic mineral prod.	0	0	0	939	268	80	0
14 Manufacture of basic metals	0	0	0	2 182	120	3 533	0
15 Manufacture of metal products	0	0	2	227	46	15	0
16 Manuf. of machinery and equipment	0	0	0	109	18	14	0
17 Manufacture of electrical equipment	0	0	8	33	6	4	0
18 Manufacture of transport equipment	0	0	0	61	10	8	0
19 Manufacturing n.e.c.	0	0	0	37	5	13	0
20 Recycling	0	0	0	5	1	1	0
21 Electricity, gas & water supply	0	0	1	23 120	5 739	9 309	0
22 Building	0	0	0	753	63	154	0
23 Civil engineering	0	0	0	737	141	70	0
24 Wholesale and retail trade	0	0	0	1 275	84	286	0
25 Hotels and restaurants	0	0	0	113	21	21	0
26 Transport and telecommunication	0	0	0	10 606	987	2 151	0
27 Dwellings	0	0	0	1 514	163	834	0
28 Public administration and services	0	0	0	667	110	173	0
29 Sewage and refuse disposal	0	0	0	35	2	27	0
30 Other service activities	0	0	0	282	49	63	0
Production activities, total	**0**	**0**	**0**	**70 524**	**10 367**	**36 307**	**0**
1 Household consumption	0	0	0	11 857	794	4 258	0
2 Fixed capital formation	0	0	0	0	0	0	0
3 Changes in inventories	0	0	0	0	0	0	0
4 Landfills	0	0	0	0	0	0	0
5 Domestic final use, total	**0**	**0**	**0**	**0**	**0**	**0**	**0**
6 Exports of imports	**0**	**0**	**0**	**0**	**0**	**0**	**0**
7 International transfers, net	**0**	**0**	**0**	**–1 483**	**–208**	**–243**	**0**
8 Total	**0**	**0**	**0**	**69 041**	**10 189**	**36 064**	**0**

OUTPUTS									TOTAL	
To use of domestic economy			**To RoW**	**To domestic nature**						
Products	Final waste	Net accu-mulation	Exports	Emissions into air	Water vapour	Discharges into water	Dissipa-tive use	Unused extrac-tion	INPUT	OUTPUT
0	9	0	0	2 498	958	0	0	0	3 464	3 464
0	0	0	0	352	126	0	0	0	477	477
0	0	0	0	6	3	0	0	0	8	8
0	1	0	0	213	77	0	0	0	290	290
5	0	0	0	507	235	0	0	0	746	746
0	0	0	0	89	40	0	0	0	129	129
0	16	0	0	1 230	760	0	0	0	2 007	2 007
20	369	0	0	23 966	12	0	0	0	36 860	36 860
0	0	0	0	33	14	0	0	0	48	48
0	3	0	0	3 221	1 120	0	0	0	4 344	4 344
0	18	0	0	1 065	399	0	0	0	1 481	1 481
0	0	0	0	63	26	0	0	0	90	90
7	13	0	0	924	342	0	0	0	1 286	1 286
0	4	0	0	5 232	600	0	0	0	5 836	5 836
0	0	0	0	178	110	0	0	0	288	288
0	0	0	0	98	43	0	0	0	141	141
0	0	0	0	28	14	0	0	0	42	42
0	0	0	0	57	22	0	0	0	79	79
0	0	0	0	37	18	0	0	0	55	55
0	0	0	0	4	2	0	0	0	7	7
445	326	0	0	25 191	12 206	0	0	0	38 168	38 168
0	0	0	0	695	275	0	0	0	970	970
0	0	0	0	698	251	0	0	0	948	948
0	1	0	0	1 155	489	0	0	0	1 645	1 645
0	0	0	0	107	47	0	0	0	155	155
0	7	0	0	10 086	3 652	0	0	0	13 745	13 745
0	15	0	0	1 751	744	0	0	0	2 510	2 510
0	4	0	0	678	268	0	0	0	950	950
20	–20	0	0	44	20	0	0	0	64	64
0	1	0	0	281	111	0	0	0	393	393
497	**769**	**0**	**0**	**80 487**	**35 476**	**0**	**0**	**0**	**117 229**	**117 229**
0	0		0	12 255	4 607	0	0	0	16 910	16 910
0	0		0	0	0	0	0	0	0	0
0	0		0	0	0	0	0	0	0	0
0	0		0	0	0	0	0	0	0	0
0	**0**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0	**–2**	**0**	**0**	**–1 475**	**–457**	**0**	**0**	**0**	**–1 934**	**–1 934**
497	**767**	**0**	**0**	**79 012**	**35 018**	**0**	**0**	**0**	**115 295**	**115 295**

Table 3.6. Share of fuels in product inputs, domestic and imported products together, million kg and percent

Industries	Fuels	Product inputs total	Share of fuels, %
1 Agriculture, hunting and fishing	969	38 860	2.5
2 Forestry, logging etc.	106	126	84.1
3 Mining of energy minerals	3	10	25.6
4 Other minig and quarrying	67	122	55.0
5 Manufacture of food products	223	9 165	2.4
6 Manufacture of textiles, etc.	29	151	19.3
7 Manufacture of wood and wood products	1 019	28 345	3.6
8 Manufacture of pulp, paper, paper prod.	17 966	64 250	28.0
9 Publishing, printing etc.	11	627	1.7
10 Manufacture of coke and petroleum	1 219	14 245	8.6
11 Manufacture of chemicals etc.	485	8 351	5.8
12 Manufacture of rubber and plastic prod.	20	615	3.3
13 Manufacture of non-metallic mineral prod.	348	10 424	3.3
14 Manufacture of basic metals	3 654	13 732	26.6
15 Manufacture of metal products	61	1 293	4.7
16 Manufacture of machinery and equipment	32	922	3.5
17 Manufacture of electrical equipment	9	510	1.8
18 Manufacture of transport equipment	18	329	5.5
19 Manufacturing n.e.c.	18	338	5.4
20 Recycling	1	1 194	0.1
21 Electricity, gas & water supply	15 049	15 156	99.3
22 Building	216	31 099	0.7
23 Civil engineering	212	64 000	0.3
24 Wholesale and retail trade	370	719	51.4
25 Hotels and restaurants	42	781	5.4
26 Transport and telecommunication	3 139	3 867	81.2
27 Dwellings	996	996	100.0
28 Public administration and services	283	625	45.3
29 Sewage and refuse disposal	29	45	64.1
30 Other service activities	111	348	32.0
Production activities, total	**46 704**	**311 245**	**15.0**
Household consumption	5 053	10 351	48.8

Measured in energy units, energy consumption gives of itself important supplementary information on the physical properties of the economy. In combustion calculations, a fairly detailed classification of 44 fuel types was used so that the mass conversions and combustion material balance calculations could be worked out as accurately as possible. Energy consumption by industries and households, and corrections for international transport are presented in Table 7 of the Tables section.

To keep the mass balance calculations uniform, a change has been made to the energy balances of steel making in comparison with the definitions and methods used in energy statistics. In physical flow accounts, blast furnace coke and oil are treated as raw materials and their net heat value is considered as an immaterial energy source, the reaction heat of a blast furnace. Thus, the general energy balance of steel making is kept uniform with energy statistics.

In energy statistics, the energy consumption of a country is generally presented without international transport. According to the activity-based boundaries of the economy in physical flow accounting, all activities, and thus also to international transport of the transport companies of a country are included in the material flows. Thus, in Table 7, the energy consumption of the transport of the telecommunications industry (26) includes the fuel consumption in international transports of Finnish firms. At the bottom of the table in the Rest of the world row, it is subtracted as a separate correction item so that the connection to the practice of energy statistics can be seen. In the Rest of the world row, the net imports of electricity are also added as an immaterial energy source.

Table 3.7 presents energy consumption by the main groups of energy and introduces the use of primary energy. Immaterial energy sources include water and wind power in the electricity, gas and water supply industry, reaction heat in some manufacturing industries and heat pumps in agriculture, dwellings and households. The energy sources total gives the direct use of primary energy. However, the generation of electricity and heat in the electricity, gas and water supply industry takes over 40% of energy sources. In the columns of net electricity and net heat, the net consumption of electricity and heat are defined as the difference between bought and sold energy. For net producers, net electricity and heat appear as negative. In manufacturing, net producers of heat are oil refining and basic metal manufacturing, and oil refining is also a net producer of electricity.

Net electricity and heat are summed up as nought by definition – when the balance of net electricity is added to net imports. This is because secondary energy electricity and heat cannot be added direct to the use of energy sources but have to be first converted into primary energy. A problem in this conversion is the high share of co-generation in Finland – in the year 1999, 37% of electricity and 73% of district heat were generated in combined heat and electricity plants. In the allocation of the fuels used in the co-generation of electricity and heat, the so-called benefit allocation method is used, where the efficiency benefits reached in co-generation compared to separate generation are allocated to electricity and heat in proportion to the fuels used in alternative separate generation. When these calculations are added to the separate production of electricity in heat and distribution losses, the resulting primary energy conversion coefficient is 2.44 for electricity and 0.97 for heat. The calculations are shown in more detail in Mäenpää (2003). The primary energy column in Table 3.6 is the sum of calculated direct energy sources, and net electricity and heat, multiplied by the primary conversion coefficients. The total sum of the column of primary energy remains the same as the sum of the energy sources, because the converted net electricity and heat columns only reallocate the energy source use of the net producers of secondary energy. After reallocation, energy consumption through own activities remains in the electricity, gas and water supply industry.

Table 3.7. Energy consumption by industry and households 1999, terajoules

Industries	Fuels	Immaterial energy sources	Energy sources, total	Net electricity
1 Agriculture, hunting and fishing	30 670	470	31 140	3 000
2 Forestry, logging etc.	4 530	0	4 530	0
3 Mining of energy minerals	70	0	70	35
4 Other minig and quarrying	2 801	0	2 801	1 877
5 Manufacture of food products	6 526	0	6 526	5 594
6 Manufacture of textiles, etc.	1 253	0	1 253	935
7 Manufacture of wood and wood production	11 997	0	11 997	5 088
8 Manuf. of pulp, paper, paper production	236 278	4 539	240 817	49 747
9 Publishing, printing etc.	460	0	460	1 435
10 Manufacture of coke and petroleum	45 752	0	45 752	-316
11 Manufacture of chemicals etc.	13 088	4 187	17 275	13 486
12 Manuf. of rubber and plastic production	872	0	872	2 636
13 Manuf. of non-metallic mineral production	11 868	0	11 868	3 216
14 Manufacture of basic metals	2 956	34 954	64 515	15 075
15 Manufacture of metal products	2 829	0	2 829	2 021
16 Manufacture of machinery and equipment	1 362	0	1 362	2 571
17 Manufacture of electrical equipment	414	0	414	2 591
18 Manufacture of transport equipment	760	0	760	1 189
19 Manufacturing n.e.c.	462	0	462	816
20 Recycling	64	0	64	46
21 Electricity, gas & water supply	522 762	41 851	564 613	–186 290
22 Building	9 103	0	9 103	799
23 Civil engineering	8 988	0	8 988	0
24 Wholesale and retail trade	15 514	0	15 514	10 561
25 Hotels and restaurants	1 409	0	1 409	4 782
26 Transport and telecommunication	131 246	0	131 246	4 771
27 Dwellings	18 680	10	18 690	13 756
28 Public administration and services	8 326	0	8 326	13 284
29 Sewage and refuse disposal	730	0	730	728
30 Other service activities	3 522	0	3 522	12 770
Households	146 289	1 240	147 529	53 844
Finnish economy, total	1 268 187	87 25	1 355 438	40 046
Rest of the world	–65 502	40 046	–25 456	–40 046
Total	**1 202 684**	**127 297**	**1 329 982**	**0**

Net heat	Primary energy
360	38 749
0	4 530
10	165
60	7 402
5 939	25 828
184	3 695
5 456	29 606
13 375	374 190
552	4 468
–12 348	33 001
8 199	57 871
926	8 149
30	19 679
–1 624	99 421
538	8 243
1 973	9 499
1 163	7 813
993	4 600
294	2 723
6	181
–115 185	1 970
0	11 037
0	8 988
7 533	48 384
1 901	14 826
2 070	144 801
54 364	104 756
13 729	53 802
317	2 798
8 146	42 333
1 040	278 840
0	1 452 350
0	–122 368
0	**1 329 982**

3.5 Emissions into air

Emissions into the air are treated in the general tables of physical flow accounts as summed together. Data on emissions by type are, however, often important for the analysing of environmental loads in order to examine different emission groups, such as greenhouse gases or acidic gases, and weight the emission types by different equivalent load coefficients. Therefore, emissions into the air are presented by emission type in Table 6 of the Tables section. Carbon dioxide emissions are further divided by mineral and biotic origin, so that the carbon dioxides of mineral origin belonging to the greenhouse gases are kept separate.

Emissions into the air can also be divided into fuel combustion and other emissions as is done in Table 3.8.

Altogether, combustion emissions account for over three quarter of all emissions into the air.

The share of other emissions is high in the areas of agriculture, mining of energy minerals, construction, and sewage and refuse disposal. In agriculture, other emissions include particularly the oxygen released by cultivated plants, carbon dioxide and methane emissions of domestic animals and carbon dioxide emissions of cultivated soil mineralisation. The other emissions from the mining of energy minerals are comprised of the carbon dioxide released by peat production bogs and peat stacks. In the manufacture of mineral products, the other emissions are mostly due to the production of caustic lime. The other emissions of construction are comprised of the fugitive carbon dioxide emissions from bitumen, welding and explosion gases. The other emissions of sewage and refuse disposal are the emissions from waste incineration and the methane emissions of sewage treatment.

At the bottom of Table 6 of the Tables section, there are correction items for international transport and transboundary emission movements, by means of which the emissions of the Finnish economy are transformed into emissions within the Finnish geographical territory. In emissions statistics generally, as in the greenhouse gas emission inventories of the Kyoto Protocol in particular, a third type of boundary is followed: emissions of the economy without international transport. In this case, not only the emissions of domestic transports outside the borders of domestic territory but also the emissions of domestic international transport inside the domestic borders have to be subtracted from the emissions of the economy. The calculated emissions are shown in this way in Table 3.9, where emission estimates are compared with those of various emission statistics.

Table 3.8. Distribution of emissions into the air through combustion and other emissions in 1999, million kg and share of fuels in emission totals, percent

Industries	Fuel combustion	Others	Total	Share of fuels, %
1 Agriculture, hunting and fishing	2 498	21 946	24 444	10.2
2 Forestry, logging etc.	352	5	357	98.6
3 Mining of energy minerals	6	1 400	1 406	0.4
4 Other minig and quarrying	213	0	213	100.0
5 Manufacture of food products	507	37	544	93.2
6 Manufacture of textiles, etc.	89	0	89	100.0
7 Manufacture of wood and wood products	1 230	24	1 255	98.1
8 Manufacture of pulp, paper, paper prod.	23 966	19	23 985	99.9
9 Publishing, printing etc.	33	6	39	85.6
10 Manufacture of coke and petroleum	3 221	214	3 436	93.8
11 Manufacture of chemicals etc.	1 065	326	1 391	76.5
12 Manufaxture of rubber and plastic prod.	63	1	64	99.1
13 Manufacture of non-metallic mineral prod.	924	1 056	1 980	46.7
14 Manufacture of basic metals	5 232	18	5 249	99.7
15 Manufacture of metal products	178	22	200	89.1
16 Manufacture of machinery and equipment	98	19	117	83.9
17 Manufacture of electrical equipment	28	8	36	77.7
18 Manufacture of transport equipment	57	11	68	83.2
19 Manufacturing n.e.c.	37	2	40	94.3
20 Recycling	4	0	4	100.0
21 Electricity, gas & water supply	25 191	21	25 212	99.9
22 Building	695	502	1 197	58.1
23 Civil engineering	698	399	1 096	63.6
24 Wholesale and retail trade	1 155	29	1 184	97.5
25 Hotels and restaurants	107	0	107	100.0
26 Transport and telecommunication	10 086	6	10 092	99.9
27 Dwellings	1 751	0	1 751	100.0
28 Public administration and services	678	116	794	85.4
29 Sewage and refuse disposal	44	139	183	24.0
30 Other service activities	281	1	282	99.6
Households	12 255	1 556	13 811	88.7
Landfills	0	352	352	0.0
Total	**92 742**	**28 237**	**120 979**	**76,7**

The differences between the estimates are caused by the different starting points of the estimations. The estimates are fairly close in general, but there is a notable difference in the carbon dioxide emissions of biotic origin. The larger quantity of biotic carbon dioxide emissions in physical flow accounts is due to the fact that only the combustion emissions of biotic fuels are presented in greenhouse gas emission inventories whereas all biotic emissions have to be included in the material balances in physical flow accounts.

Table 3.9. The emissions of the Finnish economy 1999, minus the share of domestic international transport and comparison with other emission statistics, million kg

Emission	type	Finnish economy	International transport	Total	Emission statistic	Source
Carbon dioxide	CO_2-min	68 431	–4 972	63 459	64 073	/1/
Methane	CH_4	265	0	264	269	/1/
Nitrous oxide	N_2O	24	–1	23	25	/1/
Sulphur dioxide	SO_2	96	–14	82	85	/1/
Nitrogen oxides	NOx	313	–82	232	248	/1/
Ammonia	NH_3	49	0	49	49	/2/
Carbon monoxide	CO	499	–13	486	545	/1/
Non-methane volatile organic combounds	NMVOC	216	–36	180	178	/1/
Particles		50	–5	45	48	/3/
Non-fossil carbon dioxide	CO_2-bio	36 458	0	36 458	28 987	/1/

/1/ Ministry of the Environment (2002). National Inventory report, Finland's report on the greenhouse gas emission inventory to the European Commission
/2/ Finnish Environment Institute
/3/ Statistics Finland (2002a). Energy Statistics 2002.

3.6 Household consumption

The acquisition of household consumption goods and the waste resulting from consumption are presented in Table 3.10. Foodstuffs in the table also include meals and beverages taken in restaurants. Waste includes solid and liquid waste going into municipal sewage and refuse disposal of 1438 Mkg, as well as backyard treatments of 103 Mkg and household diffuse discharges into water of 13 Mkg. The biowaste contains food scraps and faeces.

The share of fuels in household acquisitions is nearly one half. Furthermore, the share of fuel wood in the mass of fuels is again about a half. However, measured in energy units the share of fuel wood is only one fifth. The share of foodstuffs is less than 40%. A share of only 10% is left for other consumption goods, and the share of packages is about one per cent.

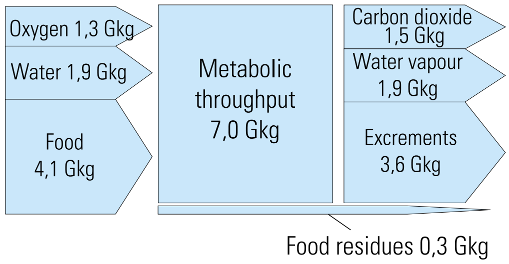
Only 15% of the mass of acquired goods are converted into waste. Only less than one per cent from fuels is left as ash. Of acquired durable goods, about two thirds are substituted with new goods for old ones and one third increases the stock of durables. Non-durable goods, as well as packages, are assumed to end up entirely as waste.

Table 3.10. Acquisition of household consumption goods and consumption waste 1999, million kg

Acquisition		Waste	
Fuels	5 053	48	Ash
Foodstuffs	4 134	442	Biowaste
Durable consumption goods	272	172	Scrap
Non-durable consumption goods	755	755	Mixed waste
Unrecycled packages	136	136	Package waste
Total	**10 351**	**1 553**	**Total**

The total metabolic flows of households are shown in Figure 3.3. In the figures, faeces and urine are measured at their full moisture content. In physical flow accounts, they are converted into 15% moisture content to correspond to the measurement practice with sewage sludge and the water left over is transformed into water vapour.

Figure 3.3.
Metabolic flows of households



3.7 Fixed capital formation

The material balance of fixed capital formation by type of capital goods is presented in Table 3.11. Withdrawals of buildings are obtained as demolition waste of buildings. The investments and withdrawals of motor vehicles belonging to capital and moving work machines are obtained from the data of the motor vehicle register. The withdrawals of other machinery and equipment, about two thirds of investments, are rough estimates.

No data were found for estimating withdrawals from civil engineering structures. This is perhaps the biggest problem of the present physical flow accounts, especially as it has a large effect on the net accumulation of the physical stock of the economy.

Presumably, some new civil engineering structures are erected to replace old ones, in which case the old structures are withdrawn and their materials may be included either in the surplus soil waste of civil engineering or they may also be included in the soil inputs used for new structures. On the other hand, in scattered settlements of contracting populations, old structures are often left unused, gradually merging into the surrounding nature as a dissipative movement from the economy to the environment. Unoccupied buildings in scattered settlements may behave in the same way. The problem in these cases is also definition of the demarcation point before which unused buildings or structures are accounted as belonging to the capital stock of the economy, and after which they are accounted as belonging to waste stock or as dissipated into nature. Yet, their worth may remain, as in special cases structures and buildings having dissipated into nature long ago are dug out again as valuable findings in archaeological excavations.

Table 3.11. Material balance of fixed capital formation, million kg

	Investments	Withdrawals (waste)	Net accumulation
Buildings	29 123	1 070	28 053
Civil engineering structures	75 902	0	75 902
Vehicles and moving work machines	137	45	92
Other machinery and equipment	444	280	164
Fixed capital formation total	**105 742**	**1 440**	**104 302**

3.8. Effects of changes in accounting boundaries

The system boundaries established in material flow accounting (MFA, European commission 2001) differ in two cases from the boundaries in the physical flow accounts of the SEEA followed in this work. In the MFA, agricultural lands and landfills are defined as belonging to the sphere of nature, while in the SEEA they are included in the economy.

The inclusion of agricultural land in nature means that the growth of cultivated plants is also a process of nature and, thus, the crop is raw material input from nature to the economy. Seeds, fertilisers and manure spread onto fields are recorded as dissipative use into nature. Oxygen tied up by cultivated plants, as well as erosion of field soil and emissions into the air generated by the mineralisation of field soil are also material flows inside nature and are therefore left out of the accounts.

When landfills are included in nature, the material flow category of final waste should be removed from the category of the economy to the category of flow from the economy to nature. At the same time, the category of accumulation of landfills should be left out altogether and emissions into the air from landfills should be change into an inner process of nature.

The flows of plant cultivation and final wastes according to physical flow accounts and material flow accounts are compared in Table 3.12. The rows in Table 3.12 follow the columns of the summary Table 3.1. The category Waste landfilled is added, however.

The summary Table 3.1 can be converted to correspond to the boundaries of the MFA by subtracting the discrepancy column of plant cultivation from the industry row of agriculture, eliminating the row of landfill accumulation, and eliminating the final waste columns included in the economy and removing their difference into a new column, Waste landfilled under the flows into nature.

Arguments in favour of the boundary practices of MFA are that agricultural fields, as well as landfills – especially before today's isolated and controlled landfills – are weakly separable from nature and the material flows in them cannot be carefully controlled. Especially the definition of a crop as an agricultural input from nature into the economy simplifies greatly the compilation of a time series natural resource use, because crops are generally well represented in agricultural statistics, and the fairly complex calculations of nutrient balances of agricultural fields are not required as in physical flow accounts.

Some defects in the boundaries of the MFA are that they do not coincide with the boundaries in national accounts, and especially some air-borne emissions which are generally looked at as generated by human activity, are left as inner flows of nature and are, thus, excluded from the accounts.

Table 3.12. Flows of plant cultivation and final waste according to the system boundaries of physical flow accounts (PFA) and material flow accounts (MFA), in million kg

	Plant cultivation			**Landfill accumulation**			**Total**		
	PFA	MFA	Dis-crepancy	PFA	MFA	Dis-crepancy	PFA	MFA	Dis-crepancy
INPUT	**44 725**	**40 118**	**4 607**	**18 189**		**18 189**	**62 914**	**40 118**	**22 796**
Unused extraction									
Raw materials	720	15 350	–14 630				720	15 350	–14 630
Water									
Air (O, N)	19 238		19 238				19 238	0	19 238
Imports									
Domestic goods	24 768	24 768	0				24 768	24 768	0
Final waste				18 189	18 189	0	18 189	18 189	0
OUTPUT	**44 726**	**40 118**	**4 608**	**18 189**		**18 189**	**62 914**	**40 118**	**22 796**
Domestic goods	15 350	15 350	0				15 350	15 350	0
Final waste				17 826		17 826	17 826	0	17 826
Changes in inventories									
Exports									
Emissions into air	18 019		18 019	362		362	18 382	0	18 382
Water vapour	11 179		11 179				11 179	0	11 179
Discharges into water	177		177				177	0	177
Waste landfilled							0	42 957	–42 957
Dissipative use		24 768	–24 768		18 189	–18 189			
Unused extraction									

4 From material flows to environmental loads of the economy

4.1 Measurement of economy and environmental loads

In national accounts, the key measurement figures for the economic activity of industry-specific production are output and value added.

Output at basic prices is the value of the products produced by the industry at factory gates before taxes and subsidies on products.

Value added for an industry is derived when the value of the intermediate products used in the production is deducted from the value of output. Value added measures what the industry has added to the value of the products.

The measurement of the overall activity of the economy is gross domestic product at market prices, which is derived from the sum of industries' value added when taxes on products minus subsidies on products are added to it. Gross domestic product is also obtained through final use of products as follows:

$$GDP = C + G + I + (E - M),$$

where C = private consumption expenditures, that is, consumption expenditures of households plus consumption expenditures of private non-profit institutions, G = government consumption expenditures, I = gross fixed capital formation including fixed investments and changes in inventories, E = value of exports, and M = value of imports.

The components of the gross domestic product can also be arranged as the national balance of supply and demand in the following way:

$$GDP + M = C + G + I + E,$$

where the left side of the balance gives the total value of the supply of final products and the right side the structure of the final use of the products.

Environmental loads of the economy can be analysed at the industry level, that is, division of environmental loads between industries in relation to the economic value they generate and, on the other hand, at the total level of the economy, that is, how environmental loads caused by the economy are divided into environmental loads of domestic production and imports and how the loads are divided into final use components, that is, loads caused by private and public consumption, capital formation and production of the products included in exports.

Environmental loads are broken down into two main groups, input factors and output factors:

- Input factors
  - Material input
  - Primary energy
- Output factors
  - Final waste
  - Greenhouse gases
  - Acidifying emissions
  - Emissions forming ground-level ozone
  - Discharges causing eutrophication of water bodies

The contents and measurement of the components are as follows.

Material input is measured at the industry level as direct material input of intermediate products and of raw materials extracted by the industry from nature. The total material input of products and gross domestic product components is calculated using only material input external to the economy and the sum of raw materials and unused extraction from domestic nature and direct and indirect material inputs of imports. Material inputs are measured as mass, in million kilograms, Mkg.

Primary energy is measured as the net calorific value of used fuels and as the energy value of electricity purchased from outside and of energy sources used for generation of heat. The measurement unit is terajoule, TJ.

Final waste is the amount of waste produced going straight to landfills or waste management. Final waste is measured as mass, in million kilograms, Mkg.

Greenhouse gas emissions are formed by emissions of mineral-based carbon dioxide, methane and nitrous oxide into air. Their greenhouse effects are calculated in carbon dioxide equivalent amounts, where the weighting factor of methane is 21 and that of nitrous oxide 310. The unit is million kilograms of carbon dioxide equivalents, Mkg CO_2 eqv.

Acidifying emissions are formed by emissions of sulphur dioxide, nitrogen oxides and ammonia into air. They are measured by their acidifying effects in equivalent amounts of sulphur dioxide, in which case the weighting factor of nitrogen oxides is 0.4 and that of ammonia 1.6.

Ground-level ozone has a detrimental effect on plants. Emissions generating ground-level ozone are methane, nitrogen oxides, carbon monoxide and non-methane hydrocarbons. The effect of emissions on ozone formation is measured by POCP values (Photochemical Ozone Creation Potential) where the weight of emissions is 0.003 for methane, 0.727 for nitrogen oxides, 0.064 for carbon monoxide and 0.209 for non-methane hydrocarbons.

Discharges causing eutrophication of water bodies are formed by discharges of phosphorus and nitrogen to waters and water deposits of nitrogen oxides and ammonia. Discharges causing eutrophication are measured in phosphorus equivalent (PO_4) amounts, in which case the general weighting factors used are total nitrogen 0.42, total phosphorus 3.06, nitrogen oxides 0.008 and ammonia 0.023. In addition, industry-specific correction factors are used for total phosphorous and nitrogen that take account of the variation of phosphorus and nitrogen components usable for algae.

Except for electricity and heat, all components of environmental load factors can be collected from material flow accounts. In primary energy and emissions the components are only added up weighted by various factors. The weighting factors of emissions are based on those used in the Finnish Environment Institute's life cycle analyses (Seppälä 1999).

The measurements of economic and environmental loads are collected into Table 4.1. The environmental load items included in final product use are given below the industries. The cells are empty where environmental load items are logically not present. Government consumption expenditure is composed of acquisition of services and, thus, does not include any direct environmental load factors. The indicator for the economic value of final use is expenditure at market prices, which is excluded from the table but used again in Chapter 4.4.

Table 4.1. Economic and environmental measurements by industry 1999

	Output	Value added	Direct material inputs	Primary energy	Final waste
	M€	M€	Mkg	TJ	Mkg
1 Agriculture, hunting and fishing	4 120	1 534	39 727	38 749	173
2 Forestry, logging etc.	2 931	2 316	50 158	4 530	0
3 Mining of energy minerals	261	97	9 377	165	3
4 Other minig and quarrying	605	191	101 037	7 402	11 207
5 Manufacture of food products	8 266	1 936	9 165	25 823	96
6 Manufacture of textiles, etc.	1 489	592	151	3 694	8
7 Manufacture of wood and wood products	4 908	1 262	28 345	29 602	58
8 Manuf. of pulp, paper, paper products	13 453	4 234	64 250	374 179	1 372
9 Publishing, printing etc.	3 900	1 568	627	4 468	12
10 Manufacture of coke and petroleum	2 533	175	14 245	33 011	41
11 Manufacture of chemicals etc.	4 612	1 639	8 351	57 864	1 760
12 Manuf. of rubber and plastic products	2 192	935	615	8 149	10
13 Manufacture of non-metallic mineral prod.	2 004	824	13 548	19 679	197
14 Manufacture of basic metals	5 229	976	13 796	99 422	927
15 Manufacture of metal products	3 938	1 597	1 293	8 243	16
16 Manufacture of machinery and equipment	8 735	2 753	922	9 497	57
17 Manufacture of electrical equipment	18 482	6 108	510	7 812	50
18 Manufacture of transport equipment	2 952	936	329	4 600	18
19 Manufacturing n.e.c.	1 461	583	338	2 723	9
20 Recycling	96	19	1 194	181	79
21 Electricity, gas & water supply	4 214	2 199	15 156	2 062	355
22 Building	11 498	4 768	31 099	11 037	1 258
23 Civil engineering	3 614	1 343	77 200	8 988	11
24 Wholesale and retail trade	19 888	11 133	719	48 378	321
25 Hotels and restaurants	4 095	1 514	781	14 825	185
26 Transport and telecommunication	17 914	10 925	3 867	144 800	52
27 Dwellings	13 090	9 202	996	104 712	15
28 Public administration and services	28 595	19 056	625	53 791	200
29 Sewage and refuse disposal	862	486	3 401	2 798	16
30 Other service activities	26 942	15 268	348	42 326	207
Household consumption			10 351	278 840	1 438
Government consumption					
Capital formation			123 489		1 070
Exports			37 875		370
Total	**222 880**	**106 171**	**663 884**	**1 452 350**	**21 593**

GHG emissions	Acidifying emissions	Groundlevel ozone	Eutro-phication
Mkg CO_2 eqv	1000 kg SO_2 eqv	1000 kg POCP eqv	1000 kg PO_4 eqv
11 834	91 504	19 471	19 328
387	2 522	4 514	724
1 406	9	9	138
216	542	253	8
675	1 208	855	51
90	160	116	8
634	1 288	3 021	23
4 586	23 635	22 212	1 355
33	70	1 280	1
3 424	7 964	10 537	59
2 524	11 883	6 509	184
64	178	266	7
1 963	1 834	1 374	14
5 237	12 145	3 677	223
187	162	684	25
105	173	444	2
28	56	379	1
57	170	644	1
27	47	535	1
4	4	6	0
21 582	43 917	25 840	284
772	3 501	8 664	65
1 015	5 305	9 425	93
1 153	3 247	5 686	54
92	88	131	1
10 209	64 095	102 058	1 004
710	823	3 151	11
530	640	902	6
2 507	81	411	4 929
239	242	605	2
9 132	20 753	72 138	1 818
81 423	**298 246**	**305 797**	**30 421**

4.2 Environmental loads of industries

Table 4.2 comparing environmental loads of industries shows the percentage distributions of value added and environmental loads. Industries where environmental load factors generally have a larger share than the value added of the industry include agriculture, hunting and fishing, other mining and quarrying, manufacture of pulp and paper, manufacture of chemicals, manufacture of non-metallic mineral products, manufacture of basic metals, and electricity, gas and water supply. Although the value-added share in the manufacture of electrical equipment is nearly 6%, the shares of all of its environmental load factors remain below 1%.

Among the individual load factors the share of direct material input is the highest in fixed capital formation and civil engineering, followed by other mining and quarrying. The double accounting included in the material inputs is visible in that the biggest material input component in all these three activities is gravel.

The material-input share is also comparatively high in the manufacture of pulp and paper, forestry, logging, etc. and agriculture, hunting and fishing. The manufacture of pulp and paper accounts for over one quarter of primary energy. Households represent nearly one fifth but if the energy consumption included in intermediate consumption of housing (primarily heating energy included in rents and maintenance charges) is also added, their share also rises to good one quarter. Transport and telecommunications make up 10%. In the industry of electricity, gas and water supply the consumption of primary energy is low, because the primary energy of electricity and district heat, including transmission losses, is transferred to the users of electricity and heat. Thus, only so-called own use of primary energy is left in the industry of electricity, gas and water supply.

Over one half of final waste is formed in mining and quarrying, mainly as tailings. Household waste represents nearly one fifth of final waste. In the manufacturing industries the biggest waste amounts are generated in the manufacture of chemicals, 8%, manufacture of pulp and paper, 6%, and manufacture of basic metals, 4%.

Over one quarter of greenhouse gases are produced in the industry of electricity, gas and water supply, 14% in agriculture, hunting and fishing, 12% in transport and telecommunications, 11% in the consumption of households, good 6% in the manufacture of basic metals, and nearly 6% in the manufacture of pulp and paper.

Of acidifying emissions 31% are generated in agriculture and forestry, 22% in transport and telecommunication, 15% in electricity, gas and water supply, and 7% in the consumption of households.

Transport and telecommunications account for one third of the emissions forming ground-level ozone, the consumption of households for nearly one quarter, electricity, gas and water supply for good 8%, manufacture of pulp and paper for nearly 8%, and agriculture, hunting and fishing for good 6%.

In eutrophication discharges the share of agriculture, hunting and fishing is nearly two thirds and that of sewage and refuse disposal, including community sewage treatment plants, 16%. Households' direct contribution to eutrophication is 6%.

Table 4.3 contains calculations of the industries' environmental loads per value added, that is, load intensities of industries. Load intensities are also presented in Figures 4.1 to 4.7, arranged according to the size of load intensity.

Table 4.2. Distribution of value added and environmental loads by industry and final use categories 1999, %

	Value added	Direct mate-rial inputs	Pri-mary energy	Final waste	GHG emis-sions	Acidi-fying emis-sions	Ground-level ozone	Eutro-phi-cation
1 Agriculture, hunting and fishing	1.4	6.0	2.7	0.8	14.5	30.7	6.4	63.5
2 Forestry, logging etc.	2.2	7.6	0.3	0.0	0.5	0.8	1.5	2.4
3 Mining of energy minerals	0.1	1.4	0.0	0.0	1.7	0.0	0.0	0.5
4 Other minig and quarrying	0.2	15.2	0.5	51.9	0.3	0.2	0.1	0.0
5 Manufacture of food products	1.8	1.4	1.8	0.4	0.8	0.4	0.3	0.2
6 Manufacture of textiles, etc.	0.6	0.0	0.3	0.0	0.1	0.1	0.0	0.0
7 Manuf. of wood and wood prod.	1.2	4.3	2.0	0.3	0.8	0.4	1.0	0.1
8 Manuf. of pulp, paper, paper prod.	4.0	9.7	25.8	6.4	5.6	7.9	7.3	4.5
9 Publishing, printing etc.	1.5	0.1	0.3	0.1	0.0	0.0	0.4	0.0
10 Manufacture of coke and petroleum	0.2	2.1	2.3	0.2	4.2	2.7	3.4	0.2
11 Manufacturing of chemicals etc.	1.5	1.3	4.0	8.2	3.1	4.0	2.1	0.6
12 Manuf. of rubber and plastic prod	0.9	0.1	0.6	0.0	0.1	0.1	0.1	0.0
13 Manuf. of non-met. mineral prod.	0.8	2.0	1.4	0.9	2.4	0.6	0.4	0.0
14 Manufacture of basic metals	0.9	2.1	6.8	4.3	6.4	4.1	1.2	0.7
15 Manufacture of metal products	1.5	0.2	0.6	0.1	0.2	0.1	0.2	0.1
16 Manuf. of machinery and equip.	2.6	0.1	0.7	0.3	0.1	0.1	0.1	0.0
17 Manuf. of electrical equipment	5.8	0.1	0.5	0.2	0.0	0.0	0.1	0.0
18 Manuf. of transport equipment	0.9	0.0	0.3	0.1	0.1	0.1	0.2	0.0
19 Manufacturing n.e.c.	0.5	0.1	0.2	0.0	0.0	0.0	0.2	0.0
20 Recycling	0.0	0.2	0.0	0.4	0.0	0.0	0.0	0.0
21 Electricity, gas & water supply	2.1	2.3	0.1	1.6	26.5	14.7	8.4	0.9
22 Building	4.5	4.7	0.8	5.8	0.9	1.2	2.8	0.2
23 Civil engineering	1.3	11.6	0.6	0.1	1.2	1.8	3.1	0.3
24 Wholesale and retail trade	10.5	0.1	3.3	1.5	1.4	1.1	1.9	0.2
25 Hotels and restaurants	1.4	0.1	1.0	0.9	0.1	0.0	0.0	0.0
26 Transport and telecommunicat.	10.3	0.6	10.0	0.2	12.5	21.5	33.4	3.3
27 Dwellings	8.7	0.2	7.2	0.1	0.9	0.3	1.0	0.0
28 Public administ. and services	17.9	0.1	3.7	0.9	0.7	0.2	0.3	0.0
29 Sewage and refuse disposal	0.5	0.5	0.2	0.1	3.1	0.0	0.1	16.2
30 Other service activities	14.4	0.1	2.9	1.0	0.3	0.1	0.2	0.0
Houshold consumption		1.6	19.2	6.7	11.2	7.0	23.6	6.0
Government consumption								
Capital formation		18.6		5.0				
Exports		5.7		1.7				
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Table 4.3. Environmental loads per value added or load intensities by industry in Finland 1999

	Direct material inputs	Primary energy	Final waste	GHG emissions	Acidifying emissions	Ground-level ozone	Eutrophication
	Kg/€	MJ/€	Kg/€	Kg/€	g/€	g/€	g/€
1 Agriculture, hunting and fishing	25.9	25.3	0.1	7.7	59.6	12.7	12.6
2 Forestry, logging etc.	21.7	2.0	0.0	0.2	1.1	1.9	0.3
3 Mining of energy minerals	96.4	1.7	0.0	14.5	0.1	0.1	1.4
4 Other minig and quarrying	530.1	38.8	58.8	1.1	2.8	1.3	0.0
5 Manufacture of food products	4.7	13.3	0.0	0.3	0.6	0.4	0.0
6 Manufacture of textiles, etc.	0.3	6.2	0.0	0.2	0.3	0.2	0.0
7 Manuf. of wood and wood prod.	22.5	23.5	0.0	0.5	1.0	2.4	0.0
8 Manuf. of pulp, paper, paper prod.	15.2	88.4	0.3	1.1	5.6	5.2	0.3
9 Publishing, printing etc.	0.4	2.8	0.0	0.0	0.0	0.8	0.0
10 Manufacture of coke and petroleum	81.4	188.6	0.2	19.6	45.5	60.2	0.3
11 Manufacture of chemicals etc.	5.1	35.3	1.1	1.5	7.3	4.0	0.1
12 Manuf. of rubber and plastic prod.	0.7	8.7	0.0	0.1	0.2	0.3	0.0
13 Manuf. of non-met. mineral prod.	16.4	23.9	0.2	2.4	2.2	1.7	0.0
14 Manufacture of basic metals	14.1	101.8	0.9	5.4	12.4	3.8	0.2
15 Manufacture of metal products	0.8	5.2	0.0	0.1	0.1	0.4	0.0
16 Manufacture of machinery and equip.	0.3	3.5	0.0	0.0	0.1	0.2	0.0
17 Manufacture of electrical equipment	0.1	1.3	0.0	0.0	0.0	0.1	0.0
18 Manufacture of transport equipment	0.4	4.9	0.0	0.1	0.2	0.7	0.0
19 Manufacturing n.e.c.	0.6	4.7	0.0	0.0	0.1	0.9	0.0
20 Recycling	61.3	9.3	4.0	0.2	0.2	0.3	0.0
21 Electricity, gas & water supply	6.9	0.9	0.2	9.8	20.0	11.8	0.1
22 Building	6.5	2.3	0.3	0.2	0.7	1.8	0.0
23 Civil engineering	57.5	6.7	0.0	0.8	4.0	7.0	0.1
24 Wholesale and retail trade	0.1	4.3	0.0	0.1	0.3	0.5	0.0
25 Hotels and restaurants	0.5	9.8	0.1	0.1	0.1	0.1	0.0
26 Transport and telecommunication	0.4	13.3	0.0	0.9	5.9	9.3	0.1
27 Dwellings	0.1	11.4	0.0	0.1	0.1	0.3	0.0
28 Public administration and services	0.0	2.8	0.0	0.0	0.0	0.0	0.0
29 Sewage and refuse disposal	7.0	5.8	0.0	5.2	0.2	0.8	10.1
30 Other service activities	0.0	2.8	0.0	0.0	0.0	0.0	0.0
Total	**4.6**	**11.1**	**0.2**	**0.7**	**2.6**	**2.2**	**0.3**

Figure 4.1 Direct material input per value added by industry in Finland 1999, kg/€
(The column of Other mining and quarrying broken off)

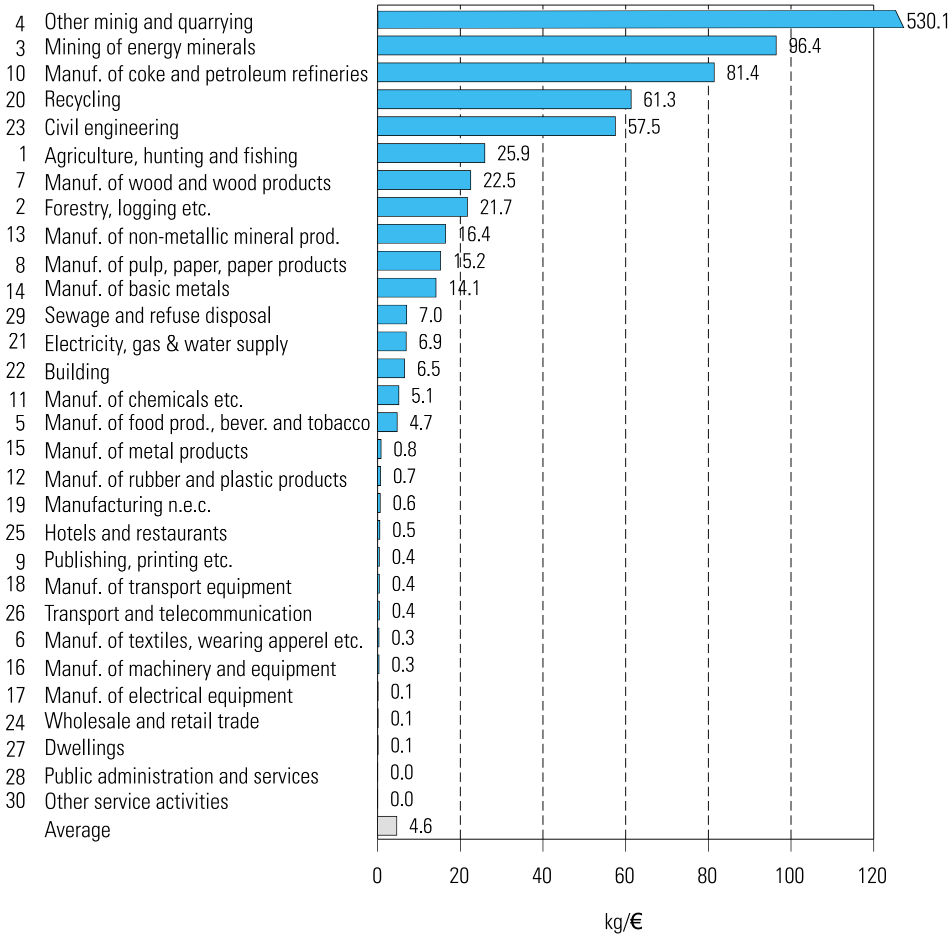


Figure 4.2 Consumption of primary energy per value added by industry in Finland 1999, MJ/€

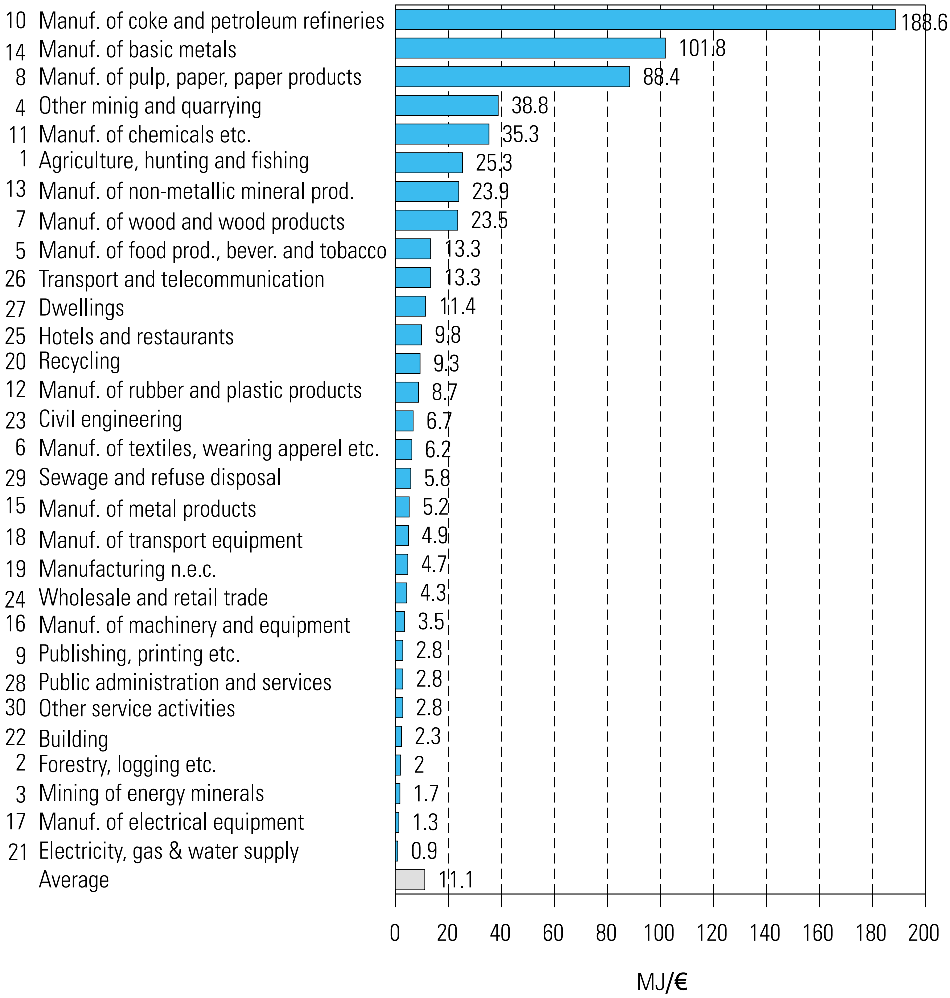


Figure 4.3. Final waste per value added by industry in Finland 1999, kg/€
(The column of Other mining and quarrying broken off)

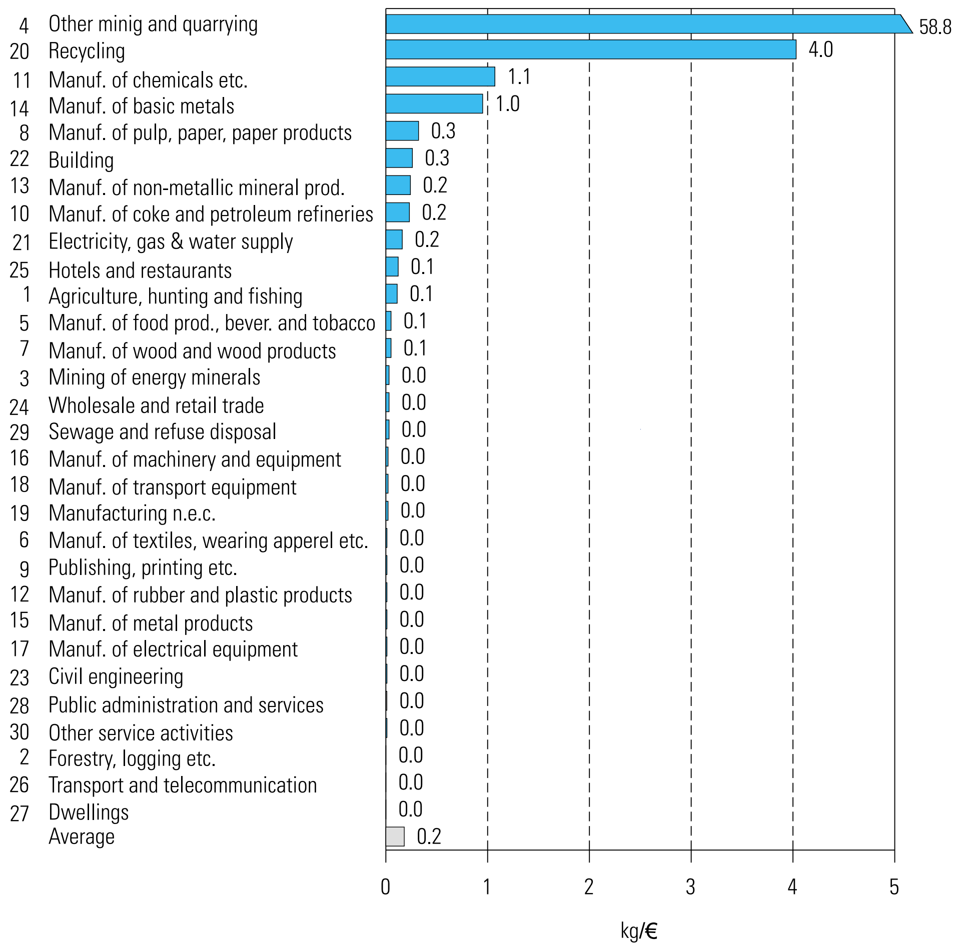


Figure 4.4 Greenhouse gas emissions per value added by industry in Finland 1999, kg CO_2 eqv /€

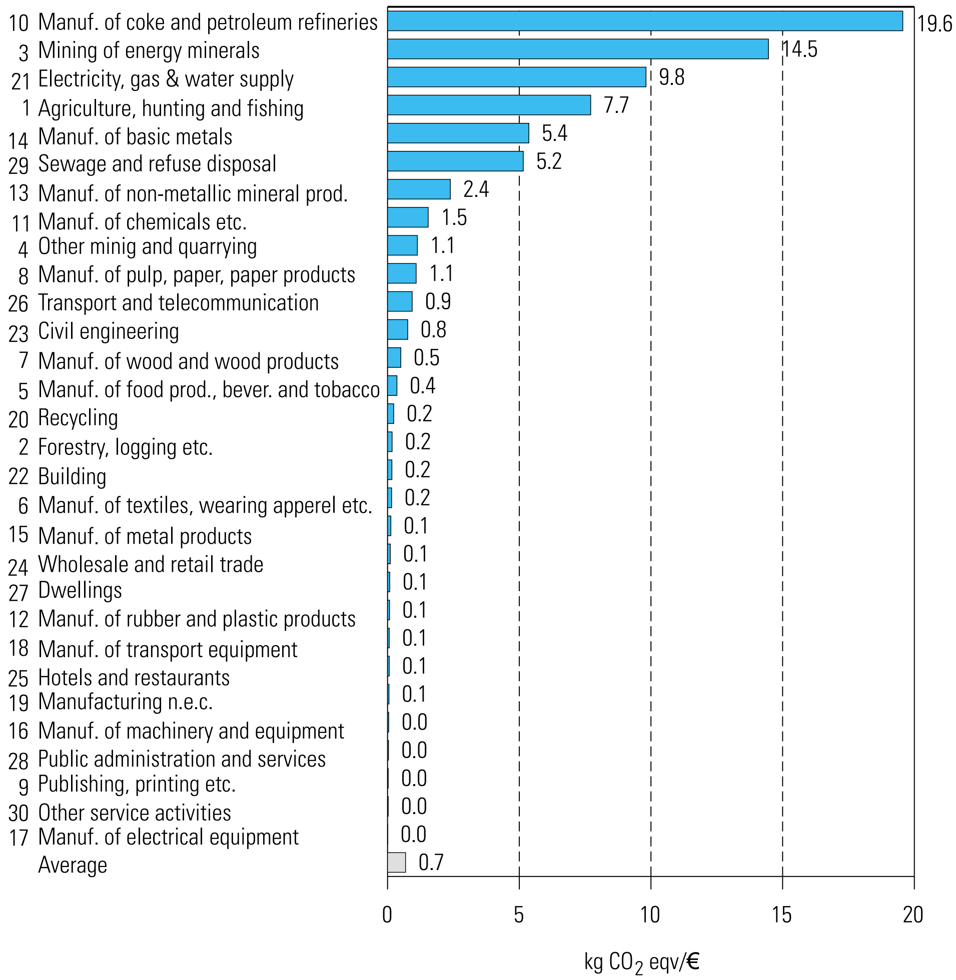


Figure 4.5. Acidifying emissions per value added by industry in Finland 1999, g SO_2 eqv /€

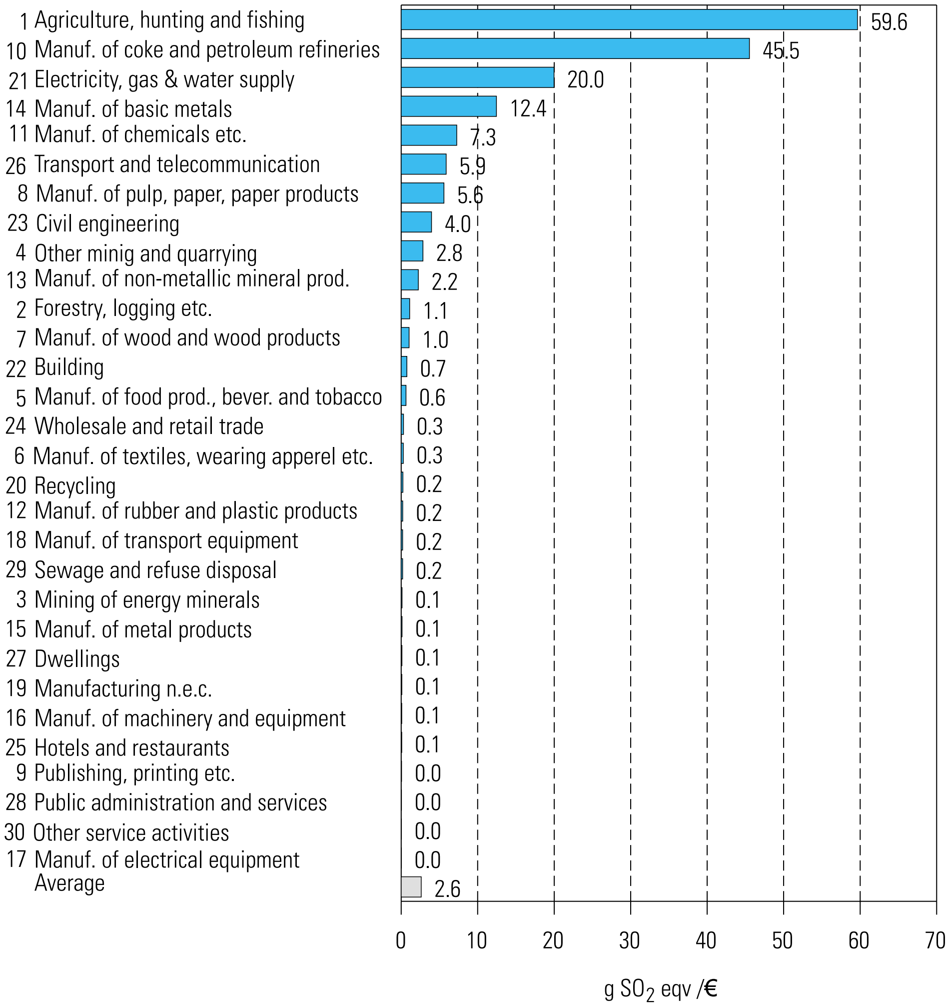


Figure 4.6. Ground-level ozone forming emissions per value added by industry in Finland 1999, g POCP eqv /€

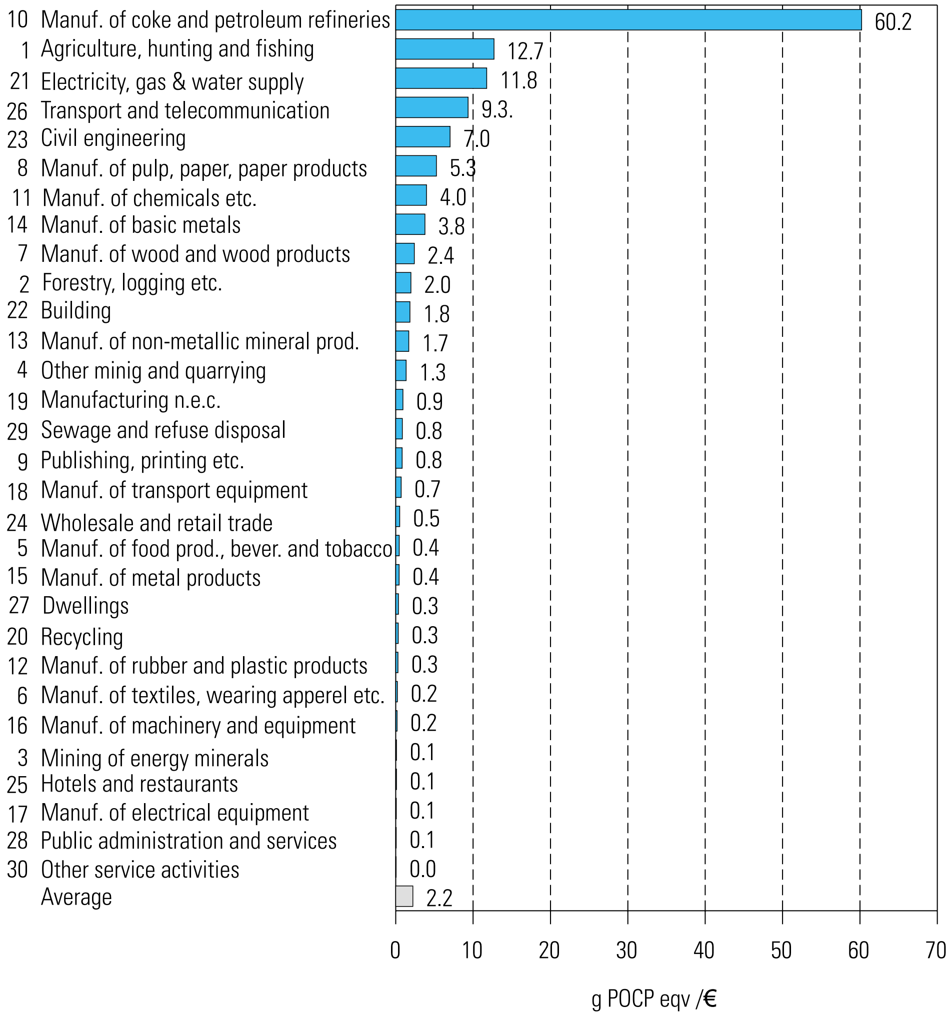
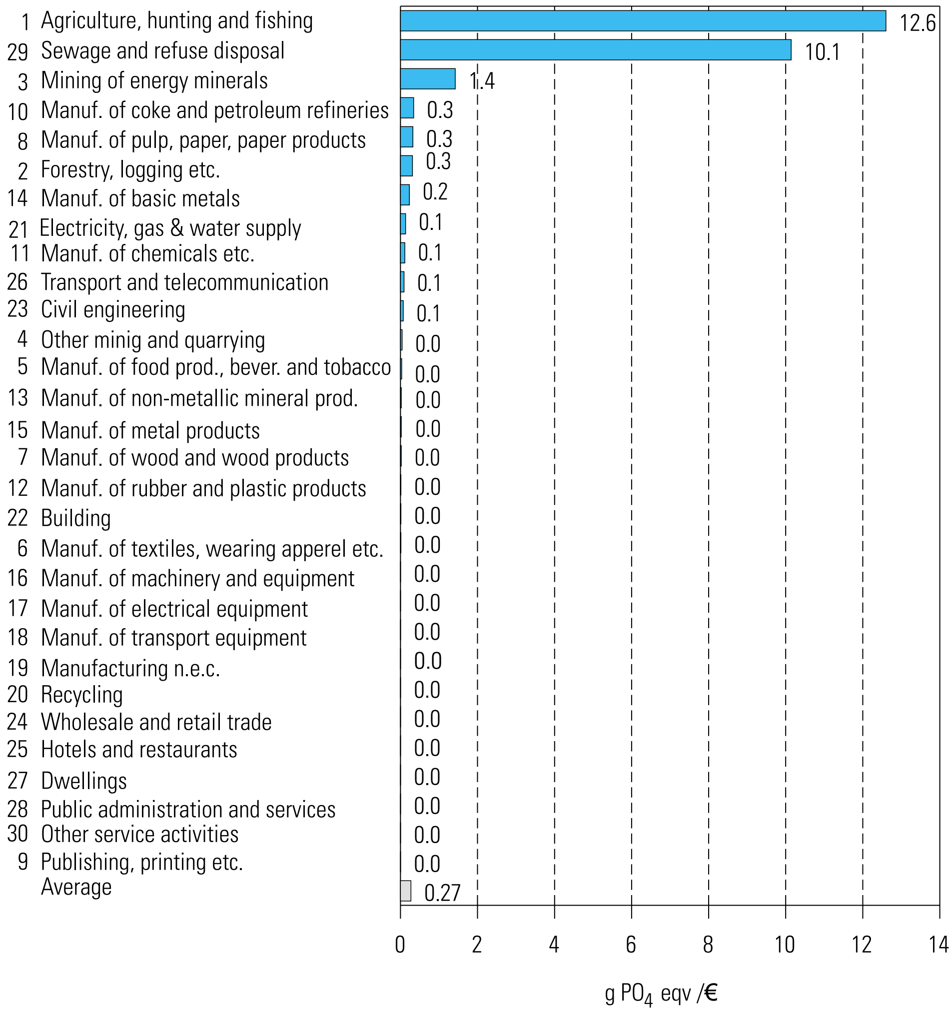


Figure 4.7. Eutrophicating emissions per value added by industry in Finland 1999, g PO_4 eqv/€



4.3 Environmental loads of products

Environmental loads of products here refer to the environmental loads generated in the whole production chain of the product – "from cradle to factory gates". In industry-specific analysis, the output of the industry was the value of the products produced by the industry. The total environmental loads of the production of products are derived when the environmental loads of the production chain of industries' intermediate products are added to the environmental loads of the producing industry. At the industry level the environmental loads of the whole production chain of products can be calculated by means of the input-output model.

The input-output model describes the flow of products from domestic production and imports to industries' intermediate consumption and final use. The basic principles of the input-output model are as follows. The starting point is the input-output structural model:

$$1) \qquad \mathbf{q} = \mathbf{A}\mathbf{q} + \mathbf{f},$$

where **q** is the output vector of products by industry, **A** is the matrix of industry x industry input coefficients, where each column indicates how much the corresponding industry uses products of different industries as its intermediate inputs per output unit, and **f** is the vector of final use of products, which can also be broken into a matrix where the columns are the items of final use of products, private and government consumption expenditure, fixed capital formation and exports. The solution obtained for the structural form is:

$$2) \qquad \mathbf{q} = (\mathbf{I} - \mathbf{A})^{-1}\, \mathbf{f} = \mathbf{B}\mathbf{f},$$

where $\mathbf{B} = (\mathbf{I} - \mathbf{A})^{-1}$, is the Leontief inverse matrix, where each column now indicates how many products produced by different industries have been needed direct and indirect for the output unit of the corresponding industry.

The direct environmental loads per product unit of the industry producing the products are derived when the industry-specific environmental load factors in Table 4.1 are divided by the outputs of industries. Let **P** be the obtained coefficient matrix of the environmental load factors of industry x. Then the matrix product

$$3) \qquad \mathbf{B}'\mathbf{P}$$

is a matrix where the columns are environmental load factors and the rows are direct and indirect environmental loads included in the output unit of each industry.

The product flows of the structural form (1) may contain either only domestic products or domestic and imported products together. The Leontief inverse matrix for domestic product flows gives in the matrix product (3) the domestic total environmental loads of the output unit of industries. When the structural form also contains the flows of imported products, the matrix product gives environmental loads directed to the domestic country of the output unit and through exports abroad.

The total environmental loads included in the output can be divided into three components:

Direct environmental loads: matrix **P**,
Domestic indirect: matrix difference $\mathbf{B}^{D}{}'\mathbf{P}$, where $\mathbf{B}^{D}$ is the Leontief inverse matrix for domestic product flows, and
Exports indirect: matrix difference $\mathbf{B}'\mathbf{P} - \mathbf{B}^{D}{}'\mathbf{P}$, where **B** includes both domestic and imported products.

When the input-output model includes only the description of domestic production and the matrix P only domestic industry-specific environmental load factors, particularly the calculation of indirect loads of imports requires the assumption that industry-specific production technologies are the same abroad as in Finland, and especially that the production technology matrix **A** and the direct load matrix **P** of industries are similar abroad and in Finland. Thus, a calculation of indirect loads of imports provides only rough estimates.

The calculation method of the input-output model also contains the assumption that all products of the same industry are produced with the same average technology of the industry. Especially by a very rough industrial classification the output of the industry may contain products that are of very different quality and produced with varying methods. This bias can be reduced by using as narrow an industrial classification as possible in the calculation, and by aggregating the results to a suitable classification only in the final stage of the calculation. In this work the calculation was made at 149 industrial levels and the results were aggregated to 30 industries.

The input-output calculations were made with a monetary input-output model, although it would have in principle been possible to use the physical input-output tables compiled in this work. Flows of immaterial services are missing from physical input-output tables and thus the environmental loads included in the production of immaterial services would not have been captured in the calculation. Monetary input-output tables for the year 1999 concerning 149 industries were obtained from Statistics Finland.

Tables 4.4 and 4.5 and Figures 4.8 to 4.14 present total environmental loads by type of load, by industry divided into 30 industries and by component in 1999.

In product examination, total use of natural resources was highest per output unit in the industries of mining and quarrying, civil engineering and forestry, logging, etc., followed by the manufacture of basic metals, manufacture of non-metallic mineral products and manufacture of wood and wood products.

Total consumption of primary energy rose highest in the manufacture of basic metals and of pulp and paper. The next highest were other mining and quarrying, manufacture of chemicals and of non-metallic mineral products. Energy consumption was also high in agriculture, hunting and fishing.

In the manufacture of electrical equipment both total use of natural resources and total consumption of primary energy were lower than in other manufacturing, although the proportion of indirect imports was relatively high in that industry.

The total content of final waste rises highest in other mining and quarrying in the product examination as well. For this reason, the share of indirect imports of final waste is also high in the manufacture of basic metals. The final waste content is also high in the manufacture of chemicals and in recycling.

Greenhouse gas emissions per output unit are highest in electricity, gas and water supply, mining of energy minerals and the manufacture of coke and refined petroleum products. Greenhouse gas emissions were also high in agriculture, hunting and fishing.

The content of acidifying emissions is clearly greatest in agriculture, hunting and fishing. Significant contributors to this are ammonia emissions from cattle husbandry, whose acidifying effect is high. Acidifying emissions in agriculture are reflected in high indirect acidifying emissions of food industry products.

Emissions forming ground-level ozone are highest per output unit in agriculture and forestry, transport and telecommunications, electricity, gas and water supply, and the manufacture of coke and refined petroleum products.

Total eutrophication discharges are largest for products of agriculture, hunting and fishing, and for sewage and refuse disposal, which includes community sewage treatment. The high eutrophication effect of agriculture is also mediated as the high indirect eutrophication effect of food industry products.

Table 4.4. Environmental loads of products by industry: total material requirement, primary energy and final waste per one euro of products 1999

	Total material requirement kg/€			
	Direct	Indirect domestic	Indirect of imports	Total
1 Agriculture, hunting and fishing	0.2	1.2	1.5	2.9
2 Forestry, logging etc.	24.9	1.9	0.2	27.0
3 Mining of energy minerals	37.5	1.0	0.6	39.1
4 Other minig and quarrying	208.3	13.3	2.9	224.5
5 Manufacture of food products	0.0	0.9	1.5	2.4
6 Manufacture of textiles, etc.	0.0	0.3	1.3	1.6
7 Manufacture of wood and wood products	0.0	10.7	1.4	12.1
8 Manufacture of pulp, paper, paper prod.	0.0	4.0	4.1	8.0
9 Publishing, printing etc.	0.0	0.7	0.9	1.7
10 Manufacture of coke and petroleum	0.0	0.3	7.9	8.2
11 Manufacture of chemicals etc.	0.0	5.1	5.6	10.7
12 Manufacture of rubber and plastic prod.	0.0	1.0	2.2	3.2
13 Manufacture of non-metallic mineral prod.	2.7	8.0	3.9	14.6
14 Manufacture of basic metals	0.0	3.3	21.0	24.4
15 Manufacture of metal products	0.0	0.7	3.9	4.6
16 Manufacture of machinery and equipment	0.0	0.4	1.7	2.1
17 Manufacture of electrical equipment	0.0	0.4	1.5	1.9
18 Manufacture of transport equipment	0.0	0.4	1.6	2.0
19 Manufacturing n.e.c.	0.0	1.0	1.5	2.5
20 Recycling	0.0	0.8	3.0	3.8
21 Electricity, gas & water supply	0.0	1.9	3.8	5.8
22 Building	0.7	3.3	1.3	5.3
23 Civil engineering	10.6	18.8	1.6	31.0
24 Wholesale and retail trade	0.0	0.4	0.4	0.8
25 Hotels and restaurants	0.0	0.6	0.6	1.2
26 Transport and telecommunication	0.0	0.7	0.5	1.1
27 Dwellings	0.0	0.7	0.4	1.1
28 Public administration and services	0.0	0.3	0.3	0.5
29 Sewage and refuse disposal	0.0	0.6	0.5	1.1
30 Other service activities	0.0	0.4	0.4	0.9
Average	**1.2**	**1.7**	**1.8**	**4.7**

Primary energy MJ/€				Final waste kg/€			
Direct	Indirect, domestic	Indirect of imports	Total	Direct	Indirect, domestic	Indirect of imports	Total
9.4	7.9	3.4	20.7	0.04	0.30	0.50	0.83
1.5	1.2	0.5	3.2	0.00	0.01	0.05	0.06
0.6	4.7	2.3	7.7	0.01	0.07	0.27	0.36
12.2	6.6	9.1	28.0	18.52	4.36	9.19	32.07
3.1	9.5	4.9	17.6	0.01	0.20	0.52	0.73
2.5	2.5	8.1	13.1	0.01	0.05	0.51	0.56
6.0	3.7	2.2	11.9	0.01	0.04	0.28	0.34
27.8	13.2	3.9	45.0	0.10	0.23	0.63	0.96
1.1	6.8	3.2	11.1	0.00	0.07	0.35	0.42
13.0	2.6	7.1	22.8	0.02	0.07	0.43	0.52
12.5	6.7	9.8	29.0	0.38	2.24	3.19	5.81
3.7	4.7	9.0	17.5	0.00	0.39	2.02	2.42
9.8	6.9	5.4	22.1	0.10	0.38	1.25	1.73
19.0	13.7	17.1	49.8	0.18	0.57	7.83	8.58
2.1	5.3	8.9	16.2	0.00	0.12	1.98	2.11
1.1	4.0	7.2	12.2	0.01	0.07	1.08	1.16
0.4	2.6	5.5	8.5	0.00	0.06	0.92	0.98
1.6	3.4	6.8	11.7	0.01	0.06	1.05	1.12
1.9	3.4	5.8	11.1	0.01	0.09	1.16	1.25
1.9	5.7	13.6	21.2	0.82	0.19	2.47	3.47
0.5	2.5	1.9	4.9	0.08	0.04	0.15	0.28
1.0	3.9	3.7	8.5	0.11	0.07	0.56	0.74
2.5	5.1	3.4	11.1	0.00	0.10	0.49	0.60
2.4	3.0	1.7	7.1	0.02	0.04	0.21	0.26
3.6	4.3	2.3	10.3	0.05	0.05	0.22	0.32
8.1	2.6	1.9	12.6	0.00	0.02	0.13	0.15
8.0	1.6	0.8	10.4	0.00	0.04	0.13	0.17
1.9	1.7	0.8	4.4	0.01	0.02	0.09	0.12
3.2	3.4	1.7	8.4	0.02	0.08	0.28	0.38
1.6	2.9	1.5	6.0	0.01	0.03	0.19	0.23
5.3	**4.2**	**3.5**	**13.0**	**0.08**	**0.14**	**0.69**	**0.91**

Table 4.5. Environmental loads of products by industry: emissions into air and water per one euro of products 1999

	Greenhouse gas emissions kg CO_2 eqv/€			
	Direct	Indirect, domestic	Indirect of imports	Total
1 Agriculture, hunting and fishing	2.87	1.53	0.49	4.89
2 Forestry, logging etc.	0.13	0.13	0.08	0.34
3 Mining of energy minerals	5.38	0.40	0.24	6.02
4 Other minig and quarrying	0.36	0.58	0.50	1.44
5 Manufacture of food products	0.08	1.81	0.70	2.59
6 Manufacture of textiles, etc.	0.06	0.26	0.48	0.80
7 Manufacture of wood and wood products	0.13	0.34	0.21	0.68
8 Manufacture of pulp, paper, paper products	0.34	0.85	0.40	1.58
9 Publishing, printing etc.	0.01	0.31	0.24	0.56
10 Manufacture of coke and petroleum refineries	1.35	0.33	4.12	5.81
11 Manufacture of chemicals etc.	0.55	0.56	0.80	1.90
12 Manufacture of rubber and plastic products	0.03	0.36	0.63	1.02
13 Manufacture of non-metallic mineral products	0.98	0.90	0.58	2.46
14 Manufacture of basic metals	1.00	1.01	0.96	2.97
15 Manufacture of metal products	0.05	0.39	0.47	0.91
16 Manufacture of machinery and equipment	0.01	0.29	0.40	0.70
17 Manufacture of electrical equipment	0.00	0.21	0.36	0.57
18 Manufacture of transport equipment	0.02	0.24	0.39	0.65
19 Manufacturing n.e.c.	0.02	0.23	0.31	0.56
20 Recycling	0.05	0.38	0.97	1.39
21 Electricity, gas & water supply	5.12	0.56	0.56	6.25
22 Building	0.07	0.30	0.27	0.64
23 Civil engineering	0.28	0.47	0.36	1.11
24 Wholesale and retail trade	0.06	0.28	0.18	0.52
25 Hotels and restaurants	0.02	0.41	0.28	0.71
26 Transport and telecommunication	0.57	0.23	0.28	1.08
27 Dwellings	0.05	0.25	0.09	0.40
28 Public administration and services	0.02	0.21	0.09	0.31
29 Sewage and refuse disposal	2.91	0.42	0.18	3.50
30 Other service activities	0.01	0.26	0.16	0.43
Average	**0.32**	**0.42**	**0.34**	**1.08**

Acidifying emissions g SO_2 eqv/€				Groundlevel ozone g POCP eqv/€				Eutrophication g PO4 eqv/€			
Direct	Indirect, domestic	Indirect of imports	Total	Direct	Indirect, domestic	Indirect of imports	Total	Direct	Indirect, domestic	Indirect of imports	Total
22.21	9.63	2.12	33.96	4.73	2.56	0.75	8.04	4.69	1.84	0.37	6.90
0.86	0.48	0.17	1.51	1.54	0.37	0.10	2.01	0.25	0.19	0.03	0.46
0.04	1.26	0.59	1.89	0.04	1.25	0.36	1.65	0.53	0.12	0.07	0.73
0.90	1.79	1.24	3.92	0.42	1.23	0.75	2.39	0.01	0.13	0.10	0.25
0.15	11.90	3.39	15.43	0.10	3.15	1.19	4.44	0.01	2.33	0.62	2.95
0.11	0.87	1.42	2.40	0.08	0.54	0.85	1.46	0.01	0.11	0.16	0.28
0.26	1.17	0.66	2.09	0.62	1.37	0.65	2.64	0.00	0.13	0.06	0.19
1.76	2.37	0.94	5.07	1.65	1.95	0.60	4.20	0.10	0.14	0.09	0.33
0.02	0.98	0.64	1.63	0.33	0.94	0.43	1.70	0.00	0.09	0.06	0.15
3.14	0.80	2.10	6.05	4.16	0.76	2.15	7.07	0.02	0.03	0.50	0.56
2.58	1.64	2.14	6.36	1.41	1.16	1.35	3.91	0.04	0.08	0.12	0.24
0.08	1.15	2.02	3.25	0.12	0.81	1.20	2.13	0.00	0.06	0.10	0.17
0.92	1.58	1.06	3.55	0.69	1.16	0.73	2.58	0.01	0.08	0.08	0.16
2.32	2.74	2.19	7.25	0.70	1.33	1.12	3.16	0.04	0.08	0.11	0.23
0.04	1.16	1.16	2.36	0.17	0.68	0.62	1.47	0.01	0.09	0.08	0.17
0.02	0.81	0.99	1.82	0.05	0.52	0.58	1.16	0.00	0.07	0.08	0.15
0.00	0.60	1.04	1.64	0.02	0.41	0.63	1.06	0.00	0.07	0.09	0.15
0.06	0.63	1.00	1.69	0.22	0.49	0.66	1.36	0.00	0.05	0.07	0.12
0.03	0.68	0.91	1.62	0.37	0.64	0.66	1.67	0.00	0.06	0.06	0.12
0.04	1.16	2.24	3.44	0.07	0.83	1.07	1.96	0.00	0.09	0.11	0.20
10.42	1.14	0.56	12.12	6.13	0.70	0.42	7.25	0.07	0.12	0.10	0.28
0.30	0.79	0.67	1.76	0.75	0.67	0.45	1.88	0.01	0.07	0.05	0.13
1.47	1.19	0.69	3.35	2.61	1.27	0.44	4.32	0.03	0.07	0.06	0.16
0.16	0.87	0.45	1.48	0.29	0.68	0.28	1.24	0.00	0.14	0.06	0.20
0.02	1.83	1.21	3.06	0.03	0.84	0.48	1.35	0.00	0.29	0.21	0.51
3.58	0.69	0.86	5.12	5.70	0.67	1.00	7.37	0.06	0.06	0.06	0.17
0.06	0.56	0.18	0.80	0.24	0.44	0.12	0.81	0.00	0.08	0.02	0.10
0.02	0.58	0.23	0.84	0.03	0.44	0.15	0.62	0.00	0.08	0.03	0.11
0.09	1.01	0.45	1.56	0.48	0.95	0.28	1.70	5.72	0.26	0.05	6.03
0.01	0.78	0.39	1.18	0.02	0.62	0.26	0.90	0.00	0.10	0.05	0.15
1.25	**1.53**	**0.85**	**3.62**	**1.05**	**0.86**	**0.53**	**2.44**	**0.13**	**0.21**	**0.09**	**0.43**

Figure 4.8. Total material requirement per output by industry in Finland 1999, kg/€
(The column of Other mining and quarrying broken off)

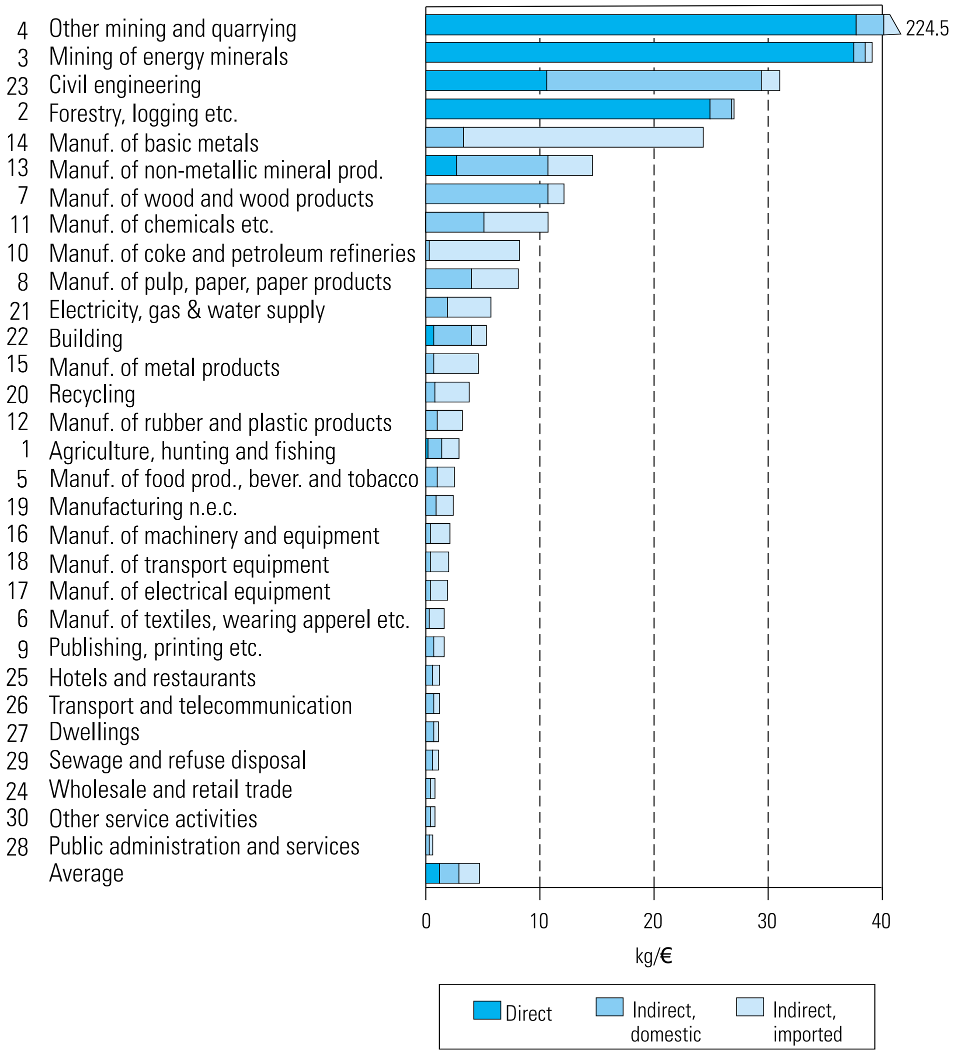


Figure 4.9. Consumption of primary energy per output by industry in Finland 1999, MJ/€

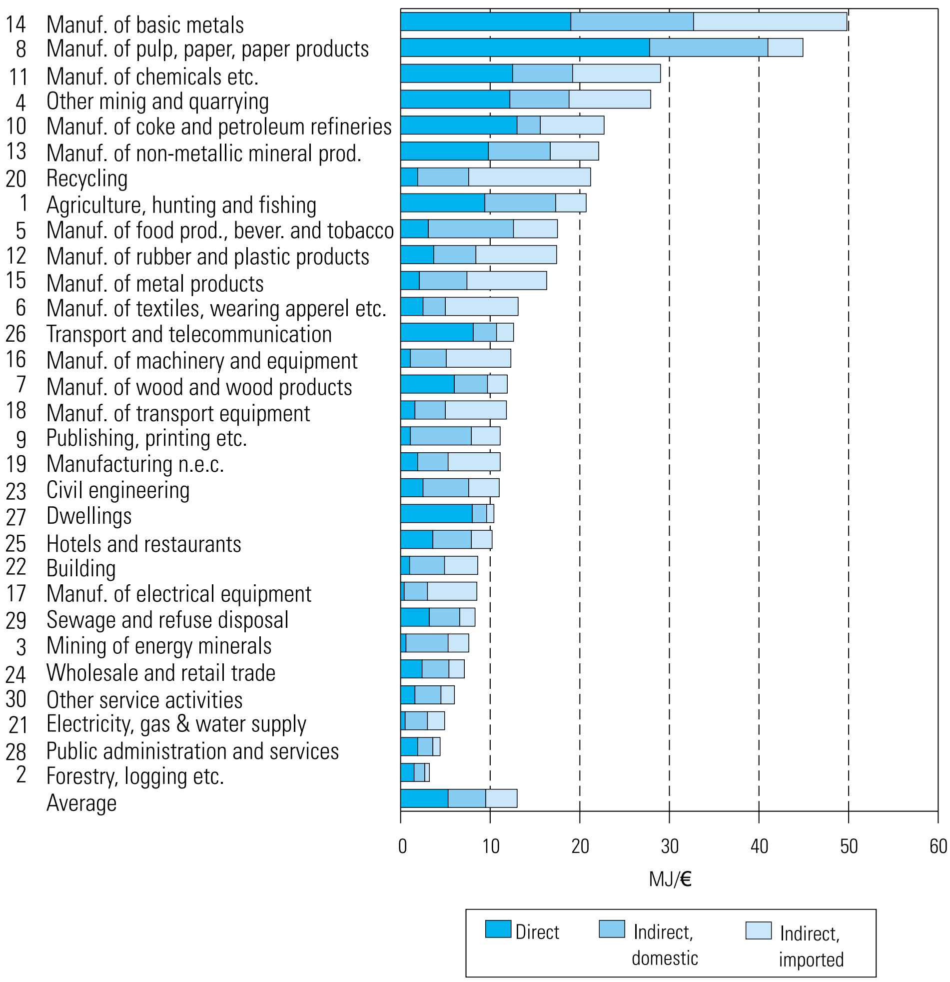


Figure 4.10. Generation of final waste per output by industry in Finland 1999, kg/€
(The column of Other mining and quarrying broken off)

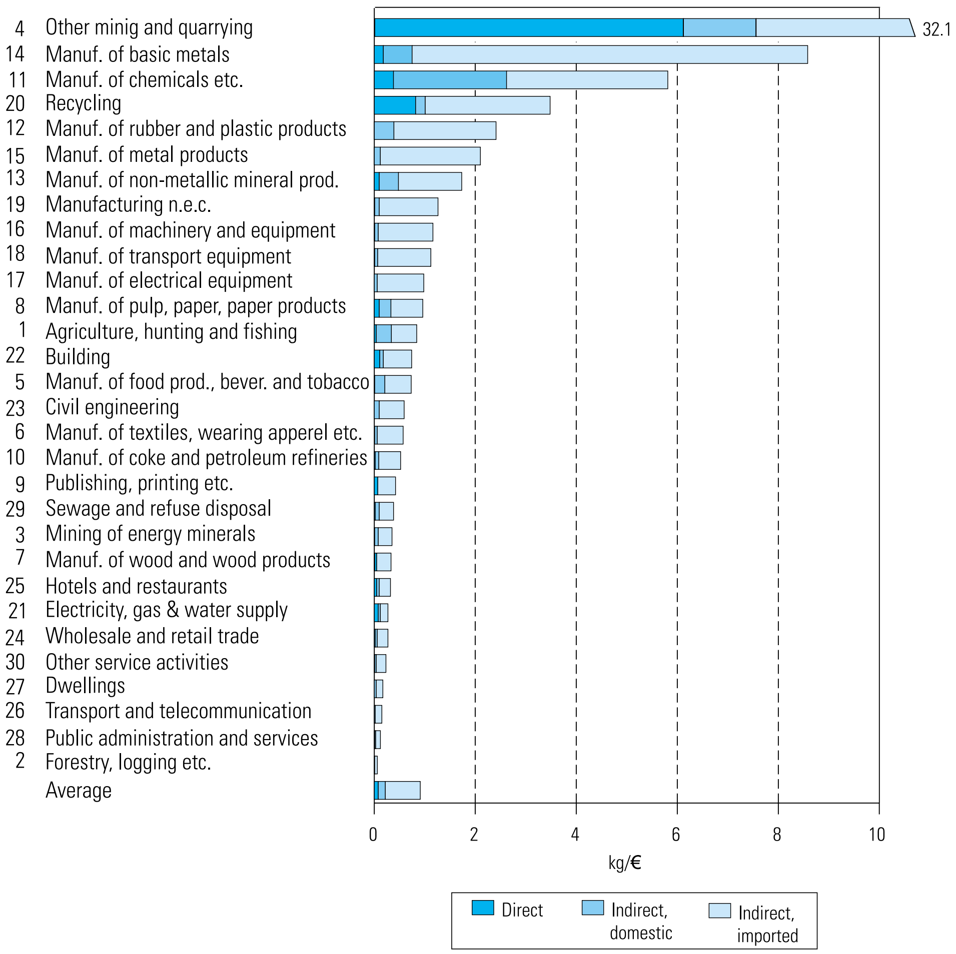


Figure 4.11. Greenhouse gas emissions per output by industry in Finland 1999, kg CO_2 eqv /€

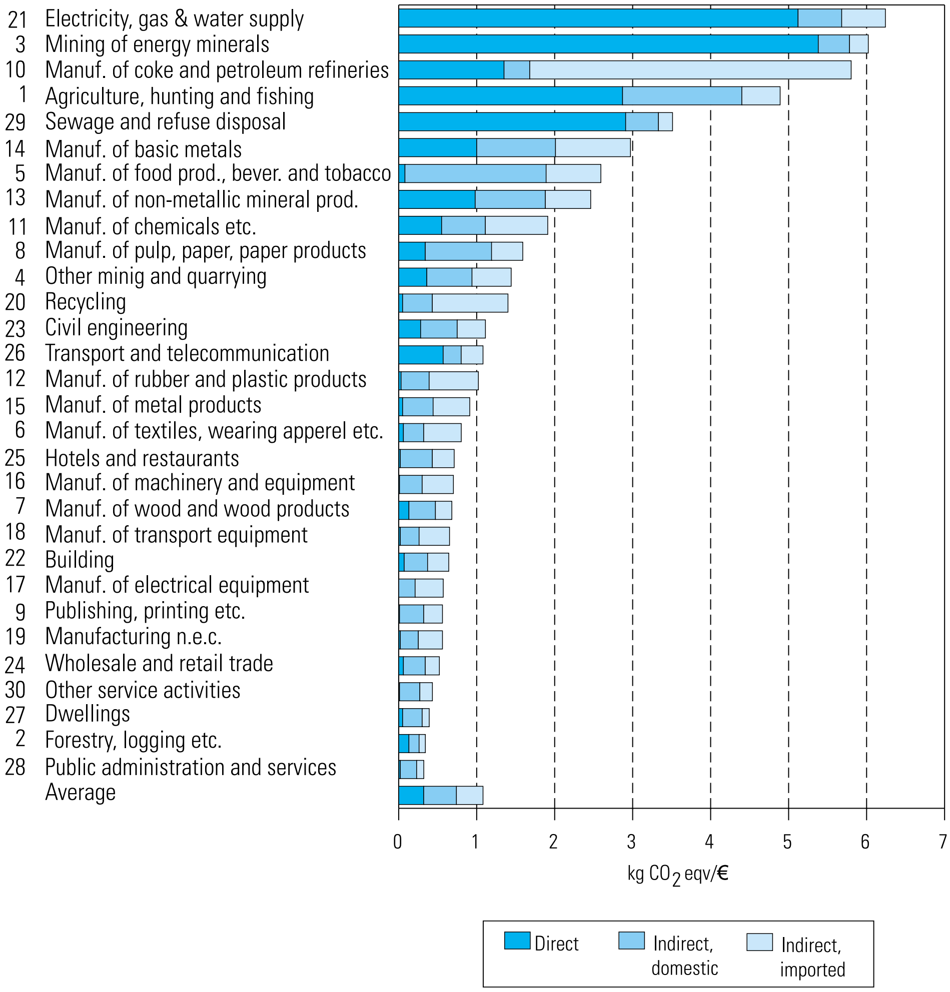


Figure 4.12. Acidifying emissions per output by industry in Finland 1999, g SO_2 eqv /€

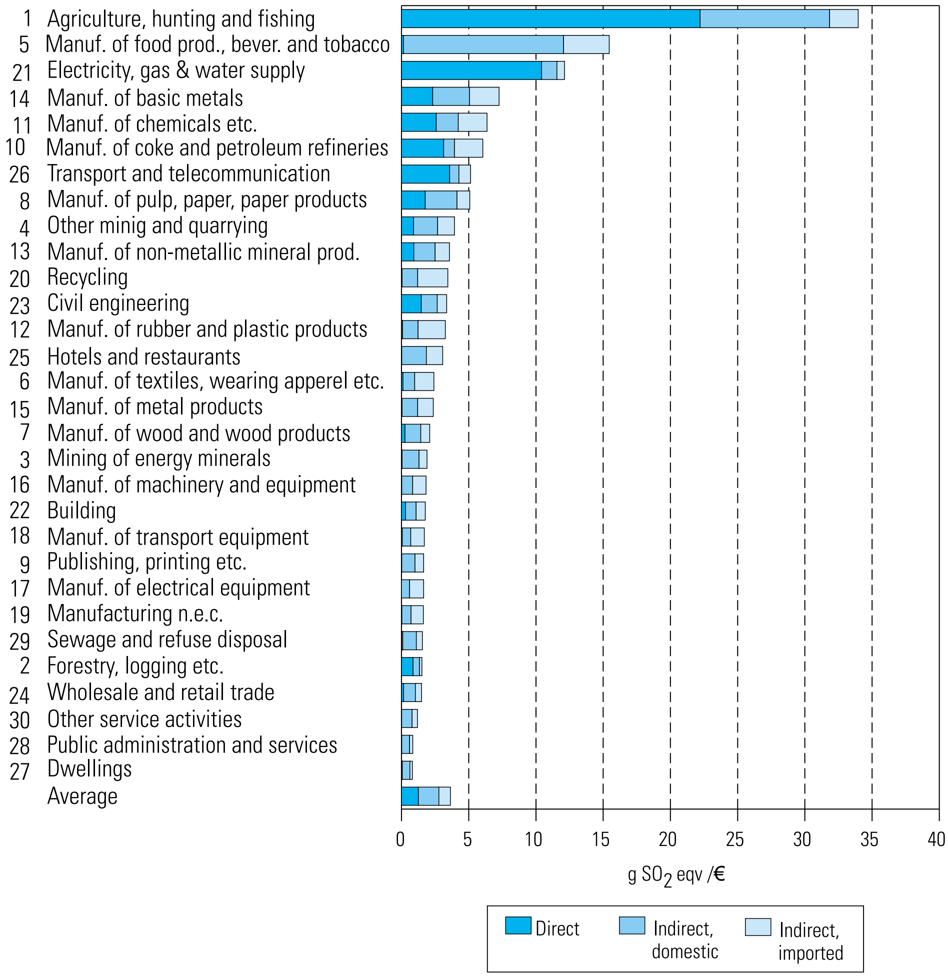


Figure 4.13. Ground-level ozone forming emissions per output by industry in Finland 1999, g POCP eqv /€

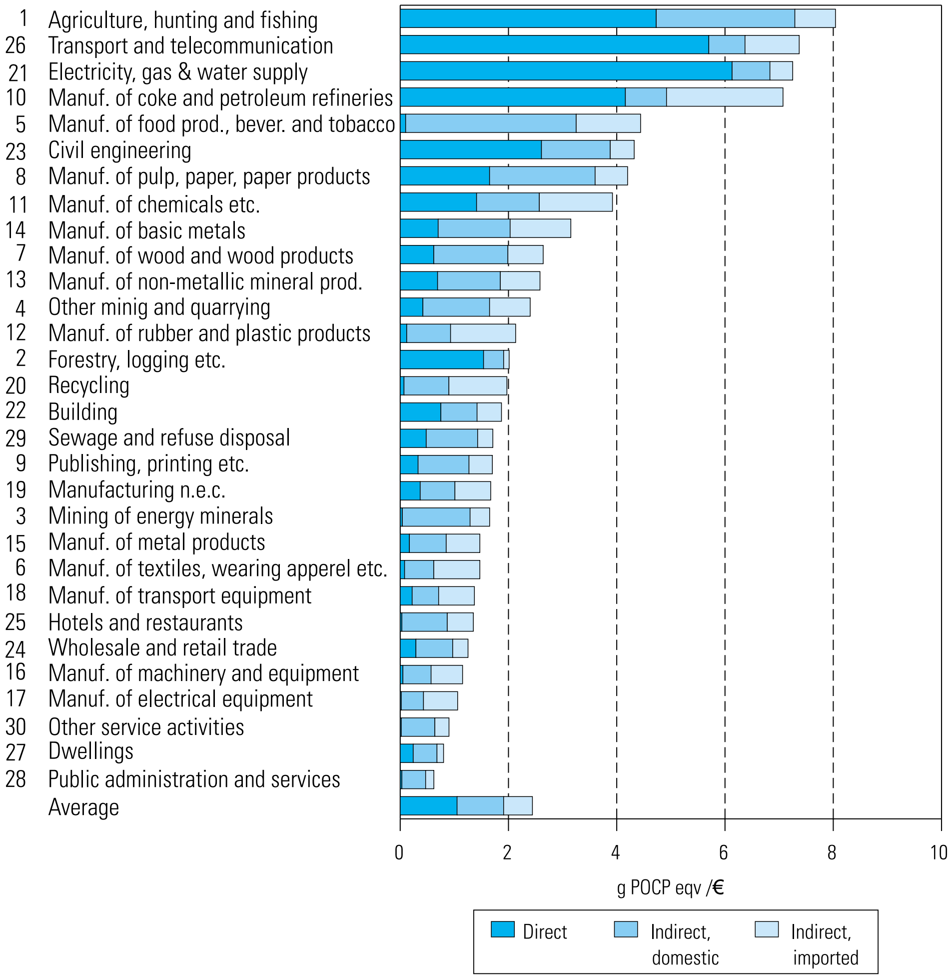
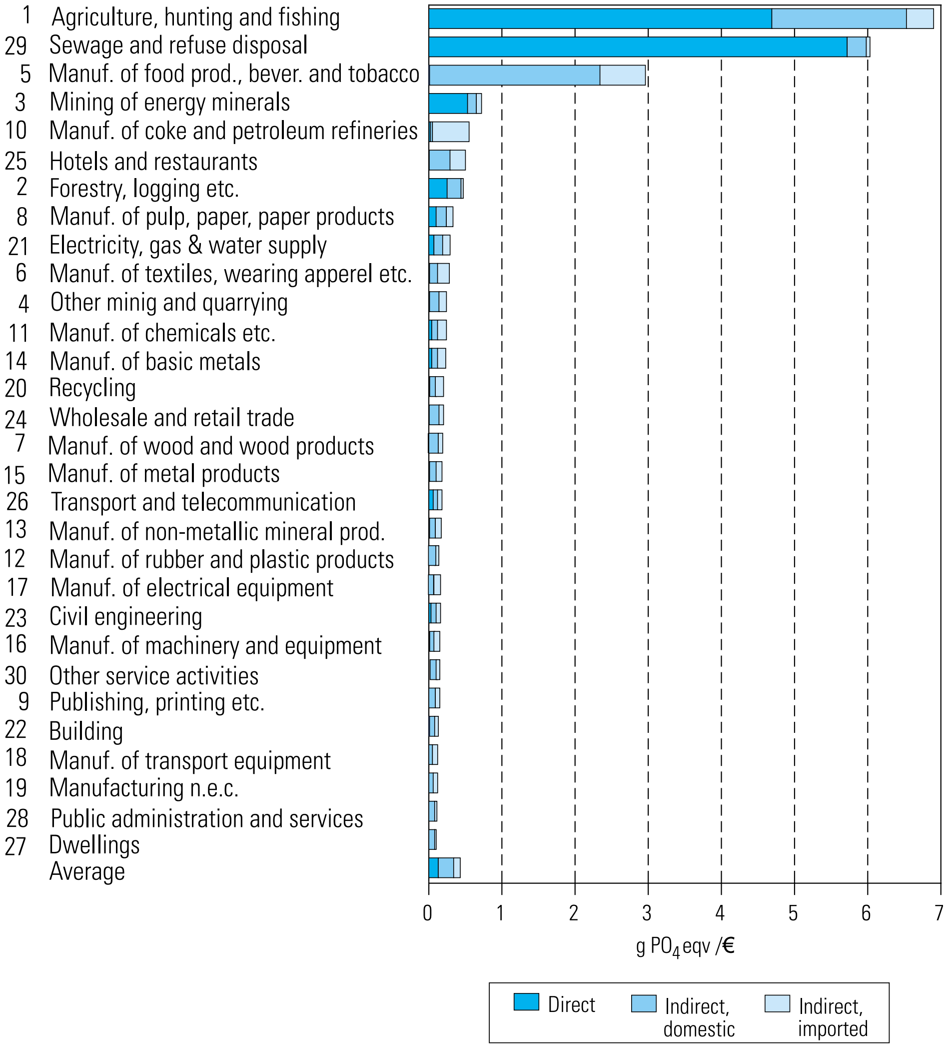


Figure 4.14. Eutrophication causing emissions per output by industry in Finland 1999, g PO_4 eqv /€



4.4 Total balances of environmental loads of Finland's economy

When the environmental load contents of products are known, the total loads of the economy can be allocated to the final use items of the products: private and government consumption, capital formation and exports. With the input-output method this is made so that the final use vector **f** present in equations (1) and (2) is divided into the final use matrix **F**, whose columns are final use items and rows industry-specific products used by each final use item.

Then the environmental loads caused by final use items are derived as a matrix operation:

4) **F'B'P.**

Table 4.6 shows the environmental loads of final use items divided into environmental loads in the domestic country and through exports abroad. Market-priced monetary values of corresponding items are also added to the beginning of the table from national accounts. The first column in money flows, the value of products produced in the domestic country sums up into gross domestic product, EUR 120 billion in 1999. The same figure is derived when total exports are subtracted from the final sum in the Total column, which follows the more general presentation mode used in national accounts.

In the table the sum of each load item in the domestic column is the same as the industry-specific loads and direct loads of final use given in Table 4.1. Thus environmental loads are indeed directed fully to final use items.

The money flows of the economy and environmental loads are collected into Table 4.7 in the same form as in the national balance of supply and demand. On the supply side money flows are formed of domestic gross domestic product and imports. In environmental loads the corresponding items are domestic loads and those caused through imports abroad. The final use items are on the use side.

In money flows, the share of imports in the supply is under one quarter. By contrast, in the use of natural resources imports account for nearly one half, or 47%, in consumption of primary energy for 28%, in final waste for as much as 80% – due to imports of mining and quarrying products – and in greenhouse gas emissions for 38%.

Exports account for 29% of the money flows on the use side, but in the use of natural resources for one half, in primary energy for 46%, in final waste for 67% and in greenhouse gas emissions for 42%.

Imports and exports have without exception larger shares of environmental loads than of money flows. One of the main reasons for this is the small share of services in Finland's foreign trade: in 1999 services accounted for 20% of Finland's imports and for only 13% of exports, while the share of the service industries was 63% of domestic value added and 50% of private consumption expenditures.

Conventional examinations of environmental loads in the national economy have concentrated on loads generated inside the national economy, which could be called a *production-based* approach. Recently, interest has been directed to international environmental loads of the national economy spread through foreign trade: how much environmental load effects are directed through imports to other countries and how much loads are caused to the national economy through exports from production going ultimately into foreign final use. When the loading caused by imports from abroad is added to the environmental loads of the national economy and the loading caused by production for exports is subtracted from it, we obtain the environmental loads of domestic final use in the national economy – private and government consumption and capital formation. This could be called a *consumption-based* approach. In recent years, such approach for greenhouse gases has been used by the OECD, for example (Ahmad & Wyckoff 2003).

Table 4.6. Monetary flows and environmental loads of final use of products in Finland 1999

	Monetary flows Billion €			Total material requirement Gkg		
Final use category	Domestic	Imported	Total	Domestic	Imported	Total
Private consumption	51	9	60	36	66	102
Government consumption	23	3	26	24	8	31
Capital formation	16	7	23	101	12	113
Exports	30	16	45	101	146	248
Total	**120**	**35**	**155**	**262**	**232**	**494**

	Greenhouse gas emissions Gkg CO_2 eqv			Acidifying emissions Mkg SO_2 eqv		
Final use category	Domestic	Imported	Total	Domestic	Imported	Total
Private consumption	36	17	53	128	58	186
Government consumption	6	3	9	17	7	25
Capital formation	7	7	14	22	19	41
Exports	32	23	55	131	61	192
Total	**81**	**50**	**132**	**298**	**145**	**443**

Primary energy PJ			Final waste Gkg		
Domestic	Imported	Total	Domestic	Imported	Total
630	150	780	4	14	18
93	27	120	1	3	4
79	105	183	3	13	16
650	276	926	13	54	68
1 452	**557**	**2 009**	**22**	**84**	**106**

Ground-level ozone Mkg POCP eqv			Eutrophication Mkg PO_4 eqv		
Domestic	Imported	Total	Domestic	Imported	Total
145	38	183	18	8	25
15	5	19	2	1	3
25	13	38	2	2	3
121	43	164	9	5	14
306	**98**	**404**	**30**	**16**	**46**

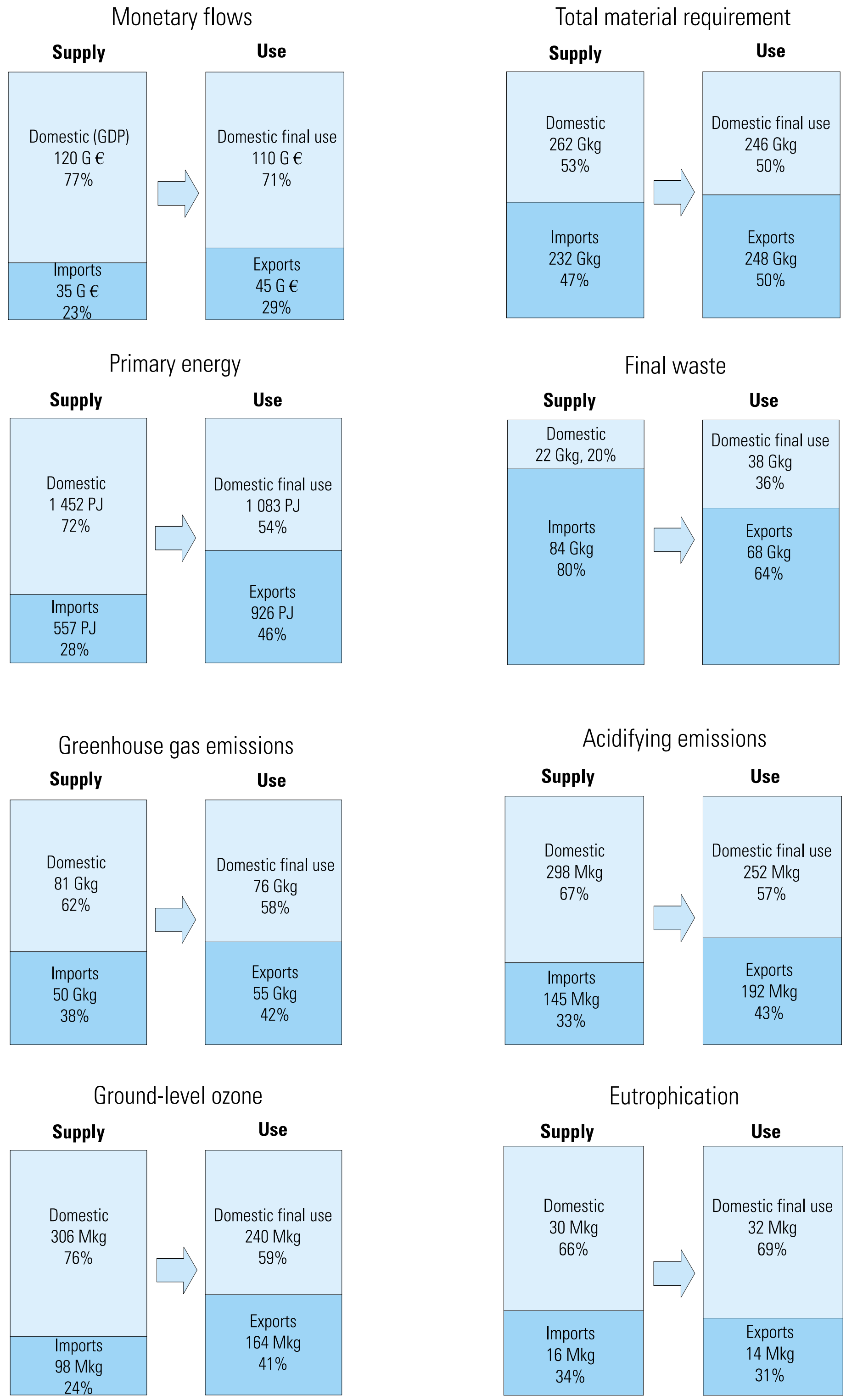
Table 4.7. Total balances of monetary flows and environmental loads in the Finnish economy 1999

	Monetary flows		Total material requirement		Primary energy		Final waste	
	Billion €	%	Gkg	%	PJ	%	Gkg	%
Supply								
Domestic	120	77	262	53	1 452	72	22	20
Imports	35	23	232	47	557	28	84	80
Total supply	**155**	**100**	**494**	**100**	**2 009**	**100**	**106**	**100**
Use								
Private consumption	60	39	102	21	780	39	18	17
Government consumption	26	17	31	6	120	6	4	4
Capital formation	23	15	113	23	183	9	16	15
Exports	45	29	248	50	926	46	68	64
Total use	**155**	**100**	**494**	**100**	**2 009**	**100**	**106**	**100**

	GHG emissions		Acidifying emissions		Ground-level ozone		Eutrophication	
	Gkg	%	Mkg	%	Mkg	%	Mkg	%
Supply								
Domestic	81	62	298	67	306	76	30	66
Import	50	38	145	33	98	24	16	34
Total supply	132	100	443	100	404	100	46	100
Use								
Private consumption	53	40	186	42	183	45	25	55
Government consumption	9	7	25	6	19	5	3	7
Capital formation	14	11	41	9	38	9	3	8
Exports	55	42	192	43	164	41	14	31
Total use	**132**	**100**	**443**	**100**	**404**	**100**	**46**	**100**

Figure 4.15 shows the total balances of money flows and environmental loads of Finland's economy in 1999. On the supply side the Domestic sections indicate the figures according to the conventional production-based approach. On the use side the Domestic final use sections show figures according to the consumption-based approach. The Imports and Exports sections demonstrate the relations between international trade.

Figure 4.15. Total balances of monetary flows and environmental loads in Finland 1999



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Tables

Supply, use and input-output tables

Tables 1. – 5. are divided into three parts .1, .2 and .3 over three pages

RoW = Rest of the World

1. Supply table 1999, million kg

	Supply by industries (NACE)					
	Agriculture, hunting and fishing	Forestry, logging etc.	Mining of energy minerals	Other mining and quarrying	Manuf. of food products, beverages and tobacco	Manuf. of textiles, wearing apperel etc.
Nr Products (CPA)	1	2	3	4	5	6
1 Products of agriculture, hunting and fishing	41 352	0	0	0	30	0
2 Products of forestry and logging	0	50 013	0	0	0	0
3 Energy minerals	0	0	8 726	0	0	0
4 Other mining and quarrying products	0	0	0	89 709	110	0
5 Food products, beverages and tobacco	16	0	0	0	7 437	0
6 Textiles, wearing apparels and leather prod.	0	0	0	0	0	104
7 Wood and products of wood and cork	0	0	0	0	0	0
8 Pulp, paper and paper products	0	0	0	0	0	0
9 Printed matter and recorded media	0	0	0	0	0	0
10 Coke and refined petroleum products	0	0	0	0	0	0
11 Chemicals and chemical products	0	0	0	0	44	2
12 Rubber and plastic products	0	0	0	0	0	1
13 Other non-metallic mineral products	0	0	0	53	0	0
14 Basic metals	0	0	0	0	0	0
15 Fabricated metal products	0	0	0	0	0	1
16 Machinery and equipment n.e.c.	0	0	0	0	0	0
17 Electrical machinery and apparatus	0	0	0	0	0	0
18 Transport equipmet	0	0	0	0	0	0
19 Other manufactured goods	0	0	0	0	0	0
20 Secondary raw materials	0	0	0	0	0	0
21 Electrical energy, gas, steam and water	0	0	0	0	0	0
22 Building work	0	0	0	0	0	0
23 Civil engineering work	0	0	0	0	0	0
24 Trade	0	0	0	0	0	0
25 Hotel and restaurant services	0	0	0	0	0	0
26 Transport, storage and telecomm. services	0	0	0	0	0	0
27 Dwelling services	0	0	0	0	0	0
28 Public administration and services	0	0	0	0	0	0
29 Sewage and refuse disposal services	0	0	0	0	9	0
30 Other services	0	0	0	0	0	0
Products, total	**41 368**	**50 013**	**8 726**	**89 762**	**7 629**	**108**
Final waste	173	0	3	11 207	92	8
Emissions into air	24 444	357	1 406	213	544	89
Water vapour	31 969	128	3	77	2 447	46
Discharges into water	184	19	5	1	1	0
Dissipative use	0	15	0	0	0	0
Into nature, total	**56 597**	**518**	**1 413**	**290**	**2 992**	**135**
Net accumulation	0	0	0	0	0	0
Total	**98 137**	**50 531**	**10 142**	**101 260**	**10 713**	**251**
Unused extraction	0	23 078	436	25 164	0	0

Manuf. of wood and wood products	Manuf. of pulp, paper, paper products	Publishing, printing etc.	Manuf. of coke and petroleum refineries	Manuf. of chemicals etc.	Manuf. of rubber and plastic products	Manuf. of non-metallic mineral products	Manuf. of basic metals	Manuf. of metal products	Manuf. of machinery and equipment
7	8	9	10	11	12	13	14	15	16
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	68	0	0	0	0	0
0	0	0	34	114	0	1 353	7	0	10
0	0	0	0	86	0	0	0	0	0
0	0	0	0	0	0	3	0	0	0
19 525	1 432	0	0	0	9	0	0	0	3
0	17 890	17	0	5	29	0	0	0	0
0	11	562	0	0	0	0	0	0	0
0	0	0	12 549	120	0	0	0	0	0
0	11 656	2	14	9 000	1	190	609	0	1
0	0	1	0	0	493	0	0	5	0
0	0	0	0	103	1	10 310	0	0	3
0	0	2	126	23	36	0	10 050	90	11
0	0	0	0	0	0	1	94	987	41
0	0	0	0	0	2	0	0	84	723
0	0	0	0	0	2	0	0	4	3
0	0	0	0	0	0	0	0	14	10
7	2	0	0	0	1	0	0	6	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4	525	0	0	0	0	7	0	0	0
0	0	0	0	0	0	0	0	0	0
19 537	**31 516**	**585**	**12 724**	**9 518**	**575**	**11 865**	**10 760**	**1 192**	**804**
58	1 372	12	41	1 760	10	197	927	16	57
1 255	23 985	39	3 436	1 391	64	1 980	5 249	200	117
8 486	26 111	34	1 307	805	50	979	1 077	115	53
1	209	0	1	5	0	0	1	0	0
0	0	0	0	0	0	0	0	0	0
9 741	**50 306**	**73**	**4 744**	**2 201**	**114**	**2 959**	**6 328**	**315**	**170**
0	0	0	0	0	0	0	0	0	0
29 335	**83 195**	**669**	**17 508**	**13 479**	**700**	**15 021**	**18 015**	**1 523**	**1 031**
0	0	0	0	0	0	2 308	0	0	0

1. Supply table 1999, million kg, *cont.*

		Supply by industries (NACE)					
		Manuf. of electrical equipment	Manuf. of transport equipment	Manu-facturing n.e.c.	Recycling	Electricity, gas & water supply	Building
Nr	Products (CPA)	17	18	19	20	21	22
1	Products of agriculture, hunting and fishing	0	0	0	0	0	0
2	Products of forestry and logging	0	0	0	0	0	0
3	Energy minerals	0	0	0	0	0	0
4	Other mining and quarrying products	0	0	0	0	0	0
5	Food products, beverages and tobacco	0	0	0	0	0	0
6	Textiles, wearing apparels and leather prod.	0	0	0	0	0	0
7	Wood and products of wood and cork	0	0	5	0	0	0
8	Pulp, paper and paper products	0	0	0	0	0	0
9	Printed matter and recorded media	0	0	0	0	0	0
10	Coke and refined petroleum products	0	0	0	0	0	0
11	Chemicals and chemical products	33	0	0	0	0	0
12	Rubber and plastic products	2	0	6	0	0	0
13	Other non-metallic mineral products	0	0	1	0	65	0
14	Basic metals	8	26	0	1 119	0	0
15	Fabricated metal products	12	24	7	0	0	0
16	Machinery and equipment n.e.c.	4	2	0	0	0	0
17	Electrical machinery and apparatus	381	1	0	0	0	0
18	Transport equipmet	0	224	0	0	0	0
19	Other manufactured goods	1	0	260	0	0	0
20	Secondary raw materials	0	0	0	0	0	0
21	Electrical energy, gas, steam and water	0	0	0	0	0	0
22	Building work	0	0	0	0	0	29 123
23	Civil engineering work	0	0	0	0	0	0
24	Trade	0	0	0	0	0	0
25	Hotel and restaurant services	0	0	0	0	0	0
26	Transport, storage and telecomm. services	0	0	0	0	0	0
27	Dwelling services	0	0	0	0	0	0
28	Public administration and services	0	0	0	0	0	0
29	Sewage and refuse disposal services	0	0	0	0	445	0
30	Other services	0	0	0	0	0	0
Products, total		**442**	**278**	**280**	**1 120**	**510**	**29 123**
Final waste		50	18	9	79	355	1 258
	Emissions into air	36	68	40	4	25 212	1 197
	Water vapour	23	26	46	2	12 212	278
	Discharges into water	0	0	0	0	1	0
	Dissipative use	0	0	0	0	0	0
Into nature, total		**60**	**94**	**86**	**7**	**37 425**	**1 474**
Net accumulation		0	0	0	0	0	0
Total		**551**	**390**	**375**	**1 205**	**38 290**	**31 855**
Unused extraction		0	0	0	0	0	8 500

Civil engineering	Wholesale and retail trade	Hotels and restaurants	Transport and telecommuni-cation	Dwellings	Public administ-ration and services	Sewage and refuse disposal	Other service activities	**Industries total**
23	24	25	26	27	28	29	30	
0	0	0	0	0	0	0	0	**41 381**
0	0	0	0	0	0	0	0	**50 013**
0	0	0	0	0	0	0	0	**8 794**
0	0	0	0	0	0	143	0	**91 480**
0	0	0	0	0	0	0	0	**7 539**
0	0	0	0	0	0	0	0	**108**
0	0	0	0	0	0	0	0	**20 975**
0	0	0	0	0	0	639	0	**18 580**
0	0	0	0	0	0	0	0	**573**
0	0	0	0	0	0	0	0	**12 669**
0	0	0	0	0	0	8	0	**21 560**
0	0	0	0	0	0	0	0	**509**
0	0	0	0	0	0	65	0	**10 601**
0	0	0	0	0	0	813	0	**12 305**
0	0	0	0	0	0	0	0	**1 168**
0	0	0	0	0	0	0	0	**816**
0	0	0	0	0	0	0	0	**390**
0	0	0	0	0	0	0	0	**250**
0	0	0	0	0	0	0	0	**278**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**29 123**
76 579	0	0	0	0	0	0	0	**76 579**
0	0	0	0	0	0	0	0	**0**
0	0	555	0	0	0	0	0	**555**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	1 557	0	**2 547**
0	0	0	0	0	0	0	0	**0**
76 579	**0**	**555**	**0**	**0**	**0**	**3 224**	**0**	**408 792**
11	321	185	52	15	200	16	207	**18 711**
1 096	1 184	107	10 092	1 751	794	183	282	**106 816**
254	492	48	3 732	762	271	29	112	**91 972**
0	0	0	0	0	0	53	0	**480**
0	0	0	677	0	30	0	30	**752**
1 350	**1 676**	**155**	**14 501**	**2 513**	**1 095**	**265**	**424**	**200 019**
0	0	0	0	0	0	0	0	**0**
77 940	**1 997**	**894**	**14 553**	**2 528**	**1 295**	**3 506**	**631**	**627 523**
25 000	0	0	0	0	0	0	0	**84 486**

1. Supply table 1999, million kg, *cont.*

	Final use				
	Households, non-durable consumption goods	Households, durable consumption goods	Fixed capital formation	Changes in inventories	Landfills
Nr Products (CPA)					
1 Products of agriculture, hunting and fishing	0	0	0	0	0
2 Products of forestry and logging	0	0	0	0	0
3 Energy minerals	0	0	0	0	0
4 Other mining and quarrying products	0	0	0	0	0
5 Food products, beverages and tobacco	0	0	0	0	0
6 Textiles, wearing apparels and leather prod.	0	0	0	0	0
7 Wood and products of wood and cork	0	0	0	0	0
8 Pulp, paper and paper products	0	0	0	0	0
9 Printed matter and recorded media	0	0	0	0	0
10 Coke and refined petroleum products	0	0	0	0	0
11 Chemicals and chemical products	0	0	0	0	0
12 Rubber and plastic products	0	0	0	0	0
13 Other non-metallic mineral products	0	0	0	0	0
14 Basic metals	0	0	0	0	0
15 Fabricated metal products	0	0	0	0	0
16 Machinery and equipment n.e.c.	0	0	0	0	0
17 Electrical machinery and apparatus	0	0	0	0	0
18 Transport equipmet	0	0	0	0	0
19 Other manufactured goods	0	0	0	0	0
20 Secondary raw materials	0	0	0	0	0
21 Electrical energy, gas, steam and water	0	0	0	0	0
22 Building work	0	0	0	0	0
23 Civil engineering work	0	0	0	0	0
24 Trade	0	0	0	0	0
25 Hotel and restaurant services	0	0	0	0	0
26 Transport, storage and telecomm. services	0	0	0	0	0
27 Dwelling services	0	0	0	0	0
28 Public administration and services	0	0	0	0	0
29 Sewage and refuse disposal services	0	0	0	0	0
30 Other services	0	0	0	0	0
Products, total	**0**	**0**	**0**	**0**	**0**
Final waste	1 266	172	1 440	0	0
Emissions into air	13 811	0	0	0	362
Water vapour	10 016	0	0	0	0
Discharges into water	13	0	0	0	0
Dissipative use	143	0	0	0	0
Into nature, total	**23 982**	**0**	**0**	**0**	**362**
Net accumulation	0	101	104 302	–442	17 826
Total	**25 249**	**272**	**105 742**	**–442**	**18 189**
Unused extraction	0	0	0	0	0

RoW			**Total**
Domestic final use total	Imports	Transfers to RoW	
0	962	0	42 343
0	10 671	0	60 684
0	17 627	0	26 422
0	9 179	0	100 660
0	1 271	0	8 809
0	132	0	240
0	1 145	0	22 120
0	562	0	19 142
0	24	0	598
0	5 047	0	17 716
0	4 626	0	26 186
0	210	0	719
0	1 079	0	11 680
0	2 181	0	14 485
0	195	0	1 363
0	353	0	1 169
0	196	0	587
0	361	0	611
0	97	0	375
0	0	0	0
0	0	0	0
0	0	0	29 123
0	0	0	76 579
0	0	0	0
0	0	0	555
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	2 547
0	2	0	2
0	**55 922**	**0**	**464 714**
2 877	13	0	21 601
14 173	2 813	–4025	119 776
10 016	738	–1214	101 513
13	0	0	492
143	0	0	895
24 345	**3 551**	**–5239**	**222 677**
121 788	–19308	1 434	103 914
149 010	**40 178**	**–3804**	**812 907**
0	0	0	84 486

2. Use table 1999, million kg

		Use by industries (NACE)					
		Agriculture, hunting and fishing	Forestry, logging etc.	Mining of energy minerals	Other mining and quarrying	Manuf. of food products, beverages and tobacco	Manuf. of textiles, wearing apperel etc.
Nr	Products (CPA)	1	2	3	4	5	6
1	Products of agriculture, hunting and fishing	34 360	0	0	0	6 338	0
2	Products of forestry and logging	316	0	0	0	6	0
3	Energy minerals	249	0	1	0	108	5
4	Other mining and quarrying products	819	0	5	25	75	2
5	Food products, beverages and tobacco	1 580	0	0	0	2 165	2
6	Textiles, wearing apparels and leather prod.	6	0	0	0	0	27
7	Wood and products of wood and cork	0	0	0	1	23	2
8	Pulp, paper and paper products	0	0	0	1	122	14
9	Printed matter and recorded media	0	0	0	0	0	0
10	Coke and refined petroleum products	606	115	2	67	102	24
11	Chemicals and chemical products	894	11	1	2	81	70
12	Rubber and plastic products	2	0	1	0	55	2
13	Other non-metallic mineral products	4	0	0	25	69	0
14	Basic metals	0	0	0	0	4	0
15	Fabricated metal products	0	0	0	1	15	1
16	Machinery and equipment n.e.c.	0	0	0	1	0	0
17	Electrical machinery and apparatus	0	0	0	0	0	0
18	Transport equipmet	0	0	0	0	0	0
19	Other manufactured goods	0	0	0	0	0	1
20	Secondary raw materials	0	0	0	0	0	0
21	Electrical energy, gas, steam and water	0	0	0	0	0	0
22	Building work	0	0	0	0	0	0
23	Civil engineering work	0	0	0	0	0	0
24	Trade	0	0	0	0	0	0
25	Hotel and restaurant services	0	0	0	0	0	0
26	Transport, storage and telecomm. services	0	0	0	0	0	0
27	Dwelling services	0	0	0	0	0	0
28	Public administration and services	0	0	0	0	0	0
29	Sewage and refuse disposal services	24	0	0	0	0	0
30	Other services	0	0	0	0	0	0
Products, total		**38 860**	**126**	**10**	**122**	**9 165**	**151**
Final waste		0	0	0	0	0	0
	Raw materials	867	50 032	9 366	100 915	0	0
	Water	33 122	0	0	0	1 024	0
	Air	25 289	373	766	223	524	100
From nature, total		**59 277**	**50 405**	**10 132**	**101 138**	**1 548**	**100**
Total		**98 137**	**50 531**	**10 142**	**101 260**	**10 713**	**251**
Unused extraction		0	23 078	436	25 164	0	0
Indirect inputs of imports		630	20	4	30	1 543	1 027

Manuf. of wood and wood products	Manuf. of pulp, paper, paper products	Publishing, printing etc.	Manuf. of coke and petroleum refineries	Manuf. of chemicals etc.	Manuf. of rubber and plastic products	Manuf. of non-metallic mineral products	Manuf. of basic metals	Manuf. of metal products	Manuf. of machinery and equipment
7	8	9	10	11	12	13	14	15	16
0	0	0	0	7	10	0	0	0	0
25 777	31 130	0	0	0	0	7	0	1	0
6	1 678	0	12 647	328	3	204	71	32	4
0	1 684	0	0	2 750	6	7 814	5 861	2	44
1	220	0	0	79	1	1	0	0	0
0	1	0	0	1	4	3	0	0	0
2 253	9 538	2	0	65	23	44	20	18	66
25	3 951	593	1	104	49	18	2	4	11
0	0	0	0	0	0	0	0	0	0
59	277	10	635	996	21	168	1 741	31	32
136	15 195	17	628	3 669	425	97	189	29	25
9	17	3	2	17	39	22	1	4	15
54	66	0	0	258	3	1 887	57	23	5
5	4	1	329	27	17	144	5 784	970	462
15	8	0	3	6	11	12	5	175	57
0	0	0	0	0	0	1	1	2	127
0	0	0	0	0	0	0	0	0	10
0	0	0	0	0	1	0	0	0	63
0	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
4	481	0	0	43	0	3	0	0	0
0	0	0	0	0	0	0	0	0	0
28 345	**64 250**	**627**	**14 245**	**8 351**	**615**	**10 424**	**13 732**	**1 293**	**922**
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3 124	65	0	0
0	39	6	0	1 625	15	534	162	2	0
990	18 905	37	3 264	3 504	70	939	4 056	228	109
990	**18 944**	**43**	**3 264**	**5 129**	**85**	**4 597**	**4 283**	**230**	**109**
29 335	**83 195**	**669**	**17 508**	**13 479**	**700**	**15 021**	**18 015**	**1 523**	**1 031**
0	0	0	0	0	0	2 308	0	0	0
1 910	17 908	285	4 134	14 590	2 065	2 745	55 301	3 965	3 352

2. Use table 1999, million kg, *cont.*

		Use by industries (NACE)					
		Manuf. of electrical equipment	Manuf. of transport equipment	Manu-facturing n.e.c.	Recycling	Electricity, gas & water supply	Building
Nr	Products (CPA)	17	18	19	20	21	22
1	Products of agriculture, hunting and fishing	0	0	0	0	0	0
2	Products of forestry and logging	0	0	7	0	184	0
3	Energy minerals	3	1	1	0	10 985	0
4	Other mining and quarrying products	0	1	0	110	48	21 655
5	Food products, beverages and tobacco	0	0	2	0	0	0
6	Textiles, wearing apparels and leather prod.	0	1	3	0	0	7
7	Wood and products of wood and cork	25	11	227	0	2 139	2 430
8	Pulp, paper and paper products	12	0	9	0	0	2
9	Printed matter and recorded media	0	0	0	0	0	0
10	Coke and refined petroleum products	9	21	19	1	408	216
11	Chemicals and chemical products	70	23	13	0	1	444
12	Rubber and plastic products	48	9	7	0	0	121
13	Other non-metallic mineral products	5	13	4	0	1	5 472
14	Basic metals	220	139	27	1 082	36	451
15	Fabricated metal products	8	34	6	0	0	103
16	Machinery and equipment n.e.c.	2	24	0	0	0	65
17	Electrical machinery and apparatus	109	12	0	0	22	33
18	Transport equipmet	0	24	0	0	0	0
19	Other manufactured goods	0	15	12	0	0	99
20	Secondary raw materials	0	0	0	0	0	0
21	Electrical energy, gas, steam and water	0	0	0	0	0	0
22	Building work	0	0	0	0	0	0
23	Civil engineering work	0	0	0	0	0	0
24	Trade	0	0	0	0	0	0
25	Hotel and restaurant services	0	0	0	0	0	0
26	Transport, storage and telecomm. services	0	0	0	0	0	0
27	Dwelling services	0	0	0	0	0	0
28	Public administration and services	0	0	0	0	0	0
29	Sewage and refuse disposal services	0	0	0	0	1 333	0
30	Other services	0	0	0	0	0	0
Products, total		**510**	**329**	**338**	**1 194**	**15 156**	**31 099**
Final waste		0	0	0	0	0	0
	Raw materials	0	0	0	0	0	0
	Water	8	0	0	6	1	0
	Air	33	61	37	5	23 134	756
From nature, total		**42**	**61**	**37**	**11**	**23 134**	**756**
Total		**551**	**390**	**375**	**1 205**	**38 290**	**31 855**
Unused extraction		0	0	0	0	0	8 500
Indirect inputs of imports		13 275	1 243	580	1	8 078	3 173

Civil engineering	Wholesale and retail trade	Hotels and restaurants	Transport and telecommuni-cation	Dwellings	Public administ-ration and services	Sewage and refuse disposal	Other service activities	**Industries total**
23	24	25	26	27	28	29	30	
5	38	127	0	0	2	2	2	40 891
0	3	14	4	797	122	4	37	58 411
456	22	5	1	17	4	0	4	26 835
57 539	0	1	0	0	0	1	0	98 443
0	169	575	0	0	0	0	0	4 796
0	5	0	0	0	2	0	0	60
4	0	0	0	0	0	0	0	16 891
0	2	7	1	0	45	0	14	4 988
0	54	0	5	0	46	0	48	154
320	345	24	3 134	183	156	3	70	9 795
321	36	6	0	0	208	0	129	22 720
14	26	0	27	0	1	0	0	443
3 224	0	15	0	0	7	0	2	11 196
831	4	0	6	0	0	0	0	10 542
620	1	0	0	0	8	0	2	1 091
0	1	0	2	0	3	0	0	230
29	3	0	1	0	8	0	12	239
0	1	0	10	0	0	0	6	105
0	10	7	0	0	12	0	19	176
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	677	0	0	0	0	677
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
637	0	0	0	0	0	22	0	2 547
0	0	0	0	0	0	0	1	2
64 000	**719**	**781**	**3 867**	**996**	**625**	**32**	**348**	**311 233**
0	0	0	0	0	0	3 368	0	3 368
13 200	0	0	0	0	0	0	0	177 568
0	0	0	0	0	0	0	0	36 544
740	1 278	113	10 686	1 532	670	105	283	98 810
13 940	**1 278**	**113**	**10 686**	**1 532**	**670**	**105**	**283**	**312 922**
77 940	**1 997**	**894**	**14 553**	**2 528**	**1 295**	**3 506**	**631**	**627 523**
25 000	0	0	0	0	0	0	0	84 486
1 146	121	176	360	35	318	1	410	138 426

2. Use table 1999, million kg, *cont.*

Nr	Products (CPA)	Final use Households, non-durable consumption goods	Households, durable consumption goods	Fixed capital formation	Changes in inventories	Landfills	**Domestic final use total**
1	Products of agriculture, hunting and fishing	842	0	0	239	0	**1 081**
2	Products of forestry and logging	2 339	0	0	–719	0	**1 620**
3	Energy minerals	44	0	0	–697	0	**–653**
4	Other mining and quarrying products	5	0	0	420	0	**425**
5	Food products, beverages and tobacco	2 927	0	0	426	0	**3 353**
6	Textiles, wearing apparels and leather prod.	87	13	0	2	0	**103**
7	Wood and products of wood and cork	0	0	0	–37	0	**–37**
8	Pulp, paper and paper products	53	0	0	–76	0	**–22**
9	Printed matter and recorded media	285	0	0	20	0	**304**
10	Coke and refined petroleum products	2 670	0	0	–19	0	**2 651**
11	Chemicals and chemical products	155	0	0	76	0	**231**
12	Rubber and plastic products	46	0	2	8	0	**56**
13	Other non-metallic mineral products	11	10	0	–15	0	**6**
14	Basic metals	0	0	0	–19	0	**–19**
15	Fabricated metal products	14	0	11	–19	0	**6**
16	Machinery and equipment n.e.c.	2	33	456	12	0	**503**
17	Electrical machinery and apparatus	9	53	74	–25	0	**111**
18	Transport equipmet	3	87	174	–22	0	**243**
19	Other manufactured goods	33	75	0	3	0	**111**
20	Secondary raw materials	0	0	0	0	0	**0**
21	Electrical energy, gas, steam and water	0	0	0	0	0	**0**
22	Building work	0	0	29 123	0	0	**29 123**
23	Civil engineering work	0	0	75 902	0	0	**75 902**
24	Trade	0	0	0	0	0	**0**
25	Hotel and restaurant services	555	0	0	0	0	**555**
26	Transport, storage and telecomm. services	0	0	0	0	0	**0**
27	Dwelling services	0	0	0	0	0	**0**
28	Public administration and services	0	0	0	0	0	**0**
29	Sewage and refuse disposal services	0	0	0	0	0	**0**
30	Other services	0	0	0	0	0	**0**
Products, total		**10 079**	**272**	**105 742**	**–442**	**0**	**115 651**
Final waste		**0**	**0**	**0**	**0**	**18 189**	**18 189**
	Raw materials	0	0	0	0	0	**0**
	Water	1 863	0	0	0	0	**1 863**
	Air	13 307	0	0	0	0	**13 307**
From nature, total		**15 170**	**0**	**0**	**0**	**0**	**15 170**
Total		**25 249**	**272**	**105 742**	**–442**	**18 189**	**149 010**
Unused extraction		0	0	0	0	0	**0**
Indirect inputs of imports		6 651	26 935	3 083	–9160	0	**27 509**

RoW		**Total**
Imports	Transfers to RoW	
371	0	**42 343**
654	0	**60 684**
240	0	**26 422**
1 791	0	**100 660**
660	0	**8 809**
78	0	**240**
5 267	0	**22 120**
14 177	0	**19 142**
139	0	**598**
5 270	0	**17 716**
3 234	0	**26 186**
220	0	**719**
478	0	**11 680**
3 963	0	**14 485**
266	0	**1 363**
436	0	**1 169**
236	0	**587**
263	0	**611**
88	0	**375**
0	0	**0**
0	0	**0**
0	0	**29 123**
0	0	**76 579**
0	0	**0**
0	0	**555**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**2 547**
0	0	**2**
37 830	**0**	**464 714**
44	**0**	**21 601**
0	0	**177 568**
0	0	**38 407**
2 304	–3804	**110 616**
2 304	**–3804**	**326 591**
40 178	**–3804**	**812 907**
0	0	**84 486**
10 052	0	**175 987**

3. Use table of domestic products 1999, imports as basic inputs, million kg

		Use by industries (NACE)					
		Agriculture, hunting and fishing	Forestry, logging etc.	Mining of energy minerals	Other mining and quarrying	Manuf. of food products, beverages and tobacco	Manuf. of textiles, wearing apperel etc.
Nr	Products (CPA)	1	2	3	4	5	6
1	Products of agriculture, hunting and fishing	34 267	0	0	0	5 721	0
2	Products of forestry and logging	306	0	0	0	6	0
3	Energy minerals	237	0	1	0	75	0
4	Other mining and quarrying products	512	0	3	25	27	0
5	Food products, beverages and tobacco	1 558	0	0	0	1 557	1
6	Textiles, wearing apparels and leather prod.	2	0	0	0	0	4
7	Wood and products of wood and cork	0	0	0	1	19	2
8	Pulp, paper and paper products	0	0	0	1	114	7
9	Printed matter and recorded media	0	0	0	0	0	0
10	Coke and refined petroleum products	206	40	1	27	41	10
11	Chemicals and chemical products	756	10	0	1	36	25
12	Rubber and plastic products	1	0	1	0	40	1
13	Other non-metallic mineral products	4	0	0	18	42	0
14	Basic metals	0	0	0	0	4	0
15	Fabricated metal products	0	0	0	0	12	0
16	Machinery and equipment n.e.c.	0	0	0	0	0	0
17	Electrical machinery and apparatus	0	0	0	0	0	0
18	Transport equipmet	0	0	0	0	0	0
19	Other manufactured goods	0	0	0	0	0	0
20	Secondary raw materials	0	0	0	0	0	0
21	Electrical energy, gas, steam and water	0	0	0	0	0	0
22	Building work	0	0	0	0	0	0
23	Civil engineering work	0	0	0	0	0	0
24	Trade	0	0	0	0	0	0
25	Hotel and restaurant services	0	0	0	0	0	0
26	Transport, storage and telecomm. services	0	0	0	0	0	0
27	Dwelling services	0	0	0	0	0	0
28	Public administration and services	0	0	0	0	0	0
29	Sewage and refuse disposal services	24	0	0	0	0	0
30	Other services	0	0	0	0	0	0
Products, total		37 871	50	6	73	7 694	51
Imports		989	77	4	49	1 471	99
Final waste		0	0	0	0	0	0
	Raw materials	867	50 032	9 366	100 915	0	0
	Water	33 122	0	0	0	1 024	0
	Air	25 289	373	766	223	524	100
From nature, total		59 277	50 405	10 132	101 138	1 548	100
Total		98 137	50 531	10 142	101 260	10 713	251
Unused extraction		0	23 078	436	25 164	0	0
Indirect inputs of imports		630	20	4	30	1 543	1 027

Manuf. of wood and wood products	Manuf. of pulp, paper, paper products	Publishing, printing etc.	Manuf. of coke and petroleum refineries	Manuf. of chemicals etc.	Manuf. of rubber and plastic products	Manuf. of non-metallic mineral products	Manuf. of basic metals	Manuf. of metal products
7	8	9	10	11	12	13	14	15
0	0	0	0	3	0	0	0	0
23 722	22 607	0	0	0	0	7	0	1
0	949	0	0	140	0	0	0	0
0	527	0	0	1 985	4	6 612	1 014	1
1	122	0	0	51	0	0	0	0
0	0	0	0	0	0	0	0	0
2 125	9 323	1	0	60	21	38	16	16
6	3 529	434	1	98	25	10	1	4
0	0	0	0	0	0	0	0	0
23	103	7	413	615	7	88	1 042	16
60	13 950	10	130	1 728	212	56	150	21
6	11	2	1	12	22	13	1	3
37	45	0	0	173	3	1 423	34	11
2	4	1	329	23	8	109	5 180	627
9	5	0	2	5	6	8	3	119
0	0	0	0	0	0	1	0	1
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
4	481	0	0	43	0	3	0	0
0	0	0	0	0	0	0	0	0
25 994	51 656	455	876	4 936	308	8 369	7 443	820
2 351	12 594	172	13 368	3 415	306	2 056	6 289	473
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3 124	65	0
0	39	6	0	1 625	15	534	162	2
990	18 905	37	3 264	3 504	70	939	4 056	228
990	18 944	43	3 264	5 129	85	4 597	4 283	230
29 335	83 195	669	17 508	13 479	700	15 021	18 015	1 523
0	0	0	0	0	0	2 308	0	0
1 910	17 908	285	4 134	14 590	2 065	2 745	55 301	3 965

3. Use table of domestic products 1999, imports as basic inputs, million kg, *cont.*

		Use by industries (NACE)					
		Manuf. of machinery and equipment	Manuf. of electrical equipment	Manuf. of transport equipment	Manu-facturing n.e.c.	Recycling	Electricity, gas & water supply
No	Products (CPA)	16	17	18	19	20	21
1	Products of agriculture, hunting and fishing	0	0	0	0	0	0
2	Products of forestry and logging	0	0	0	5	0	178
3	Energy minerals	0	0	0	0	0	5 619
4	Other mining and quarrying products	44	0	1	0	110	31
5	Food products, beverages and tobacco	0	0	0	2	0	0
6	Textiles, wearing apparels and leather prod.	0	0	0	0	0	0
7	Wood and products of wood and cork	53	21	7	204	0	2 029
8	Pulp, paper and paper products	10	11	0	7	0	0
9	Printed matter and recorded media	0	0	0	0	0	0
10	Coke and refined petroleum products	15	4	9	7	1	151
11	Chemicals and chemical products	18	35	17	7	0	1
12	Rubber and plastic products	7	26	5	5	0	0
13	Other non-metallic mineral products	4	3	9	2	0	1
14	Basic metals	238	85	79	17	1 041	36
15	Fabricated metal products	36	4	27	4	0	0
16	Machinery and equipment n.e.c.	27	1	14	0	0	0
17	Electrical machinery and apparatus	5	61	3	0	0	19
18	Transport equipmet	5	0	1	0	0	0
19	Other manufactured goods	0	0	11	7	0	0
20	Secondary raw materials	0	0	0	0	0	0
21	Electrical energy, gas, steam and water	0	0	0	0	0	0
22	Building work	0	0	0	0	0	0
23	Civil engineering work	0	0	0	0	0	0
24	Trade	0	0	0	0	0	0
25	Hotel and restaurant services	0	0	0	0	0	0
26	Transport, storage and telecomm. services	0	0	0	0	0	0
27	Dwelling services	0	0	0	0	0	0
28	Public administration and services	0	0	0	0	0	0
29	Sewage and refuse disposal services	0	0	0	0	0	1 333
30	Other services	0	0	0	0	0	0
Products, total		**464**	**251**	**184**	**267**	**1 152**	**9 396**
Imports		458	259	145	71	42	5 760
Final waste		0	0	0	0	0	0
	Raw materials	0	0	0	0	0	0
	Water	0	8	0	0	6	1
	Air	109	33	61	37	5	23 134
From nature, total		**109**	**42**	**61**	**37**	**11**	**23 134**
Total		**1 031**	**551**	**390**	**375**	**1 205**	**38 290**
Unused extraction		0	0	0	0	0	0
Indirect inputs of imports		3 352	13 275	1 243	580	1	8 078

Building	Civil engineering	Wholesale and retail trade	Hotels and restaurants	Transport and telecommunication	Dwellings	Public administration and services	Sewage and refuse disposal	Other service activities	**Industries total**
22	23	24	25	26	27	28	29	30	**31**
0	4	32	120	0	0	1	2	1	**40 152**
0	0	3	13	4	770	118	4	36	**47 778**
0	456	0	0	0	3	2	0	4	**7 488**
21 583	57 231	0	0	0	0	0	1	0	**89 709**
0	0	147	502	0	0	0	0	0	**3 941**
1	0	1	0	0	0	0	0	0	**9**
1 885	4	0	0	0	0	0	0	0	**15 826**
0	0	1	6	1	0	24	0	13	**4 303**
0	0	43	0	4	0	45	0	44	**136**
154	129	283	8	2 147	61	52	1	23	**5 684**
439	294	32	2	0	0	161	0	58	**18 209**
88	11	19	0	8	0	0	0	0	**282**
5 142	3 209	0	8	0	0	4	0	1	**10 174**
184	793	4	0	6	0	0	0	0	**8 769**
71	587	0	0	0	0	5	0	1	**906**
32	0	0	0	1	0	2	0	0	**79**
20	19	1	0	0	0	1	0	4	**135**
0	0	0	0	0	0	0	0	0	**6**
88	0	6	5	0	0	7	0	11	**136**
0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	677	0	0	0	0	**677**
0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	0	**0**
0	637	0	0	0	0	0	22	0	**2 547**
0	0	0	0	0	0	0	0	0	**0**
29 690	**63 374**	**571**	**664**	**2 848**	**834**	**423**	**29**	**197**	**256 947**
1 409	626	148	117	1 019	163	202	16	150	**54 298**
0	0	0	0	0	0	0	3 356	0	**3 356**
0	13 200	0	0	0	0	0	0	0	**177 568**
0	0	0	0	0	0	0	0	0	**36 544**
756	740	1 278	113	10 686	1 532	670	105	283	**98 810**
756	**13 940**	**1 278**	**113**	**10 686**	**1 532**	**670**	**105**	**283**	**312 922**
31 855	**77 940**	**1 997**	**894**	**14 553**	**2 528**	**1 295**	**3 506**	**631**	**627 523**
8 500	25 000	0	0	0	0	0	0	0	**84 486**
3 173	1 146	121	176	360	35	318	1	410	**138 426**

3. Use table of domestic products 1999, imports as basic inputs, million kg, *cont.*

		Final use					
		Households, non-durable consumption goods	Households, durable consumption goods	Fixed capital formation	Changes in inventories	Landfills	**Domestic final use total**
Nr	Products (CPA)	32	33	34	35	36	37
1	Products of agriculture, hunting and fishing	688	0	0	178	0	866
2	Products of forestry and logging	2 260	0	0	–679	0	1 582
3	Energy minerals	35	0	0	1 032	0	1 067
4	Other mining and quarrying products	0	0	0	–11	0	–11
5	Food products, beverages and tobacco	2 516	0	0	424	0	2 940
6	Textiles, wearing apparels and leather prod.	15	2	0	8	0	25
7	Wood and products of wood and cork	0	0	0	–33	0	–33
8	Pulp, paper and paper products	47	0	0	75	0	123
9	Printed matter and recorded media	280	0	0	18	0	298
10	Coke and refined petroleum products	1 963	0	0	–178	0	1 786
11	Chemicals and chemical products	82	0	0	122	0	205
12	Rubber and plastic products	19	0	1	–7	0	13
13	Other non-metallic mineral products	6	5	0	–62	0	–51
14	Basic metals	0	0	0	–2	0	–2
15	Fabricated metal products	3	0	11	–16	0	–3
16	Machinery and equipment n.e.c.	2	0	325	11	0	337
17	Electrical machinery and apparatus	3	26	34	–24	0	39
18	Transport equipmet	2	11	75	–22	0	65
19	Other manufactured goods	12	42	0	3	0	56
20	Secondary raw materials	0	0	0	0	0	0
21	Electrical energy, gas, steam and water	0	0	0	0	0	0
22	Building work	0	0	29 123	0	0	29 123
23	Civil engineering work	0	0	75 902	0	0	75 902
24	Trade	0	0	0	0	0	0
25	Hotel and restaurant services	555	0	0	0	0	555
26	Transport, storage and telecomm. services	0	0	0	0	0	0
27	Dwelling services	0	0	0	0	0	0
28	Public administration and services	0	0	0	0	0	0
29	Sewage and refuse disposal services	0	0	0	0	0	0
30	Other services	0	0	0	0	0	0
Products, total		**8 488**	**84**	**105 470**	**838**	**0**	**114 880**
Imports		1 591	188	271	–1279	0	771
Final waste		0	0	0	0	18 189	18 189
	Raw materials	0	0	0	0	0	0
	Water	1 863	0	0	0	0	1 863
	Air	13 307	0	0	0	0	13 307
From nature, total		**15 170**	**0**	**0**	**0**	**0**	**15 170**
Total		**25 249**	**272**	**105 742**	**–442**	**18 189**	**149 010**
Unused extraction		0	0	0	0	0	0
Indirect inputs of imports		6 651	26 935	3 083	–9160	0	27 509

RoW		Total
Imports	Transfers to RoW	
38	39	**40**
364	0	**41 381**
653	0	**50 013**
240	0	**8 794**
1 782	0	**91 480**
658	0	**7 539**
74	0	**108**
5 182	0	**20 975**
14 155	0	**18 580**
139	0	**573**
5 199	0	**12 669**
3 146	0	**21 560**
214	0	**509**
478	0	**10 601**
3 538	0	**12 305**
264	0	**1 168**
400	0	**816**
216	0	**390**
178	0	**250**
86	0	**278**
0	0	**0**
0	0	**0**
0	0	**29 123**
0	0	**76 579**
0	0	**0**
0	0	**555**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**2 547**
0	0	**0**
36 965	**0**	**408 792**
866	0	**55 935**
44	0	**21 589**
0	0	**177 568**
0	0	**38 407**
2 304	–3804	**110 616**
2 304	**–3804**	**326 591**
40 178	**–3804**	**812 907**
0	0	**84 486**
10 052	0	**175 987**

4. Use table of imports 1999, million kg

		Use by industries (NACE)					
		Agriculture, hunting and fishing	Forestry, logging etc.	Mining of energy minerals	Other mining and quarrying	Manuf. of food products, beverages and tobacco	Manuf. of textiles, wearing apperel etc.
Nr	Products (CPA)	1	2	3	4	5	6
1	Products of agriculture, hunting and fishing	92	0	0	0	617	0
2	Products of forestry and logging	11	0	0	0	1	0
3	Energy minerals	12	0	0	0	32	5
4	Other mining and quarrying products	307	0	2	0	48	2
5	Food products, beverages and tobacco	22	0	0	0	608	1
6	Textiles, wearing apparels and leather prod.	4	0	0	0	0	23
7	Wood and products of wood and cork	0	0	0	0	4	0
8	Pulp, paper and paper products	0	0	0	0	8	7
9	Printed matter and recorded media	0	0	0	0	0	0
10	Coke and refined petroleum products	400	75	1	40	61	14
11	Chemicals and chemical products	138	2	1	0	46	45
12	Rubber and plastic products	1	0	0	0	15	1
13	Other non-metallic mineral products	1	0	0	7	27	0
14	Basic metals	0	0	0	0	0	0
15	Fabricated metal products	0	0	0	0	3	0
16	Machinery and equipment n.e.c.	0	0	0	1	0	0
17	Electrical machinery and apparatus	0	0	0	0	0	0
18	Transport equipmet	0	0	0	0	0	0
19	Other manufactured goods	0	0	0	0	0	0
20	Secondary raw materials	0	0	0	0	0	0
21	Electrical energy, gas, steam and water	0	0	0	0	0	0
22	Building work	0	0	0	0	0	0
23	Civil engineering work	0	0	0	0	0	0
24	Trade	0	0	0	0	0	0
25	Hotel and restaurant services	0	0	0	0	0	0
26	Transport, storage and telecomm. services	0	0	0	0	0	0
27	Dwelling services	0	0	0	0	0	0
28	Public administration and services	0	0	0	0	0	0
29	Sewage and refuse disposal services	0	0	0	0	0	0
30	Other services	0	0	0	0	0	0
Products, total		**989**	**77**	**4**	**49**	**1 471**	**99**
Final waste		0	0	0	0	0	0
	Raw materials	0	0	0	0	0	0
	Water	0	0	0	0	0	0
	Air	0	0	0	0	0	0
From nature, total		**0**	**0**	**0**	**0**	**0**	**0**
Total		**989**	**77**	**4**	**49**	**1 471**	**99**
Indirect inputs of imports		630	20	4	30	1 543	1 027

Manuf. of wood and wood products	Manuf. of pulp, paper, paper products	Publishing, printing etc.	Manuf. of coke and petroleum refineries	Manuf. of chemicals etc.	Manuf. of rubber and plastic products	Manuf. of non-metallic mineral products	Manuf. of basic metals	Manuf. of metal products	Manuf. of machinery and equipment
7	8	9	10	11	12	13	14	15	16
0	0	0	0	3	10	0	0	0	0
2 056	8 524	0	0	0	0	0	0	0	0
6	729	0	12 647	188	3	204	71	32	4
0	1 156	0	0	766	2	1 203	4 847	1	0
1	97	0	0	28	1	0	0	0	0
0	0	0	0	1	3	2	0	0	0
128	216	0	0	5	3	6	3	3	12
20	422	159	0	6	25	8	0	0	1
0	0	0	0	0	0	0	0	0	0
36	175	4	222	381	13	79	699	15	16
77	1 244	7	498	1 941	214	40	39	8	7
3	6	1	0	5	17	9	0	2	8
17	21	0	0	85	1	464	23	12	2
3	0	0	0	4	8	35	604	343	224
6	3	0	0	2	6	3	2	56	20
0	0	0	0	0	0	1	1	1	100
0	0	0	0	0	0	0	0	0	5
0	0	0	0	0	1	0	0	0	58
0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
2 351	**12 594**	**172**	**13 368**	**3 415**	**306**	**2 056**	**6 289**	**473**	**458**
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2 351	**12 594**	**172**	**13 368**	**3 415**	**306**	**2 056**	**6 289**	**473**	**458**
1 910	17 908	285	4 134	14 590	2 065	2 745	55 301	3 965	3 352

4. Use table of imports 1999, million kg, *cont.*

	Toimialojen käyttö					
	Manuf. of electrical equipment	Manuf. of transport equipment	Manu-facturing n.e.c.	Recycling	Electricity, gas & water supply	Building
Nr Products (CPA)	17	18	19	20	21	22
1 Products of agriculture, hunting and fishing	0	0	0	0	0	0
2 Products of forestry and logging	0	0	2	0	6	0
3 Energy minerals	3	1	1	0	5 366	0
4 Other mining and quarrying products	0	0	0	0	17	72
5 Food products, beverages and tobacco	0	0	0	0	0	0
6 Textiles, wearing apparels and leather prod.	0	1	3	0	0	6
7 Wood and products of wood and cork	4	4	23	0	110	544
8 Pulp, paper and paper products	1	0	2	0	0	2
9 Printed matter and recorded media	0	0	0	0	0	0
10 Coke and refined petroleum products	4	12	12	1	257	63
11 Chemicals and chemical products	34	6	7	0	0	5
12 Rubber and plastic products	22	5	2	0	0	33
13 Other non-metallic mineral products	2	4	2	0	0	329
14 Basic metals	134	60	11	41	0	267
15 Fabricated metal products	4	6	2	0	0	32
16 Machinery and equipment n.e.c.	1	11	0	0	0	32
17 Electrical machinery and apparatus	48	9	0	0	3	12
18 Transport equipmet	0	23	0	0	0	0
19 Other manufactured goods	0	4	5	0	0	11
20 Secondary raw materials	0	0	0	0	0	0
21 Electrical energy, gas, steam and water	0	0	0	0	0	0
22 Building work	0	0	0	0	0	0
23 Civil engineering work	0	0	0	0	0	0
24 Trade	0	0	0	0	0	0
25 Hotel and restaurant services	0	0	0	0	0	0
26 Transport, storage and telecomm. services	0	0	0	0	0	0
27 Dwelling services	0	0	0	0	0	0
28 Public administration and services	0	0	0	0	0	0
29 Sewage and refuse disposal services	0	0	0	0	0	0
30 Other services	0	0	0	0	0	0
Products, total	**259**	**145**	**71**	**42**	**5 760**	**1 409**
Final waste	0	0	0	0	0	0
Raw materials	0	0	0	0	0	0
Water	0	0	0	0	0	0
Air	0	0	0	0	0	0
From nature, total	**0**	**0**	**0**	**0**	**0**	**0**
Total	**259**	**145**	**71**	**42**	**5 760**	**1 409**
Indirect inputs of imports	13 275	1 243	580	1	8 078	3 173

Civil engineering	Wholesale and retail trade	Hotels and restaurants	Transport and telecommuni-cation	Dwellings	Public administ-ration and services	Sewage and refuse disposal	Other service activities	**Industries total**
23	24	25	26	27	28	29	30	
1	6	7	0	0	0	1	0	**739**
0	0	0	0	27	4	0	1	**10 633**
0	22	5	1	14	2	0	1	**19 347**
308	0	1	0	0	0	0	0	**8 734**
0	22	73	0	0	0	0	0	**855**
0	5	0	0	0	2	0	0	**50**
0	0	0	0	0	0	0	0	**1 065**
0	0	1	0	0	22	0	1	**685**
0	11	0	1	0	2	0	4	**18**
191	62	16	986	122	104	2	47	**4 111**
26	4	4	0	0	46	0	70	**4 511**
3	7	0	19	0	1	0	0	**160**
15	0	7	0	0	3	0	1	**1 022**
38	0	0	0	0	0	0	0	**1 773**
33	1	0	0	0	3	0	1	**185**
0	1	0	1	0	1	0	0	**152**
10	2	0	0	0	6	0	8	**104**
0	1	0	10	0	0	0	6	**99**
0	4	3	0	0	5	0	8	**40**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	1	**2**
626	**148**	**117**	**1 019**	**163**	**202**	**3**	**150**	**54 285**
0	0	0	0	0	0	13	0	**13**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	0	0	0	0	0	0	0	**0**
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
626	**148**	**117**	**1 019**	**163**	**202**	**16**	**150**	**54 298**
1 146	121	176	360	35	318	1	410	**138 426**

4. Use table of imports 1999, million kg, *cont*.

Nr	Products (CPA)	Final use: Households, non-durable consumption goods	Households, durable consumption goods	Fixed capital formation	Changes in inventories	Landfills	**Domestic final use total**
1	Products of agriculture, hunting and fishing	154	0	0	61	0	**215**
2	Products of forestry and logging	79	0	0	–40	0	**38**
3	Energy minerals	9	0	0	–1729	0	**–1720**
4	Other mining and quarrying products	5	0	0	431	0	**436**
5	Food products, beverages and tobacco	411	0	0	2	0	**413**
6	Textiles, wearing apparels and leather prod.	72	12	0	–6	0	**77**
7	Wood and products of wood and cork	0	0	0	–4	0	**–4**
8	Pulp, paper and paper products	6	0	0	–151	0	**–145**
9	Printed matter and recorded media	5	0	0	2	0	**7**
10	Coke and refined petroleum products	707	0	0	158	0	**865**
11	Chemicals and chemical products	73	0	0	–46	0	**26**
12	Rubber and plastic products	27	0	1	16	0	**44**
13	Other non-metallic mineral products	5	5	0	47	0	**57**
14	Basic metals	0	0	0	–17	0	**–17**
15	Fabricated metal products	11	0	0	–2	0	**9**
16	Machinery and equipment n.e.c.	1	34	130	1	0	**165**
17	Electrical machinery and apparatus	6	28	40	–1	0	**73**
18	Transport equipmet	1	77	99	1	0	**177**
19	Other manufactured goods	21	33	0	1	0	**55**
20	Secondary raw materials	0	0	0	0	0	**0**
21	Electrical energy, gas, steam and water	0	0	0	0	0	**0**
22	Building work	0	0	0	0	0	**0**
23	Civil engineering work	0	0	0	0	0	**0**
24	Trade	0	0	0	0	0	**0**
25	Hotel and restaurant services	0	0	0	0	0	**0**
26	Transport, storage and telecomm. services	0	0	0	0	0	**0**
27	Dwelling services	0	0	0	0	0	**0**
28	Public administration and services	0	0	0	0	0	**0**
29	Sewage and refuse disposal services	0	0	0	0	0	**0**
30	Other services	0	0	0	0	0	**0**
Products, total		**1 591**	**188**	**271**	**–1279**	**0**	**771**
Final waste		0	0	0	0	0	**0**
	Raw materials	0	0	0	0	0	**0**
	Water	0	0	0	0	0	**0**
	Air	0	0	0	0	0	**0**
From nature, total		**0**	**0**	**0**	**0**	**0**	**0**
Total		**1 591**	**188**	**271**	**–1279**	**0**	**771**
Indirect inputs of imports		6 651	26 935	3 083	–9160	0	**27 509**

RoW		**Total**
Exports	Transfers from RoW	
7	0	**962**
0	0	**10 671**
0	0	**17 627**
9	0	**9 179**
2	0	**1 271**
4	0	**132**
85	0	**1 145**
22	0	**562**
0	0	**24**
71	0	**5 047**
88	0	**4 626**
6	0	**210**
0	0	**1 079**
425	0	**2 181**
2	0	**195**
36	0	**353**
20	0	**196**
85	0	**361**
2	0	**97**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**0**
0	0	**2**
866	**0**	**55 922**
0	0	**13**
0	0	**0**
0	0	**0**
0	0	**0**
0	**0**	**0**
866	**0**	**55 935**
10 052	0	**175 987**

5. Input-output table 1999, million kg

Nr	Industries (NACE)	Use by industries (NACE) Agriculture, hunting and fishing	Forestry, logging etc.	Mining of energy minerals	Other mining and quarrying	Manuf. of food products, beverages	Manuf. of textiles, wearing apperel etc.
		1	2	3	4	5	6
1	Agriculture, hunting and fishing	34 265	0	0	0	5 739	0
2	Forestry, logging etc.	306	0	0	0	6	0
3	Mining of energy minerals	221	0	1	0	75	0
4	Other minig and quarrying	488	0	3	24	26	0
5	Manuf. of food products, beverages and tobacco	1 560	0	0	0	1 499	1
6	Manuf. of textiles, wearing apperel etc.	2	0	0	0	0	4
7	Manuf. of wood and wood products	0	0	0	1	18	2
8	Manuf. of pulp, paper, paper products	0	0	0	1	111	7
9	Publishing, printing etc.	0	0	0	0	3	0
10	Manuf. of coke and petroleum refineries	206	40	1	27	41	10
11	Manuf. of chemicals etc.	769	10	0	1	70	23
12	Manuf. of rubber and plastic products	1	0	1	0	44	2
13	Manuf. of non-metallic mineral products	27	0	0	19	43	0
14	Manuf. of basic metals	2	0	0	0	5	0
15	Manuf. of metal products	0	0	0	0	13	1
16	Manuf. of machinery and equipment	0	0	0	0	0	0
17	Manuf. of electrical equipment	0	0	0	0	0	0
18	Manuf. of transport equipment	0	0	0	0	0	0
19	Manufacturing n.e.c.	0	0	0	0	2	0
20	Recycling	0	0	0	0	0	0
21	Electricity, gas & water supply	0	0	0	0	0	0
22	Building	0	0	0	0	0	0
23	Civil engineering	0	0	0	0	0	0
24	Wholesale and retail trade	0	0	0	0	0	0
25	Hotels and restaurants	0	0	0	0	0	0
26	Transport and telecommunication	0	0	0	0	0	0
27	Dwellings	0	0	0	0	0	0
28	Public administration and services	0	0	0	0	0	0
29	Sewage and refuse disposal	24	0	0	0	0	1
30	Other service activities	0	0	0	0	0	0
Domestic products, total		**37 871**	**50**	**6**	**73**	**7 694**	**51**
	Households, non-durable consumption goods	0	0	0	0	0	0
	Households, durable consumption goods	0	0	0	0	0	0
	Fixed capital formation	0	0	0	0	0	0
	Changes in inventories	0	0	0	0	0	0
	Landfills	0	0	0	0	0	0
Domestic final use, total		**0**	**0**	**0**	**0**	**0**	**0**
Imports		989	77	4	49	1 471	99
Exports		0	0	0	0	0	0
Final waste		0	0	0	0	0	0
	Raw materials	867	50 032	9 366	100 915	0	0
	Water	33 122	0	0	0	1 024	0
	Air	25 289	373	766	223	524	100
From nature, total		59 277	50 405	10 132	101 138	1 548	100
Total		97 148	50 454	10 138	101 211	9 242	152

Manuf. of wood and wood products	Manuf. of pulp, paper, paper products	Publishing, printing etc.	Manuf. of coke and petroleum refineries	Manuf. of chemicals etc.	Manuf. of rubber and plastic products	Manuf. of non-metallic mineral products	Manuf. of basic metals	Manuf. of metal products	Manuf. of machinery and equipment
7	8	9	10	11	12	13	14	15	16
0	0	0	0	3	0	0	0	0	0
23 722	22 607	0	0	0	0	7	0	1	0
0	949	0	0	139	0	0	0	0	0
0	521	0	0	1 929	4	6 277	993	1	44
2	108	0	5	50	1	47	1	0	0
0	1	0	0	0	0	0	0	0	0
1 932	8 530	1	0	51	21	35	16	16	53
199	15 651	434	20	211	25	14	2	4	10
0	11	1	0	0	1	1	0	0	0
23	103	7	425	621	7	88	1 157	16	15
57	2 407	10	100	1 427	203	218	133	19	16
9	16	2	1	12	24	12	1	4	8
37	71	0	0	255	3	1 326	68	13	5
2	101	0	318	211	8	24	4 115	619	228
10	5	0	2	6	6	8	12	113	49
0	0	0	0	0	0	5	4	8	22
1	5	0	5	0	1	1	3	1	5
0	0	0	0	1	0	0	22	2	6
1	3	0	0	1	0	0	0	2	0
0	0	0	0	2	0	92	216	1	0
0	0	0	0	0	0	84	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	569	0	0	17	4	129	700	0	0
0	0	0	0	0	0	0	0	0	0
25 994	**51 656**	**455**	**876**	**4 936**	**308**	**8 369**	**7 443**	**820**	**464**
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2 351	12 594	172	13 368	3 415	306	2 056	6 289	473	458
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3 124	65	0	0
0	39	6	0	1 625	15	534	162	2	0
990	18 905	37	3 264	3 504	70	939	4 056	228	109
990	18 944	43	3 264	5 129	85	4 597	4 283	230	109
26 984	70 601	498	4 140	10 064	393	12 965	11 726	1 050	573

5. Input-output table 1999, million kg, *cont.*

	Toimialojen käyttö					
	Manuf. of electrical equipment	Manuf. of transport equipment	Manu-facturing n.e.c.	Recycling	Electricity, gas & water supply	Building
Nr Industries (NACE)	17	18	19	20	21	22
1 Agriculture, hunting and fishing	0	0	0	0	0	0
2 Forestry, logging etc.	0	0	5	0	178	0
3 Mining of energy minerals	0	0	0	0	5 619	0
4 Other minig and quarrying	0	1	0	0	29	21 410
5 Manuf. of food products, beverages and tobacco	1	0	2	31	0	2
6 Manuf. of textiles, wearing apperel etc.	0	0	0	0	0	2
7 Manuf. of wood and wood products	21	7	200	0	1 603	1 885
8 Manuf. of pulp, paper, paper products	10	0	9	0	425	0
9 Publishing, printing etc.	0	0	0	0	0	0
10 Manuf. of coke and petroleum refineries	4	9	7	1	151	154
11 Manuf. of chemicals etc.	33	16	7	28	1	378
12 Manuf. of rubber and plastic products	26	5	7	0	0	93
13 Manuf. of non-metallic mineral products	4	11	2	6	3	5 373
14 Manuf. of basic metals	72	71	15	934	36	173
15 Manuf. of metal products	15	25	5	1	0	75
16 Manuf. of machinery and equipment	1	15	0	3	0	37
17 Manuf. of electrical equipment	63	4	0	0	19	22
18 Manuf. of transport equipment	0	1	0	3	0	1
19 Manufacturing n.e.c.	0	11	6	0	1	86
20 Recycling	0	8	0	11	0	0
21 Electricity, gas & water supply	0	0	0	0	0	0
22 Building	0	0	0	0	0	0
23 Civil engineering	0	0	0	0	0	0
24 Wholesale and retail trade	0	0	0	0	0	0
25 Hotels and restaurants	0	0	0	0	0	0
26 Transport and telecommunication	0	0	0	0	0	0
27 Dwellings	0	0	0	0	0	0
28 Public administration and services	0	0	0	0	0	0
29 Sewage and refuse disposal	0	0	0	133	1 333	0
30 Other service activities	0	0	0	0	0	0
Domestic products, total	**251**	**184**	**267**	**1 152**	**9 396**	**29 690**
Households, non-durable consumption goods	0	0	0	0	0	0
Households, durable consumption goods	0	0	0	0	0	0
Fixed capital formation	0	0	0	0	0	0
Changes in inventories	0	0	0	0	0	0
Landfills	0	0	0	0	0	0
Domestic final use, total	**0**	**0**	**0**	**0**	**0**	**0**
Imports	259	145	71	42	5 760	1 409
Exports	0	0	0	0	0	0
Final waste	0	0	0	0	0	0
Raw materials	0	0	0	0	0	0
Water	8	0	0	6	1	0
Air	33	61	37	5	23 134	756
From nature, total	42	61	37	11	23 134	756
Total	**293**	**245**	**304**	**1 163**	**32 530**	**30 446**

Civil engineering	Wholesale and retail trade	Hotels and restaurants	Transport and telecommuni-cation	Dwellings	Public administ-ration and services	Sewage and refuse disposal	Other service activities	**Industries total**
23	24	25	26	27	28	29	30	
4	32	118	0	0	1	2	1	40 165
0	3	13	4	770	118	4	36	47 778
420	0	0	0	3	2	0	4	7 436
56 281	0	0	0	0	0	1	0	88 031
40	148	504	0	0	2	0	2	4 004
0	1	0	0	0	0	0	0	11
4	0	0	0	0	0	0	0	14 397
20	2	7	1	0	24	0	14	17 199
0	42	0	4	0	44	0	44	153
129	283	8	2 147	61	52	1	23	5 817
335	27	2	0	0	142	0	53	6 483
11	17	0	8	0	1	0	0	306
4 085	4	8	0	0	20	0	1	11 384
78	4	0	5	0	0	0	0	7 022
467	1	0	0	0	5	0	1	819
25	0	0	1	0	2	0	0	125
25	1	0	0	0	3	0	7	167
16	0	0	0	0	0	0	0	52
5	6	4	0	0	6	0	10	146
786	0	0	0	0	0	0	0	1 117
445	0	0	0	0	0	0	0	529
0	0	0	0	0	0	0	0	0
0	0	0	677	0	0	0	0	677
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
197	0	0	0	0	0	22	0	3 129
0	0	0	0	0	0	0	0	0
63 374	**571**	**664**	**2 848**	**834**	**423**	**29**	**197**	**256 947**
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
626	148	117	1 019	163	202	16	150	54 298
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3 356	0	3 356
13 200	0	0	0	0	0	0	0	177 568
0	0	0	0	0	0	0	0	36 544
740	1 278	113	10 686	1 532	670	105	283	98 810
13 940	1 278	113	10 686	1 532	670	105	283	312 922
77 314	**1 849**	**777**	**13 535**	**2 366**	**1 093**	**3 490**	**480**	**573 225**

5. Input-output table 1999, million kg, *cont.*

Nr	Industries (NACE)	Final use Households, non-durable consumption goods	Households, durable consumption goods	Fixed capital formation	Changes in inventories	Landfills	Final use total
1	Agriculture, hunting and fishing	682	0	0	156	0	838
2	Forestry, logging etc.	2 260	0	0	–679	0	1 582
3	Mining of energy minerals	35	0	0	1 031	0	1 066
4	Other minig and quarrying	0	0	0	3	0	3
5	Manuf. of food products, beverages and tobacco	2 522	0	0	443	0	2 965
6	Manuf. of textiles, wearing apperel etc.	15	2	0	7	0	24
7	Manuf. of wood and wood products	0	1	0	–38	0	–36
8	Manuf. of pulp, paper, paper products	50	0	0	80	0	130
9	Publishing, printing etc.	280	0	0	6	0	286
10	Manuf. of coke and petroleum refineries	1 963	0	0	–174	0	1 789
11	Manuf. of chemicals etc.	80	0	0	69	0	149
12	Manuf. of rubber and plastic products	18	1	2	–7	0	15
13	Manuf. of non-metallic mineral products	6	5	0	–29	0	–18
14	Manuf. of basic metals	0	0	0	47	0	47
15	Manuf. of metal products	3	2	68	–20	0	53
16	Manuf. of machinery and equipment	2	0	268	3	0	272
17	Manuf. of electrical equipment	3	26	35	–22	0	41
18	Manuf. of transport equipment	2	10	73	–21	0	64
19	Manufacturing n.e.c.	12	37	0	2	0	51
20	Recycling	0	0	0	0	0	0
21	Electricity, gas & water supply	0	0	0	–20	0	–20
22	Building	0	0	29 123	0	0	29 123
23	Civil engineering	0	0	75 902	0	0	75 902
24	Wholesale and retail trade	0	0	0	0	0	0
25	Hotels and restaurants	555	0	0	0	0	555
26	Transport and telecommunication	0	0	0	0	0	0
27	Dwellings	0	0	0	0	0	0
28	Public administration and services	0	0	0	0	0	0
29	Sewage and refuse disposal	0	0	0	0	0	0
30	Other service activities	0	0	0	0	0	0
Domestic products, total		**8 488**	**84**	**105 470**	**838**	**0**	**114 880**
	Households, non-durable consumption goods	0	0	0	0	0	0
	Households, durable consumption goods	0	0	0	0	0	0
	Fixed capital formation	0	0	0	0	0	0
	Changes in inventories	0	0	0	0	0	0
	Landfills	0	0	0	0	0	0
Domestic final use, total		**0**	**0**	**0**	**0**	**0**	**0**
Imports		1 591	188	271	–1279	0	771
Exports		0	0	0	0	0	0
Final waste		0	0	0	0	18 189	18 189
	Raw materials	0	0	0	0	0	0
	Water	1 863	0	0	0	0	1 863
	Air	13 307	0	0	0	0	13 307
From nature, total		15 170	0	0	0	0	15 170
Total		**23 658**	**84**	**105 470**	**838**	**18 189**	**148 239**

RoW		Products		To nature					Stocks	Total
Exports	Transfers to RoW	Total	Final waste	Emissions into air	Water vapour	Dis-charges into water	Dis-sipative use	Into nature, total	Nett accu-mulation	
365	0	41 368	173	24 444	31 969	184	0	56 597	0	98 137
653	0	50 013	0	357	128	19	15	518	0	50 531
225	0	8 726	3	1 406	3	5	0	1 413	0	10 142
1 728	0	89 762	11 207	213	77	1	0	290	0	101 260
660	0	7 629	92	544	2 447	1	0	2 992	0	10 713
73	0	108	8	89	46	0	0	135	0	251
5 176	0	19 537	58	1 255	8 486	1	0	9 741	0	29 335
14 187	0	31 516	1 372	23 985	26 111	209	0	50 306	0	83 195
146	0	585	12	39	34	0	0	73	0	669
5 117	0	12 724	41	3 436	1 307	1	0	4 744	0	17 508
2 887	0	9 518	1 760	1 391	805	5	0	2 201	0	13 479
254	0	575	10	64	50	0	0	114	0	700
499	0	11 865	197	1 980	979	0	0	2 959	0	15 021
3 691	0	10 760	927	5 249	1 077	1	0	6 328	0	18 015
320	0	1 192	16	200	115	0	0	315	0	1 523
407	0	804	57	117	53	0	0	170	0	1 031
233	0	442	50	36	23	0	0	60	0	551
161	0	278	18	68	26	0	0	94	0	390
84	0	280	9	40	46	0	0	86	0	375
3	0	1 120	79	4	2	0	0	7	0	1 205
1	0	510	355	25 212	12 212	1	0	37 425	0	38 290
0	0	29 123	1 258	1 197	278	0	0	1 474	0	31 855
0	0	76 579	11	1 096	254	0	0	1 350	0	77 940
0	0	0	321	1 184	492	0	0	1 676	0	1 997
0	0	555	185	107	48	0	0	155	0	894
0	0	0	52	10 092	3 732	0	677	14 501	0	14 553
0	0	0	15	1 751	762	0	0	2 513	0	2 528
0	0	0	200	794	271	0	30	1 095	0	1 295
96	0	3 224	16	183	29	53	0	265	0	3 506
0	0	0	207	282	112	0	30	424	0	631
36 965	**0**	**408 792**	**18 711**	**106 816**	**91 972**	**480**	**752**	**200 019**	**0**	**627 523**
0	0	0	1 266	13 811	10 016	13	143	23 982	0	25 249
0	0	0	172	0	0	0	0	0	101	272
0	0	0	1 440	0	0	0	0	0	104 302	105 742
0	0	0	0	0	0	0	0	0	–442	–442
0	0	0	0	362	0	0	0	362	17 826	18 189
0	**0**	**0**	**2 877**	**14 173**	**10 016**	**13**	**143**	**24 345**	**121 788**	**149 010**
866	0	55 935	0	2 813	738	0	0	0	0	55 935
0	0	0	0	–4025	–1214	0	0	0	0	0
44	0	21 589	0	0	0	0	0	0	0	21 589
0	0	177 568	0	0	0	0	0	0	0	177 568
0	0	38 407	0	0	0	0	0	0	0	38 407
2 304	–3804	110 616	0	0	0	0	0	0	0	110 616
2 304	0	330 396	0	0	0	0	0	0	0	330 396
39 313	**0**	**760 776**	**19 977**	**116 601**	**100 775**	**492**	**895**	**224 002**	**0**	**1 004 756**

6. Emissions into air 1999, million kg

Industries	CO_2-min	CH_4	N_2O	SO_2	NO_x	NH_3	CO
1 Agriculture, hunting and fishing	6 122	84	13	2	23	49	15
2 Forestry, logging etc.	345	0	0	0	6	0	4
3 Mining of energy minerals	1 406	0	0	0	0	0	0
4 Other minig and quarrying	211	0	0	0	0	0	0
5 Manuf. of food products, beverages and tobacco	491	8	0	1	1	0	1
6 Manuf. of textiles, wearing apperel etc.	88	0	0	0	0	0	0
7 Manuf. of wood and wood products	192	19	0	0	2	0	3
8 Manuf. of pulp, paper, paper products	3 879	18	1	14	26	0	30
9 Publishing, printing etc.	32	0	0	0	0	0	0
10 Manuf. of coke and petroleum refineries	3 388	0	0	6	4	0	1
11 Manuf. of chemicals etc.	1 149	1	4	10	6	0	1
12 Manuf. of rubber and plastic products	63	0	0	0	0	0	0
13 Manuf. of non-metallic mineral products	1 950	0	0	1	1	0	1
14 Manuf. of basic metals	5 220	0	0	10	5	0	1
15 Manuf. of metal products	184	0	0	0	0	0	0
16 Manuf. of machinery and equipment	103	0	0	0	0	0	1
17 Manuf. of electrical equipment	28	0	0	0	0	0	0
18 Manuf. of transport equipment	56	0	0	0	0	0	0
19 Manufacturing n.e.c.	27	0	0	0	0	0	0
20 Recycling	4	0	0	0	0	0	0
21 Electricity, gas & water supply	20 873	2	2	31	34	0	14
22 Building	728	0	0	0	8	0	6
23 Civil engineering	927	0	0	1	12	0	4
24 Wholesale and retail trade	1 134	0	0	1	7	0	8
25 Hotels and restaurants	88	0	0	0	0	0	0
26 Transport and telecommunication	9 859	1	1	15	125	0	33
27 Dwellings	618	3	0	0	1	0	13
28 Public administration and services	502	1	0	0	1	0	3
29 Sewage and refuse disposal	9	9	0	0	0	0	0
30 Other service activities	227	0	0	0	0	0	1
Households	8 526	12	1	1	50	0	359
Landfills	0	106	0	0	0	0	0
Total	**68 431**	**265**	**24**	**96**	**313**	**49**	**499**
Foreign transport in Finland	2 180	0	0	6	37	0	6
Finnish transport in RoW	–3616	0	–1	–10	–57	0	–9
Transboundary pollution to Finland	0	0	0	206	297	62	0
Transboundary pollution from Finland	0	0	0	–70	–202	–31	0
International transfers, net	**–1437**	**0**	**0**	**133**	**74**	**31**	**–3**
Into Finnish environment, total	**66 995**	**264**	**24**	**228**	**388**	**80**	**497**

NMVOC	Particles	CO_2-bio	O_2, N_2	Total
6	3	4 243	13 882	24 444
1	1	0	0	357
0	0	0	0	1 406
0	0	0	0	213
1	0	42	0	544
0	0	0	0	89
6	2	1 030	0	1 255
7	12	19 999	0	23 985
6	0	0	0	39
35	1	0	0	3 436
11	0	104	105	1 391
1	0	0	0	64
2	0	25	0	1 980
2	3	8	0	5 249
2	0	13	0	200
1	0	12	0	117
1	0	7	0	36
2	0	9	0	68
2	0	10	0	40
0	0	0	0	4
0	8	4 247	0	25 212
11	1	0	442	1 197
3	1	0	147	1 096
1	1	33	0	1 184
0	0	19	0	107
44	9	5	0	10 092
6	2	1 107	0	1 751
1	0	286	0	794
0	0	165	0	183
1	0	52	0	282
61	6	4 794	0	13 811
0	0	247	0	352
216	**50**	**36 458**	**14 576**	**120 979**
16	2	0	0	2 247
–26	–3	0	0	–3722
0	0	0	0	565
0	0	0	0	–303
–10	**–1**	**0**	**0**	**–1213**
207	**49**	**36 458**	**14 576**	**119 766**

7. Energy consumption 1999, Terajoules

Industries	Oil 1	Natural gas 2	Coal 3	Nuclear fuel 4	Peat 5	Forest wood 6
1 Agriculture, hunting and fishing	25 560	610	0	0	450	4 050
2 Forestry, logging etc.	4 530	0	0	0	0	0
3 Mining of energy minerals	53	0	0	0	17	0
4 Other minig and quarrying	2 801	0	0	0	0	0
5 Manuf. of food products, beverages and tobacco	4 167	1 168	292	0	767	50
6 Manuf. of textiles, wearing apperel etc.	1 006	243	0	0	0	1
7 Manuf. of wood and wood products	2 292	299	0	0	3	173
8 Manuf. of pulp, paper, paper products	10 788	30 211	2 897	0	9 703	388
9 Publishing, printing etc.	455	6	0	0	0	0
10 Manuf. of coke and petroleum refineries	154	13 610	18	0	0	0
11 Manuf. of chemicals etc.	5 542	583	2 048	0	1 260	0
12 Manuf. of rubber and plastic products	718	154	0	0	0	0
13 Manuf. of non-metallic mineral products	2 871	3 008	4 233	0	0	0
14 Manuf. of basic metals	5 271	2 291	849	0	0	0
15 Manuf. of metal products	1 266	1 559	0	0	0	0
16 Manuf. of machinery and equipment	1 179	179	0	0	1	4
17 Manuf. of electrical equipment	278	136	0	0	0	0
18 Manuf. of transport equipment	738	22	0	0	0	0
19 Manufacturing n.e.c.	338	29	0	0	0	1
20 Recycling	64	0	0	0	0	0
21 Electricity, gas & water supply	16 809	79 180	94 638	239 940	58 003	1 514
22 Building	9 103	0	0	0	0	0
23 Civil engineering	8 988	0	0	0	0	0
24 Wholesale and retail trade	14 399	1 078	0	0	3	35
25 Hotels and restaurants	1 003	228	0	0	3	175
26 Transport and telecommunication	131 153	43	0	0	3	48
27 Dwellings	7 760	680	0	0	40	10 200
28 Public administration and services	6 614	123	0	0	22	1 567
29 Sewage and refuse disposal	113	0	0	0	6	50
30 Other service activities	2 978	25	0	0	45	475
Households	115 559	250	100	0	430	29 950
Finnish economy, total	**384 549**	**135 712**	**105 075**	**239 940**	**70 754**	**48 680**
International transport of Finnish vehicles	–65 502	0	0	0	0	0
Total	**319 047**	**135 712**	**105 075**	**239 940**	**70 754**	**48 680**

Wood residues	Other residues	Immaterial fuels	Total	Electricity, net	Heat, net
7	8	9	10	11	12
0	0	470	31 140	3 000	360
0	0	0	4 530	0	0
0	0	0	70	35	10
0	0	0	2 801	1 877	60
68	13	0	6 526	5 594	5 939
3	0	0	1 253	935	184
9 229	0	0	11 997	5 088	5 456
181 359	933	4 539	240 817	49 747	13 375
0	0	0	460	1 435	552
0	31 971	0	45 752	–316	–12348
942	2 713	4 187	17 275	13 486	8 199
0	0	0	872	2 636	926
76	1 680	0	11 868	3 216	30
0	21 150	34 954	64 515	15 075	–1624
0	4	0	2 829	2 021	538
0	0	0	1 362	2 571	1 973
0	0	0	414	2 591	1 163
0	0	0	760	1 189	993
94	0	0	462	816	294
0	0	0	64	46	6
21 199	11 479	41 851	564 613	–186290	–115185
0	0	0	9 103	799	0
0	0	0	8 988	0	0
0	0	0	15 514	10 561	7 533
0	0	0	1 409	4 782	1 901
0	0	0	131 246	4 771	2 070
0	0	10	18 690	13 756	54 364
0	0	0	8 326	13 284	13 729
0	562	0	730	728	317
0	0	0	3 522	12 770	8 146
0	0	1 240	147 529	53 844	1 040
212 971	**70 505**	**87 251**	**1 355 438**	**40 046**	**0**
0	0	40 046	–65 502	–40 046	0
212 971	**70 505**	**127 297**	**1 329 982**	**0**	**0**

Annex I

Classifications

1. Aggregated industries
2. Aggregated products
3. Waste classification
4. Fuels and other energy sources
5. Emissions into air

1. Aggregated industries

No	Description	NACE Codes
1	Agriculture, hunting and fishing	01, 05
2	Forestry, logging etc.	2
3	Mining of energy minerals	10, 11, 12
4	Other minig and quarrying	13, 14
5	Manufacture of food products, beverages and tobacco	15, 16
6	Manufacture of textiles, wearing apperel etc.	17,18,19
7	Manufacture of wood and wood products	20
8	Manufacture of pulp, paper, paper productss	21
9	Publishing, printing etc.	22
10	Manufacture of coke and petroleum refineries	23
11	Manufacture of chemicals etc.	DG
12	Manufacrure of rubber and plastic products	DH
13	Manufacture of non-metallic mineral products	26
14	Manufacture of basic metals	27
15	Manufacture of metal products	28
16	Manufacture of machinery and equipment	29
17	Manufacture of electrical equipment	DL
18	Manufacture of transport equipment	DM
19	Manufacturing n.e.c.	36
20	Recycling	37
21	Electricity, gas & water supply	E
22	Building	F
23	Civil engineering	F
24	Wholesale and retail trade	G
25	Hotels and restaurants	H
26	Transport and telecommunication	I
27	Dwellings	7021
28	Public administration and servicest	L, M, N
29	Sewage and refuse disposal	90
30	Other service activities	701, 7022, 703, KB, O, P

2. Aggregated products

No	Description	CPA Codes
1	Products of agriculture, hunting and fishing	01, 05
2	Products of forestry and logging	2
3	Energy minerals	10, 11, 12
4	Other mining and quarrying products	13, 14
5	Food products, beverages and tobacco products	15, 16
6	Textiles, wearing apparels; furs and leather products	17,18,19
7	Wood and products of wood and cork (except furniture)	20
8	Pulp, paper and paper products	21
9	Printed matter and recorded media	22
10	Coke, refined petroleum products and nuclear fuels	23
11	Chemicals, chemical products and man-made fibres	DG
12	Rubber and plastic products	DH
13	Other non-metallic mineral products	26
14	Basic metals	27
15	Fabricated metal products, except machinery and equipmet	28
16	Machinery and equipment n.e.c.	29
17	Electrical machinery and apparatus	DL
18	Transport equipmet	DM
19	Other manufactured goods	36
20	Secondary raw materials	37
21	Electrical energy, gas, steam and hot water; collected and purified water	E
22	Building work	F
23	Civil engineering work	F
24	Trade	G
25	Hotel and restaurant services	H
26	Transport, storage and telecommication services	I
27	Dwelling services	7021
28	Public administration and services	L, M, N
29	Sewage and refuse disposal services and sanitation	90
30	Other services	701,7022,703, KB, O,P

3. Waste classification

CPA	Description
1511400	Raw offal, inedible
1513130	Flours, meals and pellets of meat unfit for human consumption, greaves
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	Other non-ferrous metals and articles thereof, cermets, ash and residues, containing metals or metallic compounds
2745400	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

4. Fuels and other energy sources

Code	CPA	Nr[1]	Description
1111	2320220	8	Refinery Gas
1112	2320210	1	Liquefied Petroleum Gas
1121	2320130	1	Naphtha
1122	2320110	1	Motos Gasoline
1123	2320110	1	Aviation Gasoline
1131	2320140	1	Kerosene Type Jet Fuel
1132	2320140	1	Other Kerosene
1133	2320151	1	Diesel Fuel
1134	2320159	1	Light Fuel Oil for Heating
1135	2320159	1	Light Fuel Oil for Working Machines
1141	2320170	1	Heavy Fuel Oil for Heating
1142	2320170	1	Heavy Fuel OIl, Ships
1143	2320170	8	Other heavy fuel oils
1150	2320320	8	Petroleum Coke
1160	2320320	8	Recycled Waste Oil
1190	2320320	1	Other Petroleum Products
1212	1010100	3	Hard Coal
1222	1010100	3	Patent fuel
1230	2310100	3	Coke Oven Coke
1240	4020100	8	Coke Oven Gas
1250	4020100	8	Blast furnace Gas
1310	1110200	2	Natural gas
2110	1030100	5	Milled Peat
2120	1030100	5	Sod Peat
3111	212140	6	Firewood
3112	212140	6	Small Tree chips
3113	212140	6	Forest Residue Chips
3121	2010400	7	Bark
3122	2010400	7	Sawdust etc.
3123	2010400	7	Industrial Chips
3129	2010400	7	Other
3130	2414800	7	Black Liquor and Other Concentrated Liquors
3140	9990102	7	Other Wastes and By-products from Wood Processing Industry
3150	2010400	7	Construction and Demolition Wood
3160	2010400	7	Patent Wood Fuels
3210	9990201	8	Gases Derived from Biomass and Wastes
3230	9990202	8	Recovered/Recycled Fuel
4110	2330000	4	Nuclear Fuel
4910	9999999	8	Other By-Products and Wastes
4920	9999999	9	Nonmaterial energy sources
4990	9999999	8	Other Energy Sources
5100	4010100	11	Electricity
5210	4030200	12	District Heat
5220	4030200	12	Process Heat

5. Emissions into air

CO_2-min	Carbon dioxide, mineral origin
CH_4	Methane
N_2O	Nitrous oxide
SO_2	Sulphur dioxide
NOx	Nitrogen oxides
NH_3	Ammonium
CO	Carbon monoxide
NMVOC	Non-methane volatile organic compounds
Particles	Particles
CO_2-bio	Carbon dioxide, biotic origin
O_2, N_2	Oxygen, nitrogen

Annex 2

Main data sources

1. Use of domestic natural resources and production and use of products

Agriculture, reindeer herding, collecting and hunting
The basic data source for the figure on agriculture is the Yearbook of farm statistics (MMM 2001). Statistics on reindeer herding, and collecting and hunting are taken from the Finnish statistical yearbook of forestry, Tables 6.2 ja 6.8. The yield of household gardening comes from data from the Household Consumption Survey of Statistics Finland. The farm models of the Research Centre of Agriculture and Food Economy have been utilised in the estimation of intermediate inputs of agriculture.

Forestry
The statistics derive from the Finnish statistical yearbook of forestry (METLA 2002).

Fishery and fish farming
Fish catch and fish farming statistics of the Game and Fishery Research Centre.

Extraction of energy minerals (peat)
Extraction of fuel and horticultural peat: Finnish statistical yearbook of forestry (METLA 2002), Table 6.11., and production and inventory changes of fuel peat: Energy statistics (Statistics Finland 2000), Table 2.10.

Extraction of other minerals
Mines: unpublished detailed data on quantities of overburden soil, total extraction, gross ore and concentrate production by ore from the mining statistics of the Ministry of Trade and Industry. Extraction of gravel, crush, construction stone and other soil materials: Soil extraction register of the Finnish Environment Institute (Rintala 2002).

Manufacturing
PRODCOM statistics of Statistics Finland at the 3-digit industry level of NACE. The PRODCOM statistics contain both value and physical quantity data on products and are divided into four parts: sales of products, purchases of products, acquisitions of packages and acquisition and use of fuels and other energy sources.

Because the information on purchases and sales lack data on the deliveries of products between the production units of multiple-branch enterprises located in different industries, most of these kinds of flows are systematically checked from other sources. Such checks have included e.g. collections of production data from mining statistics and data from forestry statistics on the use of raw wood and forest industry by-products in the forest industry.

The physical measurement units of many products in PRODCOM statistics are such that they cannot be transformed into mass units, e.g. product quantity is expressed as number of pieces or as meters, or quantity is lacking altogether. In such cases, the general practice has been to change the value data into mass units by means of a kilogram price of the product taken from the import or export data of foreign trade statistics.

Construction and services
The intermediate use of construction and services is mainly estimated by the supply surplus method. The estimates of fuel use are derived from energy statistics.

Household consumption
The quantitative data on the acquisition of foodstuffs by households has been obtained from the 1998 Household Consumption Survey of Statistics Finland, in which questions concerning quantity were included as a special inquiry (Tennilä 2000). The data

have been updated for the year 1999 against the time series of Statistics Finland on household consumption expenditure at constant prices. The questionnaire inquired about the numbers and quantities of meals and beverages taken in restaurants, from which the material quantity households received from restaurants, and the intermediate use of foodstuffs by restaurants and hotels were estimated.

Alcohol consumption of households is systematically underestimated in questionnaire inquiries. Therefore, alcohol consumption of households both as direct acquisitions and in restaurants was taken from the drug statistics of STAKES (2000). Data on imports of alcohol through tourism were also obtained from the statistics of STAKES.

Data on the acquisitions and disposals of motor vehicles by households were obtained from a special printout the Transport Statistics unit of Statistics Finland produced from the register of motor vehicles listing the registrations and withdrawals in the register in 1999, the motor vehicle stock at the end of 1998 and 1999 by owner group, and the weights of owned vehicles.

Estimates of disposals of electrical apparatus were taken from the calculation system for electrical scrap estimation of the Finnish electrical industry association SETELI (2003).

Capital formation

Gross fixed capital formation was mainly estimated by the supply surplus method. However, capital formation for vehicles was taken from a special printout from the motor vehicle register.

For the liquidation of fixed capital, the disposal of buildings was taken from the data on demolition waste in the waste statistics of Statistics Finland (2002) and for machinery and equipment withdrawals the withdrawals of motor vehicles were assumed to be 1/3 of the gross formation.

Data for changes in inventories were obtained for a few products only. These were corn and potatoes from the Yearbook of farm statistics, raw wood from the Finnish statistical yearbook of forestry, some fuels from the Energy statistics of Statistics Finland and sales inventories of vehicles from the special printout from the motor vehicle register.

2 Foreign trade

Both in terms of value and quantity, the figures for the imports and exports of products were received from Statistics Finland, where the product classifications of the foreign trade statistics of Customs were converted into the CPA classifications of national accounts. Imports included fuel purchases of domestic aircraft and vessels abroad and exports included fuel purchases of foreign aircraft and vessels in the territory of Finland by means of corresponding value items in national accounts. The imports also include the alcohol purchases of tourists abroad based on the statistics of STAKES (2000).

3 Fuels and energy consumption

Data on the fuel consumption of industries and households in mass units are derived uniformly from the estimates of energy consumption measured in energy units, gigajoules. The main data sources were the Energy statistics of Statistics Finland (2002) and fuel statistics of industry at the 3-digit level of NACE. The data from the fuel statistics of industry were corrected to a certain extent against additional information from the Environment and Energy unit of Statistics Finland.

In the Energy statistics the data on the energy consumption of transport only includes domestic transports. The fuel consumption of domestic aircraft was obtained from the environment report of Finnair Oy (Finnair 2000). The fuel consumption of international transport by Finnish vessels has been estimated by means of national accounts data on the imports and exports of bunker fuel oils and data from the Energy statistics on the sales of bunker oils in Finland.

The treatment of blast furnace coke and oil in physical flow accounts differs from that in Energy statistics. In Energy statistics, the heat value of blast furnace coke is defined as the difference between the heat content of blast furnace gas and that of coke. In physical flow accounts, blast furnace coke and oil are treated as raw materials and their net heat content as immaterial process heat, so that the total energy balance of blast furnaces does not change from that in the Energy statistics.

The consumption of material energy resources estimated in energy units has been converted into mass units by conversion coefficients mainly based on a fuel study done by the Technical Research Centre of Finland (Alakangas 2000).

4 Packages

The package flow in physical flow accounting includes disposable packages and packages replacing the withdrawals of reusable packages. The reusable packages may be interpreted as part of the capital stock of transport and storage. The data on packages according to this definition were obtained from the package statistics of industry. The ending of packages as waste of the users of packaged products was derived in accordance of the use of the products of the packaging industries. For imported products, the package coefficients were assumed to be the same as those for domestic products.

5 Waste

The basic source of data on the waste generation of manufacturing industries were the waste data for the year 1999 in VAHTI, the information system of the Finnish Environmental Administration. The waste data in VAHTI are classified in accordance with the European Waste Classification, EWC. 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 statistics 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.

Capital wastes includes 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 (Innala 2001).

6 Emissions into air

The main data sources for emissions into the air were the greenhouse gas inventories of Finland (Pipatti 2001, Ministry of the Environment 2002), especially the detailed Excel spreadsheet on inventories, and the data on emissions in Energy statistics (Statistics Finland 2002a, Tables 15.1-.4). Additionally, data from the LIPASTO calculation system of the Technical Research Centre of Finland (Mäkelä et al. 2002) were utilised for the estimation of emissions from transport and working machines.

Energy-related emissions were allocated to industries as part of the general accounting of mass balances of fuel combustion. Other process-related emissions were estimated separately.

Emissions from international transports in the Finnish sea and air territory, needed as conversion items of emission balances, are mainly based on data from the LIPASTO system (Mäkelä et al. 2002).

The data on cross-boundary movements of sulphur, nitrogen and ammonium emissions were obtained from calculations for the year 2000 in the international EMEP programme (EMEP 2003).

7 Discharges into water

Estimates of discharges into water by industry are based on data compiled by the "'Water accounts" project of Statistics Finland (Muukkonen 2003) and on the data of Silvo et al. (2002). The main substances of the discharges are total nitrogen, total phosphorus and biological or chemical oxygen consumption. However, oxygen consumption is not a discharge itself but measures the oxygen consumption caused by organic materials decomposing in water. Thus, oxygen consumption has to be converted into the related mass of organic material.

8 Indirect inputs of imports

Indirect inputs of imports comprise the material inputs (raw materials and unused extraction) that are required to produce the imported products but not included in the mass of those products. The coefficients of indirect inputs are mainly based on estimates provided by the Wuppertal Institute (Bringezu 2000). The coefficients have been previously used in the compilation of a time series on the total resource use of Finland (Mäenpää et al. 2000). In this project which studied certain imported products, such as coal, natural gas, limenite and nuclear fuel, the coefficients were estimated in accordance with the special conditions relating to Finnish imports. To improve the coverage of the coefficients they were now estimated for some additional imported products, like fish, textiles and certain chemicals.

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Annex 3

Accounting methods

Content

1 Introduction

In the following, calculation methods are presented for four themes: moisture changes of product flows, mass balances of combustion of fuels, mass content of water discharges and biological metabolism of cultivated plants, domestic animals and human population. The exact method for biological metabolism is increasingly in special focus because the difficulties of accurate measurement encountered so far are underlined in the SEEA (2003, 117).

2 Changes in the water content of products

In primary production, the water content of the products entering the economy is often high: 25 – 90% for plants, 45% for wood and about 10% for minerals. In the basic industries where these raw materials are processed into intermediate and final products the moisture of the material flows is generally lowered. The drying is most often realised through evaporation, in which case the water leaving the product flow remains unobserved.

Some products, such as beverages and paints include added water.

To keep the mass balances of material flows in order, moisture changes or additions of water and evaporation, have to be included in them.

However, a relatively simple method can be developed for managing moisture changes in the compilation of physical flow accounts.

Let m_i be the moisture rate of product i, u_{ij} the use of product i by industry j and s_{ij} the supply of product i by industry j. Then

$w_j = \Sigma_i m_i s_{ij} - \Sigma_i m_i uij\ \Sigma_i m_i(s_{ij} - u_{ij})$, and
$|w_j|$ = water input, if $w_j > 0$
= water vapour output, if $w_j < 0$.

The equation can be presented more comprehensively in a matrix form as follows. Let **m** be the vector of moisture rates of products, **S** the product x industry supply matrix and **U** the product x industry use matrix. Then

$\mathbf{w} = \mathbf{m}'\mathbf{S} - \mathbf{m}'\mathbf{U} = \mathbf{m}'(\mathbf{S}\text{-}\mathbf{U})$, where
$|w_j|$ = water input, if $w_j > 0$
= water vapour output, if $w_j < 0$.

Physical flow accounts include 718 material products. Moisture rates are estimated for 236 products at the beginning of the processing chains. In refined products the water content is generally so low that moisture changes have no significance. However, working with a product by product moisture vector means that new data about significant moisture contents can be easily included in the compilation system.

Industries where the share of released water vapour is high are especially forest industries, manufacture of food products and manufacture of non-metallic minerals. Added water can be found in the manufacture of beverages, manufacture of chemicals and manufacture of non-metallic minerals. The water shares in inputs and outputs are presented separately for the food and forest industries in Table 2.1.

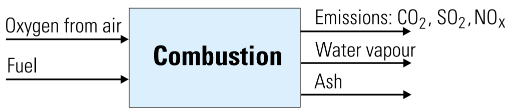
Table 2.1 Shares of added water in inputs and of water vapour in outputs of selected industries

		Input			Output		
		Water	Products	Total	Products	Water	Total
4	Manufacture of food products	0.7	99.3	100.0	79.0	21.0	100.0
5	Manufacture of beverages & tobacco	56.1	43.9	100.0	99.7	0.3	100.0
7	Manufacture of wood & wood products	0.0	100.0	100.0	79.7	20.3	100.0
8	Manufacture of pulp, paper, paper products	0.0	100.0	100.0	72.2	27.8	100.0

3 Combustion of fuels

Combustion of fuels combines the combustible substances of fuels and the oxygen of the air and thus transforms them into gases. The heat born in the combustion also evaporates the water contained in the fuel. The incombustible substances of the fuel are left as ash.

Figure 3.1.
Material flows of combustion



In principle, the material flows of combustion could be accounted for from the substance composition of fuels. The substance composition of fuels classified in accordance with the physical flow accounts is expressed in Table 3.1. The data are mainly derived from Alakangas (2000).

In the conditions of complete combustion, the material flows of combustion could be accounted precisely from data on substance composition: from the elements of the fuel, carbon C, nitrogen N, and sulphur S are oxidised into CO_2, NO_2 (mainly) and SO_2. Hydrogen H is oxidised into water H_2O and is combined with the vapour of the water originally contained in the fuel. The external oxygen required is obtained by subtracting the oxygen contained in the fuel from the oxygen used to oxidise the other elements of the fuel.

In practice, however, the combustion is incomplete and emissions are reduced with end-of-pipe measures. In incomplete combustion, some of the combustible substances remain in the ash, some of the carbon is oxidised into carbon monoxide CO only or released as methane CH_4. In high temperatures, some of the nitrogen contained in the combustion air is oxidised, too. Thus, the exhaust fumes of cars have high nitrous oxide emissions although the transport fuels do not contain nitrogen.

The "empirical" emission coefficients of fuels obtained from the GHG inventory and emission statistics of Finland (Pipatti 2001, Statistics Finland 2002) are shown in Table 3.3. For most of the fuels, the share of carbon dioxide is over 99% of the total emissions. Thus, in rough estimates, the other emissions could be ignored. However, including them in accounts is useful for maintaining an exact connection with emission statistics.

With the empirical emission coefficients, external oxygen and oxidised nitrogen of air can be obtained by the equation:

Oxygen and nitrogen from air = (Ash + Water vapour + Emissions to air) – Mass of fuel.

Table 3.1. Mass-energy relation and substance composition of the most important fuels

Code	Fuel	kg/GJ	Substance composition Moisture	Ash	C	H	O	N	S	Total
1111	Refinery Gas	19.3	0.000	0.000	0.921	0.061	0.008	0.007	0.004	1.000
1112	Liquefied Petroleum Gas	21.6	0.000	0.000	0.798	0.202	0.000	0.000	0.000	1.000
1121	Naphtha	22.8	0.000	0.000	0.855	0.145	0.000	0.000	0.000	1.000
1122	Motor Gasoline	22.8	0.000	0.000	0.870	0.130	0.000	0.000	0.000	1.000
1123	Aviation Gasoline	23.2	0.000	0.000	0.870	0.130	0.000	0.000	0.000	1.000
1131	Kerosene Type Jet Fuel	23.1	0.000	0.000	0.881	0.118	0.000	0.000	0.000	1.000
1132	Other Kerosene	23.2	0.000	0.000	0.841	0.159	0.000	0.000	0.000	1.000
1133	Diesel Fuel	24.1	0.000	0.000	0.846	0.151	0.002	0.000	0.000	1.000
1134	Light Fuel Oil for Heating	23.5	0.000	0.000	0.862	0.135	0.002	0.000	0.001	1.000
1135	Light Fuel Oil for Working Machines	23.5	0.000	0.000	0.862	0.134	0.002	0.000	0.002	1.000
1141	Heavy Fuel Oil for Heating	24.3	0.003	0.000	0.868	0.116	0.003	0.005	0.005	1.000
1142	Heavy Fuel Oil, Ships	24.6	0.005	0.000	0.868	0.107	0.010	0.000	0.009	1.000
1143	Other Heavy Fuel oils	24.6	0.005	0.000	0.868	0.110	0.010	0.000	0.005	1.000
1150	Petroleum Coke	28.1	0.000	0.000	0.752	0.100	0.100	0.044	0.004	1.000
1160	Recycled Waste Oil	24.4	0.000	0.000	0.857	0.126	0.002	0.000	0.015	1.000
1190	Other Petroleum Prod	27.1	0.005	0.000	0.844	0.130	0.012	0.000	0.008	1.000
1212	Hard Coal	39.7	0.100	0.126	0.657	0.036	0.068	0.010	0.002	1.000
1222	Patent Fuel	39.7	0.100	0.126	0.657	0.036	0.068	0.010	0.002	1.000
1230	Coke Oven Coke	34.1	0.000	0.000	0.864	0.055	0.055	0.025	0.001	1.000
1240	Coke Oven Gas	16.3	0.000	0.000	0.679	0.187	0.077	0.047	0.010	1.000
1250	Blast Furnace Gas	214.7	0.000	0.000	0.358	0.005	0.636	0.000	0.001	1.000
1310	Natural Gas	20.3	0.000	0.000	0.738	0.244	0.006	0.012	0.000	1.000
2110	Milled Peat	98.7	0.500	0.025	0.293	0.024	0.148	0.008	0.001	1.000
2120	Sod Peat	81.2	0.400	0.030	0.308	0.035	0.214	0.012	0.001	1.000
3111	Firewood	78.1	0.225	0.009	0.383	0.046	0.331	0.006	0.000	1.000
3112	Small Tree Chips	121.1	0.500	0.006	0.247	0.030	0.213	0.004	0.000	1.000
3113	Forest Residue Chips	122.0	0.500	0.010	0.245	0.029	0.212	0.004	0.000	1.000
3121	Bark	101.7	0.400	0.012	0.294	0.035	0.254	0.005	0.000	1.000
3122	Sawdust etc.	100.1	0.400	0.003	0.299	0.036	0.258	0.005	0.000	1.000
3123	Industrial Chips	102.7	0.400	0.018	0.291	0.035	0.251	0.005	0.000	1.000
3129	Other	102.7	0.400	0.018	0.291	0.035	0.251	0.005	0.000	1.000
3130	Black Liquor	84.2	0.250	0.015	0.355	0.039	0.340	0.000	0.000	1.000
3140	Other Residues from Wood Industry	84.2	0.250	0.015	0.355	0.039	0.340	0.000	0.000	1.000
3150	Construction and Demolition Wood	82.2	0.250	0.023	0.364	0.044	0.314	0.006	0.000	1.000
3160	Patent Wood Fuels	49.8	0.150	0.026	0.412	0.049	0.356	0.007	0.000	1.000
3210	Gases Derived from Biomass and Wastes	38.7	0.020	0.000	0.370	0.070	0.432	0.097	0.011	1.000
3230	Recovered/Recycled Fuel	119.4	0.250	0.038	0.356	0.049	0.303	0.003	0.001	1.000
4110	Nuclear Fuel	0.0	0.000	1.000	0.000	0.000	0.000	0.000	0.000	1.000
4910	Other By-products and Wastes	62.5	0.250	0.050	0.350	0.048	0.298	0.003	0.001	1.000

Table 3.2. Emission coefficients of fuels, kg/GJ

Code	Fuel	CO_2-min	CH_4	N_2O	SO_2	NO_x	CO	NMVOC	Particles	CO_2-bio
1111	Refinery Gas	65.0	0.007	0.002	0.138	0.119	0.021	0.000	0.019	0.0
1112	Liquefied Petroleum Gas	63.1	0.004	0.002	0.015	0.107	0.032	0.000	0.000	0.0
1121	Naphtha	72.5	0.090	0.008	0.008	0.197	0.402	0.000	0.000	0.0
1122	Motor Gasoline	72.7	0.030	0.011	0.003	0.520	4.140	0.470	0.002	0.0
1123	Aviation Gasoline	71.5	0.000	0.000	0.002	0.086	23.946	0.314	0.000	0.0
1131	Kerosene Type Jet Fuel	74.4	0.000	0.000	0.019	0.224	0.093	0.027	0.000	0.0
1132	Other Kerosene	71.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0
1133	Diesel Fuel	74.1	0.004	0.002	0.001	0.605	0.248	0.077	0.060	0.0
1134	Light Fuel Oil for Heating	74.1	0.007	0.008	0.030	0.090	0.190	0.000	0.015	0.0
1135	Light Fuel Oil for Working Machines	75.4	0.004	0.031	0.082	1.300	0.480	0.215	0.137	0.0
1141	Heavy Fuel Oil for Heating	77.4	0.006	0.003	0.230	0.090	0.032	0.000	0.044	0.0
1142	Heavy Fuel Oil, Ships	77.4	0.006	0.003	0.450	1.900	0.032	1.200	0.060	0.0
1143	Other Heavy Fuel Oils	77.4	0.006	0.003	0.266	0.098	0.032	0.000	0.044	0.0
1150	Petroleum Coke	77.4	0.006	0.003	0.244	0.090	0.032	0.000	0.000	0.0
1160	Recycled Waste Oil	77.4	0.004	0.002	0.718	0.170	0.010	0.000	0.000	0.0
1190	Other Petroleum Products	76.6	0.006	0.003	0.429	0.195	0.032	0.000	0.000	0.0
1212	Hard Coal	94.6	0.005	0.004	0.162	0.154	0.014	0.000	0.010	0.0
1222	Patent Fuel	94.6	0.005	0.004	0.162	0.154	0.014	0.000	0.010	0.0
1230	Coke Oven Coke	108.0	0.007	0.003	0.035	0.244	0.061	0.000	0.000	0.0
1240	Coke Oven Gas	40.5	0.004	0.001	0.317	0.142	0.034	0.000	0.146	0.0
1250	Blast Furnace Gas	282.1	0.002	0.001	0.317	0.142	0.039	0.000	0.146	0.0
1310	Natural Gas	56.1	0.005	0.002	0.001	0.058	0.028	0.000	0.000	0.0
2110	Milled Peat	106.0	0.009	0.017	0.199	0.160	0.053	0.000	0.013	0.0
2120	Sod Peat	106.0	0.010	0.016	0.199	0.160	0.073	0.000	0.013	0.0
3111	Firewood	0.0	0.300	0.002	0.000	0.061	1.151	0.612	0.160	108.5
3112	Small Tree Chips	0.0	0.046	0.003	0.000	0.098	0.450	0.000	0.160	109.6
3113	Forest Residue Chips	0.0	0.032	0.010	0.000	0.133	0.294	0.000	0.160	109.6
3121	Bark	0.0	0.030	0.012	0.000	0.095	0.225	0.000	0.160	109.6
3122	Sawdust etc.	0.0	0.035	0.009	0.000	0.095	0.316	0.000	0.160	109.6
3123	Industrial Chips	0.0	0.033	0.009	0.000	0.095	0.302	0.000	0.160	109.6
3129	Other	0.0	0.029	0.012	0.000	0.095	0.223	0.000	0.160	109.6
3130	Black Liquor	0.0	0.001	0.002	0.057	0.077	0.132	0.000	0.036	110.0
3140	Other Residues from Wood Industry	0.0	0.004	0.013	0.057	0.077	0.110	0.000	0.036	109.6
3150	Construction and Demolition Wood	0.0	0.029	0.012	0.000	0.095	0.223	0.000	0.160	109.6
3160	Patent Wood Fuels	0.0	0.033	0.009	0.000	0.118	0.302	0.000	0.000	109.6
3210	Gases Derived from Biomass & Wastes	0.0	0.004	0.004	0.003	0.153	0.013	0.000	0.000	52.5
3230	Recovered/Recycled Fuel	0.0	0.015	0.030	0.000	0.121	0.040	0.000	0.160	157.4
4110	Nuclear Fuel	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.0

Table 3.3. Mass balances of fuel combustion per one GJ of fuels

		INPUT			OUTPUT			
Code	Fuel	Fuel	Air	Total	Emissions	Ash	Vapour	Total
1111	Refinery Gas	19.3	81.1	100.3	65.3	0.0	35.0	100.3
1112	Liquefied Petroleum Gas	21.6	69.8	91.4	63.3	0.0	28.1	91.4
1121	Naphtha	22.8	76.8	99.7	73.2	0.0	26.5	99.7
1122	Motor Gasoline	22.8	80.9	103.7	77.9	0.0	25.8	103.7
1123	Aviation Gasoline	23.2	96.7	119.9	95.8	0.0	24.1	119.9
1131	Kerosene Type Jet Fuel	23.1	84.7	107.8	74.8	0.0	33.0	107.8
1132	Other Kerosene	23.2	79.9	103.1	71.5	0.0	31.6	103.1
1133	Diesel Fuel	24.1	80.0	104.1	75.1	0.0	29.0	104.1
1134	Light Fuel Oil for Heating	23.5	79.2	102.7	74.4	0.0	28.3	102.7
1135	Light Fuel Oil for Working Machines	23.5	78.3	101.9	77.6	0.0	24.3	101.9
1141	Heavy Fuel Oil for Heating	24.3	77.0	101.3	77.8	0.0	23.5	101.3
1142	Heavy Fuel Oil, Ships	24.6	78.9	103.5	81.1	0.0	22.4	103.5
1143	Other Heavy Fuel Oils	24.6	75.4	100.1	77.8	0.0	22.2	100.1
1150	Petroleum Coke	28.1	81.6	109.7	77.8	0.0	31.9	109.7
1160	Recycled Waste Oil	24.4	82.4	106.8	78.3	0.0	28.5	106.8
1190	Other Petroleum Products	27.1	59.1	86.2	77.3	0.0	8.9	86.2
1212	Hard Coal	39.7	77.1	116.8	94.9	5.0	16.9	116.8
1222	Patent Fuel	39.7	84.0	123.7	94.9	5.0	23.8	123.7
1230	Coke Oven Coke	34.1	131.6	165.7	108.4	0.0	57.4	165.7
1240	Coke Oven Gas	16.3	25.6	41.9	41.1	0.0	0.7	41.9
1250	Blast Furnace Gas	214.7	539.6	754.4	282.7	0.0	471.6	754.4
1310	Natural Gas	20.3	40.4	60.6	56.2	0.0	4.4	60.6
2110	Milled Peat	98.7	90.8	189.5	106.5	2.5	80.6	189.5
2120	Sod Peat	81.2	93.7	174.9	106.5	2.4	66.0	174.9
3111	Firewood	78.1	70.0	148.1	110.8	0.7	36.6	148.1
3112	Small Tree Chips	121.1	82.5	203.6	110.4	0.8	92.5	203.6
3113	Forest Residue Chips	122.0	89.1	211.1	110.2	1.2	99.7	211.1
3121	Bark	101.7	83.1	184.8	110.1	1.2	73.4	184.8
3122	Sawdust etc.	100.1	81.8	181.9	110.2	0.3	71.4	181.9
3123	Industrial Chips	102.7	82.6	185.4	110.2	1.8	73.3	185.4
3129	Other	102.7	86.5	189.2	110.1	1.8	77.3	189.2
3130	Black Liquor	84.2	78.1	162.3	110.3	1.3	50.7	162.3
3140	Other Residues from Wood Industry	84.2	81.1	165.3	109.9	1.3	54.1	165.3
3150	Construction and Demolition Wood	82.2	86.9	169.0	110.1	1.8	57.1	169.0
3160	Patent Wood Fuels	49.8	100.3	150.1	110.1	1.3	38.7	150.1
3210	Gases Derived from Biomass & Wastes	38.7	31.8	70.5	52.6	0.0	17.9	70.5
3230	Recovered/Recycled Fuel	119.4	72.7	192.0	157.8	4.5	29.8	192.0
4110	Nuclear Fuel	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4910	Other By-products and Wastes	62.5	32.0	94.5	75.8	3.1	15.5	94.5

When accounting for a per mass unit of fuel, ash is obtained direct from the Ash column of Table 3.1, water is obtained by adding to the Water column of the table the water formed by oxidising hydrogen, from which the hydrogen content of methane and NMVOC emissions are first subtracted. Emissions to air are obtained from Table 3.2.

Table 3.3 shows the obtained material flow balances of combustion. Mass balances of combustion by industry are obtained by multiplying the energy value of fuel use by industry by the figures in the table.

For keeping the mass balance calculations uniform, a change has been made to the energy balances of steel making in comparison to the definitions and methods used in energy statistics. In steel making, the blast furnace is fed with coke and oil for generating the heat needed for smelting ferrous concentrate and tying up the oxygen of the concentrate. The flue gases generated in the oxygen-scarce space contain non-combusted substances, such as carbon monoxides and thus the flue gases are taken care of as blast furnace gas, the energy content of which is further utilised. In the Energy statistics of Statistics Finland, blast furnace coke, oil and gas are all accounted as energy sources, but the heat value of coke is subtracted from the energy content of blast furnace gas to prevent double accounting. The combustion mass balance calculations for blast furnace coke and oil would become exceptional in this approach: their emissions into the air would in this case form a new fuel, and the ash would also be embodied in the more general residual flow, such as in blast furnace slag. Therefore, in the physical flow accounts, blast furnace coke and oil are treated as raw materials and their net heat value is considered as an immaterial energy source, a reaction heat from the blast furnace. Thus, the general energy balance of steel making is kept uniform with Energy statistics.

A considerable share (about 60%) of the mass content of blast furnace gas is formed by nitrogen molecules, N_2. Nitrogen molecules are very inactive, they are derived from the air used in the processes and leave the combustion process without taking part in the combustion. Therefore, nitrogen is subtracted from the mass of blast furnace gas.

4 Discharges into water

The data on discharges in the Finnish waste water statistics contain sample measurement estimates on total nitrogen (tot N), total phosphorus (tot P) and metal discharges. Discharges of organic materials are indicated indirect by oxygen consumption measured either as biological oxygen consumption (BOD_7) or chemical oxygen consumption (COD). Table 4.1 shows discharge data by industry. Only the COD is shown because it is considered as a more reliable indicator of mass of organic materials.

For estimating the mass of organic materials from the COD the data are problematic. As a preliminary estimate, it is assumed that organic materials include only carbohydrates $(CH_2O)_n$ for which the decomposition equation is $CH_2O + O_2 \longrightarrow H_2O + CO_2$. Using atomic weights, we assume that the relation of the mass of organic materials to the oxygen consumed is 0.95. However, in order to take into account the share of inorganic materials, the coefficient is cautiously raised to 1.1 for industries other than the manufacture of pulp and paper. For industries where the COD is not measured, the share of organic and other materials are estimated from the total nitrogen release by using a coefficient of 2.7, which is the average relation in those industries where the COD is measured, except for the pulp and paper industry. The total mass estimates are shown in the rightmost column of the table. However, these estimates should be considered as preliminary and rather unreliable.

Table 4.1. Data on discharges into water in waste water statistics and total mass estimate, Mkg

No	Description	COD	tot N	tot P	Metals	Total mass
1	Agriculture, hunting and fishing		41 278.0	367.0		183 630
2	Forestry, logging etc		4 192.0	356.0		18 738
3	Mining of energy minerals		11.0	5.0		4 830
4	Other mining and quarrying	647.8	11.5	0.4	44.9	762
5	Manufacture of food products	417.6	88.9	6.5	1.5	610
6	Manufacture of textiles etc	148.2	18.3	0.3		186
7	Manufacture of wood and wood products	966.3	5.0	3.3		982
8	Manufacture of pulp, paper & paper products	203 288.8	2 853.2	224.2		209 444
9	Publishing, printing etc					0
10	Manufacture of coke and petroleum refineries	899.6	49.4	3.1		1 004
11	Manufacture of chemicals etc	3 867.4	327.7	9.8	198.5	4 940
12	Manufacture of rubber and plastic products	24.2	14.4	0.3		234
13	Manufacture of non-metallic mineral products	4.2	7.6	0.5	0.2	20
14	Manufacture of basic metals	34.7	489.9	1.2	155.5	1 328
15	Manufacture of metal products	9.2	6.6	0.2	9.9	150
16	Manufacture of machinery and equipment	0.2	0.3	0.4	2.3	4
17	Manufacture of electrical equipment	31.4	1.9	0.6	0.7	34
18	Manufacture of transport equipment					0
19	Manufacturing n.e.c.					0
20	Recycling		0.2	0.2	0.1	0
21	Electricity, gas & water supply	527.0	25.4	0.9	1.8	584
26	Transport and telecommunication		2.0	0.3		48
27	Dwellings					0
28	Public administration and services	0.1	0.4	0.6	0.1	0
29	Sewage and refuse disposal	2 779.5	12 198.3	259.2		52 624
30	Other service activities		0.1	0.3		0
	Households		273.0	41.0		12 560
	Total					**492 710**

5 Biological metabolism

5.1 Introduction

The methods for calculating the metabolic balances of plant cultivation, domestic animals and human population were first developed in the project "Material flows and eco-efficiency of agriculture" carried out in collaboration by the Agricultural and Food Research Centre of Finland and the Thule Institute. The methods have been published earlier in Finnish in Mäenpää & Vanhala (2002). In that work, the calculations were done for the year 1995 and are here now updated for 1999.

The basic objective behind the work was to develop such calculation models for metabolic mass balances which from the available statistical data on agriculture, food production and consumption could exactly compute the unobservable flows of metabolic mass balances using the considerable empirical knowledge obtained – and revealed – in the nutrition research of domestic animals and humans.

The basic building blocks of nutrition research are the nutrients and the metabolic flows of living organisms generated by their synthesising and combusting. Thus, in order to develop exact calculation methods for metabolisms, the exact stoiciometric chemistry of nutrients has to be first revealed. This has been done in Chapter 5.2.

5.2 Basic chemistry of metabolism

Nutrients

The material content of living organisms can be divided into the following nutrients:

Carbohydrates
Proteins
Fats
Alcohol
Minerals
Water.

The first four are called energy nutrients, because their combustion is the basis for the energy production of living organisms. Of the energy nutrients, only alcohol belongs to human nutrition. In nutrition studies, carbohydrates are often divided further into easily digested carbohydrates and indigestible fibres.

The nutrient composition of the plant and animal products contained in the food chain has been extensively plotted out by nutrition research. Some examples of these are presented in Table 5.2.1.

Table 5.2.1. Nutrient composition of plant and animal products, some examples

	Nutrient composition, % on average						
	Proteins	Fats	Carbo-hydrates	Fibres	Minerals	Water	Total
Plants							
Potato	2.1	0.0	18.0	0.7	1.2	78.0	100.0
Wheat	11.9	1.9	67.7	2.8	1.7	14.0	100.0
Pasture grass	3.4	0.8	8.8	4.2	1.8	81.0	100.0
Tomato	1.0	0.3	3.5	0.7	0.5	94.0	100.0
Garden berries	0.5	0.6	7.5	1.9	0.5	89.1	100.0
Animals							
Beef cattle	18.0	10.0	0.0	0.0	4.0	68.0	100.0
Suckling pig	12.0	36.0	0.0	0.0	2.6	49.4	100.0
Milk	3.3	4.3	4.3	0.0	0.7	87.4	100.0
Egg (with shell)	13.0	10.5	0.0	0.0	10.5	66.0	100.0
Egg (without shell)	12.1	11.8	0.3	0.0	1.1	74.6	100.0
Human body	18.0	18.0	0.0	0.0	4.3	59.7	100.0

The egg appears in the Table both with and without shell as an example of a product which can be different in content, on the one hand, as an animal product and, on the other, as edible food.

Energy nutrients are mainly composed of four elements: carbon (C), hydrogen (H), oxygen (O) and nitrogen (N). Nitrogen is only contained in proteins. Each energy nutrient has a characteristic molecular structure, and even though especially proteins and fats are comprised of a variety of molecules, the elementary composition of each of them is relatively similar. Table 5.2.2 presents the average relative elementary composition of energy nutrients.

Table 5.2.2. Average elementary composition of energy nutrients, % in mass units (Source: Maynard et al. 1979, 63)

Elements	Carbohydrates	Fats	Proteins	Alcohol
C	44	77	54	52
H	6	12	7	13
O	50	11	23	35
N			16	
Total	**100**	**100**	**100**	**100**

With dissimilar molecular structures, nutrients from different sources may differ in elementary composition to some extent. The range of variation in the elementary composition of proteins is presented in Table 5.2.3 as an example. Proteins also include some sulphur (S) and phosphorus (P). However, in the calculations of this study they are rounded away due to their minor mass share.

Table 5.2.3.
Range of variation in the elementary composition of proteins, %
(Maynard et al. 1979, 137)

Elements	Symbol	Lower	Upper
Carbon	C	51.0	55.0
Hydrogen	H	6.5	7.3
Oxygen	O	21.5	23.5
Nitrogen	N	15.5	18.0
Sulphur	S	0.5	2.0
Phosphorus	P	0.0	1.5

Mass balances of photosynthesis

The basic production of nutrients occurs in the photosynthesis of plants. Below, the mass balances of nutrient photosynthesis are derived by means of the elementary composition of nutrients. To refresh the basics, the atomic masses of the elements included in nutrients are presented in Table 5.2.4. The masses of the most important molecules are shown in Table 5.2.5.

Table 5.2.4
Atomic masses of main elements

Name	Symbol	Atomic mass
Carbon	C	12
Hydrogen	H	1
Oxygen	O	16
Nitrogen	N	14

Table 5.2.5.
Masses of main molecules

Name	Equation	Molecular mass
Carbon dioxide	CO_2	44
Water	H_2O	18
Oxygen (from air)	O_2	32

The mass balances of photosynthesis could be derived by means of chemical reaction equations. For example, the reaction equation for the forming of the most important carbohydrate, glucose, is:

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2,$$

which expressed in atomic mass is:

$$6(12+2x16) + 6(2x1+16) \longrightarrow$$
$$(6x12+12x1+6x16) + 6(2x16)$$
$$\longrightarrow 264 +108 \longrightarrow 180+192$$

from which we get:

1.47 kg carbon dioxide + 0.6 kg water
⟶ 1 kg glucose + 1.07 kg oxygen.

Thus, the photosynthesis of one kilogram of glucose uses 1.47 kg of carbon dioxide and 0.6 kg of water and releases 1.07 kg of oxygen.

However, the use of reaction equations presumes homogenous matter the molecular pattern of which is known. Thus, in Table 5.2.6, the material flows of nutrient photosynthesis are derived by means of mass balance tables, where only the (average) elementary composition of a nutrient is needed. The original form of the tables is from Max Kleiber (Kleiber 1987, 83), who used them for the balance calculations of nutrient combustion in animals.

In Table 5.2.6, the mass balance of the photosynthesis of carbohydrates has been formed as follows: the second column presents the elementary composition of carbohydrate per kilogram. Located under the section Building materials are columns for the use of carbon dioxide and water and that for the release of oxygen. The columns are calculated as follows: the carbon content of a kilogram of carbohydrates, 0.44 kg, is taken from the carbon dioxide of air. As two oxygen atoms are released per one carbon atom, a total of ((2*16)/12)*0.44 = 1.17 kg of oxygen is released. Hydrogen, 0.06 kg, is taken from water, which yields (16/(2*1))*0.06 = 0.58 kg of oxygen. Carbohydrates contain oxygen of about half of their mass. The difference between the oxygen tied up in carbohydrates and the oxygen contained in the used carbon dioxide and water, 1.15 kg, is released to the air.

The photosynthesis balances of fats and proteins can be formed in accordance with the method for carbohydrates. As the oxygen content of fats is very low, only 11 per cent, the synthesis of fats releases twice as much oxygen as does the synthesis of the same amount of carbohydrates. The nitrogen contained in proteins is taken up by plants mostly as nitrates, NO_3.

Table 5.2.6. Mass balances of nutrient photosynthesis

Carbohydrates

	Composition kg/kg	Building materials CO_2	H_2O	O_2
C	0.44	0.44		
H	0.06		0.06	
O	0.50	1.17	0.48	–1.15
Total	**1.00**	**1.61**	**0.54**	**–1.15**

Fats

	Composition kg/kg	Building materials CO_2	H_2O	O_2
C	0.77	0.77		
H	0.12		0.12	
O	0.11	2.05	0.96	–2.90
Total	**1.00**	**2.82**	**1.08**	**–2.90**

Proteins

	Composition kg/kg	Building materials CO_2	H_2O	NO_3	O_2
C	0.54	0.54			
H	0.07		0.07		
O	0.23	1.44	0.56	0.55	–2.32
N	0.16			0.16	
Total	**1.00**	**1.98**	**0.63**	**0.71**	**–2.32**

Table 5.2.7. Summary of balances of nutrient photosynthesis, kg/kg

	CO_2	H_2O	NO_3	O_2	Total
Carbohydrates	1.61	0.54	0.00	–1.15	1.00
Fats	2.82	1.08	0.00	–2.90	1.00
Proteins	1.98	0.63	0.71	–2.32	1.00

Table 5.2.7 summarises the mass balances of the photosynthesis of energy nutrients.

Mass balances of metabolic combustion

Animals use some of the energy nutrients for building and renewing their tissue mass but most of them are used for energy production through their combusting. The combustion is a reverse reaction to photosynthesis. In combustion, the solar energy tied up by photosynthesis into the nutrients is released for the use of the vital functions of animals.

The characteristics of the combustion can be demonstrated with an example of glucose. The chemical reaction equation for the combustion of glucose is:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O,$$

which can be expressed by means of atomic weights as:

1 kg glucose + 1.07 kg oxygen ⟶
1.47 kg carbon dioxide + 0.6 kg water.

In the combustion, the nutrient is dissolved with oxygen into carbon dioxide and water.

The mass balances of combustion for different nutrients are presented in Table 5.2.8.

The balance for carbohydrates is formed as follows: when carbon is combusted into carbon dioxide, two atoms of oxygen are tied up for one atom of carbon, or for 0.44 kg of carbon ((2*16)/12)*0.44 = 1.17 kg of oxygen is consumed. In combusting hydrogen into water, one atom of oxygen is needed for two hydrogen atoms, or for 0.06 kg of hydrogen (16/(2*1))*0.06 = 0.48 kg of oxygen is used. Thus, for the carbon dioxide and water formed by combustion, a total of 1.17 + 0.48 = 1.65 kg of oxygen is tied up. Some, or 0.5 kg, of this oxygen is obtained from the oxygen contained in the carbohydrates themselves and the rest, 1.15 kg, is needed from outside.

The low share of oxygen in fats means that fats use twice as much oxygen in their combustion as carbohydrates.

Proteins also include nitrogen in addition to carbon, hydrogen and oxygen. Perfect combustion of proteins should produce carbon dioxide, water and elementary nitrogen (N_2). However, the physiological combustion of proteins is incomplete in the tissues of animals, and the end product of combustion is not elementary nitrogen but for mammals urea, $(NH_2)_2CO$, and for birds uric acid, $C_5H_4N_4O_3$. Thus, the mass balance of protein combustion has to be formed separately for mammals and birds. In forming the balances, the amounts of the elements of urea or uric acid are derived from the amount of nitrogen. Carbon dioxide and water are formed from the carbon and hydrogen left over. Urea and uric acid are yielded quite profusely, urea over one third and uric acid almost half in relation to the original mass of proteins.

The exact term for the alcohol belonging to human nutrition is ethyl alcohol, C_2H_5OH. Ethyl alcohol itself is a metabolic product of yeast fungus. In fermentation, carbohydrates are split into alcohol and carbon dioxide, or expressed in terms of glucose:

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2.$$

With atomic weights, we can calculate that one kg of glucose yields 0.51 kg of ethyl alcohol and 0.49 kg of carbon dioxide. Thus, in the alcohol industry, almost half of the carbohydrates used are lost as carbon dioxide in producing pure alcohol.

The mass balances for the combustion of energy nutrients are summarised in Table 5.2.9. In the table, the balances for proteins are also presented in the form of so-called non-uric protein where the elementary content of urea/uric acid is first subtracted from the elementary content of the original protein. This practice simplifies many metabolic calculations.

Table 5.2.8. Mass balances of nutrient combustion

Carbohydrates

	Compositon kg/kg	Combustion result CO_2	H_2O	O_2
C	0.44	0.44		
H	0.06		0.06	
O	0.50	1.17	0.48	–1.15
Total	**1.00**	**1.61**	**0.54**	**–1.15**

Fats

	Compositon kg/kg	Combustion result CO_2	H_2O	O_2
C	0.77	0.77		
H	0.12		0.12	
O	0.11	2.05	0.96	–2.90
Total	**1.00**	**2.82**	**1.08**	**–2.90**

Proteins, mammals

	Compositon kg/kg	Combustion result Urea	CO_2	H_2O	O_2
C	0.54	0.07	0.47		
H	0.07	0.02		0.05	
O	0.23	0.09	1.26	0.38	–1.50
N	0.16	0.16			
Total	**1.00**	**0.34**	**1.73**	**0.42**	**–1.50**

Proteins, birds

	Compositon kg/kg	Combustion result Uric acid	CO_2	H_2O	O_2
C	0.54	0.17	0.37		
H	0.07	0.01		0.06	
O	0.23	0.14	0.98	0.47	–1.36
N	0.16	0.16			
Total	**1.00**	**0.48**	**1.35**	**0.53**	**–1.36**

Alcohol

	Compositon kg/kg	Combustion result CO_2	H_2O	O_2
C	0.52	0.52		
H	0.13		0.13	
O	0.35	1.39	1.04	–2.08
Total	**1.00**	**1.91**	**1.17**	**–2.08**

Table 5.2.9. Summary of the mass balances of nutrient combustion, kg/kg

	CO_2	H_2O	Urea/uric acid	O_2	Total
Carbohydrates	1.61	0.54		–1.15	1.00
Fats	2.82	1.08		–2.90	1.00
Proteins, mammals	1.73	0.42	0.34	–1.50	1.00
Protein, without urea	2.66	0.65		–2.31	1.00
Proteins, birds	1.35	0.53	0.48	–1.36	1.00
Protein, without uric acid	2.60	1.02		–2.62	1.00
Ethyl alcohol	1.91	1.17		–2.08	1.00

Energy content of nutrients

In nutrition studies, the gross energy of nutrients means their heat value in the conditions of perfect combustion. The average gross energies of nutrients are presented separately for human food and animal feed in Table 5.2.10. The differences of gross energies between nutrients in food and feed are explained by the differing average elementary composition of nutrients in food and feed.

Table 5.2.10.
Average gross energy values of nutrients in human food and animal feed, MJ/kg (human food: Yki-Järvinen 1999, 258, feed: Tuori et al. 1996, 8)

	Food	Feed
Carbohydrates	17.5	17.3
Fats	39.3	34.1
Proteins	24.0	24.2
Ethyl alcohol	29.6	

The energy value of fats is much higher than that of the others. As presented in Table 5.2.8, the main reason for this is that as they contain little oxygen fats take a lot of oxygen from outside for their combustion whereas the other nutrients have a larger share of oxygen and thus use less external oxygen.

The physiology of animals and humans cannot utilise the entire gross energy of the eaten feed or food. The undigested nutrients leave the body as faeces and the energy content of nutrients is thus left unused in faeces. The urea formed in the incomplete combustion of proteins leaves the body in urine, as also does the energy of urea. The splitting of nutrients by intestinal bacteria yields methane, which leaves the body as intestinal gases. The energy values of urea, uric acid and methane are presented in Table 5.2.11.

Table 5.2.11.
Energy values of some nutrient excretions

	MJ/kg
Urea	10.6
Uric acid	11.5
Methane	55.8

In studies of human nutrition, the energy values of nutrients are generally expressed as *physiological fuel values*. Physiological fuel values measure the energy the human body can utilise from the gross energy of nutrients. A physiological fuel value corresponds to the concept of *metabolic energy* used in the nutrition research of domestic animals. One central factor is the digestibility of nutrients, i.e. the amount of nutrients the digestive organs of a human can absorb to be used by the body and what proportion goes through the digestive system. A further factor is the incomplete combustion of proteins.

Gross energy, digestibility and physiological fuel values of nutrients are presented in Table 5.2.12. The energy value of urea is subtracted from the gross energy of proteins. The average energies depend on the assumed sub-composition of the nutrients and, thus, these figures differ somewhat in literature.

Table 5.2.12. Gross energy, digestibility and physiological fuel values of nutrients (Yki-järvinen 1999, 258; Maynard et al. 1978, 199)

	Gross energy	Digestibility	Physiological fuel values
	kJ/g	%	kJ/g
Carbohydrates	17.5	97	16.7
Fats	39.3	95	37.6
Proteins	24.0 – 5.8	92	16.7

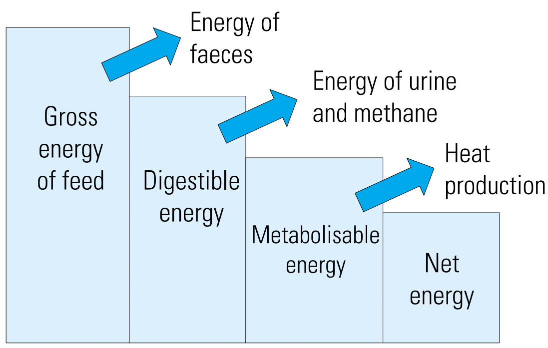
In the nutrition research of domestic animals, the nutritional properties of feeds have been studied quite comprehensively, see e.g. Maynard et al. (1972) and Tuori et al. (1996). In feed studies, utilisation of the gross energy of feeds is analysed in multiple steps as illustrated in Figure 5.2.1.

The indigestible part of the gross energy of feed leaves the animal body as faeces. On average, about one quarter of the gross energy leaves the body in faeces. Some of the energy of the digestible nutrients leaves as intestinal gases, methane, and in urine. Of the metabolisable energy left, the energy that is used to split nutrients and build tissue compounds vanishes furthermore as heat. The net energy left is eventually usable for the building of tissues and for vital functions.

In feed studies, the metabolisable, or net, energy is generally estimated.

Although the nutrition cycle is generally expressed as an energy cycle, only about half of the energy nutrients are combusted into energy. One quarter pass through the intestinal system and one quarter is used as building materials for body and animal products.

Figure 5.2.1.
Distribution of the gross energy of feed



5.3 Mass balances of plant cultivation

Crop yield

Total crop yields of plant cultivation in Finland in 1999 are presented in Table 5.3.1 by plant type. Estimated crops of kitchen gardens for households' own use are added to the crops of ordinary agriculture.

The data on the crop yields of ordinary agriculture mostly derive from the Yearbook of farm statistics. Pasture grass, however, is reported only by cultivated area and ornamental plants are reported partly by the piece and partly by cultivated area. The yield for pasture grass is estimated in this study as 16,000 kg/ha. The conversion of ornamental plants to mass units is presented in Mäenpää et al. (2000b, 13). Straw includes the use of straw as a drying agent in animal husbandry and the amount is estimated from the use side.

The crop yield estimates of kitchen gardens are based on the results of the household consumption studies of Statistics Finland, see also Mäenpää et al. (2000b, 13).

Plant nutrient use of crop yield

Table 5.3.2. presents calculations for the nutrient contents of the crop yields.

The columns of nutrient compositions express the nutrient compositions of the used part of each cultivated plant. The column of coefficients of ancillary biomass presents the estimated relations of the unused parts of plants (stalks, leaves, roots) to the used parts. The total utilised crop yield and its content of nutrients are shown at the bottom of the table. Calculated total ancillary biomass and the biomass yield of fallows and their nutrient contents are also shown.

Table 5.3.1. Total crop yields of plant cultivation in Finland 1999, Mkg

	Ordinary agriculture	Kitchen gardens	**Total**
Wheat	298		**298**
Barley	1 568		**1 568**
Rye	24		**24**
Oats	990		**990**
Potatoes	706	85	**791**
Legumes	11	1	**12**
Turnip rape and rape seeds	88		**88**
Sugar beet	1 172		**1 172**
Straw	500		**500**
Hay	593		**593**
Silage	6 799		**6 799**
Other fodder	321		**321**
Pasture grass	1 816		**1 816**
Ornamental plants	22		**22**
Tomatoes	36	2	**38**
Onions	16	0	**16**
Cabbages	35	4	**39**
Lettuces	4	1	**5**
Root crops	62	28	**90**
Cucumbers	44	0	**44**
Other vegetables	39	3	**42**
Fruits and nuts	8	34	**42**
Garden berries	12	28	**40**
Total	**15 164**	**186**	**15 350**

Table 5.3.2. Total biomass production of plant cultivation in Finland 1999 and its nutrient content

Plant	Crop Mkg	Nutrient composition, % Carbo-hydrates	Fats	Proteins	Minerals	Water	Ancillary biomass coefficient
Wheat	298	70.5	1.9	11.9	1.7	14.0	1.40
Barley	1 568	70.8	1.9	10.8	2.5	14.0	1.40
Rye	24	71.2	1.7	11.2	1.9	14.0	1.40
Oats	990	66.6	5.3	11.2	3.1	14.0	1.20
Potatoes	791	18.7	0.0	2.1	1.2	78.0	0.25
Legumes	12	11.9	0.4	5.1	0.9	81.7	1.00
Turnip rape and rape	88	27.6	38.2	21.6	4.6	8.0	3.30
Sugar beet	1 172	20.1	0.0	1.3	1.6	77.0	1.00
Straw	500	74.4	1.7	3.4	5.5	15.0	0.00
Hay	593	68.9	1.7	8.3	4.2	17.0	1.00
Silage	6 799	16.2	1.1	3.7	2.1	77.0	1.15
Other fodder	321	16.2	1.1	3.7	2.1	77.0	1.00
Pasture grass	1 816	13.0	0.8	3.4	1.8	81.0	1.00
Ornamental plants	22	2.3	0.2	1.1	0.9	95.5	1.00
Tomatoes	38	4.2	0.3	1.0	0.5	94.0	1.00
Onions	16	8.8	0.2	1.3	0.5	89.3	1.00
Cabbages	39	5.7	0.2	1.2	0.8	92.2	0.35
Lettuces	5	2.3	0.2	1.1	0.9	95.5	0.35
Root crops	90	9.7	0.2	1.2	1.0	88.0	1.00
Cucumbers	44	4.9	0.1	0.2	0.7	94.0	1.00
Other plants	42	4.9	0.1	0.2	0.7	94.0	1.00
Fruits and nuts	42	13.2	0.3	0.3	0.3	86.0	2.00
Garden berries	40	9.4	0.6	0.5	0.5	89.1	2.00
Crop total, mill. kg	15 350	4 601	231	763	343	9 412	
Ancillary biomass, mill. kg	15 987	2 585	173	588	331	12 310	
Fallow biomass, mill. kg	4 254	688	46	157	88	3 276	
Total	**35 591**	**7 874**	**449**	**1 508**	**762**	**24 998**	

The nutrient compositions of plants are based on Tuori et al. (1996) for feed plants, and on data obtained from the National Public Health Institute (KTL) for plants used as human food. The coefficients of ancillary biomass can be found in Mäenpää et al. (2000b). The nutrient composition of ancillary biomass is assumed to follow the composition of silage. The biomass yield of fallows is assumed to be 20,000 kg/ha, about half of the per hectare biomass yield of silage.

The total nutrient yield of plant cultivation can be converted into plant nutrients[1)] by means of the mass balances of photosynthesis. The conversion is made in Table 5.3.3. The data of the Total row of Table 5.3.2 have been moved to the "Nutrient

[1)] In the Finnish language the terms "nutrients" – meaning carbohydrates, fats, etc. - and "plant nutrients" - meaning carbon dioxide, water, nitrate, etc. – have more clearly distinctive terms than in English; therefore I have some problems of clear presentation here.

Table 5.3.3. Plant nutrient balance of the plant biomass yield in Finland 1999, Mkg

	Carbohydrates	Fats	Proteins	Minerals	Water	Total
Nutrient yield	**7 874**	**449**	**1 508**	**762**	**24 998**	**35 591**
Plan nutrient use						
Carbon dioxide	12 703	1 269	2 985			16 957
Water	4 252	485	950		24 998	30 685
Nitrate			1 068			1 068
Other minerals				762		762
Oxygen	–9 081	–1 305	–3 496			–13 882
Nutrients total	**7 874**	**449**	**1 508**	**762**	**24 998**	**35 591**

Table 5.3.4. Summary of metabolic balances of plant cultivation 1999, Gkg

INPUT		OUTPUT 1		OUTPUT 2	
Air (CO_2)	17	Air (O_2)	14	Air (O_2)	14
Water	31	Ancillary biomass	20	Water	25
Minerals	2	Harvest	15	Dry-matter	11
Total	**49**	**Total**	**49**	**Total**	**49**

yield" row of the table. The energy nutrients have been converted to the use of plant nutrients and to oxygen release by means of the unit mass balances of photosynthesis. The use of minerals other than nitrates, and the use of water included in the fresh weight of the biomass yield, are obtained as direct transfers. In accordance with the balance principle, the use of plant nutrients subtracted by oxygen released is equal to the yield of the nutrients.

Table 5.3.4 presents the balance summary for plant cultivation. The total material input is 51Gkg, which is distributed into carbon dioxide from air, water and minerals. The total output has been analysed in two ways. Output 1 classifies outflowing materials, in addition to the released oxygen, as ancillary biomass and ordinary crop yield in fresh weights. Output 2 separates the yield into, besides oxygen, total water content and dry matter content.

The balances only include the water embodied in the biomass. However, plants require considerably more water than the embodied water because water also functions as a transporter of plant nutrients. It has been estimated that the total water requirement of plants is some 300 – 500 kg per dry matter yield kg of their above-soil parts (Heinonen et al. 1992, 202).

Tables 5.3.2 – .4 have been computed by an integrated Excel spreadsheet program. Thus, by only supplying new data on crop yields, the balances can be automatically updated for any year.

Mass balance of agricultural soil

The mass balance of agricultural soil is reached when the input side of the mass balances of plant cultivation is added up from the fertilisers, manure, seeds and other inputs of plant cultivation, and the output side is established from other material flows, leaving out the agricultural soil. The mass balance of agricultural soil is presented in Table 5.3.5. The fresh weights of the material flows are separated into dry matter and water flows because an analysis of water is very difficult in respect of agricultural soil.

Table 5.3.5. Mass balance of agricultural soil in 1999, Mkg

INPUT	Fresh mass	Dry matter	Water	OUTPUT	Fresh mass	Dry matter	Water
Seeds	308	203	105	Harvest	15 350	5 937	9 412
Ancillary biomass	20 241	4 655	15 586	Ancillary biomass	20 241	4 655	15 586
Carbon dioxide	16 957	16 957	0	Oxygen	13 882	13 882	0
Oxygen for CO_2 release	2 227	2 227	0	CO_2 from agricultural soil	4 116	4 116	0
Manure and straw	22 586	2 309	20 277	N_2O from agricultural soil	12	12	0
Artificial fertilisers	829	746	83	NH_3 from artificial fertilisers	2	2	0
Lime	819	737	82	NH_3 from manure spreading	8	8	0
Peat	200	160	40	Discharges into water	177	177	0
Sewage sludge	24	19	5				
Biocides	2	2	0				
Fall-outs	43	43	0				
Nitrogen fixation	11	11	0				
Total	**64 247**	**28 070**	**36 177**	**Total**	**53 788**	**28 789**	**24 998**
				Water vapour and drainage, net			**11 179**
				Net add. to agricultural soil		**–720**	
				Total		**28 070**	**36 177**

On the input side of the balance, there are first the seeds and the ancillary biomass recovered into the cultivated soil. As the ancillary biomass also lies on the output side of the balance, it could be netted out, too. However, it is worth noting that about half of the carbon tied up by photosynthesis from the air is moved to the agricultural soil by the ancillary biomass. The amounts of manure and drying straw contained in manure are obtained from the mass balances of animal husbandry in Chapter 5.4. Drying straw that was eliminated from the ancillary biomass in Table 5.3.2 is recovered here as input to agricultural soil. The mass of fertilisers is measured here as the total mass of fertilisers. Generally, fertiliser use is presented in statistics as the quantity of plant nutrient elements – nitrogen, phosphorus, potassium, trace elements – and not as the true total mass of materials used as fertilisers - see e.g. the Yearbook of farm statistics (2002, 90). In fertilisers, the ordinary plant nutrients are as compounds (e.g. NO_3, P_2O_5) and some additive materials are used for granulation. Thus, the share of elementary nutrients in the total mass of fertilisers is only about one third. However, an estimate of the total material mass of used fertilisers is presented in the private statistics of Kemira Agro Oy.

For the input side, the masses of acidification fall-out to agricultural fields and nitrogen fixation are estimated. The estimation methods behind the fall-outs and nitrogen fixation are very rough. However, the estimates show that their share of the total material input is minor.

The output side first contains the crop yield, ancillary biomass and the oxygen released by photosynthesis. Then there are estimates of emissions to the air from agricultural soil. The estimates of carbon dioxide and nitrous oxide emissions born from the mineralisation of organic matter of the soil have been taken from the national greenhouse gas emissions inventory of Finland (Pipatti 2001, 38). The estimates of ammonia emissions from the spreading of fertilisers and manure are from SYKE. Of the emissions to air, only carbon dioxide emissions from organic soil are of significance in total material flows.

The row Total shows that in fresh weight, the measured mass of materials brought to the agricultural soil, 64.2 Gkg, is significantly greater than the mass of materials yielded from the soil, 53.8 Gkg. The main reason for this is that the amount of water incoming with inputs – especially with manure – is greater than the water tied up in the biomass yield. As the treatment of water in mass balances is problematic, it is more meaningful to analyse the dry matter balance. Measured in dry matter, the output, 28.8 Gkg, is somewhat higher than the input, 28.1 Gkg. Thus the net loss of dry matter is 0.7 Gkg.

5.4 Mass balances of animal husbandry

General principles

Modern nutrition research is largely based on the energy approach (e.g. Maynard et al.1979). In the energy approach, the nutriments needed by an animal are first determined as energy requirements. On the other hand, the useful energy of feeds is also estimated. The amount of feed needed to satisfy the nutriment requirements of animals can be determined by combining these data. The nutrient composition is certainly also important. When the costs of feeds are also known, the optimal feed combination that satisfies the total energy requirements of the animal and is appropriate in nutrient content can be determined.

For the assessment of greenhouse gas emissions, the IPCC (1996) has recommended the use of a mathematical model based on the energy approach. However, the model is constructed for cattle only. The model has also been applied in Finland's national greenhouse gas emissions inventory for the methane emissions of cattle (Pipatti 2001, D-4 – D-6).

In this work, the energy approach was also first tested for the formation of metabolic balances for domestic animals. However, it showed that when the quantities of used feed and their nutrient compositions are known, the mass balances of nutrients give a more exact approach to the mass balances of metabolism than twisting around through the energy approach would do. On the contrary, energy balances can be introduced from metabolic mass balances using the gross energy values of nutrients and their excretions.

Mass balances are determined for the following types of domestic animals:

Dairy cow
Beef cattle
Sow
Suckling pig
Hen
Chicken
Fur animal.

An Excel spreadsheet model has been developed for forming a metabolic balance for each animal type.

The model inputs are the yearly feed quantities and animal products per animal place of each animal type. For animals other than fur animals, the data for these are available from the farm models of the MTTL. The farm models also include estimates of feed losses. The nutrient composition and digestibility estimates are from Tuori et al. (1996).

The model calculates the quantities of eaten and digestible feed by nutrient. The undigested nutrients leave the animal as faeces. A fraction of the carbohydrates is lost in the intestinal system as methane. Some of the digested nutrients are absorbed by animal products: growth of body mass, milk and eggs. The part that is left is combusted for energy production. The combustion residual of proteins, i.e. urea, leaves the body in urine - with poultry the uric acid leaves in combined excrements. The outside oxygen used in the combustion is taken and the yielded carbon dioxide is removed by respiration.

The digestibility of minerals is assumed to be 50 per cent throughout. Some of the digested minerals are absorbed by animal products. According to the principle of mineral equilibrium it is assumed that the rest of the digested minerals compensate the minerals leaving the body as a result from the renewing of tissue compounds. The exchanged minerals leave the body in urine.

Water acts in an organism as a general solvent and transporter of the ordinary nutrients and cell excretions and, moreover, as a general heat regulator. Especially the amount of water used in heat regulation can vary considerably. The mass balances of water are calculated according to the principle of water equilibrium. The total use of water is composed of the water content of feeds, estimated need of separate drinking water and the metabolic water created in the combustion of nutrients. A share of the water is tied up by animal products – it is otherwise minor but considerable in the milk of dairy cows. The elimination of water in urine and faeces is controlled in the model by the parameters of dry matter shares. The rest of the water leaves the body as water vapour via respiration and perspiration.

Manure is composed of faeces, urine, feeding losses, drainage straw for the part of the solid manure and washing water for the part of the liquid manure. Some of the faeces and urine of dairy cows end up direct in pastures. Shares of solid and liquid manure have been set for each animal type. The share of the solid manure leads to an estimate of the use of drainage straw and the share of the liquid manure leads to an estimate of the use of washing water.

Metabolic balances for each type of domestic animal place are introduced in the following chapters. However, before this some general characteristics need to be introduced.

The original data

As the lifetime of a domestic animal varies from 7 weeks to 4 years, choice of the accounting unit in relation to which calculations should be done is problematic. The accounting unit has to be capable of being generalised to the whole stock of the type of animal in question. In this work, the concept of *animal place* will be used.

An animal place is a calculated average for the period of one year inclusive of reproduction of the animal.

For a chosen type of animal the animal place is determined as follows:

Dairy cow

A dairy cow is kept for four years, after which it is slaughtered. The cow calves once a year. In order to reproduce the cow stock, every fourth calf is kept for growing to a heifer and further to a cow. Thus, one animal place of a dairy cow contains one heifer and ¼ of a calf in addition to the cow. In a year, a dairy cow yields milk, a calf of 50 kg of which ¾ are delivered for beef cattle breeding, and ¼ of its own body mass which is delivered for slaughtering, and which corresponds to the yearly growth of the body mass of a heifer.

Beef cattle

Beef cattle are acquired as 50 kg calves and grown over 14 months to a liveweight of 480 kg. Thus, the yield for one year is 411 kg liveweight, and 12/14, or 43 kg, of a calf are used up.

Sow

The lifetime of a sow is three years. In a year, a sow has 22 pigs which are grown to the weight of 22 kg at the sow farm. Every third year one pig is kept in order to reproduce a sow. The end weight of a sow is 300 kg. Thus, the average yearly growth of the body mass is 100 kg, which is delivered for slaughtering.

Suckling pig

The lifetime of a suckling pig is 4 months in which time it grows from a 22 kg to a 108 kg liveweight. One animal place year of a suckling pig contains three pigs.

Hen

The lifetime of a hen is one year, during which it lays 18 kg of eggs. One egg, 60 g, per year is grown to a 1.2 kg hen.

Table 5.4.1. Nutrient contents of animal products, %

	Proteins	Fats	Carbohydrates	Minerals	Water	Total
Calf	19	3	0	4	74	100
Cow	19	12	0	5	64	100
Milk	3	4	4	1	88	100
Beef cattle	18	10	0	4	68	100
Pig	17	6	0	3	74	100
Pork	12	36	0	3	49	100
Egg	13	11	0	11	66	100
Chicken	22	18	0	3	57	100
Fur skin	40	2	0	5	53	100

Table 5.4.2. Amounts of feeds per animal place, kg/year

	Dairy cow	Bull	Sow	Suckling pig	Hen	Chicken	Fur animal
barley (1-03)	685	326	554	373	10	0.2	0.0
oats (1-08)	1 385	0	699	0	10	0.2	0.0
hay (19-04)	2 729	0	0	0	0	0.0	0.0
silage (18-30)	10 734	6 834	0	0	0	0.0	0.0
pasture grass (16-03)	5 126	0	0	0	0	0.0	0.0
Own feed, total	**20 658**	**7 160**	**1 253**	**373**	**20**	**0.3**	**0.0**
protein concentrate (5-34)	864	258	263	0	0	0.0	0.0
mineral feed (5-04)	88	26	0	0	0	0.0	0.0
growth feed (5-35)	0	47	0	300	0	16.8	0.0
drink feed (8-30)	0	21	760	0	0	0.0	0.0
egg laying extract (5-26)	0	0	0	0	17	0.0	0.0
poultry limestone	0	0	0	0	3	0.0	0.0
feed for fur animals	0	0	0	0	0	0	84.5
Concentrated feed, total	**952**	**352**	**1 023**	**300**	**20**	**16.8**	**84.5**

The feeding losses for each animal type have been assumed to be the same as in the farm models of the MTTL. By feed type, the feeding losses are:

Corn	5 %
Hay	15 %
Silage	20 %
Concentrated feeds	3 %

Tuori et al. (1996) includes estimates of the nutrient composition and digestibility of different feeds by a very detailed division – barley, for example, is divided into five sub-groups. In the modelling of mass balances, feeds are classified into considerably rougher groups and typical values are used from the data of Tuori et al. In Table 5.4.2, the codes in brackets refer to the feed codes used in Tuori et al.

Table 5.4.3 shows the nutrient compositions of the feeds calculated from the data of Tuori et al. As in nutrition studies in general, carbohydrates are further divided into digestible carbohydrates and indigestible fibres.

Table 5.4.3. Nutrient composition of feeds, %

	Proteins	Fats	Carbo-hydrates	Fibres	Minerals	Water	Total
barley (1-03)	10.8	1.9	65.9	4.9	2.5	14.0	100.0
oats (1-08)	11.2	5.3	55.9	10.7	3.1	14.0	100.0
hay (19-04)	8.3	1.7	39.8	29.1	4.2	17.0	100.0
silage (18-30)	3.7	1.1	9.5	6.6	2.1	77.0	100.0
pasture grass (16-03)	3.4	0.8	8.8	4.2	1.8	81.0	100.0
protein concentrate (5-34)	43.9	7.2	27.1	5.3	5.7	11.0	100.0
mineral feed (5-04)	41.4	0.9	27.0	14.4	6.3	10.0	100.0
growth feed (5-35)	45.8	3.0	28.2	5.1	5.9	12.0	100.0
drinking feed (8-30)	7.0	0.9	13.1	0.1	0.9	78.0	100.0
egg laying extract (5-26)	34.4	3.9	32.1	11.5	7.1	11.0	100.0
poultry limestone	0.0	0.0	0.0	0.0	90.0	10.0	100.0
feed for fur animals	8.2	9.0	3.8	0.0	9.0	70.0	100.0

Table 5.4.4. Digestibility of feeds by type of animal, %

	Proteins	Fats	Carbohydrates	Fibres
Ruminant animals				
barley (1-03)	72	75	89	30
oats (1-08)	77	90	76	30
hay (19-04)	56	50	61	60
silage (18-30)	74	73	74	75
pasture grass (16-03)	74	60	80	80
protein concentrate (5-34)	90	83	91	70
mineral feed (5-04)	86	34	60	25
growth feed (5-35)	90	74	91	70
drinking feed (8-30)	87	72	95	50
Pigs				
barley (1-03)	71	55	89	15
oats (1-08)	74	82	77	15
protein concentrate (5-34)	88	78	91	60
growth feed (5-35)	88	63	91	60
drinking feed (8-30)	93	89	96	10
Poultry				
barley (1-03)	64	60	77	0
oats (1-08)	68	84	63	0
growth feed (5-35)	87	50	36	0
egg laying extract (5-26)	80	50	30	0
Fur animals				
feed for fur animals	85	90	78	0

Table 5.4.4 presents digestibility percentages of feeds, likewise taken from Tuori et al. The nutritive values of feeds differ by type of animal because due to their different digestive systems the digestibility of feeds varies by animal. The table shows that especially the digestibility of fats and fibres is weaker for pigs than for ruminants. For poultry, the digestibility is generally lower.

The amounts of drinking water by animal type are estimated to be as follows:

Dairy cow	80 l/day, heifer 40 l/day
Beef cattle	40 l/day
Sow	16 l/day
Suckling pig	9 l/day
Hen	0.23 l/day
Chicken	0.30 l/day
Fur animal	0.03 l/day

Metabolic balances

Metabolic balances are presented for animal places below. The balances for a dairy cow, which are presented first, are considered in greater detail and the basics of the calculation methods are explained, too. Only the main characteristics are explained for the other animal places.

Dairy cow

The metabolic balance of a dairy cow is presented in Table 5.4.5.

The intake rows first include eaten feed by nutrient content, and the amount of drinking water. Oxygen intake through respiration is determined on the use side by the oxygen consumed in energy production.

On the use side, the indigestible parts of energy nutrients and minerals leave the body in faeces. Urea formed from the protein used in energy production, and minerals from renewing tissue compounds leave in urine. The water contents of faeces and urine are determined by the parameters of their dry matter shares. Methane yield is determined by the digestion of carbohydrates and fibres. The parameter values controlling the methane yield are set in such a way that approximately the same methane emissions of domestic animals are reached as in Fin-

Table 5.4.5. Metabolic balance of a dairy cow, kg/year

	Proteins	Fats	Carbo hydrates	Fibres	Minerals	Water	Oxygen	Carbon dioxide	Total kg/year	Energy MJ/year
Intake										
Feed	1 305	312	3 610	1 685	477	11 534			18 922	133 799
Water						32 850			32 850	
Respiration							4 963		4 963	
Total	**1 305**	**312**	**3 610**	**1 685**	**477**	**44 384**	**4 963**	**0**	**56 735**	**133 799**
Use										
Faeces	308	81	917	597	238	8 565			10 706	36 397
Urine	268				190	7 171			7 628	2 839
Methane			94	38					132	7 330
Milk	184	252	266	0	40	5 438			6 180	17 637
Calf	10	2	0	0	2	37			50	281
Heifer growth	25	16	0	0	7	85			133	1 152
– 1/4 calf	–2	0	0	0	–1	-9			–13	
Energy production	513	-38	2 333	1 049		–3 151	4 963	–5 670	0	68 162
Respiration, exhalation						26 249		5 670	31 919	
Total	**1 305**	**312**	**3 610**	**1 685**	**477**	**44 384**	**4 963**	**0**	**56 735**	**133 799**

land's national greenhouse gas inventory (Pipatti 2001, D-4 – D-6). Some of the digested nutrients are tied up direct by animal products, i.e. milk, calves and growth of the heifer. As every fourth calf is used for reproduction and transformed into a heifer, it has to be subtracted for the sake of accounting consistency.

The energy nutrients left after the tying up into animal products are available for energy production. The amounts of energy nutrients used for combustion are shown first in the row of energy production – here the share of urea is subtracted from protein and thus the protein is a so-called non-urea protein. The amount of fats available for energy production is negative. The reason for this is that more fats are tied up into animal products, in this case milk, than are available in digested food. In the animal organisms, this deficit is compensated for by transforming carbohydrates into fats. In the row of energy production, the negative fats calculate correctly the effect of this transformation upon the elementary composition of the combusted nutrients and their energy values. The water and carbon dioxide yielded and the oxygen consumed by combustion of energy nutrients are calculated by means of the mass balances of the combustion of nutrients. The so-called metabolic water formed by combustion joins the water equilibrium and the carbon dioxide leaves in respiration. The water leaving in respiration and exhalation is determined by the water equilibrium.

The material flows of the metabolic balances are transformed into energy, megajoules, in the last column of the table. The transformations have been done from the columns of the energy nutrients using the gross energy values of the energy nutrients and their excretions of Chapter 3.4. In animal nutrition research, the generally used concepts of metabolic and net energy are not needed, because different energy losses associated with these concepts become visible via the separated material flows of the metabolic balance. According to the metabolic balance in faeces, urine and methane, about 35% of the gross energy of feeds are lost, the animal products tie up 35% of energy, and the last 50% are used as energy.

The results of the metabolic balances can also be presented as a reduced external mass balance as in Table 5.4.6. In Balance 1, the inputs and outputs are classified as products, and in Balance 2 they are analysed into dry matter, water and gas content of the products. The total sum of the external balances is slightly higher than that of the metabolic balance, because in the external balance ¼ of a calf is removed to the input side.

Balance 2 shows the considerable changes in the forms of material existence caused by metabolism. The dry matter and liquid water contents of outputs are nearly half of the dry matter and liquid water of inputs. By contrast, over six times more gases evaporate into the air than are taken in.

Table 5.4.6. External mass balances of dairy cow, kg/year

Balance 1

INPUT	**56 748**	**OUTPUT**	**56 748**
Feed	18 922	Milk	6 180
1/4 calf	13	Calf	50
Water	32 850	Heifer	133
Oxygen	4 963	Faeces	10 706
		Urine	7 628
		Water vapour	26 249
		Carbon dioxide	5 670
		Methane	132

Balance 2

INPUT	**56 748**	**OUTPUT**	**56 748**
Dry matter	7 391	Dry matter	3 401
Water	44 394	Water	21 295
Gas	4 963	Gas	32 051

Beef cattle

The metabolic balance of beef cattle is shown in Table 5.4.7, and the external balances in Table 5.4.8. According to the energy balance, about 30% of the gross energy of feeds is lost in excreta, products tie up some 10%, and 60% is used for energy production.

Table 5.4.7. Metabolic balance of beef cattle, kg/year

	Proteins	Fats	Carbo-hydrates	Fibres	Minerals	Water	Oxygen	Carbon dioxide	Total	Energy
									kg/year	MJ/year
Intake										
Feed	377	85	816	396	140	4 305			6 118	32 978
Water						14 600			14 600	
Respiration							1 464		1 464	
Total	**377**	**85**	**816**	**396**	**140**	**18 905**	**1 464**	**0**	**22 182**	**32 978**
Use										
Faeces	76	21	168	108	84	1 831			2 289	7 352
Urine	80				41	1 895			2 016	846
Methane			23	10					33	1 813
Beef cattle	74	41	0	0	16	280			411	3 195
– Calf	–8	–1	0	0	–2	–32			–43	
Energy production	155	24	625	278		–925	1 464	–1 620	0	19 771
Respiration, exhalation						15 856		1 620	17 476	
Total	**377**	**85**	**816**	**396**	**140**	**18 905**	**1 464**	**0**	**22 182**	**32 978**

Table 5.4.8. External mass balances of beef cattle, kg/year

Balance 1

INPUT	**22 225**	**OUTPUT**	**22 225**
Feed	6 118	Meat	411
Calf	43	Faeces	2 289
Water	14 600	Urine	2 016
Oxygen	1 464	Water vapour	15 856
		Carbon dioxide	1 620
		Methane	33

Balance 2

INPUT	**22 225**	**OUTPUT**	**22 225**
Dry matter	1 824	Dry matter	710
Water	18 936	Water	4 006
Gas	1 464	Gas	17 509

Sow

The metabolic balance of a sow is presented in Table 5.4.9 and the external balances in Table 5.4.10. According to the energy balance in excreta, about one quarter of the gross energy of feeds is lost, products tie up one quarter and about half is used for energy production.

Table 5.4.9. Metabolic balance of sow, kg/year

	Proteins	Fats	Carbo hydrates	Fibres	Minerals	Water	Oxygen	Carbon dioxide	Total	Energy
									kg/year	MJ/year
Intake										
Feed	295	69	883	111	55	770			2 182	26 686
Water						5 840			5 840	
Respiration							900		900	
Total	**295**	**69**	**883**	**111**	**55**	**6 610**	**900**	**0**	**8 922**	**26 686**
Use										
Faeces	53	15	134	88	27	1 798			2 115	5 640
Urine	46				5	2 481			2 531	483
Methane			15	0					15	856
Body mass of pigs	82	29	0	0	16	356			484	2 981
Sow meat (liveweight)	28	84	0	0	6	116			234	3 553
– 1/3 replacement pig	–1	0	0	0	0	-5			–7	–45
Energy production	87	–59	735	22		–577	900	–1 108	0	13 173
Respiration, exhalation						2 442		1 108	3 550	
Total	**295**	**69**	**883**	**111**	**55**	**6 610**	**900**	**0**	**8 922**	**26 641**

Table 5.4.10. External mass balances of beef cattle, kg/year

Balance 1

INPUT	**8 930**	**OUTPUT**	**8 930**
Feed	2 182	Pigs	484
1/3 pig	7	Sow meat	234
Water	5 840	Faeces	2 115
Oxygen	900	Urine	2 531
		Water vapour	2 442
		Carbon dioxide	1 108
		Methane	15

Balance 2

INPUT	**8 930**	**OUTPUT**	**8 930**
Dry matter	1 415	Dry matter	614
Water	6 615	Water	4 751
Gas	900	Gas	3 565

Suckling pig

The metabolic balance of a suckling pig is presented in Table 5.4.11 and the external balances in Table 5.4.12. The energy balance shows that about one quarter of the gross energy of feeds is lost in excreta, products tie up nearly 45% and energy production consumes 45%.

Table 5.4.11. Metabolic balance of suckling pig, kg/year

	Proteins	Fats	Carbo-hydrates	Fibres	Minerals	Water	Oxygen	Carbon dioxide	Total	Energy
									kg/year	MJ/year
Intake										
Feed	172	15	316	32	26	85			645	10 695
Water						3 285			3 285	
Respiration							208		208	
Total	**172**	**15**	**316**	**32**	**26**	**3 370**	**208**	**0**	**4 139**	**10 695**
Use										
Faeces	27	6	33	21	16	411			514	1 799
Urine	40				4	1 432			1 476	425
Methane			6	0					6	326
Suckling pigs (liveweight)	39	117	0	0	8	160			324	4 918
– pigs	–11	–4	0	0	–2	–49			–66	
Energy production	77	–104	277	11		–248	208	–222	0	3 227
Respiration, exhalation						1 664		222	1 885	
Total	**172**	**15**	**316**	**32**	**26**	**3 370**	**208**	**0**	**4 139**	**10 695**

Table 5.4.12. External mass balances of suckling pig, kg/year

Balance 1

INPUT	**4 205**	**OUTPUT**	**4 205**
Pigs	66	Pork	324
Feed	645	Faeces	514
Water	3 285	Urine	1 476
Oxygen	208	Water vapour	1 664
		Carbon dioxide	222
		Methane	6

Balance 2

INPUT	**4 205**	**OUTPUT**	**4 205**
Dry matter	578	Dry matter	311
Water	3 418	Water	2 003
Gas	208	Gas	1 891

Hen

The metabolic balance of a hen is presented in Table 5.4.13 and the external balances in Table 5.4.14. The metabolism of birds differs from that of mammals in that their urine is associated with faeces and the result from the combustion of protein is not urea but uric acid. Of the gross energy of feeds, about half is lost in excreta, products tie up less than one quarter and over one quarter is used for energy production.

Table 5.4.13. Metabolic balance of hen, kg/year

	Proteins	Fats	Carbo-hydrates	Fibres	Minerals	Water	Oxygen	Carbon dioxide	Total	Energy
									kg/year	MJ/year
Intake										
Feed	7.6	1.3	16.9	3.3	4.7	4.8			38.6	579.3
Water						82.8			82.8	
Respiration							13.0		13.0	
Total	**7.6**	**1.3**	**16.9**	**3.3**	**4.7**	**87.6**	**13.0**	**0.0**	**134.4**	**579.3**
Use										
Faeces	3.5	0.5	7.1	3.3	2.7	44.0			61.1	280.7
Methane			0.0	0.0					0.0	0.0
Eggs	2.3	1.9	0.0	0.0	1.9	11.9			18.0	121.1
Poultry meat (liveweight)	0.1	0.4	0.0	0.0	0.0	0.6			1.2	17.9
– replacement chicken	–0.1	–0.4	0.0	0.0	0.0	–0.6			–1.2	
Energy production	1.8	–1.0	9.8	0.0		–8.9	13.0	–14.7	0.0	159.6
Respiration, exhalation						40.6		14.7	55.3	
Total	**7.6**	**1.3**	**16.9**	**3.3**	**4.6**	**87.6**	**13.0**	**0.0**	**134.4**	**579.3**

Table 5.4.14. External mass balances of hen, kg/year

Balance 1

INPUT	**135.6**	**OUTPUT**	**135.5**
Feed	38.6	Eggs	18.0
Chicken	1.2	Meat	1.2
Water	82.8	Faeces	61.1
Oxygen	13.0	Water vapour	40.6
		Carbon dioxide	14.7
		Methane	0.0

Balance 2

INPUT	**135.6**	**OUTPUT**	**135.5**
Dry matter	34.4	Dry matter	23.8
Water	88.2	Water	56.5
Gas	13.0	Gas	55.3

Chicken

The metabolic balance of a chicken is shown in Table 5.4.15 and the external balances in Table 5.4.16. Of the gross energy of feeds, over 43% are lost in excreta, products tie up about half and only 7% are left for energy production.

Table 5.4.15. Metabolic balance of chicken, kg/year

	Proteins	Fats	Carbo-hydrates	Fibres	Minerals	Water	Oxygen	Carbon dioxide	Total	Energy
									kg/year	MJ/year
Intake										
Feed	7.5	0.5	4.8	0.9	1.0	2.0			16.6	295.9
Water						109.5			109.5	
Respiration							2.2		2.2	
Total	**7.5**	**0.5**	**4.8**	**0.9**	**1.0**	**111.5**	**2.2**	**0.0**	**128.3**	**295.9**
Use										
Faeces	2.9	0.2	3.1	0.9	0.7	19.7			27.3	143.4
Methane			0.0	0.0					0.0	0.0
Poultry meat	2.7	2.1	0.0	0.0	0.4	6.8			12.0	136.7
– replacement eggs	–0.1	0.0	0.0	0.0	0.0	–0.3			–0.4	–2.8
Energy production	2.0	–1.7	1.7	0.0		–4.2	2.2	0.1	0.0	18.6
Respiration, exhalation						89.5		–0.1	89.4	
Total	**7.5**	**0.5**	**4.8**	**0.9**	**1.0**	**111.5**	**2.2**	**0.0**	**128.3**	**295.9**

Table 5.4.16. External mass balances of chicken, kg/year

Balance 1

INPUT	**128.7**	**OUTPUT**	**128.7**
Feed	16.6	Meat	12.0
Eggs	0.4	Faeces	27.3
Water	109.5	Water vapour	89.5
Oxygen	2.2	Carbon dioxide	–0.1
		Methane	0.0

Balance 2

INPUT	**128.7**	**OUTPUT**	**128.7**
Dry matter	14.7	Dry matter	12.8
Water	111.8	Water	26.5
Gas	2.2	Gas	89.4

Fur animal
The metabolic balance of a fur animal is shown in Table 5.4.17 and the external balances in Table 5.4.18. The balances include reproduction of the animal stock, too, because one cub is kept for each slaughtered and skinned mother animal. The carcass is recycled in feed mixing mills as fur animal feed.

Table 5.4.17. Metabolic balance of fur animal, kg/year

	Proteins	Fats	Carbo-hydrates	Fibres	Minerals	Water	Oxygen	Carbon dioxide	Total	Energy
									kg/year	MJ/year
Intake										
Feed	6.7	7.4	3.1	0.0	7.4	57.4			82.0	468
Water						12.3			12.3	
Respiration							25.1		25.1	
Total	**6.7**	**7.4**	**3.1**	**0.0**	**7.4**	**69.7**	**25.1**	**0.0**	**119.4**	**468**
Use										
Faeces	1.0	0.7	0.7	0.0	3.7	14.3			20.4	62
Urine	1.7				3.6	47.5			52.8	18
Methane			0.0	0.0					0.0	3
Fur skin	0.2	0.0	0.0	0.0	0.0	0.2			0.4	4
Slaughtering waste	0.5	1.6	0.0	0.0	0.1	2.1			4.3	66
Energy production	3.3	5.1	2.4	0.0		–15.6	25.1	–20.3	0.0	316
Respiration, exhalation						21.1		20.3	41.4	
Total	**6.7**	**7.4**	**3.1**	**0.0**	**7.4**	**69.7**	**25.1**	**0.0**	**119.4**	**468**

Table 5.4.18. External mass balances of fur animal, kg/year

Balance 1

INPUT	**119.4**	**OUTPUT**	**119.4**
Feed	82.0	Fur	0.4
Water	12.3	Slaughtering waste	4.3
Oxygen	25.1	Faeces	20.4
		Urine	52.8
		Water vapour	21.1
		Carbon dioxide	20.3
		Methane	0.0

Balance 2

INPUT	**119.4**	**OUTPUT**	**119.4**
Dry matter	24.6	Dry matter	13.8
Water	69.7	Water	64.2
Gas	25.1	Gas	41.4

Manure balances

The balances of manure formation are presented in Table 5.4.19. First, the starting data are presented which directs faeces and urine to pastures, solid manure and liquid manure. On the input side, manure is formed by faeces, urine, feed loss, drainage straw of solid manure and washing water of liquid manure.

On the output side, manure is subtracted by the emissions of ammonia and methane during the storage of manure. In the spreadsheet on manure formation, the input factors of manure are accounted by nutrient. Ammonia emissions are calculated from the nitrogen of proteins by the emission parameters used in Grönroos (1998). The calculations of methane emissions are based on the carbon content of manure so that the emissions match as closely as possible the estimates of Finland's greenhouse gas inventory (Pipatti 2001). Emissions from manure spread on fields are moved to the soil balance of plant cultivation.

Total balances of animal husbandry

The total mass balances of domestic animals presented in Table 5.4.20 are reached by combining the metabolic balances and manure balances. In Table 5.4.21, the balances by animal place are raised to correspond with the total production of animal husbandry in Finland in the year 1999. This is done by means of the number of animal places so that the yield of animal products corresponds with the yield estimates of agricultural statistics. The corresponding data available from statistics are shown in the Comparison column. The carcass weights of meat yields are changed into liveweights. On the output side, the rows Calves, Pigs and Chickens are the young of different types of animal place. No special animal place has been determined for the growing of chickens and hens are used for representing it, too.

The total external mass balance of animal husbandry is presented in Table 5.4.22.

Table 5.4.19. Manure balances, kg/animal place/year

	Dairy cow	Beef cattle	Sow	Suckling pig	Hen	Chicken	Fur animal
Starting data							
Grazing days / year	120	0	0	0	0	0	0
Share of solid manure	60%	60%	40%	40%	100%	100%	100%
Input	**34 849**	**10 890**	**11 412**	**4 017**	**62.7**	**27.8**	**75.8**
Faeces	10 706	2 289	2 115	514	61.1	27.3	20.4
Urine	7 628	2 016	2 531	1 476	0.0		52.8
Feed loss	2 688	1 394	93	28	1.5	0.5	2.5
Straw	827	191	372	0	0.0	0.0	0.0
Washing water	13 000	5 000	6 300	2 000	0.0	0.0	0.0
Output 1	**34 849**	**10 890**	**11 412**	**4 017**	**62.7**	**27.8**	**75.8**
Manure	34779	10 866	11 397	4 009	62.3	27.6	75.5
Ammonia emissions	50	19	11	8	0.3	0.3	0.3
Methane emissions	20	5	4	1	0.0	0.0	0.0
Output 2	**34 849**	**10 890**	**11 412**	**4 017**	**62.7**	**27.8**	**75.8**
Dry matter	4 179	1 055	735	162	18.1	7.8	11.8
Water	30 600	9 811	10 662	3 846	44.2	19.7	63.6
Gas	71	24	15	9	0.3	0.3	0.3

Table 5.4.20. Combined mass balances of domestic animals, kg/animal place/year

	Dairy cow	Beef cattle	Sow	Suckling pig	Hen	Chicken	Fur animal
Input	**73 250**	**28 767**	**15 688**	**6 166**	**135.9**	**128.8**	**121.9**
Forage plants	20 658	7 160	1 253	373	20.2	0.3	0.0
Concentrated feed	952	352	1 023	300	19.9	16.8	84.5
Straw	827	191	372	0	0.0	0.0	0.0
Water (drinking & washing)	45 850	19 600	12 140	5 285	82.8	109.5	12.3
Oxygen	4 963	1 464	900	208	13.0	2.2	25.1
Output	**73 250**	**28 767**	**15 688**	**6 166**	**135.9**	**229.1**	**121.9**
Milk	6 180	0	0	0	0.0	0.0	0.0
Calves	38	–43	0	0	0.0	0.0	0.0
Beef cattle	133	411	0	0	0.0	0.0	0.0
Pigs	0	0	477	–66	0.0	0.0	0.0
Pork	0	0	234	324	0.0	0.0	0.0
Eggs	0	0	0	0	18.0	–0.4	0.0
Hens	0	0	0	0	–1.2	0.0	0.0
Chickens	0	0	0	0	1.2	12.0	0.0
Fur skin	0	0	0	0	0.0	0.0	0.4
Slaughtering waste	0	0	0	0	0.0	0.0	4.3
Manure	34 779	10 866	11 397	4 009	62.3	127.9	75.5
Ammonia	50	19	11	8	0.3	0.3	0.3
Methane	153	38	19	7	0.0	0.0	0.1
Carbon dioxide	5 670	1 620	1 108	222	14.7	–0.1	20.3
Water vapour	26 249	15 856	2 442	1 664	40.6	89.5	21.1

Table 5.4.21. Total mass balances of animal husbandry in Finland 1999, Mkg

	Dairy cow	Beef cattle	Sow	Suckling pig	Hen	Chicken	Fur animal	Total	Com-parison
Animal places, 1000 units	401	330	105	770	3500	7500	3705		
Input	**29 373**	**9 493**	**1 664**	**4 748**	**476**	**966**	**482**	**47 203**	
Forage plants	8 284	2 363	132	287	71	2	0	11 139	10 029
Concentrated feed	382	116	107	231	70	126	333	1 365	1 345
Straw	332	63	39	0	0	0	0	434	500
Water (drinking & rinsing)	18 386	6 468	1 275	4 069	290	821	49	31 358	
Oxygen	1 990	483	112	160	45	16	100	2 908	
Output	**29 373**	**9 493**	**1 664**	**4 748**	**476**	**966**	**482**	**47 203**	
Milk	2 478	0	0	0	0	0	0	2 478	2 475
Calves	15	–14	0	0	0	0	0	1	
Beef cattle	53	136	0	0	0	0	0	189	189
Pigs	0	0	50	–51	0	0	0	–1	
Pork	0	0	11	249	0	0	0	260	259.8
Eggs	0	0	0	0	63	–3	0	60	59
Chicken	0	0	0	0	–4	0	0	–4	
Poultry meat	0	0	0	0	4	90	0	94	94
Fur skins	0	0	0	0	0	0	1	1	
Slaughtering waste	0	0	0	0	0	0	16	16	
Manure	13 946	3 586	1 244	3 087	218	207	299	22 586	20 000
Ammonia	20	6	1	6	1	2	1	38	29
Methane	61	12	2	5	0	0	0	81	84
Carbon dioxide	2 273	535	131	171	51	–1	81	3 242	
Water vapour	10 526	5 232	225	1 281	142	671	84	18 162	

Table 5.4.22.
Aggregated external mass balance of Finnish animal husbandry in 1999, Gkg

INPUT	47.2	OUTPUT	47.2
Dry matter	5.3	Dry matter	2.9
Water	39.0	Water	22.8
Gas	2.9	Gas	21.5

5.5 Natural production and fishing

In the following, natural production refers to activities that produce food direct from nature, such as collecting and hunting. Reindeer husbandry and bee-keeping are also here included in natural production activities because reindeer and bees obtain the most of their nourishment from nature even though artificial feeding of reindeer has become increasingly widespread.

With the exception of fish farming, fishing is also characteristically natural production, so discussing it in the same context as other natural production is plausible. However, according to established convention it is classified as a separate group of its own.

The yield and use of natural production in the year 1999 are presented in Table 5.5.1.

The amounts of catches are presented in liveweights. Carcass weights of catches have been assumed to be 50% for reindeer and other mammals. One third of birds and 15% of fish have been assumed to end up as slaughtering waste.

Other uses include pelts of reindeer and elks, use of professional fishing catch as feed for fur animals, use of catch from recreational fishing as feed for pets, fry for intermediate use in fish farming and final use in fish planting into natural waters.

The yield from fish and fry farming was 15.4 million kg and 19.3 million kg were used as feed for fish farming in the year 1999. Thus, nearly two thirds of the nutrient content of fish feed would be absorbed by the growth of the body mass of farmed fish.

The greater part of the catch of professional fishing is used as feed. Thus, the share of recreational fishing in the use of fish as human food is about half.

Slaughtering waste includes the waste from natural production. Reindeer are, in fact, increasingly slaughtered in slaughterhouses, which belong to the food industry.

Table 5.5.1. Catch and use of natural production and fishing 1999, Mkg

	Catch	For human food	Other uses	Products total	Slaughtering waste
Natural production	**67.0**	**55.8**	**0.9**	**56.7**	**10.3**
Reindeer	4.2	2.0	0.3	2.3	1.9
Honey	1.9	1.9		1.9	0.0
Forest berries	41.0	41.0		41.0	0.0
Forest mushrooms	2.2	2.2		2.2	0.0
Hunting	17.7	8.7	0.6	9.3	8.4
Fishing and fish farming	**176.2**	**81.8**	**81.1**	**162.9**	**13.4**
Professional fishing	112.7	29.1	78.5	107.6	5.1
Recreational fishing	48.2	38.8	2.6	41.4	6.7
Fish farming	15.4	13.9		13.9	1.5
Fry farms	0		0	0.0	0.0
Crayfish, etc.	0	0		0.0	0
Total	**243.3**	**137.6**	**82.0**	**219.6**	**23.7**

5.6 Metabolism of the human population

Food consumption

The basic data on human food consumption were derived from the 1998 household consumption survey of Statistics Finland. In addition to the regular consumption expenditure in money terms, the survey also inquired about the quantities of acquired foodstuffs (Tennilä 2000). The inquiry was directed at households chosen by random sampling. The number of households included in the sample was 4,359 and, as the average size of household was 2.16 persons, the inquiry covered the consumption procurements of 9,400 individuals.

Acquired foodstuffs were classified into 248 types in the inquiry. However, meals and drinks taken in restaurants and canteens were asked about as numbers of total portions by 37 portion types. In this work, the portions were transformed into their foodstuff contents against the data of the FINELI databank (FINELI 2001) of the National Public Health Institute (KTL). The FINELI databank includes comprehensive estimates of the foodstuff contents of different portions of meals and drinks. Liquid foodstuffs were measured as litres in the consumption survey. In this work, they were converted to kilograms. Milk products were converted by the density coefficient of 1.03 kg/l.

It has been found in the context of consumption expenditure estimations in national accounts that consumption surveys systematically yield too low estimates for the consumption of alcoholic beverages. Thus, in this work, too, these estimates of the consumption survey were replaced by estimates from the intoxicant statistics of STAKES (2000), which are based on retail and on-license sales. The quantitative data are expressed both as beverage litres and as pure alcohol litres. The statistics of STAKES also estimate the amounts of alcohol consumed abroad or imported as tourist alcohol. In this work, such alcohol was added to the alcohol consumption figures. Litres were converted to kilograms using the proportion of pure alcohol in the total of alcoholic beverages and the density of pure alcohol, 0.789 kg/l.

The data of the consumption survey are from the year 1998. They were converted to the year 1999 by the fixed price consumption expenditure time series of national accounts. The consumption expenditure time series of national accounts includes 51 foodstuffs at its most detailed level. The classifications of consumption commodities used in national accounts and in the consumption survey are both based on the international COICOP classification (Classification of Individual Consumption by Purpose), the national accounts one at the 5-digit and the consumption survey one at the 7-digit level.

Alcohol consumption figures for the year 1999 are based direct on the statistics of STAKES (STAKES 2001).

Consumption of foodstuffs by households in 1998 and 1999 is presented in Table 5.6.1. The foodstuffs are aggregated into 19 product groups, which are numbered in succession.

The FINELI databank of the National Public Health Institute (FINELI 2001) includes wide and detailed data on the energy nutrient contents of foodstuffs. The data covering over 600 foodstuffs for which energy nutrient contents were obtained by estimates of mineral and water contents were obtained for this study from the National Public Health Institute. The nutrient distribution for each of the 19 foodstuff groups was reached by applying these detailed data to the COICOP groups of the consumption survey and by subsequent aggregation. The physiological fuel values of the foodstuff groups were then estimated by applying the physiological fuel values of nutrients in Table 5.3.4 to the nutrient distribution data. Table 5.6.2 shows the nutrient content distributions of the 19 aggregated foodstuff groups and their physiological fuel values.

Table 5.6.1. Food of households as acquired foodstuffs in Finland 1999, Mkg

	Mkg			%		
	Home	Restaurant	Total	Home	Restaurant	Total
1 Flour, other grain products	219	36	255	6.1	6.0	6.1
2 Bread and biscuits	206	16	223	5.8	2.8	5.3
3 Beef	13	10	22	0.4	1.6	0.5
4 Pork	40	9	48	1.1	1.5	1.2
5 Poultry	24	0	25	0.7	0.1	0.6
6 Other meat	10	0	10	0.3	0.0	0.2
7 Sausages and other meat products	184	11	195	5.2	1.8	4.7
8 Fish	56	19	75	1.6	3.2	1.8
9 Milk and dairy products	908	102	1 009	25.5	17.1	24.3
10 Eggs	36	4	40	1.0	0.7	1.0
11 Oils and fats	58	23	81	1.6	3.9	2.0
12 Fruits and berries	311	1	311	8.7	0.1	7.5
13 Potatoes	209	44	253	5.9	7.4	6.1
14 Other plants	276	55	331	7.7	9.3	8.0
15 Sugar, jam, honey, confectionery	132	3	135	3.7	0.5	3.3
16 Other foodstuffs	11	1	13	0.3	0.2	0.3
17 Coffee, tea and cocoa	43	1	44	1.2	0.2	1.1
18 Other non-alcoholic beverages	372	119	492	10.4	20.1	11.8
19 Alcoholic beverages	458	140	599	12.9	23.6	14.4
Total	**3 566**	**595**	**4 160**	**100.0**	**100.0**	**100.0**

In order to arrive at the eaten intake of food, various losses have to be subtracted from the acquired foodstuffs. The share of inedible parts was assessed for each foodstuff item for this purpose. For example, the bones in meat and fish products, egg shells and the skins of fruit and potatoes are inedible parts. Coffee and tea, from which only a fraction is extracted into the drink are especially problematic in this respect. However, instant coffee and tea are fully extracted into the drink. The data on the shares of inedible parts were mainly derived from Lallukka & Ovaskainen (2001) and the Social Insurance Institution (1990). In addition to the losses of inedible parts, an overall loss of 3% was assumed.

Table 5.6.3 shows the shares of the losses by aggregated food group and the intake of eaten food after the losses. The average share of losses is 7%, so the average share of inedible parts is 4 %.

In respect of prepared meals the intake expresses reliably only the amount of dry matter. However, water is more problematic. Some of the water contained in foodstuffs evaporates in cooking but, on the other hand, soups, coffee and tea include added water. These changes in the water content of prepared meals are not assessed, but in the metabolic balances the amount of drinking water is set in such a way that it covers the water equilibrium with the water content of the ”raw” foodstuffs.

The bottom row of Table 5.6.3 shows total daily acquisition and intake of food and total daily physiological energy per person. Thus, about 2 kg of food is consumed per person per day and the physiological energy intake is 10.2 megajoules per day.

Table 5.6.2. Nutrient composition and physiological fuel values of foodstuffs

	Nutrient content, %								Energy
	Carbo-hydrates	Fats	Proteins	Alcohol	Fibres	Mine-rals	Water	Total	MJ/kg
1 Flour, other grain products	47.2	8.1	9.2	0.0	4.4	1.7	29.4	100.0	12.5
2 Bread and biscuits	42.7	4.4	8.6	0.0	6.1	2.3	36.0	100.0	10.2
3 Beef	0.0	8.4	19.3	0.0	0.0	0.9	71.4	100.0	5.8
4 Pork	0.1	16.5	17.0	0.0	0.0	1.7	64.7	100.0	7.9
5 Poultry	0.2	6.4	21.3	0.0	0.0	0.9	71.2	100.0	4.3
6 Other meat	0.0	5.5	20.8	0.0	0.0	1.2	72.5	100.0	4.7
7 Sausages and other meat products	4.5	14.3	14.7	0.0	0.2	2.5	63.7	100.0	8.6
8 Fish	2.5	7.2	16.3	0.0	0.1	3.0	70.9	100.0	5.1
9 Milk and dairy products	4.9	1.3	3.1	0.0	0.0	0.7	90.0	100.0	1.8
10 Eggs	0.3	11.8	12.1	0.0	0.0	1.1	74.6	100.0	5.8
11 Oils and fats	0.2	76.7	0.6	0.0	0.0	1.1	21.3	100.0	29.0
12 Fruits and berries	14.0	0.9	0.7	0.0	2.3	0.5	81.5	100.0	2.3
13 Potatoes	15.7	0.1	1.7	0.0	1.2	1.1	80.3	100.0	2.5
14 Other plants	4.9	0.6	1.3	0.0	1.8	0.9	90.5	100.0	1.2
15 Sugar, jam, honey, confectionery	71.1	5.5	2.2	0.0	0.5	0.7	20.0	100.0	14.3
16 Other foodstuffs	7.6	3.0	1.7	0.0	0.2	52.2	35.3	100.0	2.7
17 Coffee, tea and cocoa	42.4	5.7	21.5	0.0	3.7	18.1	8.7	100.0	3.1
18 Other non-alcoholic beverages	7.7	0.0	0.1	0.0	0.0	0.2	92.0	100.0	1.3
19 Alcoholic beverages	3.8	0.0	0.3	5.6	0.0	0.1	90.1	100.0	2.3
On average	**13.2**	**4.8**	**4.1**	**0.9**	**1.0**	**1.1**	**74.9**	**100.0**	**4.8**

Table 5.6.3. Food acquisition, losses and intake of households in 1999, kg per capita and intake as energy, MJ per capita

	Acquisition kg	Loss %	Intake kg	Energy MJ	Distribution (%) kg	MJ
1 Flour, other grain products	49.3	1.5	47.8	594	6.5	16.0
2 Bread and biscuits	43.0	1.3	41.7	426	5.6	11.5
3 Beef	4.3	0.5	3.7	24	0.5	0.6
4 Pork	9.4	1.4	8.0	72	1.1	1.9
5 Poultry	4.8	1.4	3.3	20	0.4	0.5
6 Other meat	1.9	0.4	1.6	8	0.2	0.2
7 Sausages and other meat products	37.6	1.2	36.4	313	4.9	8.5
8 Fish	14.5	3.1	11.4	67	1.5	1.8
9 Milk and dairy products	195.2	5.9	189.3	593	25.5	16.0
10 Eggs	7.7	7.7	0.1	0	0.0	0.0
11 Oils and fats	15.7	0.5	15.2	429	2.1	11.6
12 Fruits and berries	60.2	11.8	48.4	133	6.5	3.6
13 Potatoes	49.0	7.5	41.5	170	5.6	4.6
14 Other plants	64.1	5.8	58.2	71	7.9	1.9
15 Sugar, jam, honey, confectionery	26.2	0.8	25.4	363	3.4	9.8
16 Other foodstuffs	2.4	0.1	2.4	6	0.3	0.2
17 Coffee, tea and cocoa	8.5	6.5	2.0	26	0.3	0.7
18 Other non-alcoholic beverages	95.1	2.9	92.3	123	12.5	3.3
19 Alcoholic beverages	115.8	3.5	112.3	269	15.2	7.2
Total	**804.6**	**63.6**	**741.0**	**3 707**	**100.0**	**100.0**
Per person/ day	2.2		2.0	10.2		

Comparison with other studies

The National Nutrition Council of Finland has given reference values for the energy requirements of men and women in different age groups as shown in Table 5.6.4 and for those of children and adolescents as given in Table 5.6.5.

Table 5.6.4. Reference values for energy requirements in groups of adults with moderate to low physical activity, MJ/day (National Nutrition Council of Finland 1999, 18)

	Regular physical activity		Limited physical activity	
Age group	Males	Females	Males	Females
19 – 30 years	12.4	9.8	10.2	8.1
31 – 60 years	12.1	9.7	10.0	8.0
61 – 75 years	10.9	8.9	8.9	7.3
> 75 years	10.0	8.7	8.2	7.2

Table 5.6.5.
Reference values for energy requirements of children and adolescents, MJ/day
(National Nutrition Council of Finland 1999, 19)

Age group	MJ/day
< 1 year	3
1 – 3 years	6
4 – 10 years	7.5
11 – 18 years	10

The energy yield of 10.2 MJ per person per day from the food intake in Table 5.6.3 as the population average matches well with these reference values, being perhaps somewhat over them.

In 1997, the National Public Health Institute made its latest nutrition study (NBHI 1998), in which 1,632 Finnish men and 1,501 Finnish women chosen by random sampling were subjects of an interview survey. The survey was limited to the 25 to 64-year-old population. The interview concerned the meals and beverages of the day preceding the interview. By means of the nutrient content data in the FINELI, the meals and beverages were converted further into the intake of nutrient energy. The study resulted in an average energy intake of 9.5 MJ per day for men and 6.8 MJ per day for women, or 8.1 MJ per day for the adult population on the average. One reason for the low energy intake figures is that the interviews were conducted on weekdays and, thus, the more abundant meals of weekends and on the eves of public holidays were systematically overlooked.

Water equilibrium

The intake of water can vary considerably. The water use of the human body can be considered as maintaining the water equilibrium of the body. The typical water balance of an adult person is presented in Table 5.6.6.

Table 5.6.6. Typical daily water balance of typical adult person (Nienstedt et al. 1992, 233)

Input	litres	%	Output	litres	%
Water content of food	0.9	36	Perspiration	0.4	16
Drinking water	1.3	52	Respiration	0.5	20
Metabolic water	0.3	12	Water in faeces	0.1	4
			Water in urine	1.5	60
Total	**2.5**	**100**	**Total**	**2.5**	**100**

Growth and reproduction of population

The generally used reference weights for adults in nutrition studies are 70 kg for men and 60 kg for women (see e.g. National Nutrition Council of Finland 1999, 18; Yki-Järvinen 1999, 255). Thus, the weight of the average human being is 65 kg. The weights are ideal weights, though, rather than real average weights of the Finnish population. On the other hand, in old age weight typically decreases. Thus, the weight of 65 kg may be a good estimate for the end weight of human beings.

The growth of the human body mass is centred on the first twenty years. In the metabolic balance of a person that can be generalised to the whole population, the average growth of the body has to be distributed over the person's whole lifetime. If the average lifetime of a person is assumed to be 80 years and the end weight 65 kg, the average growth of the body mass is 0.8 kg per year.

The population balance of Finland in the year 1999 is presented in Table 5.6.7. The population growth rate was only 0.21% per year and the birth rate was 1.12%. Mortality was 15% lower than birth rate. Net migration increased the population by only 0.04%.

The average population of Finland for the year 1999 was 5.165 million. This figure, multiplied by the average yearly growth of body mass per person of 0.8 kg, results in a body mass growth for the whole population of 4.1 million kg. In the population equilibrium, this would be the same as the body mass leaving the population. If the average 65 kg end weight were assumed, then 49,000 dead people in 1999 would leave a total of 3.2 million kg of body mass. Thus, of the total of 4.1 million kg increase of body mass, 3.2 million kg would be used for the reproduction of the population and 0.9 million kg would be left to the net body mass growth of the population.

The calculations above are rough. The share of the body mass growth of the total material flows of food is very small for humans, however: if the estimated average yearly body mass growth were 0.8 kg per person according to Table 5.6.3, the average food intake per person would be 741 kg. Thus, only 0.001% of the food intake would be absorbed by the growth of body mass.

Table 5.6.7.
Population balance of Finland in 1999, 1,000 persons (Statistical Yearbook of Finland 1999, tables 27 and 57)

	1,000 persons	%
Population 1 Jan.1999	5 160	100.00
Live birds	58	1.12
Deaths	–49	–0.95
Net migration	2	0.04
Population 31 Dec.1999	5 171	100.21

Metabolic balances

The metabolic balance of an average person is presented in Table 5.6.8. The balance has been formed by the same principles as the balances for domestic animals in Chapter 5.3. One gram/person/day is used as the measurement unit for human nutrition studies in general.

On the intake side, foodstuffs are divided into meals and beverages. Milk is included in meals, however, following the general classification usage. In addition to the water included in meals and beverages, separate drinking water is added so that together they and the metabolic water sum up to 2.5 litres (1 litre of water = 1 kg).

On the use side, the share of faeces in food intake is determined in accordance with the digestibility rates of Table 5.2.12. Hence 8% of protein, 5% of fats and 3% of carbohydrate intake leave the body in faeces. Alcohol is digested entirely and fibres pass through the body totally. The digestibility of minerals is assumed to be roughly 50%.

The digestibility rates of human food are considerably higher than the digestibility rates of feed by domestic animals. Thus, the share of faeces is also lower for humans than for animals. The reason for the higher digestibility of human food may be due to a higher share of animal products and especially to the cooking of human food.

For humans, as well as for domestic animals, the dry matter of urine is formed by urea as a combustion residue of proteins and by minerals leaving the body as a consequence of tissue renewing, which in the mineral equilibrium is equal to the quantity of digested new minerals.

Although no information on the methane emissions of human digestion was found for this study, it is assumed that the intestinal bacteria of carbohydrate digestion yield methane emissions of 1% of carbohydrates. The amount of methane emissions is, however, minor.

The share of the body mass growth derived from the reproduction of the population remains very small in the total metabolic flows as well.

Because of the high digestibility and low production of body mass, the main share, or 80%, of the dry matter of human food is combusted in energy production.

The division of the use of water between faeces, urine and evaporation has been controlled according to the shares of the water equilibrium in Table 5.6.6.

The metabolic balance has been converted into external mass balances in Table 5.6.9 and in Table 5.6.10 they have been raised further to the level of the total Finnish population.

The shares of the growth of the body mass and methane are so small that they could be rounded away, too.

Table 5.6.8. Human metabolic balance in 1999, g/person/day

	Carbo-hydrates	Fats	Proteins	Alcohol	Fibres	Minerals	Water	Oxygen	Carbon dioxide	Total g/day
Intake										
Meals	240.0	96.8	81.7	0.0	20.6	21.6	1 003.5			1 464.2
Beverages	33.8	0.4	2.5	17.7	0.2	1.8	509.5			565.8
Drinking water							987.1			987.1
Respiration								700.3		700.3
Total	**273.8**	**97.2**	**84.2**	**17.7**	**20.8**	**23.4**	**2 500.0**	**700.3**	**0.0**	**3 717.5**
Use										
Faeces	5.5	4.9	6.7	0.0	20.8	11.7	112.5			162.1
Urine						11.6	1 687.4			1 725.4
Methane	2.7									2.7
Growth of body mass		0.4	0.4			0.1	1.3			2.2
Energy production	265.6	92.0	50.6	17.7			–312.9	700.3	–814.0	0.0
Respiration, perspiration							1 011.1	0.0	814.0	1 825.1
Total	**273.8**	**97.2**	**84.2**	**17.7**	**20.8**	**23.4**	**2 500.0**	**700.3**	**0.0**	**3 717.5**

Table 5.6.9. External mass balances of humans in 1999, g/person/day

Balance 1

INPUT	3 717	OUTPUT	3 717
Meals	1 464	Body mass	2
Beverages	566	Faeces	162
Water	987	Urine	1 725
Oxygen	700	Water vapour	1 011
		Carbon dioxide	814
		Methane	3

Balance 2

INPUT	3 717	OUTPUT	3 717
Dry matter	517	Dry matter	89
Water	2 500	Water	1 801
Gas	700	Gas	1 011

Table 5.6.10. External metabolic mass balances of Finnish population in 1999, Mkg

Balance 1

INPUT	3 717	OUTPUT	3 717
Meals	2 764	Body mass	4
Beverages	1 068	Faeces	306
Water	1 863	Urine	3 257
Oxygen	1 322	Water vapour	1 908
		Carbon dioxide	1 536
		Methane	5

Balance 2

INPUT	3 717	OUTPUT	3 717
Dry matter	976	Dry matter	167
Water	4 719	Water	3 400
Gas	1 322	Gas	3 450

Food waste

The waste of human nutrition is divided into food remains and human excretions. The formation of food waste per person and that of the total population are presented in Table 5.6.11. Food waste is divided into solids and liquids. The liquid waste is formed by subtracting the remains of coffee and tea from those beverages and by adding the remains of milk.

The accumulation of food waste per person is 753 kg per year, of which 49 kg are dry matter.

In the management of waste, solid food remains end up either in mixed community waste or in compost. Liquid remains and excreta generally end up in sewage.

Only some of the food waste is formed in the homes of households. Fourteen per cent of the mass of foodstuffs are taken outside homes in restaurants and canteens (see Table 5.6.1). Thus, this part of food remains is accumulated in the branch of restaurants and canteens. Human excreta end up in the sewage of wherever people are at various times: home, workplace, school, restaurant or other place of leisure activities. The distribution could be assessed against time use studies.

Table 5.6.11. Formation of food waste in 1999

	Kg/person/year			Total population, Mkg		
	Total	Dry matter	Water	Total	Dry matter	Water
Remains	**64**	**17**	**46**	**329**	**89**	**240**
Solid	51	16	35	263	83	180
Liquid	13	1	12	66	7	60
Excretions	**689**	**32**	**657**	**3 564**	**166**	**3 398**
Faeces	59	18	41	306	94	212
Urine	630	14	616	3 258	72	3 185
Total	**753**	**49**	**703**	**3 893**	**255**	**3 637**

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This publication describes Finnish physical flow accounts as balances and gives a systematic presentation of the calculation method and concepts applied in the accounting. By and large the publication follows the models developed in the active international collaboration of recent years, but adds precision to the accounting standard and makes it more practicable.

Physical flow accounts form a consistent framework for presenting fragmented environmental data. Almost all environmental effects are crystallised in physical flows. Compilation of statistics on the use of material is also necessary because the widely adopted goal in the environmental policy is achievement of economic growth without respective relative growth in the use of natural resources.

Physical flow accounts can be regarded as a milestone in the continuum that national accounts started decades ago. National accounts describe monetary flows in the economy, while physical flow accounts measure the use of materials, or "society's metabolism", within the same framework. Physical flow accounts present quantitative flows of materials from nature to the economy, inside the economy, between national economies and back to nature from the economy.

This volume embodies the physics, substance and philosophy of economics. It can be used as a guidebook on environmental policy a well as for studies and research into interaction between the environment and economy. The author, Dr. Ilmo Mäenpää, is an internationally recognised researcher of the subject and an authority on it in Finland.

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