INTRODUCTION

This study examines how energy consumption correlates with the production and consumption structures of commodities – i.e. what are the energy requirements of the various branches of production, and how much energy is involved in producing final products and in the various uses to which they are put. It also shows the link between air emissions and economic structures, since such emissions result primarily from the production and consumption of energy.

Direct consumption by households – in the home and by private motor vehicles – accounts for a little over a quarter of total energy consumption. This means that almost three quarters of total energy is used in the production of goods and services ("commodities").

Energy consumption and air emissions resulting from production can be analysed from two angles. First, we can determine the amounts of energy different branches consume and the extent of the emissions they produce. A revealing indicator for comparing branches is energy consumption or emissions relative to the volume of production. A good way of measuring production by a branch is in terms of value added – in other words, how much the branch has added to the economic value of the commodities it has produced. We refer to energy consumption and emissions relative to value added as the branch's "specific consumption" and "specific emissions".

The second approach is to determine the amounts of energy which end products in fact represent, and the extent of the emissions resulting from the entire production process. Final uses of commodities are divided into four main groups: private consumption, public consumption, capital formation and export. Production structure is largely determined by how the final use of commodities is distributed over these four groups and the internal commodity structures of the groups.

About half of the commodities produced by the various branches are used as intermediate products in the production of other commodities. The input output model describes the flows of commodities between the various branches and their distribution over the final use groups. The model can be used to determine how much production by other branches is used in the production processes for the various final commodities. Thus the model can also be used to determine the total amounts of energy and emissions involved in producing the various final commodities. It is then possible to establish how the energy used for producing commodities ultimately correlates with their final use structures.

Total energy consumption is measured in terms of the consumption of primary energy in the form of oil, coal, gas, peat, wood and hydroelectric or nuclear power. About two thirds of primary energy is converted into electricity or district heating before final use. These are clean forms of energy which produce no emissions when used; the emissions are produced when they are being generated from primary sources. In order to be able to assess the impact of the various branches on total energy consumption and total emissions, consumption of electricity and heat has to be converted back into the amounts of primary energy consumed in generating them and the emissions produced.

Section 2 describes the principal features of the methods used, together with the main concepts. The method used for converting electricity and heat back to primary energy and the input output analysis are explained in greater detail in Annexes 1 and 2.

Section 3 examines energy consumption and emissions by production branches at a more aggregated level, while going into greater detail in the case of manufacturing and transport. Finally, in a comparison between branches, it examines how energy, employment and capital are interrelated.

Section 4 shows the total energy and total emissions represented by commodities, using the input output model. In Section 5 the energy and emissions accounted for by household consumer goods are set out by group of consumer goods.

In Section 6 energy and emissions accounted for by the final use of commodities are set out by four main groups: private consumption. public consumption, exports and capital formation. The section also contains total energy and emission balance sheets for the economy. Finally, it shows how changes in total energy consumption can to a great extent result from changes in macroeconomic structure.

The calculations are based on the most recent input output tables – those for 1993. In general, the same methods were used as for the Oulu University study relating to 1990 (Mäenpää – Tervo 1996), but this time it was possible to use a much more detailed branch breakdown. The branch data on energy and emissions were produced by Statistics Finland's environment and energy unit. They are derived from the basic figures set out in Statistics Finland's publication on energy and emissions (Official Statistics of Finland, Environment 1996:3), but a more precise branch breakdown was made for 1993.

2 CONCEPTS AND METHODS

In the basic data on energy consumption and air emissions, energy consumption is divided into 58 branches (cf. Annex 3) corresponding to the breakdown used in Statistics Finland's input output tables for 1993. These in fact used 66 branches (including public services and other activities as final consumption columns) but some of them have had to be combined as it is not possible to distinguish their respective energy consumptions reliably. Indeed, the allocation of energy consumption between the service branches is very unclear.

For each branch, the basic data on energy consumption are broken down according to the following 24 types of energy:

1 Motor petrol
2 Other petrol
3 Diesel oil
4 Light fuel oil
5 Heavy fuel oil
6 LPG
7 Natural gas
8 Coal
9 Coke
10 Peat
11 Fuel wood
12 Industrial residual wood
13 Black liquor
14 Blast furnace gas
15 Coke gas
16 Biogas
17 Refinery residuals
18 Other residuals
19 Industrial reaction heat
20 Nuclear power
21 Hydroelectric power
22 Electricity, net imports
23 Heat, net
24 Electricity, net

The energy values of primary sources are calculated according to the methods used in Statistics Finland's revised publication on energy statistics (Official Statistics of Finland, Energy 1997:1). The primary sources are then combined to form three main strategic groups:

- Imported energy (1–9, 20, 22);
- Indigenous primary energy (10, 11, 21);
- Recovered energy (12–19).

Air emissions from energy consumption by the various branches have been calculated using the specific emission coefficients of the detailed energy classification. Emissions by power stations were therefore determined using Statistics Finland's computation model for air emissions, "Ilmari". Four types of air emissions need to be examined:

- sulphur dioxide, SO_2;
- nitrogen oxides, NO_x;
- carbon dioxide emissions from fossil fuels, CO_2 (foss);
- carbon dioxide emissions from wood based and other biomass fuels, CO_2 (bio);

Since the emission calculations include only emissions resulting from energy consumption, the total emissions of sulphur dioxide in particular are underestimated.

In the presentation of the results, SO_2 and NO_x emissions have been combined in the form of SO_2 equivalent acidifying emissions. It was assumed that the acidifying capacity of oxides of nitrogen was 70% of that of a similar amount of sulphur dioxide.

Before the analysis proper, the branch figures for energy consumption and emissions were converted to primary energy equivalents so that the primary energy and emissions for heat and electricity obtained from outside a given branch were allocated to the branches which consumed the heat and electricity. The conversion method is described in greater detail in Annex 1.

A problem when linking energy and emissions with production activities and commodity flows is that one and the same activity or commodity is measured in different ways depending on the viewpoint.

The level of production in a given branch can be measured in terms of either total output or value added. “Total output“ is the value in Finnish markka (FIM) of the commodities produced by the branch. As the term suggests, “value added“ means how much a branch adds to the value of the intermediate products it uses in its products. “Value added“ is also the sum of the returns on a branch's inputs of labour and capital. It shows how much the branch increases income formation in the economy, i.e. GDP. Value added is an appropriate way of measuring the productive activity of a branch. The appropriate yardstick for measuring commodity flows is total output.

When comparing branches, it makes sense to relate energy consumption and emissions to the level of production of a given branch. Since there are two ways of measuring the level of production, we need two different terms for the ratios. The following terms will be used below:

- specific energy consumption and specific emissions = energy consumption and emissions/ value added;

- energy input coefficient and emissions coefficient =energy and emissions/total output.

Commodity flows undergo further changes on the way from the producer to the consumer. There are transport and trade margins (transport and trade at the same time make their own contribution to the energy and emissions represented by the commodity) and also taxes.

The total output of a branch is measured at producer's or ex works prices. When they reach the final consumer, commodities are measured at purchaser prices – in other words, the price includes transport and trade margins and taxes. Since the coefficient defined above refers to the ratio in terms of producer prices, a third term is used when examining final use:

- energy and emission intensity = energy and emissions/commodities at purchaser's prices.

The input/output table shows the final balance of the production activities and commodity flows of the various branches, and gives a systematic account of the changes in value.

3 ENERGY CONSUMPTION AND AIR EMISSIONS BY BRANCH

3.1 General

In a branch-by-branch comparison, energy consumption can be related to either the total output or the value added of the branches. Total output is a measure of the total value of the commodities produced by a branch, whereas value added, as the term suggests, is a measurement of how much a branch increases the value of the intermediate products it uses. In other words, it shows how much the branch increases income formation in the economy, i.e. GDP.

In this section, branches are considered in terms of their production activity, and energy consumption and air emissions are therefore correlated with value added. The ratios are known as the specific energy consumption and the specific emissions.

First of all, the entire economy is examined, and the 58 branches in the basic calculations combined to form 18 main branches. Manufacturing and transport are then analysed in greater detail. Finally, energy consumption is compared with the inputs of capital and labour.

Section 4 examines the amounts of energy represented by commodities using the input output method and energy consumption is correlated with total output at producer prices.

3.2 The economy as a whole

Figure 1 shows the specific primary energy consumption, or energy consumption per unit of value added, for the main branches of the economy in 1993. Primary energy is divided into three main categories:

- imported energy: oil, coal, nuclear fuel, imported electricity;
- indigenous primary energy: peat, wood, forest-processed chips, hydroelectric energy;
- recovered energy: manufacturing by-products and waste, e.g. sawdust and wood chippings, sulphite and black lye, blast furnace and coke gas, refinery waste, waste heat from manufacturing.

Specific energy consumption is highest by a wide margin in wood processing and second highest in the chemical industry. However, a large part of energy consumption in these branches is accounted for by use of their own by-products and waste for energy purposes - 46% and 43% of the energy used by forestry and the chemical industry respectively is recovered energy.

It is interesting to note that specific energy consumption in the metal industry is a little lower than in agriculture. Specific energy consumption is very low in forestry because a large part, i.e. payment for natural resources. If the value added of forestry included only the value of the labour and capital inputs for tree felling and forest management, the specific energy consumption would be considerably higher.

Specific energy consumption in the housing branch is also relatively high. However, this is not really a production branch in the strict sense, and is therefore not directly comparable.

Primary energy consumption by the various branches as shown in Figure 1 also includes electricity consumption converted to primary energy equivalents. This reveals that in 1993 each unit of electricity consumed had required about twice as much energy from primary sources to produce – in other words the total efficiency of electricity was around 50%. This figure takes account of both generation and transmission losses.

Figure 1. Specific consumption of primary energy by branch – 1993

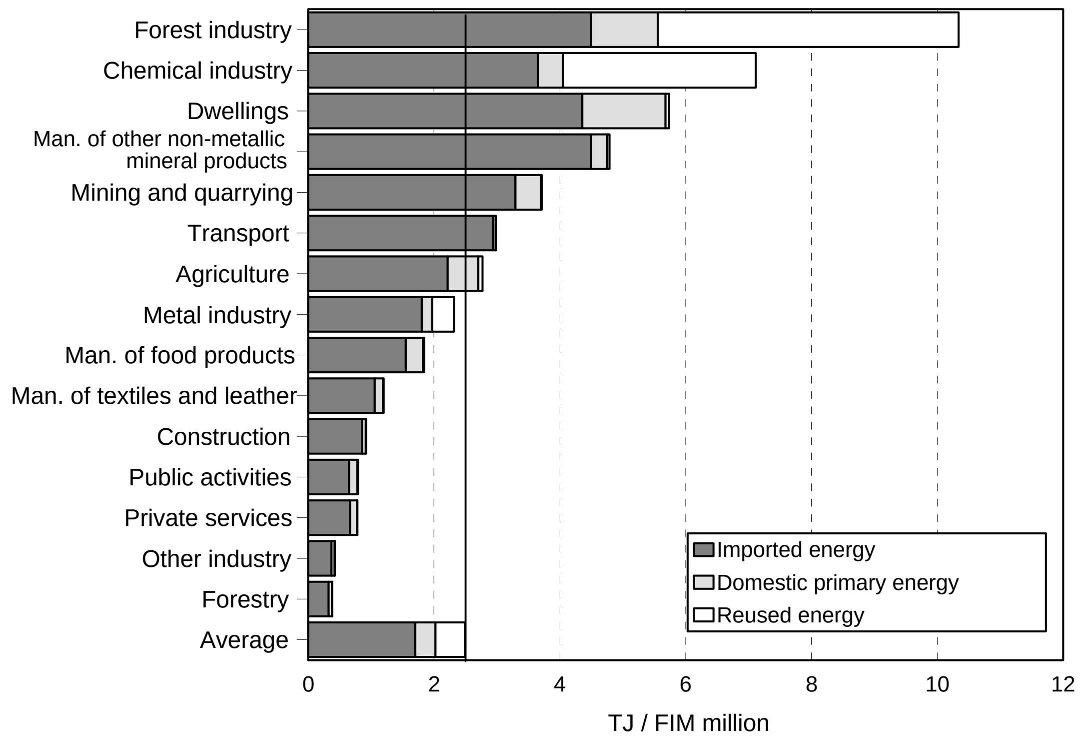


Figure 2. Specific consumption of electricity by branch – 1993

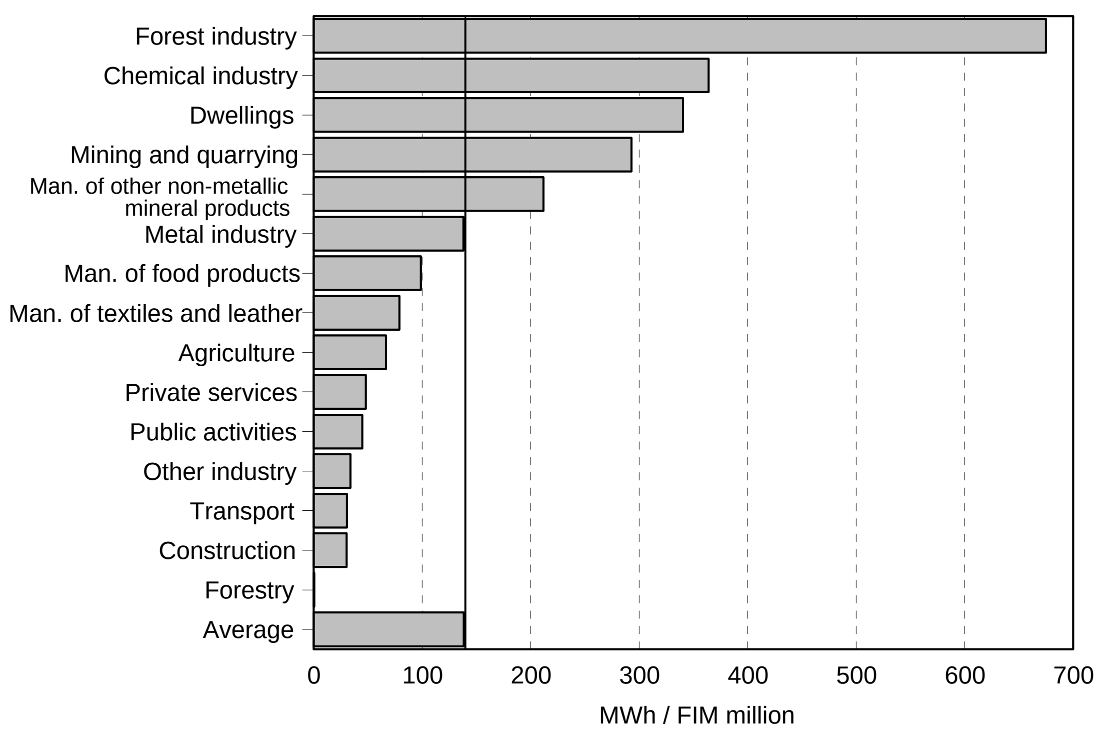


Figure 3. Proportion of total energy consumption by branch accounted for by electricity, in primary energy equivalents – 1993

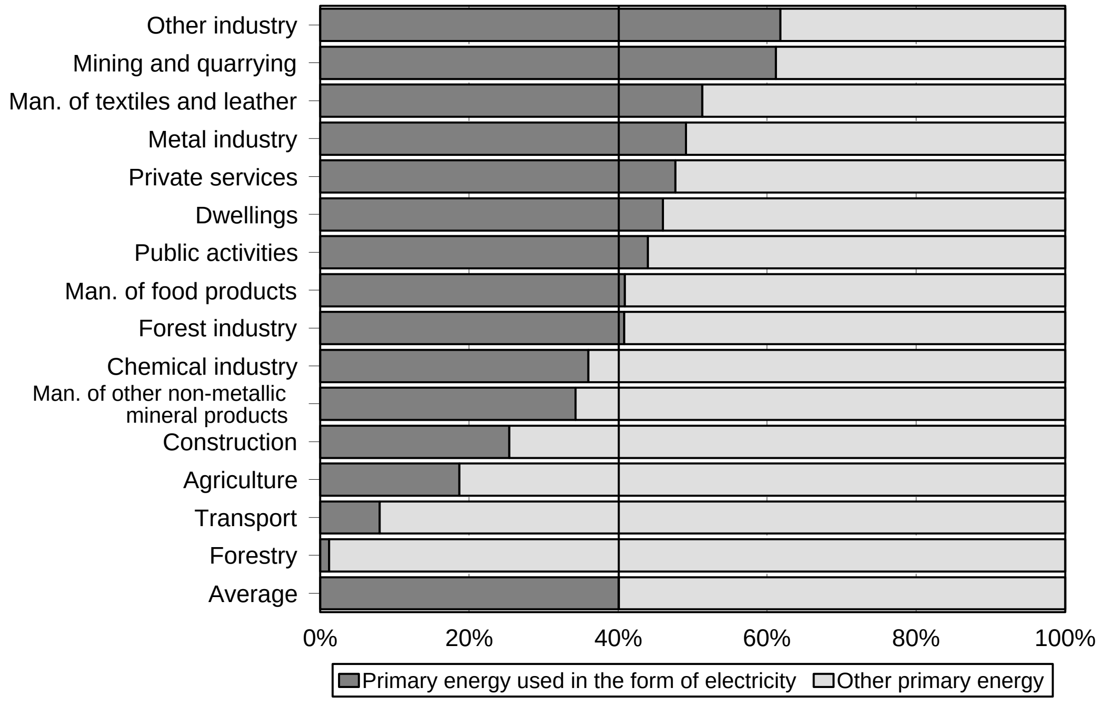


Figure 2 shows the specific electricity consumption of the various main branches in terms of electrical energy. Except in transport, the specific electricity consumption profile by branch is fairly similar to the specific primary-energy consumption profile.

Figure 3 shows, in primary energy equivalents, the proportion of the branches' total energy consumptions accounted for by electricity. On average, about 40% of the total primary energy consumed by the branches is used in the form of electricity, but this figure is a little over 60% in mining and quarrying and other manufacturing. Very little electricity is used in forestry. Electricity consumption is higher than the average in private services, public services and housing.

Figure 4 shows the specific emissions of carbon dioxide by main branch. The figures also include the emissions from the primary energy sources used to produce the electricity consumed by the branch.

The emissions are divided into those from fossil fuels and peat and those from biological sources (mainly wood based fuels). It is widely held that using biomass makes space for the growth of new biomass, which fixes as much atmospheric carbon dioxide as was produced by burning the biomass fuels. CO_2 emissions from biomass fuels have therefore been left out of account in the calculations.

The specific emissions of carbon dioxide by wood processing clearly stand out as the highest. However, if we disregard emissions from biomass fuel, forestry joins the group of other high emission branches – chemicals and mining and quarrying.

Figure 5 shows the specific emissions by main branch of sulphur dioxide and nitrogen oxides – the acidifying agents. The oxides of nitrogen are converted on the basis of their acidifying capacity to sulphur dioxide equivalents using a factor of 0.7 (one tonne of nitrogen oxides has the same acidifying capacity as 700 kg of sulphur dioxide).

Only acidifying emissions connected with energy are considered in this study. In addition to these there are emissions from industrial processes and emissions of ammonia from animal production in agriculture.

Transport is the branch that produces the most acidifying emissions, with particularly high levels of nitrogen oxides. The use of tractors in agriculture and forestry and of machinery in the mining and quarrying and construction branches also produces high levels of nitrogen emissions.

Figure 4. Specific emissions of carbon dioxide by branch – 1993

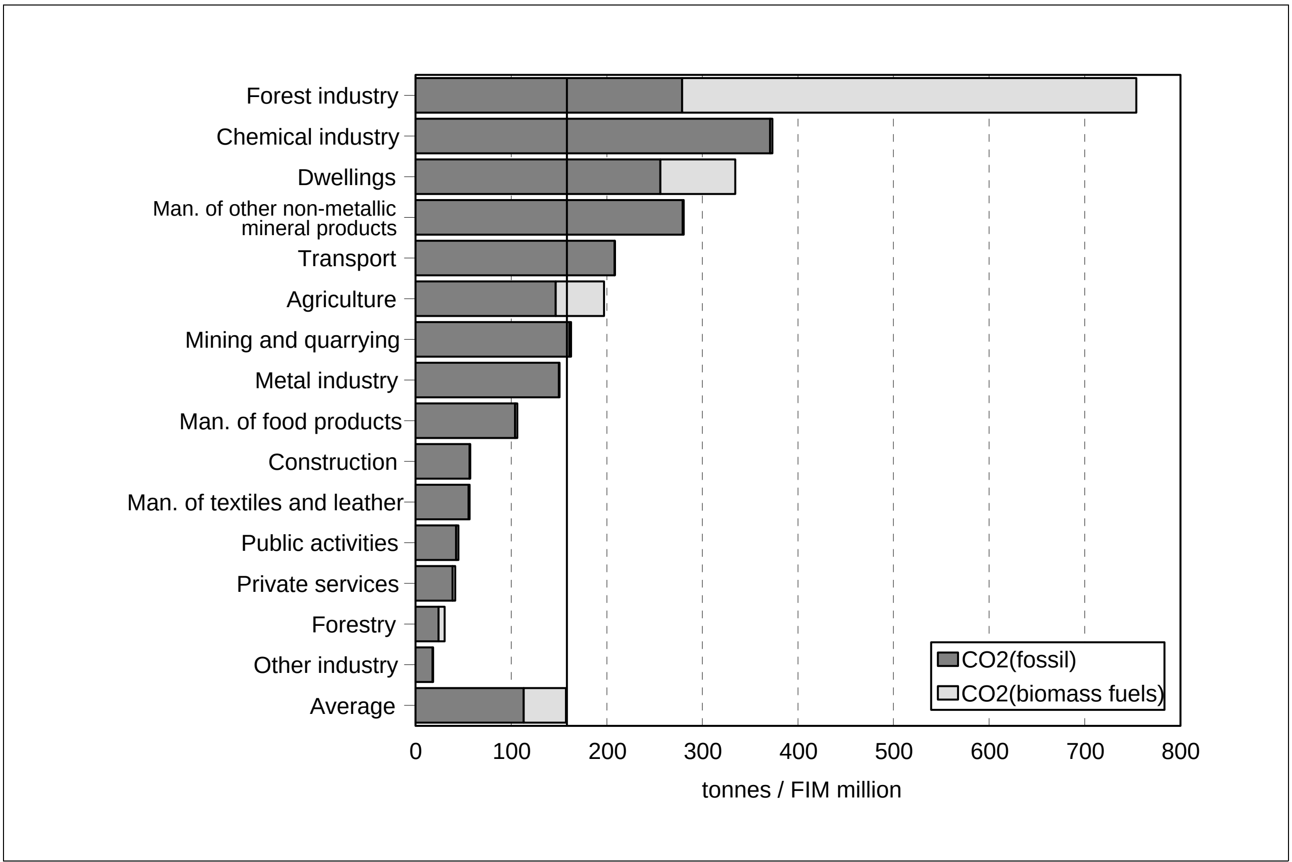


Figure 5. Specific emissions of acidifying agents by branch – 1993

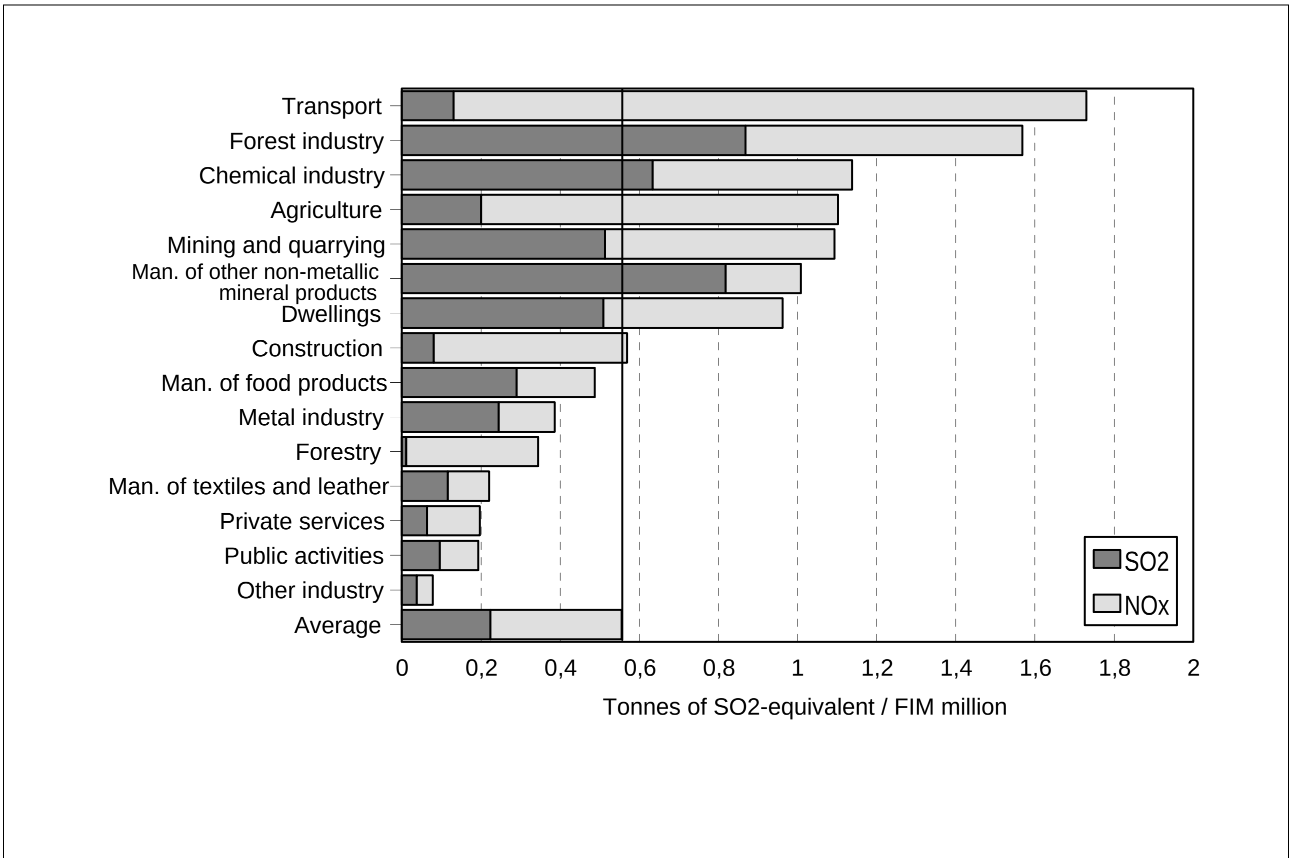


Table 1. Primary energy, air emissions, value added and employment by branch – Finland, 1993 (%)

	Primary energy	"External" energy	CO_2 (foss.)	SO_2 + NO_x	Value added	Employment
Agriculture	3,4	4,1	3,9	6,0	3,1	7,9
Forestry	0,3	0,4	0,5	1,4	2,3	1,5
Manufacturing	50,9	40,0	44,7	37,7	25,3	20,3
Construction	1,8	2,3	2,5	5,1	5,1	6,9
Transport	6,2	7,7	9,6	16,2	5,4	4,7
Private services	8,4	10,3	9,2	9,5	27,6	32,7
Public services	6,5	7,9	7,7	7,1	21,2	26,0
Housing	22,4	27,4	22,1	16,9	10,1	0,0
Total	100,0	100,0	100,0	100,0	100,0	100,0

Table 2. Primary energy, air emissions, value added and employment in industry – Finland 1993 (%)

	Primary energy	Energy from external sources	CO_2 (foss.)	SO_2 + NO_x	Value added	Employment
Mining and quarrying	1,2	1,8	1,3	2,1	1,6	1,1
Food	4,7	7,3	6,6	7,5	13,1	12,3
Textiles, clothing, leather and fur goods, footwear	0,7	1,1	0,8	0,8	3,1	5,5
Forestry	58,1	49,0	39,3	53,7	29,1	28,7
Chemicals	15,5	13,8	20,3	15,1	11,3	9,0
Ceramics, glass, stone	2,8	4,4	4,2	3,6	3,1	3,5
Metals	16,9	22,5	27,4	17,1	37,6	38,3
Other	0,1	0,1	0,1	0,1	1,1	1,5
Total	100,0	100,0	100,0	100,0	100,0	100,0

Table 1 shows the percentages of total primary energy consumption, air emissions, value added and employment accounted for by the various branches. Energy consumption has been calculated in two ways – as total primary energy and as energy from external sources, recovered energy used in industry being subtracted from the total.

Manufacturing accounts for more than half the total consumption of primary energy, but a mere 40% if we consider only energy from external sources. It is responsible for almost 45% of carbon dioxide emissions and a little less than 40% of acidifying emissions. On the other hand, its contribution to value added is only about one quarter and to employment only about one fifth. Private and public services together account for around 15% of energy consumption and around 17% of emissions of both carbon dioxide and acidifying agents, while producing almost 50% of value added and providing almost 60% of jobs.

Table 2 shows the breakdown of energy, consumption, air emissions, value added and employment over the various branches of industry. Wood processing accounts for more than half the total consumption of primary energy and acidifying emissions but only somewhat less than one third of both value added and employment. The metals industry is responsible for around 17% of both energy consumption and acidifying emissions but contributes around 38% to value added and employment.

If we consider only energy from external sources, consumption by wood processing drops to less than a half and consumption by the chemicals industry also falls, while in the metals industry it rises to over a fifth.

3.3 Manufacturing industry

Figure 6 gives a detailed breakdown of the specific consumption of primary energy by the various branches of industry. The figures are highest in pulp and paper manufacture, manufacture of oil and coal products, manufacture of industrial chemicals and synthetics, iron and steel production and production of other metals.

Figure 6. Specific consumption of primary energy in manufacturing industry – 1993

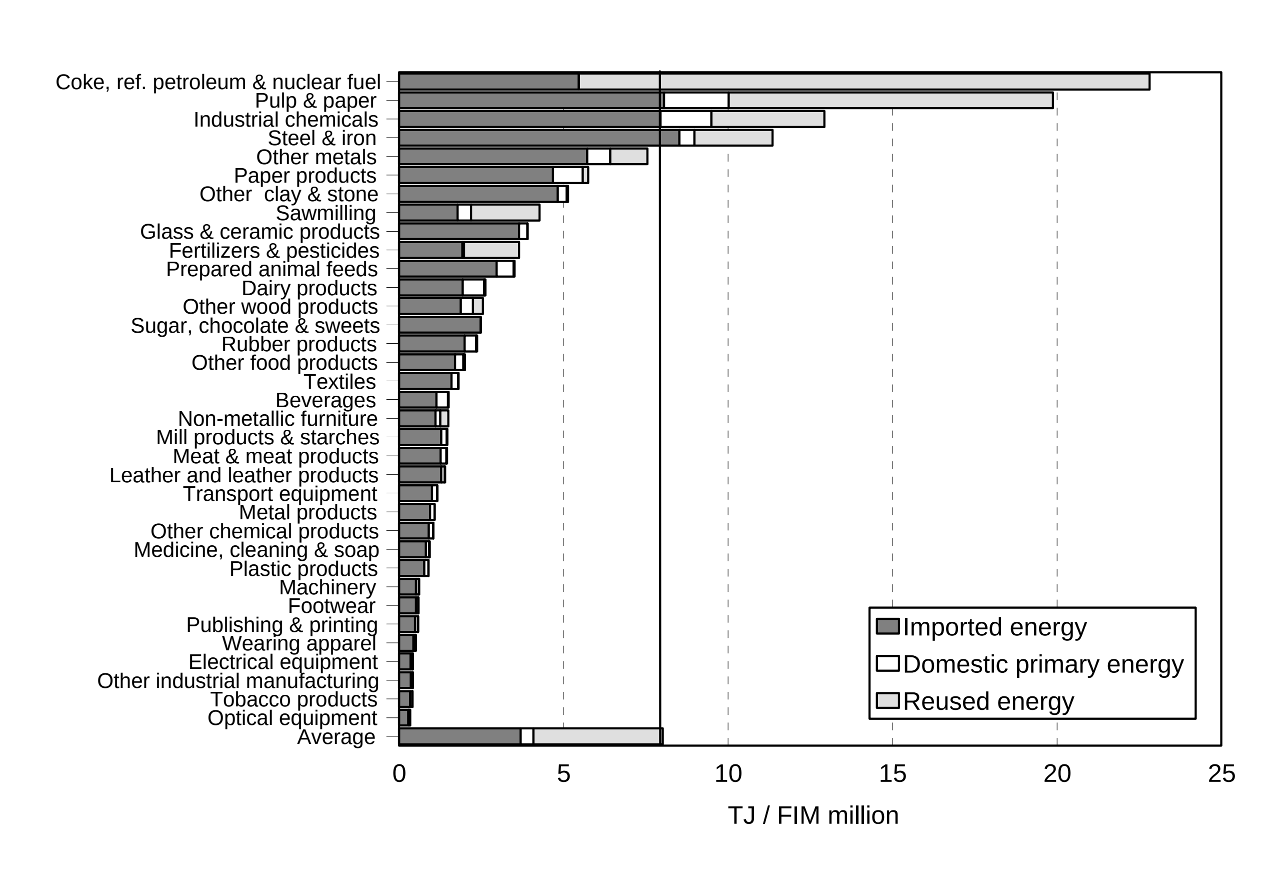


Figure 7. Specific emissions of CO_2 in manufacturing industry – 1993

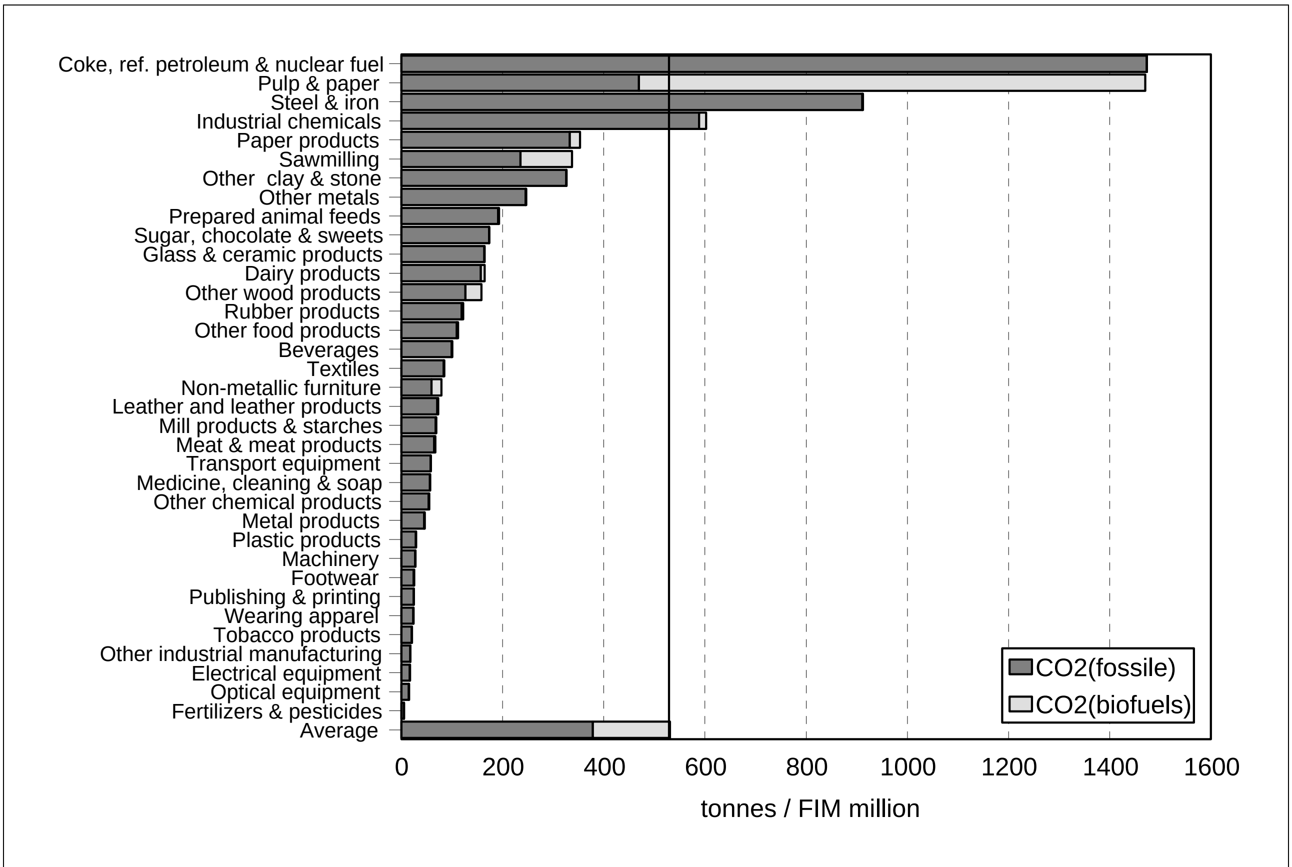
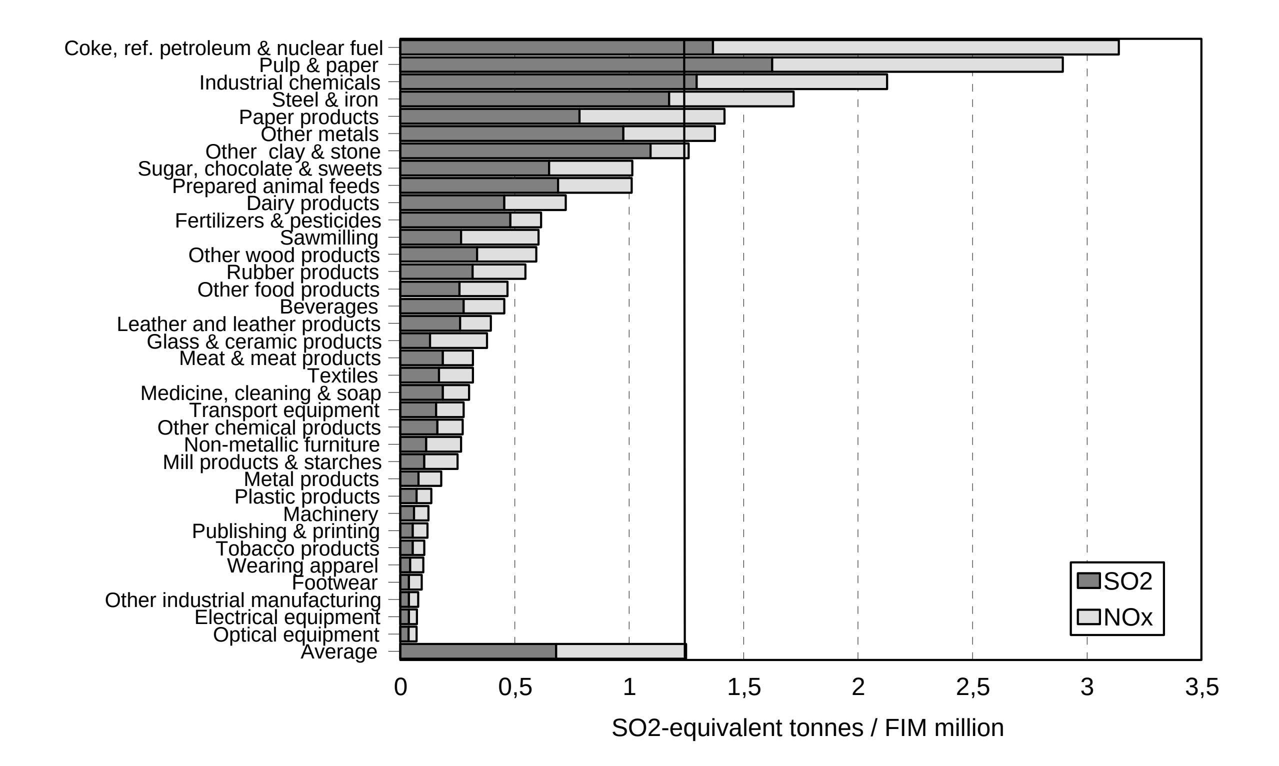


Figure 8. Specific emissions of acidifying agents in manufacturing industry – 1993



The lowest specific energy consumption is found in manufacture of electrical equipment. If this branch continues to grow as it has done so far in the 1990s, its rapid expansion will lower the total specific energy consumption of energy by industry as a whole, since its contribution to value added rose from 9% in 1990 to almost 15% in 1996 and its share in the metals industry grew from 25% to 33% over the same period.

Figure 6 also clearly shows that specific energy consumption is high in the branches involved in the initial processing of raw materials, but decreases at later stages. In the textiles, clothing, leather and fur goods and footwear industry, specific consumption of energy is three times higher in manufacture of textiles than in manufacture of clothing and twice as high in manufacture of leather and fur products than in manufacture of footwear. In the manufacture of wood products, energy consumption is successively lower in sawmills, manufacture of other wood products and manufacture of non metal furniture. Similarly, in the pulp and paper industry consumption decreases successively from manufacture of pulp and paper to manufacture of paper products and finally to graphics and publishing. The same phenomenon can be seen in the chemical and metals industries.

Figure 7 shows the specific emissions of carbon dioxide by the branches of industry. They are noticeably higher in manufacture of pulp and paper and manufacture of oil and coal products than in other branches. However, a good two thirds of the CO_2 emissions by the pulp and paper industry comes from biomass fuels. Carbon dioxide emissions are also high in iron and steel manufacturing and manufacture of industrial chemicals and synthetics. Fig. 8 shows specific emissions of acidifying agents by industry.

3.4 Transport

Specific energy consumption by the transport branches is shown in Figure 9. Transport mainly consumes imported energy in the form of oil products. Specific energy consumption by air transport is by far the highest. Obviously, energy consumption is low in supporting transport activities and telecommunications. Surprisingly, specific consumption of primary energy by rail transport is slightly higher than the figure for road transport. However, if specific consumption was calculated in terms of physical units of performance – i.e. passenger/tonne kilometres – the opposite would be found, as rail prices per passenger/tonne kilometre are lower than road transport prices. The result is also affected by the fact that electricity accounts for a large proportion of energy consumption by rail transport – more than half the primary energy consumed by the branch in terms of primary energy equivalents. Thus, the low overall efficiency of electricity as a form of energy increases total energy consumption by rail transport.

Figure 9. Specific consumption of primary energy by the transport branches – 1993

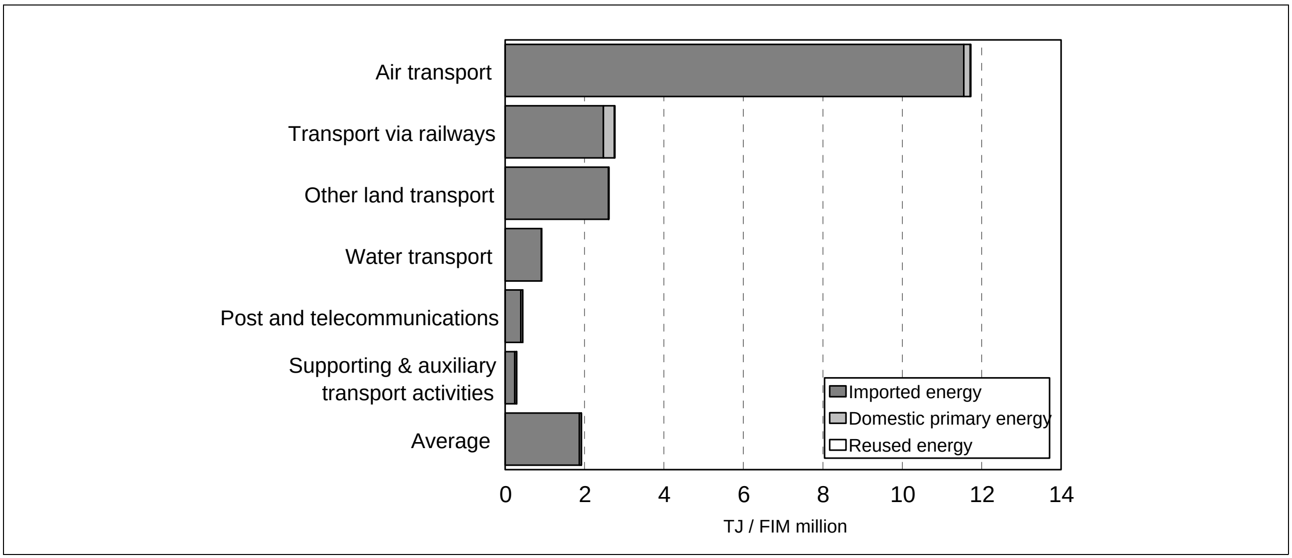


Figure 10. Specific emissions of carbon dioxide by the transport branches – 1993

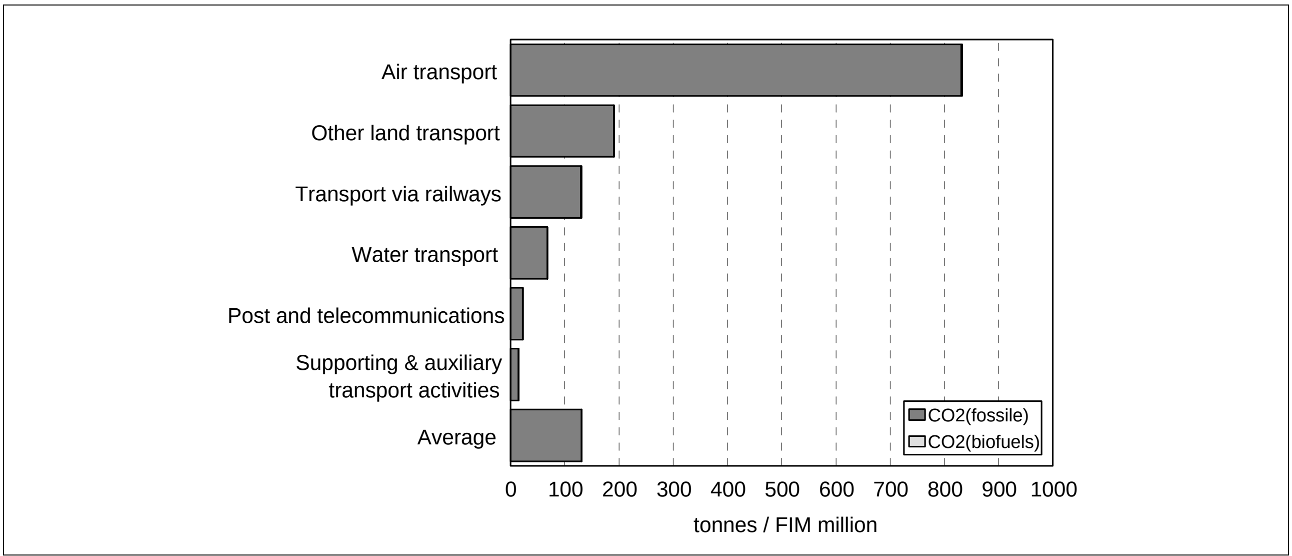


Figure 11. Specific emissions of acidifying agents by the transport branches – 1993

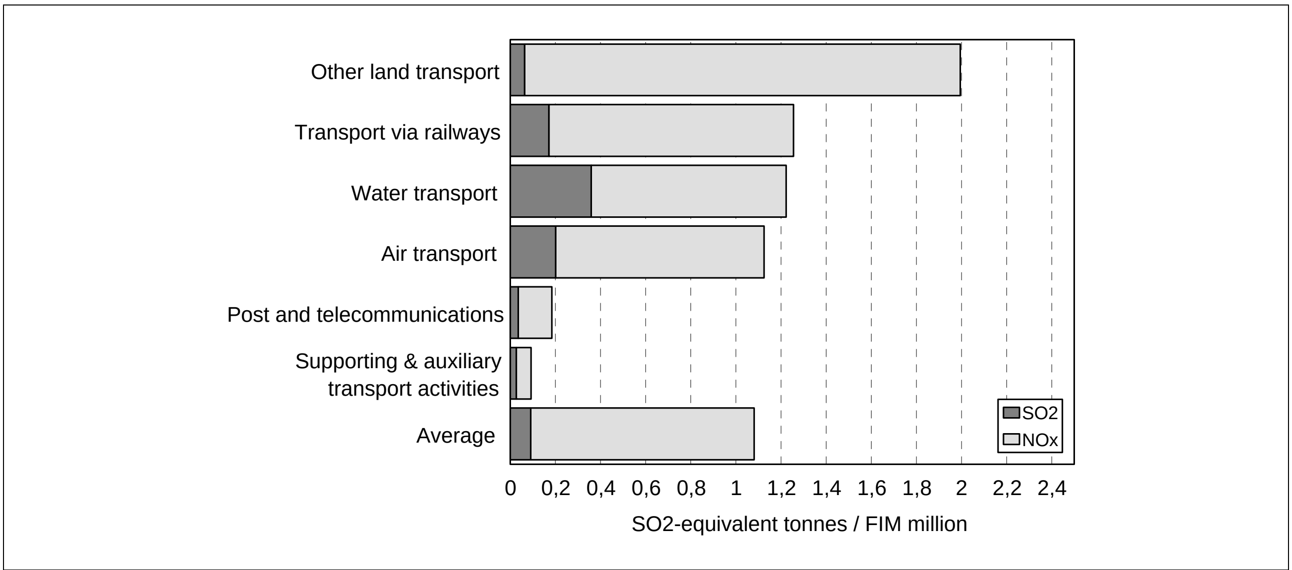


Figure 10 shows the specific emissions of carbon dioxide by the transport branches. They are almost entirely from fossil fuels. Again, carbon dioxide emissions by air transport are in a class of their own. Emissions for road transport are higher than for rail transport.

Figure 11 shows the emissions of acidifying agents by the various transport branches. Here, because of its high levels of SO_2 emissions, road transport shows the highest figure. Thanks to turbine engines, specific acidifying emissions by air transport are lower than by other transport branches.

3.5 Energy, employment and capital

This section contains a branch-by-branch comparison of the correlation between energy consumption and the other basic inputs to production – labour and capital. Like specific energy consumption, the labour input coefficient is calculated in terms of input per unit of value added. No figures for capital stock are available at the level of breakdown used here, so capital consumption per unit of added value is used as the capital coefficient. In order to show the scatter, all three variables were standardised so that the branch average for each of them is one hundred. A detailed breakdown into 58 branches was used for the comparison.

Figure 12 shows the distribution of the various branches in terms of specific energy consumption and the labour input coefficient, while Figure 13 shows the distribution in terms of specific energy consumption and the capital coefficient.

Even if there are no very direct correlations, it can nevertheless be seen that a high level of specific energy consumption tends to go with a low labour input coefficient and a high capital coefficient, while low specific energy consumption is most often found in branches with a high labour-input coefficient and a low capital coefficient. The scatter is somewhat wider in non manufacturing branches than in manufacturing. The activities of non manufacturing branches also differ very widely.

The correlation factor for specific energy consumption and labour input is -0.31 for all 58 branches and -0.40 for the 34 industrial branches. The correlation between energy and capital is +0.46 for all branches and +0.74 for manufacturing. The corresponding figures for the correlation between labour and capital are -0.20 and -0.24. It can therefore be seen that a branch's energy intensity correlates comparatively strongly with its capital intensity, but is to some extent inversely proportional to its labour intensity.

Figure 12. Specific energy consumption and labour input coefficient by branch – 1993. The variables have been standardised so that the branch average is 100

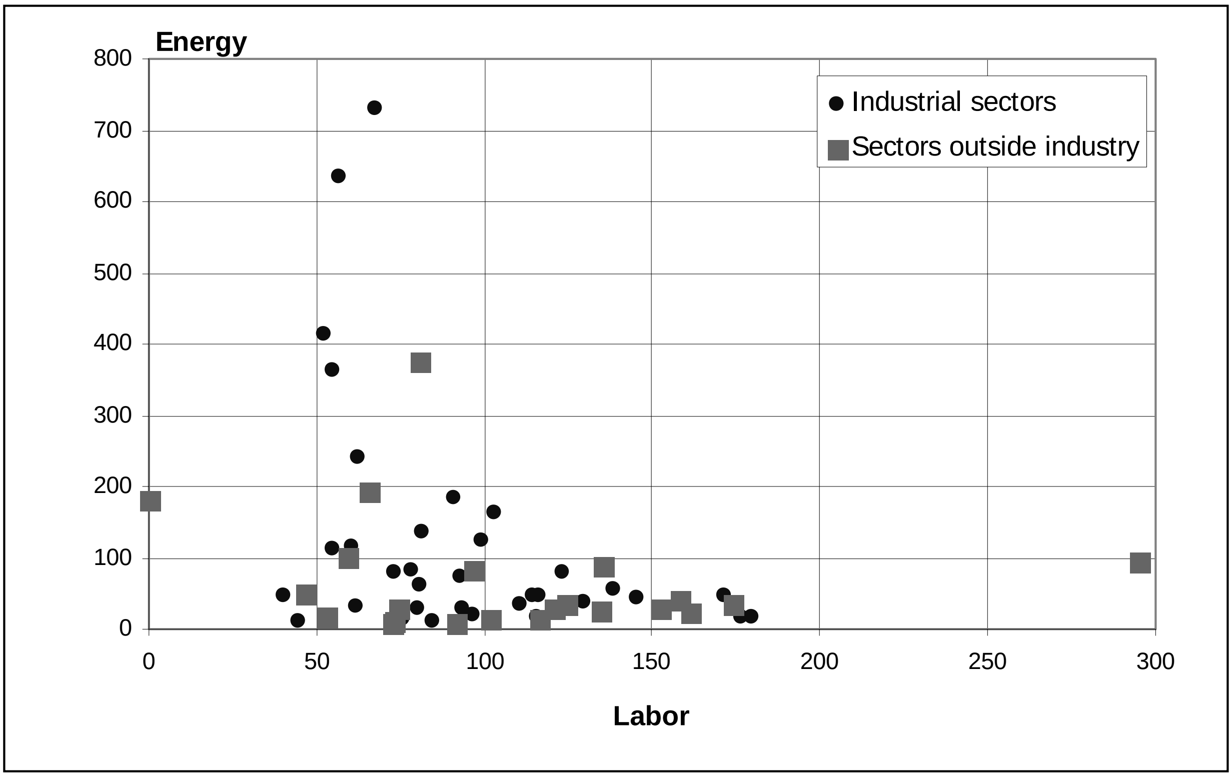
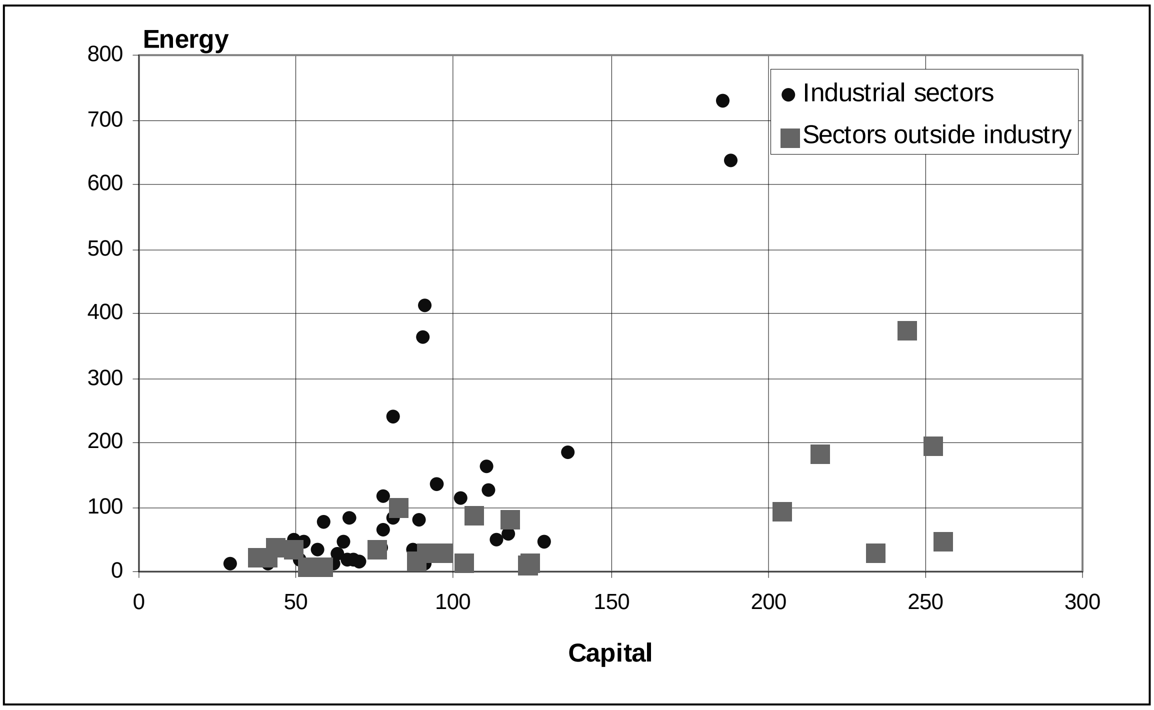


Figure 13. Specific energy consumption and capital input coefficient by branch – 1993. The variables have been standardized so that the branch average is 100



4 ENERGY AND EMISSION COEFFICIENTS OF COMMODITIES

4.1 General

We shall now examine the energy and emissions represented by the commodities produced by the various branches. Instead of relating them to value added, energy and emissions will now be considered relative to the total value of a branch's production - i.e. total output. The ratios obtained will be referred to as the energy and emission coefficient of a branch or of a commodity produced by a branch.

The energy and emission coefficients of commodities are broken down into three components:

- Direct energy and emission coefficients, i.e. the specific energy consumption and emissions of the branch producing the commodity relative to the total output value;
- Indigenous indirect energy and emission coefficients, i.e. the energy consumed and emissions caused by other branches in producing indigenous intermediate products used by the branch, relative to the branch's total output value;
- Imported indirect energy and emission coefficients, i.e. the energy consumed and emissions caused in other countries by the production of imported intermediate products used by the branch, relative to the branch's total output value

The indirect energy and emission coefficients are calculated from the direct coefficients using the input/output model as described in greater detail in Annex 2.

The sum of a commodity's direct and indirect coefficients, or the total energy and emissions coefficient, shows how much energy has gone into the production of the commodity and the volume of emissions caused throughout the entire production process.

The imported indirect energy and emission coefficients are calculated figures: they have been obtained on the assumption that the production techniques for the commodities – in other words the energy and emission coefficients of the branches producing them – are the same as those of the corresponding branches in Finland. This method reveals how much energy would have been consumed, and emissions caused, by the production of the commodities if they had been produced in Finland.

Figure 14. Primary energy coefficients of commodities by branch – 1993

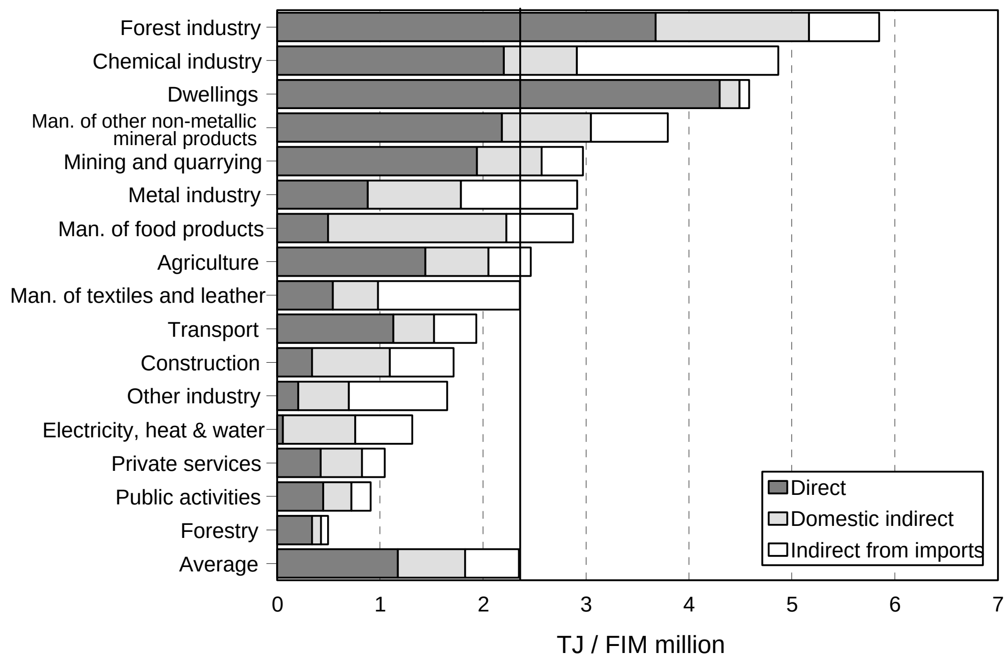


Figure 15. Fossil based carbon dioxide emission coefficients of commodities by branch – 1993

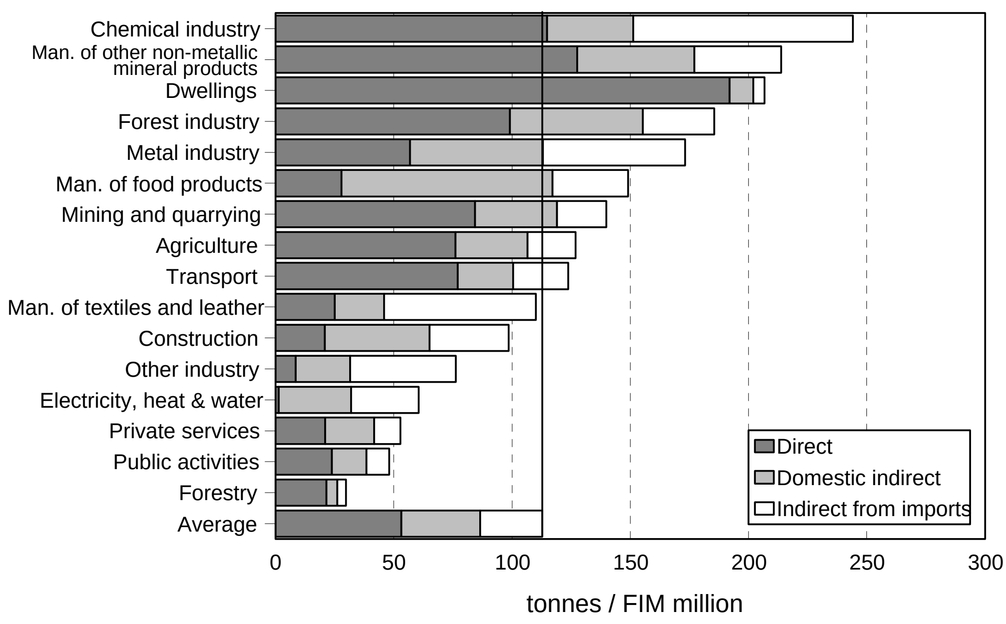
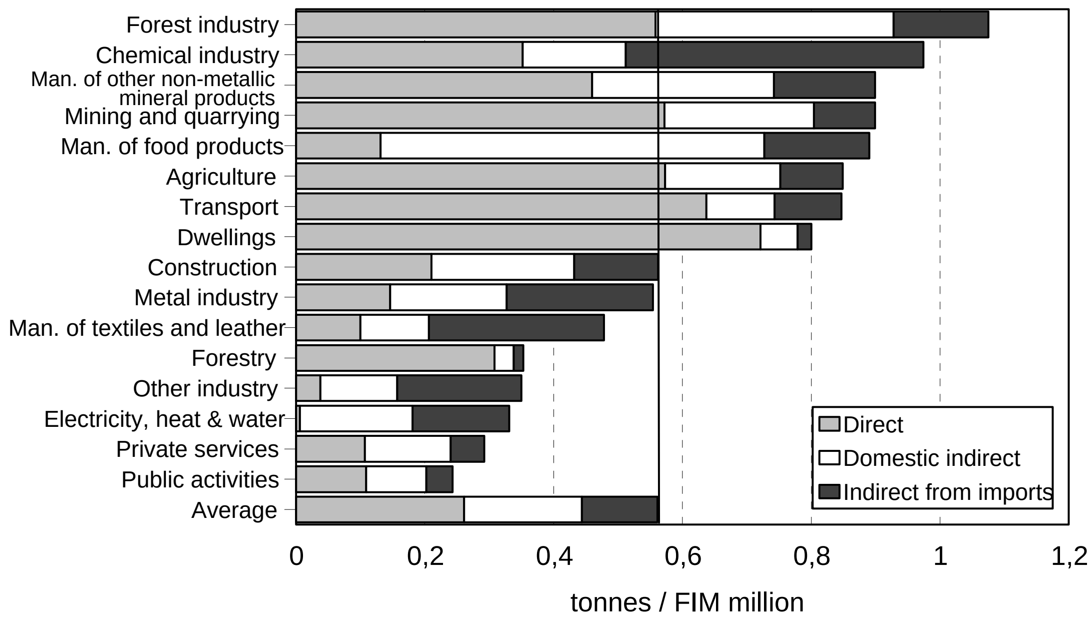


Figure 16. Acidifying emission coefficients of commodities by branch – 1993



4.2 Main branches

Figure 14 shows the primary energy coefficients for the various branches broken down into direct consumption of energy by the branch, the energy content of intermediate products produced in Finland and the energy represented by imported products.

On average, the value of total output is made up of about 50% inputs of intermediate products and 50% value added. The direct energy coefficients for the branches are therefore around 50% lower than the specific energy consumption shown in Figure 1. Around 50% on average of the total energy coefficient is accounted for by direct energy and around 50% by indirect energy.

Indirect energy consumption typically accounts for only a small proportion of the total in the primary branches, but for a large proportion in downstream processing branches – particularly the food industry, textiles and clothing, other manufacturing and construction.

Figure 14 also shows electricity, heat and water supply. The direct energy coefficient is small in this branch and includes only direct energy used for water supply, since in the calculations the primary energy used in generating electricity and heat has been transferred to the consumers of the electricity and heat. However, the indirect energy consumed by the branch includes, inter alia, the energy used in the manufacture and transport of the fuels used for electricity and heat generation. This energy is also transferred to the consumers when calculating total energy consumption by the branches using the input/output model.

Figures 15 and 16 show the coefficients for carbon dioxide emissions from fossil fuel sources and emissions of acidifying agents respectively.

Figure 17. Primary energy coefficients of commodities by branch of industry – 1993

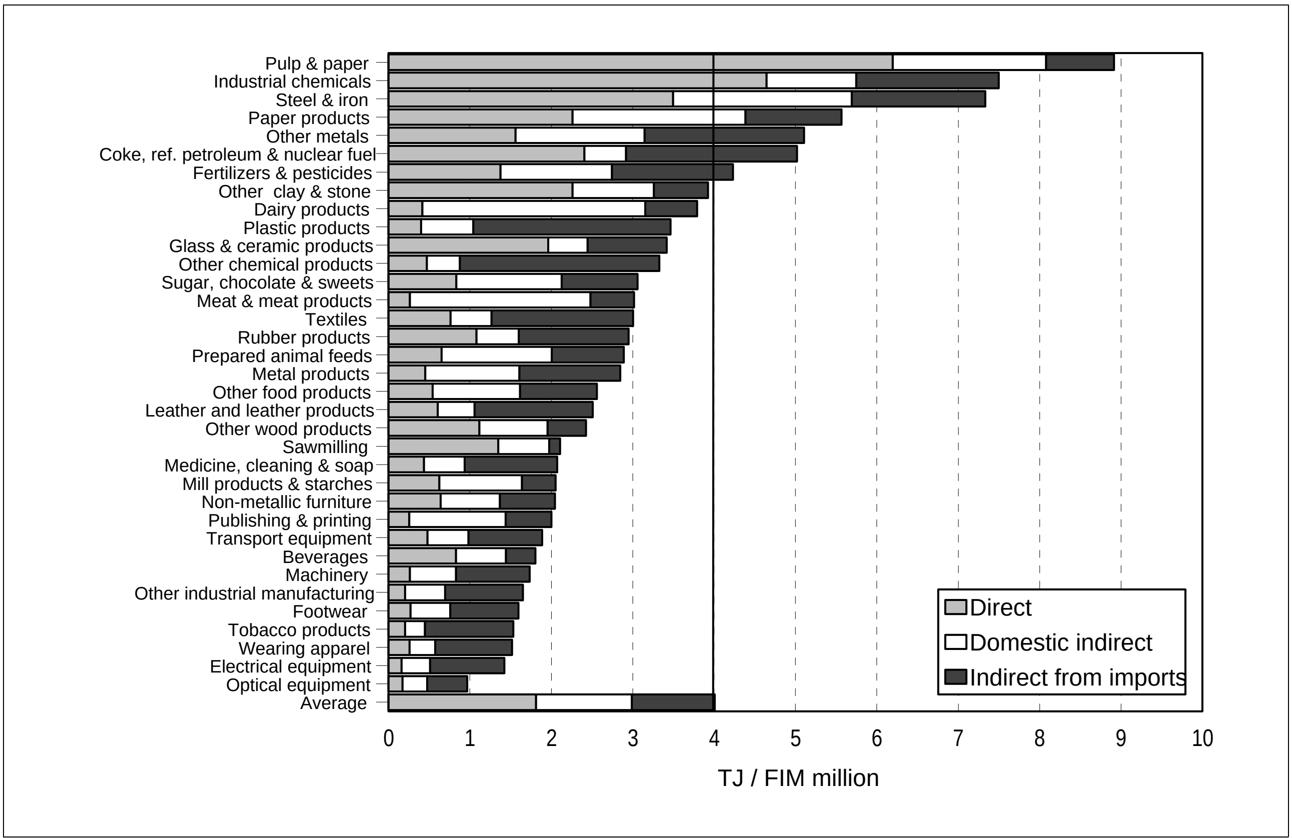


Figure 18. Carbon dioxide emission coefficients of commodities by branch of industry – 1993

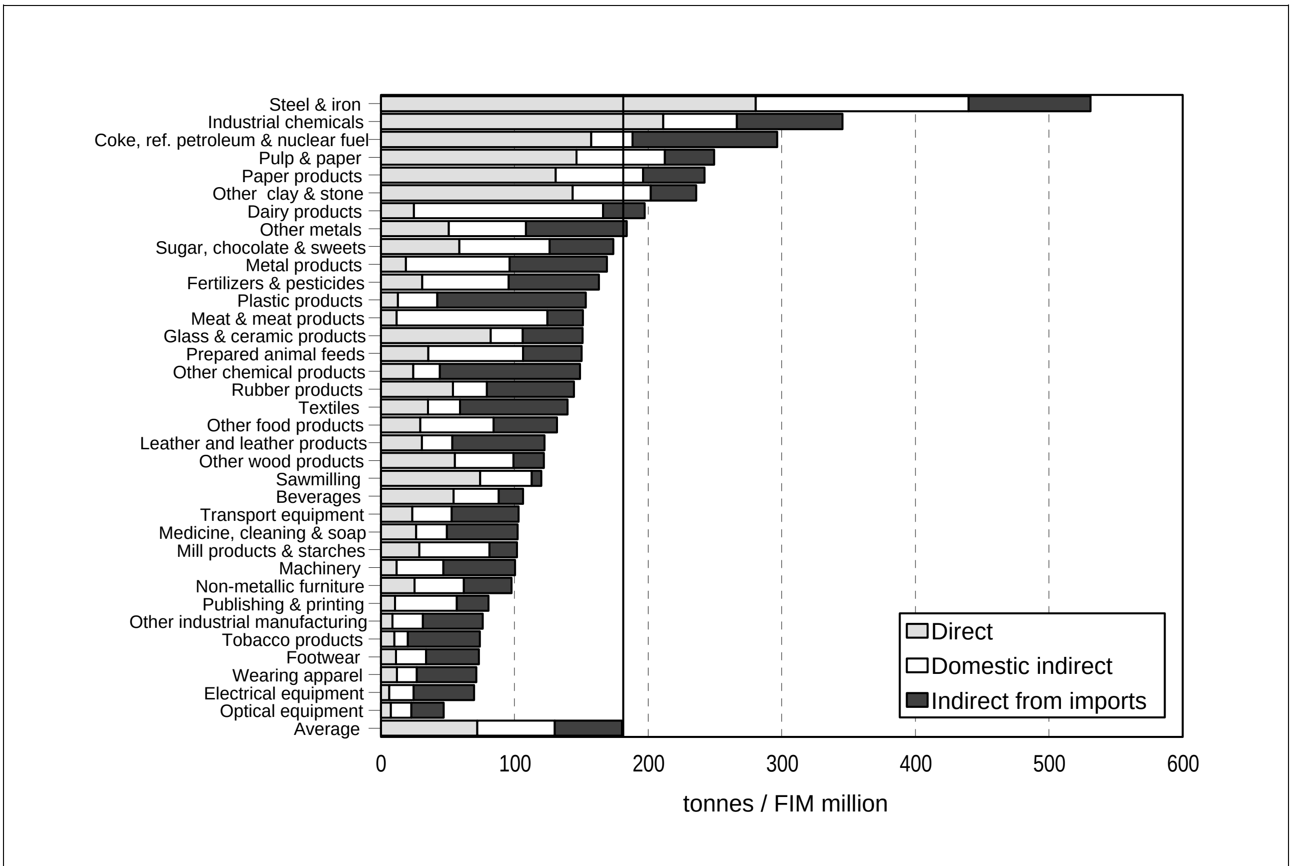
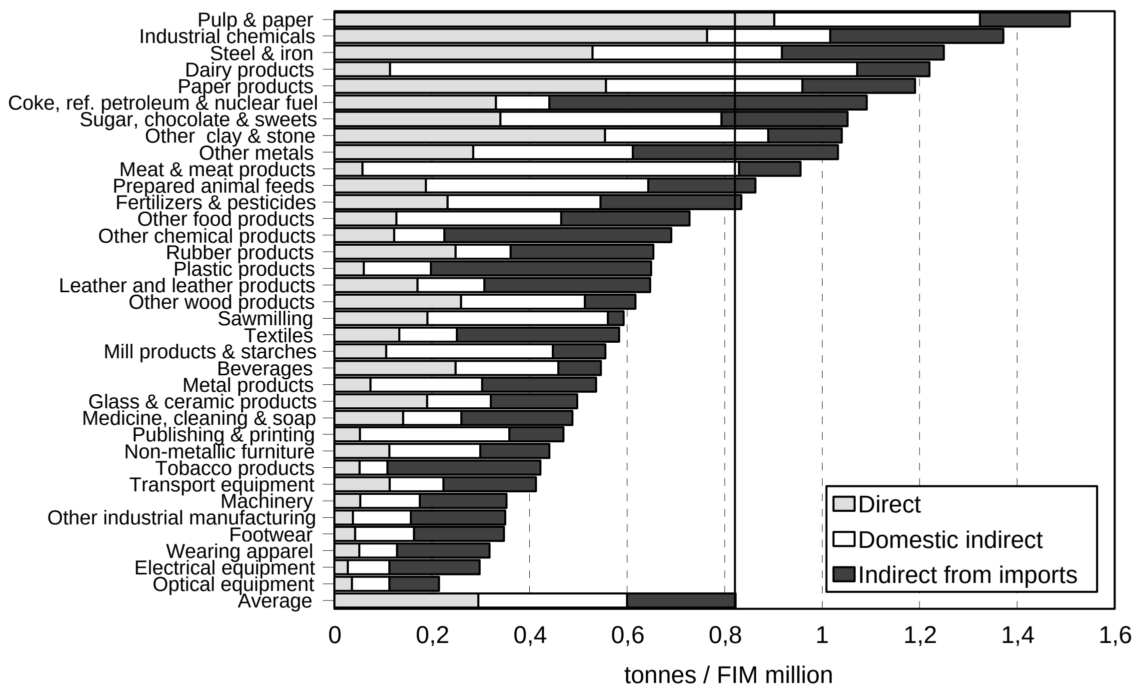


Figure 19. Acidifying emission coefficients of commodities by branch of industry – 1993



4.3 Manufacturing industry

Figure 17 shows the primary energy coefficients for industry in a detailed branch breakdown. The highest coefficients are found in pulp and paper manufacture, industrial chemicals and synthetics manufacture and iron and steel manufacture.

A comparison of the branches of industry reveals the same phenomenon as observed in the examination by main branch: as the manufacturing process progresses, indirect energy accounts for an increasing proportion of a commodity’s total energy coefficient. It can be observed, however, that a commodity’s total energy coefficient also decreases further downstream. The value of commodities therefore rises more rapidly than the total energy used in their production. This can be seen by comparing manufacture of textiles with manufacture of clothing, sawmills with manufacture of non metal furniture, manufacture of pulp and paper with manufacture of paper products and then with graphics and publishing, manufacture of industrial chemicals and synthetics with other chemical products and plastics, and manufacture of iron and steel with manufacture of metal products and manufacture of machinery.

Figure 18 shows the carbon dioxide emission coefficients for fossil fuels. The highest are in manufacture of iron and steel. The total CO_2 coefficients are low in mechanical engineering in spite of the relatively high coefficients of the raw materials used. The coefficient of emissions of acidifying agents are shown in Figure 19.

5 ENERGY AND EMISSION INTENSITIES OF HOUSEHOLD CONSUMER COMMODITIES

The energy and emissions represented by household consumer commodities can be calculated from the energy and emission coefficients of the branches concerned if the breakdown of the purchaser's price into the outputs of the branches of manufacture at producer's prices, trade and transport margins, and commodity taxes is known. We will now examine consumer commodities in terms of purchaser's prices rather than producer's prices by branch; we will therefore focus on the energy and emission intensities rather than the corresponding energy and emission coefficients.

Figure 20 shows the energy intensities of household consumer commodities per FIM 1 million of consumption expenditure. Expenditure is broken down into 16 groups of consumer commodities.

The highest energy intensity is found in the group running costs for private vehicles, i.e. fuel and maintenance costs for private cars. The second highest figure is found in housing. Energy intensity in purchased transport services is slightly more than half the figure for running costs for private vehicles. Energy intensity in the food group is also fairly high.

Figures 21 and 22 show the emission intensities of household consumer commodities. The emission intensities of running costs for private vehicles stand out alongside the energy intensities – particularly as regards acidifying emissions but also in terms of carbon dioxide.

Table 3 shows the relative impact of energy and emissions by group of consumer commodities. It shows the proportions of energy and emissions accounted for by the five biggest commodity groups in terms of energy consumption; the remaining commodities have been grouped together under other goods and services. The figures for expenditure show the breakdown in terms of FIM.

Most primary energy and carbon dioxide is accounted for by housing, with around 40% of both. Housing also accounts for just over a quarter of acidifying emissions and a little less than a quarter of expenditure in FIM. Direct consumption of energy by housing and the consumption of fuel by private cars is often referred to as the direct consumption of energy by households. In terms of primary energy 316 PJ were directly consumed in 1993. If the energy used in the production of household commodities is also included in consumption by households, the total rises to 610 PJ. Thus around half of the total energy consumed by households is consumed directly and around half indirectly.

Table 3. Breakdown of primary energy, air emissions and expenditure by group of consumer commodities – 1993 (%)

	Primary energy	Carbon dioxide emissions	Acidifying emissions	Expenditure
Housing	43,6	38,3	26,5	24,8
Running costs, private vehicles	17,5	23,2	35,2	7,3
Food	13,5	13,4	14,2	16,0
Restaurants and hotels	3,8	3,7	3,5	7,9
Transport services	3,3	4,1	5,0	2,6
Other goods and services	18,3	17,3	15,6	41,4
Total	100,0	100,0	100,0	100,0

Figure 20. Primary energy intensities of household consumer commodities – 1993

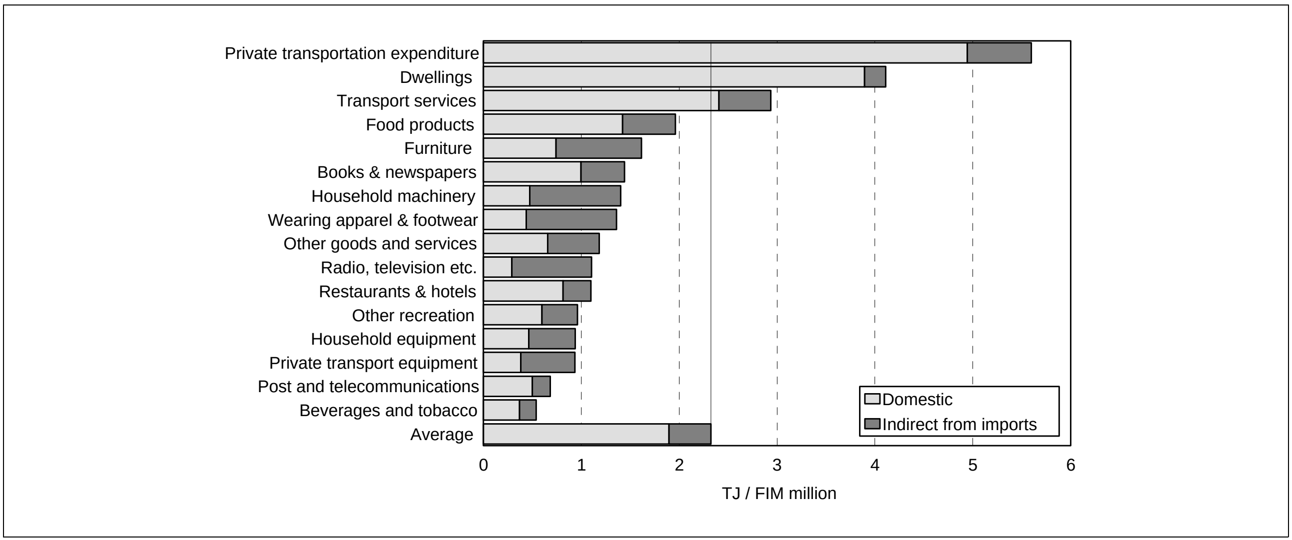


Figure 21. Carbon dioxide emission intensities of household consumer commodities – 1993

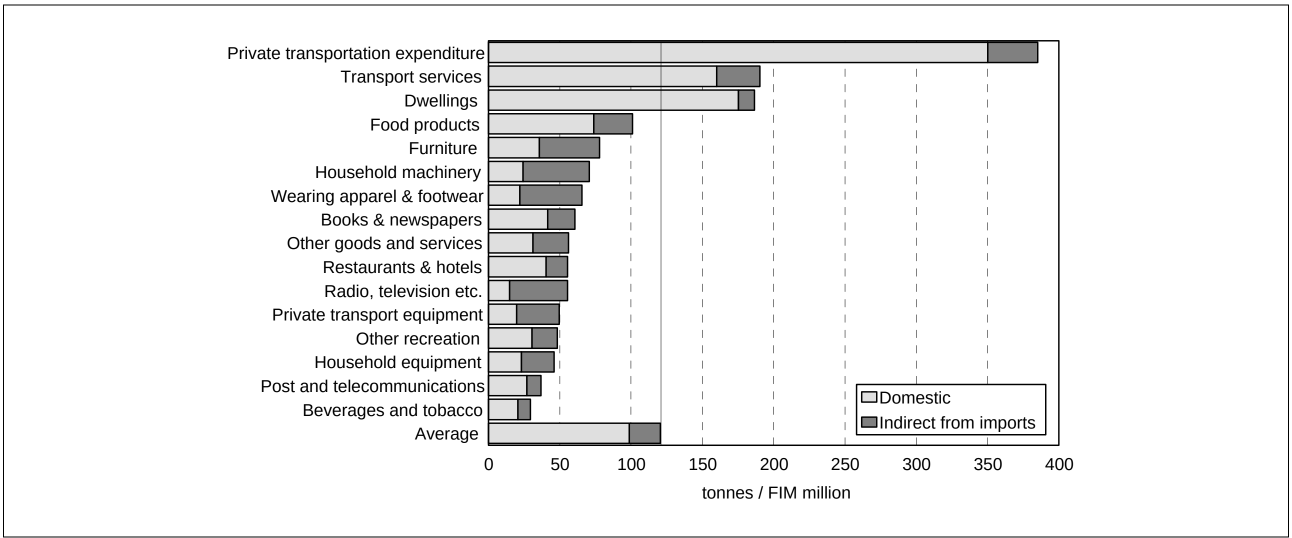
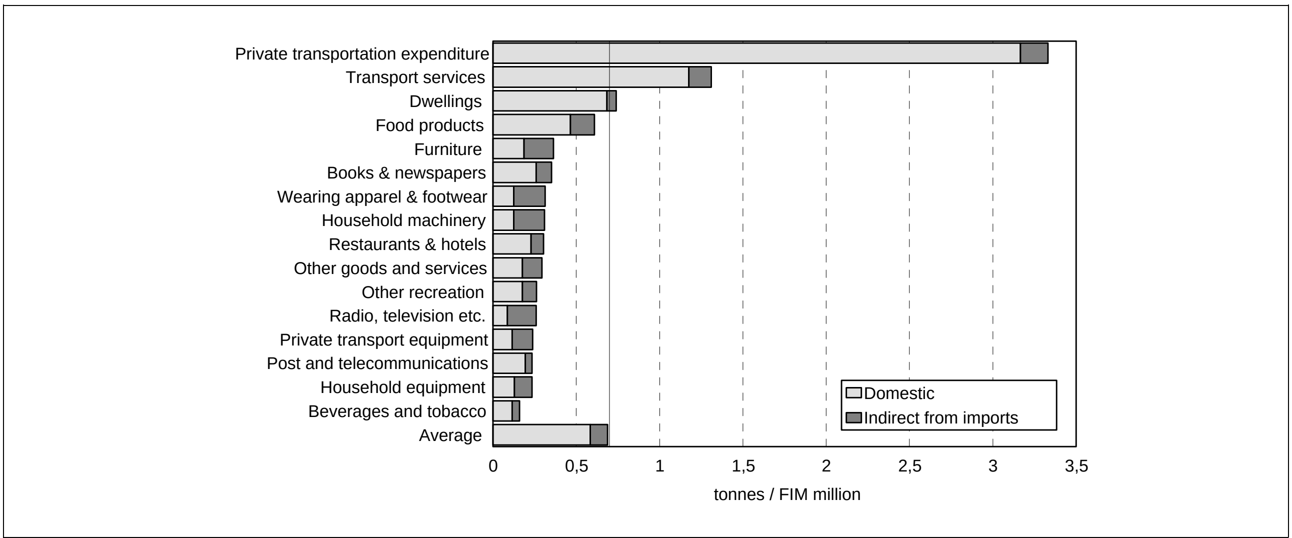


Figure 22. Acidifying emission intensities of household consumer commodities – 1993



6 ENERGY CONSUMPTION AND EMISSIONS BY THE ECONOMY AS A WHOLE

6.1 General

In the national accounts, Gross Domestic Product is divided into six resources balance-sheet items:

- Private consumption (consumption expenditure of households + private non profit institutions);
- Public consumption (added value of central and local government and social security funds + intermediate consumption - sales);
- Increase in inventories;
- Investment (private and public fixed capital formation);
- Exports (goods and services);
- Imports (goods and services).

In 1993 GDP was made up as follows:

	FIM bn
Private consumption	275
Public consumption	112
Investment	71
Exports	159
Imports	-133
Increase in inventories and statistical error	-2
Total GDP	482

The figure for increase in inventories and statistical error is very small and this amount will be eliminated in the following analysis by dividing it pro rata over the main items.

In the input/output tables, the resources balance-sheet items appear as final-use columns. The input/output model can therefore be used to calculate the proportion of the activities of the various branches which is included in its entirety in each of the resources balance-sheet items. The energy consumption and emissions which these amounts represent can then be determined.

6.2 Energy and emission intensities of the economy as a whole

Figure 23 shows the energy intensities of the items making up GDP. The energy intensity of private consumption is almost as high as the GDP average, but then around a half of GDP goes on private consumption. Energy intensity is lowest in public consumption, since this mainly consists of services. The energy intensity of investment is also low. The proportion of indirect imported energy in the total energy intensity of investment is high, since a large proportion of investment goods are imported.

The energy intensity of exports is noticeably higher than the average and exports are much more energy intensive than imports. The energy accounted for by imports was calculated on the assumption that the energy intensity of imported goods is the same as that for similar goods produced in Finland. The differences between the energy intensities of exports and imports therefore only reflect the structural difference between the two: The goods exported by Finland tend to be substantially more energy intensive than those imported. The rapid growth in the proportion of Finland’s exports accounted for by non energy intensive high tech products – particularly electronics – in the 1990s is ironing out the structural differences between exports and imports, but these were nevertheless still very apparent in Finland’s foreign trade in 1993.

In the energy intensity calculation for the economy as a whole, the amount of indirect energy represented by imports is eliminated from the GDP energy consumption figure and hence also from the energy intensity. The amount of indirect imported energy accounted for by private and public consumption, investment and exports is equal to the total amount of energy represented by imports. If imports are subtracted from these amounts when calculating GDP, a figure of zero is also obtained for imported energy in the energy calculation.

Figures 24 and 25 show the carbon dioxide and acidifying emission intensities of the various GDP components. The general structure of the carbon dioxide intensities in particular is in line with the energy intensities, although the difference between the carbon dioxide intensities of exports and imports is smaller than the corresponding difference between the energy intensities. This is because a great deal of the energy represented by wood processing products – which make up a large proportion of exports – comes from wood, and wood based carbon dioxide emissions are not taken into account in the calculations. The large proportion of acidifying emissions that come from transport brings the emission intensity of public consumption to above the GDP average.

Figure 23. Primary energy intensities of the GDP components – 1993

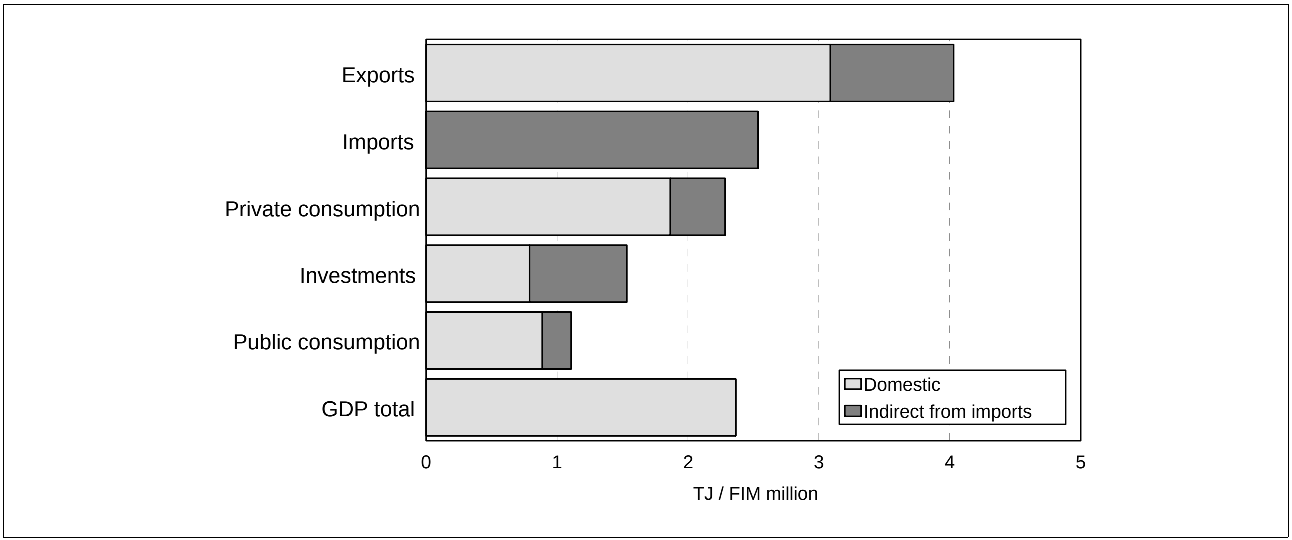


Figure 24. Fossil based carbon dioxide intensities of the GDP components – 1993

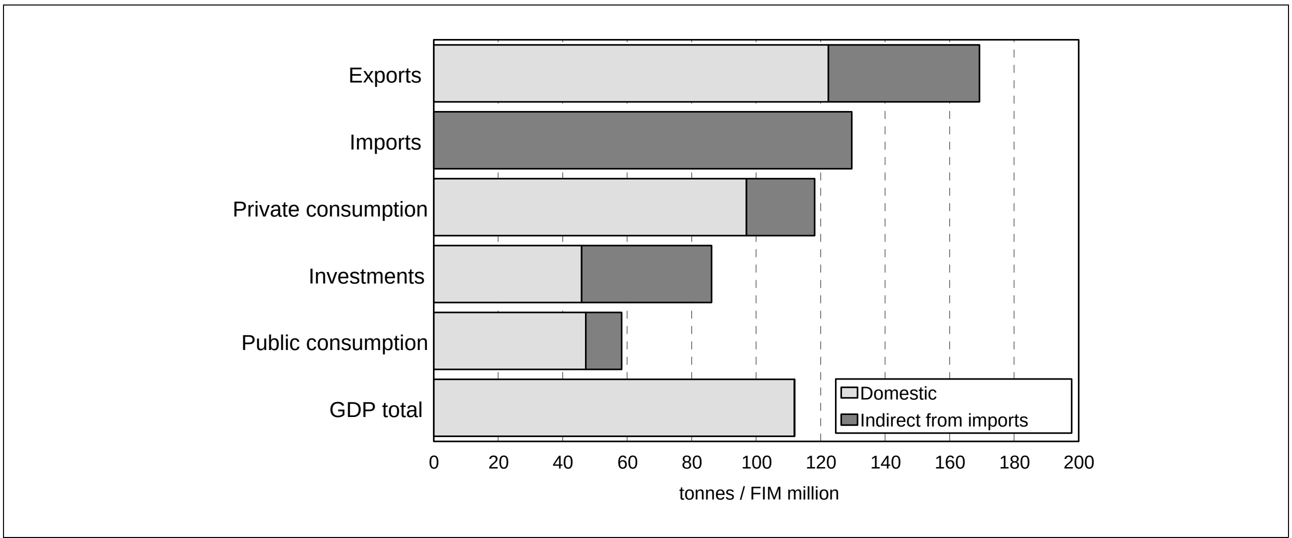


Figure 25. Acidifying emission intensities of the GDP components – 1993

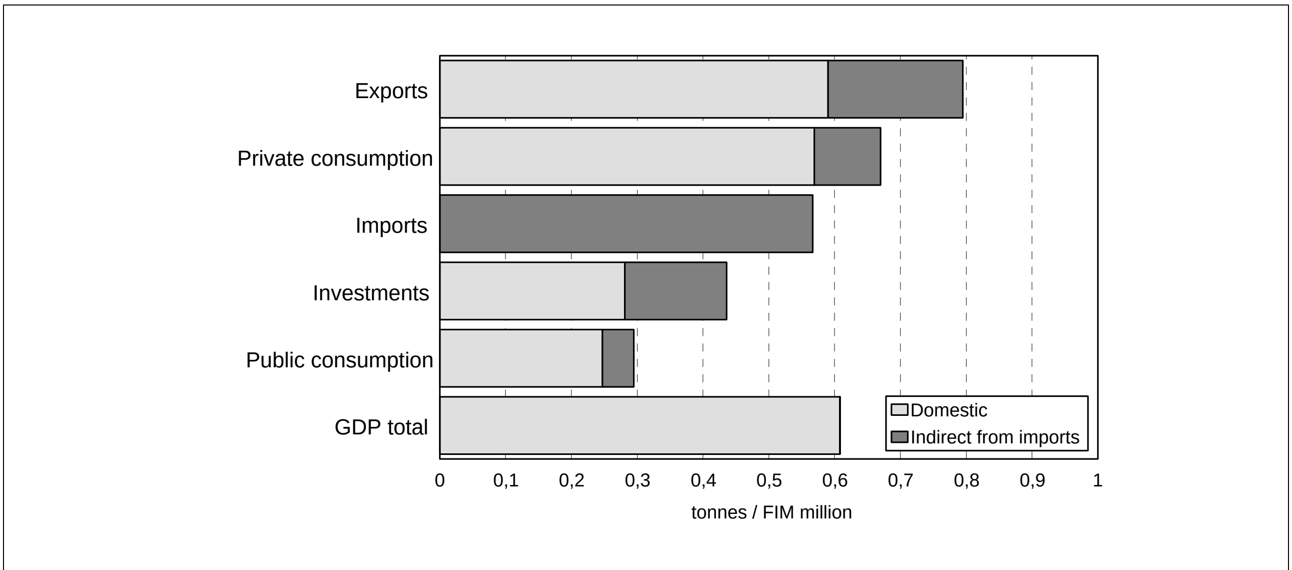


Figure 26. Balance sheet for the Finnish economy – 1993

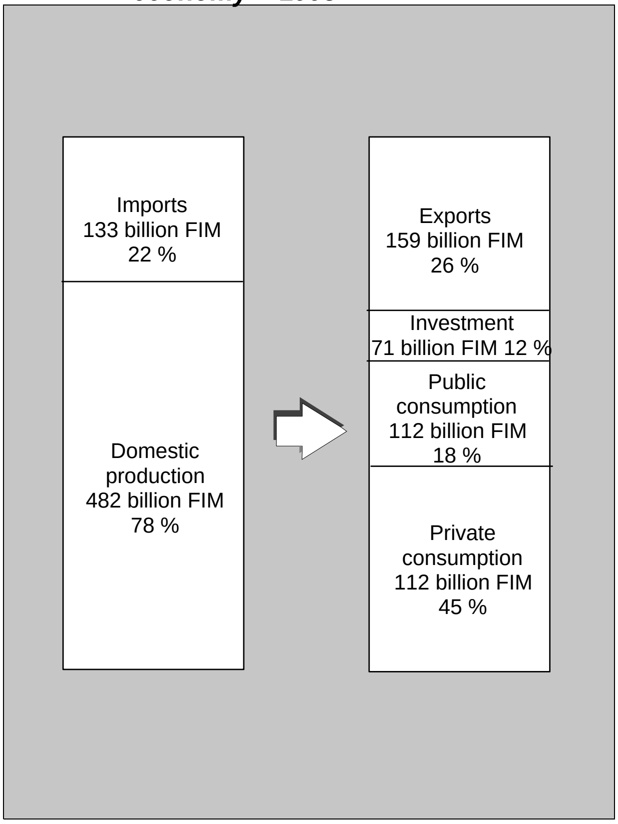
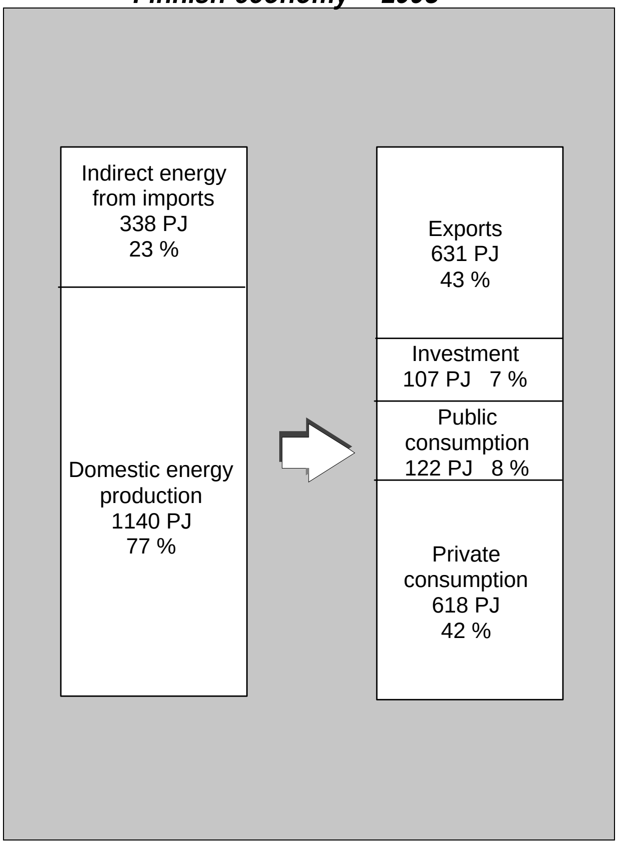


Figure 27. Primary energy balance sheet for the Finnish economy – 1993



6.3 Total energy and emission balance sheets

The GDP components can also be shown in the form of total supply and demand balance sheets (resource balance sheets) for commodities, where

total supply = indigenous production (GDP) + imports, and

total demand = private and public consumption + investment + exports.

The total energy balance sheet can be presented in the form of a commodity balance sheet for the economy, as in Figure 27. Energy supply breaks down into energy used in Finland and energy represented by imports in much the same way as the supply of goods measured in FIM. The proportion of energy used in exports on the other hand (43%) is much larger than the proportion of total demand accounted for by exports in FIM (26%). Private consumption broadly speaking accounts for the same proportion of energy and value in FIM - somewhat more than 40%. Public consumption and investment are much smaller in terms of energy consumption than in terms of FIM.

The structures of emissions of carbon dioxide and acidifying agents on the supply side in the total balance sheets (Figures 28 and 29) show the same pattern as commodities in terms of FIM and energy supply, although exports account for a smaller proportion of total emissions than of total energy.

6.4 Structural change in the economy and energy intensity

Finland's GDP fell by slightly more than 12% between 1990 and 1993, whereas energy consumption remained more or less constant. The energy intensity of the Finnish economy therefore rose by almost 2%.

One explanation for this increase is the change in the structure of total demand. Figure 30 shows the breakdown of demand in Finland for the years 1990 and 1993. While private and public consumption remained virtually constant, the proportion represented by investment plummeted from 22% to 13% and exports rose from 19% to 25%. A comparison of the GDP components shows that investment has a particularly low energy intensity while exports again have the highest. This change in structure increased the energy intensity of the economy as a whole.

The impact of structural change on energy intensity can be assessed by multiplying the percentages accounted for by the various items in 1990 and 1993 by the indigenous energy intensities for the economy in 1993. In this way it can be shown that the change in the structure of demand was responsible for a 9% increase in the energy intensity of the economy – in other words three quarters of the 12% increase. The remaining 3% was due to changes in individual branches, weather conditions and in particular the branches' capacity utilisation rate.

Figure 28. Carbon dioxide balance sheet for the Finnish economy - 1993

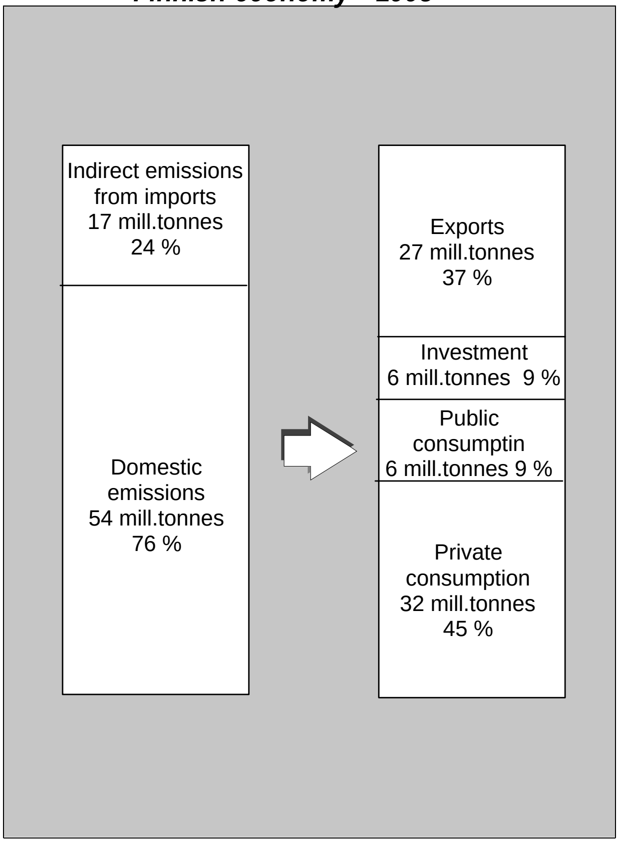


Figure 29. Acidifying emissions balance sheet for the Finnish economy – 1993

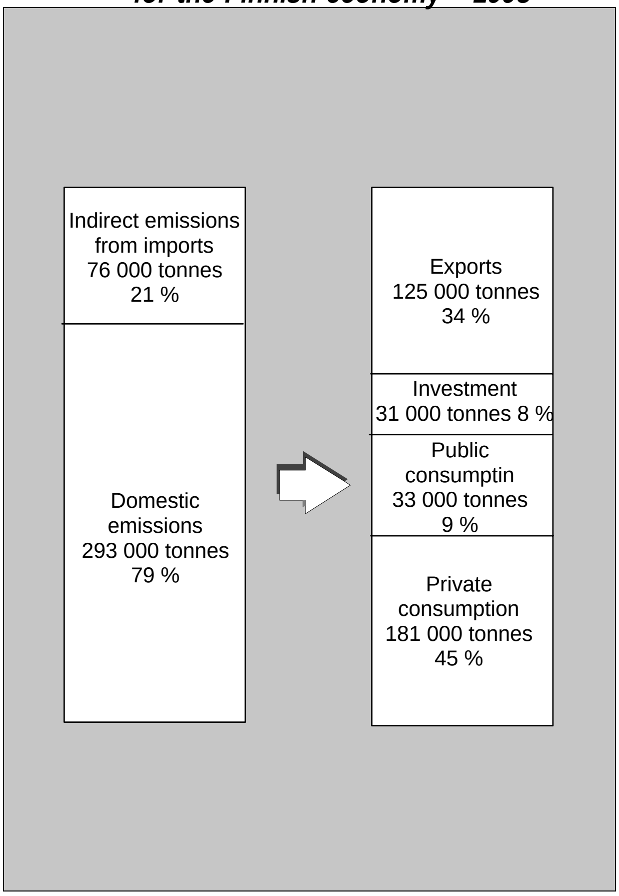
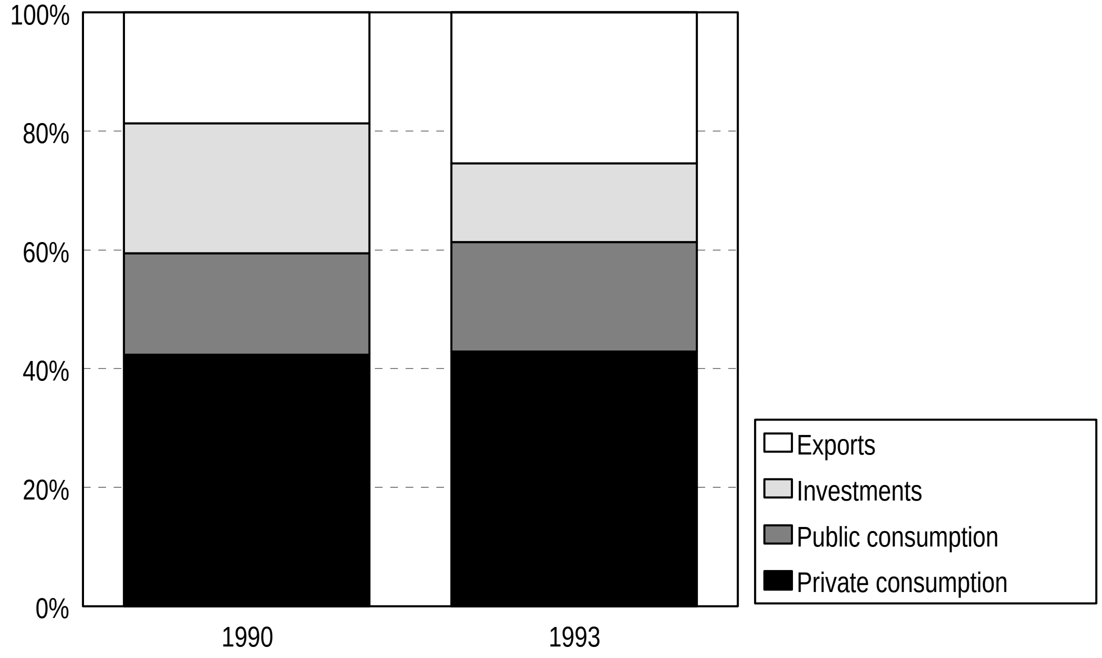


Figure 30. Percentages of the total accounted for by the various GDP components in Finland – 1993



Bibliography

I. Mäenpää and H. Tervo, 1994 Suomen talouden energiankulutuksen ja ilmapäästöjen rakenteet vuonna 1990, Panos tuotosanalyysi (The structure of energy consumption and air emissions in the Finnish economy in 1990, input output analysis), University of Oulu, Department of Northern Finnish Studies, published as No 15 in the series Taloustieteellisiäkeskustelualoitteita (Topics for economic debate), Oulu.

SVT (Official Statistics of Finland) Energy 1997:1, Energiatilastot (Energy Statistics) 1996, Statistics Finland, Helsinki.

SVT Environment 1996:1, Energia ja päästöt, Hiilidioksidi-, typendioksidi- ja rikkidioksidipäästöt Suomessa 1980 1993 (Energy and emissions: emissions of carbon dioxide, oxides of nitrogen and sulphur dioxide in Finland, 1980 1993), Statistics Finland, Helsinki.

ANNEX 1

PRIMARY ENERGY CONSUMPTION AND AIR EMISSIONS BY BRANCH – METHODS

In the basic data on energy consumption and air emissions, energy consumption is divided into 58 branches (cf. Annex 3) corresponding to the breakdown used in Statistics Finland's input output tables for 1993. These in fact used 66 branches (including public services and other activities as final consumption columns) but some of them have had to be combined as it is not possible to distinguish their respective energy consumption reliably. The allocation energy consumption between the service branches is also very unclear.

For each branch, the basic data on energy consumption are broken down according to the following 24 types of energy:

1	Motor petrol	13	Black liquor
2	Other petrol	14	Blast furnace gas
3	Diesel oil	15	Coke gas
4	Light fuel oil	16	Biogas
5	Heavy fuel oil	17	Refinery residuals
6	LPG	18	Other residuals
7	Natural gas	19	Industrial reaction heat
8	Coal	20	Nuclear power
9	Coke	21	Hydroelectric power
10	Peat	22	Electricity, net imports
11	Fuel wood	23	Heat, net
12	Industrial waste wood	24	Electricity, net

The energy values of primary sources are calculated according to the methods used in Statistics Finland's revised publication on energy statistics (Official Statistics of Finland, Energy 1997:1). The primary sources are then combined to form three main strategic groups:

- Imported energy (1-9, 20, 22);
- Indigenous primary energy (10, 11, 21);
- Recovered energy (12-19).

Air emissions from energy consumption by the various branches are calculated using the specific energy coefficients of the detailed energy classification. Emissions by power stations are therefore determined using Statistics Finland's computation model for air emissions, "Ilmari".

Four types of air emissions need to be examined:

- sulphur dioxide, SO_2;
- nitrogen oxides, NO_x;
- carbon dioxide emissions from fossil fuels, CO_2 (foss);
- carbon dioxide emissions from wood based and other biomass fuels, CO_2 (bio);

Since these emission calculations include emissions resulting only from energy consumption, the total emissions of sulphur dioxide in particular are underestimated.

In the presentation of the results, SO_2 and NO_x emissions have been combined in the form of SO_2 equivalent acidifying emissions. It was assumed that the acidifying capacity of oxides of nitrogen was 70% of that of a similar amount of sulphur dioxide.

Before the analysis proper, the branch figures for energy consumption and emissions were converted to primary energy equivalents so that the primary energy and emissions for heat and electricity obtained from outside a given branch were allocated to the branches which consumed the heat and electricity. The conversion method is shown in greater detail in Tables 1 4.

Table 1 shows final energy consumption and air emissions aggregated by branch. Net balances are shown for consumption of heat and electricity in the form of negative production figures. Losses of heat and electricity and the statistical error are defined in such a way that the figures cancel each other out - in other words, the sum of the heat and electricity columns is zero.

In addition to electricity and heat production for public supply, the electricity and heat supply branch includes the majority of industrial power plants and some industrial district heating plants. However, some power plants also come under the various branches of industry, and in addition heat and electricity are also transferred between various manufacturing establishments. The fuels consumed by the electricity and district heating plants in the various branches are included in the direct fuel consumption of each of the branches, net of own production and transfers so as to avoid double counting. The net figures are obtained by means of the "external balance" method, i.e.:

net = (bought + received) - (sold + supplied to others).

Table 1. Basic aggregated data on energy consumption and air emissions, 1993 –- energy in PJ, emissions in tonnes

	Imported energy	Indig. primary energy	Recovered energy	Heat, net	Electricity net	SO_2 1 000 t	NO_x 1 000 t	CO_2 (foss.) mill. t	CO_2 (bio) mill.
Primary production	27,6	5,6	0,8	0,5	4,9	2,8	21,5	2,1	0,7
Forest industry	19,5	0,9	53,3	93,3	67,0	7,6	6,7	1,6	5,4
Metal industry	35,1	0,0	6,0	3,6	19,3	5,7	3,7	4,6	0,0
Other manufacturing	30,5	1,8	29,8	14,5	23,6	8,9	7,5	4,6	0,1
Electricity and heat supply	457,0	101,0	108,9	–189,1	–210,7	61,1	71,7	23,8	9,4
Transport and storage	59,3	0,0	0,0	1,2	2,8	2,4	49,8	4,4	0,0
Private services	39,3	1,7	0,0	16,9	22,9	2,2	30,0	2,9	0,2
Public services	11,4	1,1	0,0	20,0	14,0	1,4	4,1	0,8	0,1
Housing	43,9	24,7	0,0	45,1	50,4	3,1	6,2	3,3	3,0
Private transport	80,5	0,0	0,0	0,0	0,0	0,9	80,4	5,9	0,0
Losses and statistical error	0,0	0,0	0,0	–6,0	5,9	0,0	0,0	0,0	0,0
Total	804,3	136,8	198,7	0,0	0,0	96,1	281,6	54,0	18,9

Table 2. Transfer of energy consumption and air emissions resulting from electricity and heat supply to manufacturing branches and production of electricity and heat for public supply - energy in PJ, emissions in tonnes

	Imported energy	Indig. primary energy	Recovered energy	Heat, net	Electricity, net	SO_2 1 000 t	NO_x 1 000 t	CO_2 (foss.) mill. t	CO_2 (bio) mill.
Primary production	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Forest industry	38,6	15,9	90,0	–86,4	–28,0	12,2	16,0	4,2	8,8
Metal industry	1,8	0,0	7,4	–0,8	–2,4	1,1	1,0	0,1	0,0
Other manufacturing	16,6	1,4	6,3	–16,3	–3,4	3,6	3,8	1,4	0,0
Electricity and heat supply	–457,0	–101,0	–108,9	189,1	210,7	–61,1	–71,7	–23,8	–9,4
Transport and storage	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Private services	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Public services	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Housing	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Private transport	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Separate power production	278,8	48,5	0,2	0,0	–144,6	11,8	13,8	4,8	0,0
CHP	101,5	31,1	4,4	–71,5	–32,3	26,1	32,6	11,4	0,5
Separate heat production	19,8	4,1	0,7	–14,1	0,0	6,2	4,5	1,9	0,1
Losses and statistical error	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Total	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Industrial power and districting heating plants are then transferred from electricity and heat supply to the branches to which they belong. Public supply plants are divided into three basic groups: separate power production, combined heat and power production and separate heat production. The transfer balance sheet is shown at aggregated level in Table 2.

The data in Tables 1 and 2 were produced by Statistics Finland's energy and environment unit using the detailed classification by 58 branches and 24 types of energy.

Table 3 shows the results of applying the transfers shown in Table 2 to Table 1. After power stations have been transferred, the group other manufacturing becomes a net producer of heat. At a more detailed level it can be seen that the chemical industry is responsible for this. In this more detailed breakdown, branches which are found to be net producers of heat include production of basic metals.

Table 3. Energy consumption and air emissions – 1993, when industrial power plants are transferred to manufacturing branches, and production of electricity and heat for public supply are differentiated - energy in PJ, emissions in tonnes

	Imported energy	Indig. primary energy	Recovered energy	Heat, net	Electricity net	SO_2 1 000 t	NO_X 1 000 t	CO_2 (foss.) mill. t	CO_2 (bio) mill.
Primary production	27,6	5,6	0,8	0,5	4,9	2,8	21,5	2,1	0,7
Forest industry	58,1	16,8	143,3	6,8	39,0	19,8	22,7	5,8	14,2
Metal industry	36,9	0,0	13,3	2,8	17,0	6,8	4,7	4,7	0,0
Other manufacturing	47,1	3,2	36,1	–1,8	20,2	12,5	11,4	6,0	0,1
Electricity and heat supply	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Transport and storage	59,3	0,0	0,0	1,2	2,8	2,4	49,8	4,4	0,0
Private services	39,3	1,7	0,0	16,9	22,9	2,2	30,0	2,9	0,2
Public services	11,4	1,1	0,0	20,0	14,0	1,4	4,1	0,8	0,1
Housing	43,9	24,7	0,0	45,1	50,4	3,1	6,2	3,3	3,0
Private transport	80,5	0,0	0,0	0,0	0,0	0,9	80,4	5,9	0,0
Separate electricity production	278,8	48,5	0,2	0,0	–144,6	11,8	13,8	4,8	0,0
CHP	101,5	31,1	4,4	–71,5	–32,3	26,1	32,6	11,4	0,5
Separate heat production	19,8	4,1	0,7	–14,1	0,0	6,2	4,5	1,9	0,1
Losses and statistical error	0,0	0,0	0,0	–6,0	5,9	0,0	0,0	0,0	0,0
Total	804,3	136,8	198,7	0,0	0,0	96,1	281,6	54,0	18,9

Finally, production of power and heat for public supply is broken down over the branches in proportion to their net consumption of electricity and heat. The variables "separate power production", "combined heat and power production" and "separate heat production" are indicated by superscript S, SL or L. Total net electricity from electricity and heat production is represented by the letter s and total heat by the letter l – thus both are negative figures. Hence $s = s^S + s^{SL}$ and $l = l^L + l^{SL}$. Energy and heat losses and statistical error are represented by h^s and h^l. Thus the net amounts of electricity and heat left over for consumption from the total produced are $s + h^s$ and $l + h^l$. It is assumed that the proportional breakdown of the fuels and emissions used in and resulting from combined heat and power production is the same as in the production of electricity and heat separately. The calculated fuel efficiency is therefore assumed to be the same in combined heat and power production as in separate production. The primary energy and emission vectors in electricity and heat production are represented by P^S, P^{SL} and P^L. Thus in terms of electricity and heat units, the average primary energy and emissions accounted for by electricity and heat available for consumption are shown by the following vectors:

$$p^s = (P^s+P^{SL}s^{SL}/(s^{SL}+l^{SL}))/(s+h^s)$$
and
$$p^l = (P^l+P^{SL}l^{SL}/(s^{SL}+l^{SL}))/(l+h^l)$$

By adding the electricity and heat vectors for the various branches calculated on the basis of net consumption to the primary energy and emission figures for the branches we obtain the final result shown in Table 4. The values in the electricity and heat consumption columns and the electricity and heat production rows are zero. The primary energy and emissions used in and resulting from electricity production have been entirely transferred to other branches: the total row in Table 4 is exactly the same as in the source table, Table 1.

Certain elements in the calculation of the primary energy equivalents for electricity and heat might have been dealt with differently.

In some branches of manufacturing industry net consumption of heat is negative – in other words, they are net producers of heat. In the calculation method applied above, the negative figures for net heat consumption result from the fact that the average primary energy consumption and emissions resulting from heat production for public supply – which corresponds to negative consumption – are subtracted from the primary energy consumption and emissions of the branch in question. This could be called the "compensation approach": branches are credited to the extent to which they reduce the need to produce heat for public supply.

Table 4. Energy consumption and air emissions by the various branches in 1993 when electricity and heat consumption is reconverted to primary energy sources – energy in PJ, emissions in tonnes

	Imported energy	Indig. primary energy	Recovered energy	Heat, net	Electricity net	SO_2 1 000 t	NO_X 1 000 t	CO_2 (foss.) mill. t	CO_2 (bio) mill.
Primary production	36,9	7,4	0,9	0,0	0,0	3,5	22,3	2,4	0,7
Forest industry	135,2	31,9	143,9	0,0	0,0	26,1	30,1	8,4	14,3
Metal industry	70,2	6,5	13,6	0,0	0,0	9,5	7,8	5,8	0,0
Other manufacturing	81,8	9,6	36,2	0,0	0,0	14,3	13,6	6,8	0,1
Electricity and heat supply	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Transport and storage	65,5	1,3	0,1	0,0	0,0	3,0	50,5	4,6	0,0
Private services	97,2	14,1	0,9	0,0	0,0	9,3	38,2	5,8	0,3
Public services	56,3	11,4	0,9	0,0	0,0	8,3	11,9	3,7	0,2
Housing	179,2	54,3	2,3	0,0	0,0	20,9	26,5	10,5	3,2
Private transport	80,5	0,0	0,0	0,0	0,0	0,9	80,4	5,9	0,0
Total	804,3	136,6	198,7	0,0	0,0	96,0	281,5	53,9	18,9

An alternative approach would be to devise a method for estimating the primary energy and emissions represented by the negative net heat consumption of a branch. The negative net heat consumption calculated for a branch and the corresponding amounts of primary energy and emissions would then be transferred to separate heat production. Only then would the average energy and emissions calculated for heat be distributed over the net consumers of heat. This could be called the "transfer approach".

At first sight the transfer approach would seem the more realistic. If a branch is a net producer of energy, this is usually because combustible waste resulting from the production process can be best used as a source of energy. In such cases, the net heat production of a branch genuinely reduces the heat generation requirements of the surrounding community. With the compensation approach, recoverable energy and emissions resulting from the production process remain in the branch, but the branch is given credit in terms of typical primary energy sources and emissions for reduced heat production.

The breakdown between electricity and heat of the primary energy used in combined heat and power production has been based on the simple assumption that the efficiency is the same in both cases. Usually an efficiency ratio is determined for heat and the "residual energy" and "residual emissions" are subsequently allocated to electricity. However, this approach presupposes the use of comprehensive data on power plants, which has not been possible in this case.

Part of separate electricity production could be allocated more specifically to branches of industry on the basis of the relative shares of the various branches in the ownership of power generating companies. However, it would be very difficult to ascertain the extent to which the amounts of electricity supplied corresponded to the relative shareholding.

Even in the aggregated tables in this section, consumption of energy by households is divided into two parts - housing and fuel for private vehicles. Housing comprises all the energy, including electricity, used for domestic purposes. In the subsequent analyses, all this energy is included under consumption by the housing ownership, administration and rental branch. The alternative is to allocate only heating energy and electricity consumed by fixed property to the housing branch. However, a large proportion of the electricity consumed by households is used for household appliances and these are mostly part of the fixtures. Lighting is also a component of household use. On the other hand, the fuel consumed by private cars and other motor vehicles is not linked to any branch, but is directly included in households' final consumption. This is the only energy group to be given "special treatment" in this report. Fuels for private vehicles are left out of account in Sections 3 and 4 and are only considered in the analysis of final consumption of commodities in Sections 5 and 6.

ANNEX 2

THE MATHEMATICS OF INPUT-OUTPUT ANALYSIS

This Annex describes the link between the analysis of energy and emissions and input/output analysis.

1 Commodity flows

Symbols used:

- **x** = n-vector, total output by branch;
- **m** = n-vector, imports by importing branch;
- **A** = n x n matrix, branch by branch matrix of intermediate consumption input coefficients; the element ij in matrix **A** shows how much of branch i's output is used as input by branch j per unit output;
- **y** = n-vector, final consumption of the branches' products. This can be broken down further into the following GDP components:
- $\mathbf{y}^C$ = private consumption by branch of production, which is further made up of consumption expenditure by households and to a small extent of intermediate consumption by private non profit institutions;
- $\mathbf{y}^G$ = public intermediate consumption;
- $\mathbf{y}^I$ = gross fixed capital formation by branch of production ("investment");
- $\mathbf{y}^V$ = changes in inventories + statistical error, and
- $\mathbf{y}^E$ = exports.

The basic formula for input/output analysis – the commodity flow balance sheet – takes the form:

1) $\mathbf{x+m = Ax+y = Ax+y^C+y^G+y^I+y^V+y^E}$,

where the left side, **x + m**, is the total supply of commodities by branch and the right side is the total demand for commodities. This basic formula can also be written in the form:

2) $\mathbf{x = Ax+y-m = Ax+y^C+y^G+y^I+y^V+y^E -m}$.

Gross domestic product is made up of the following items:

3) GDP=C+G+I+V+E-M.

The vectors $\mathbf{y^C, y^G, y^I, y^V, y^E, -m}$ show the commodity content of the GDP components at producer's prices but do not correspond to the value of the GDP components, since these also include other cost components such as labour costs, repayments on capital, taxes etc.

Equation (1) yields the following for total output **x**:

4) $\mathbf{x = (I\text{-}A)^{-1} (y\text{-}m)} \iff \mathbf{x = B (y\text{-}m)}$,

where $\mathbf{B = (I - A)^{-1}}$ is the inverse Leontief matrix. The element ij shows how much of branch i's output is entirely accounted for, directly or indirectly, by the production by branch j of one unit of its final output.

Equation (4) also yields:

5 $$\begin{aligned}\mathbf{x} &= \mathbf{B (y\text{-}m)}\\ &= \mathbf{B (y^C+y^G+y^I+y^V+y^E -m)}\\ &= \mathbf{By^C+By^G+By^I+By^V+By^E -Bm}\\ &= \mathbf{x^C+x^G+x^I+x^V+x^E\text{-}x^M},\end{aligned}$$

hence:

6) $\mathbf{x = x^C+x^G+x^I+x^V+x^E\text{-}x^M}$,

i.e. total output by a branch is broken down on the basis of how much of the branch's output is entirely accounted for, directly or indirectly, by each of the GDP components. The breakdown of the use of total output $\mathbf{x^C, x^G, x^I, x^V, x^E, -x^M}$ can also be obtained directly by means of the matrix operation:

7) $[\mathbf{x^C+x^G+x^I+x^V+x^E, -x^M}] = [\mathbf{y^C+y^G+y^I+y^V+y^E, -m}]$.

2 Basic inputs

The analysis is now extended to include energy and emissions, where

P = the m x n matrix of energy input and emission coefficients by branch, in which the rows m show the types of energy input and emission coefficients and the columns n show the branches.

This can be expressed more concisely and more generally as:

P = the m x n matrix of the basic input coefficients.

The total basic inputs can be calculated directly as the product of total output and the matrix **P**:

8) $\mathbf{p = Px}$,

where **p** is the total amount of basic inputs per type, the m-vector.
By combining (8) and (5) we obtain:

$$9)\quad \mathbf{p} = \mathbf{Px}=\mathbf{PB(y\text{-}m)} = \mathbf{PB}\,(\mathbf{y}^C+\mathbf{y}^G+\mathbf{y}^I+\mathbf{y}^V+\mathbf{y}^E -\mathbf{m}) = \mathbf{PBy}^C+\mathbf{PBy}^G+\mathbf{PBy}^I+\mathbf{PBy}^V+\mathbf{PBy}^E- \mathbf{PBm} = \mathbf{p}^C+\mathbf{p}^G+\mathbf{p}^I+\mathbf{p}^V+\mathbf{p}^E -\mathbf{p}^M,$$

in which the basic inputs are divided over the various GDP components on the basis of how much of the basic inputs are used in the production of each of the components.
The breakdown can be obtained directly in tabular form by applying the matrix equation:

$$10)\quad [\mathbf{p}^C,\mathbf{p}^G,\mathbf{p}^I,\mathbf{p}^V,\mathbf{p}^E, -\mathbf{p}^M] = \mathbf{PB}\,[\mathbf{y}^C,\mathbf{y}^G,\mathbf{y}^I,\mathbf{y}^V,\mathbf{y}^E, -\mathbf{m}].$$

The final consumption vectors are combined to produce the matrices:

$$\mathbf{P}^Y =[\mathbf{p}^C,\mathbf{p}^G,\mathbf{p}^I,\mathbf{p}^V,\mathbf{p}^E]$$
$$\mathbf{Y} =[\mathbf{y}^C,\mathbf{y}^G,\mathbf{y}^I,\mathbf{y}^V,\mathbf{y}^E].$$

Equation (10) is then condensed to read:

$$10)\quad [\mathbf{P}^Y, -\mathbf{p}^M] = \mathbf{PB}[\mathbf{Y}, -\mathbf{m}].$$

The matrix product **PB**, which is an m x n matrix, is interesting in itself. The element hj shows how much of the basic input h is directly or indirectly accounted for by a unit of branch j's output.

3 Indigenous production and imports

In the input/output tables, commodity flows are divided into indigenous production and imports. For the sake of clarity, this distinction was not yet made in Sections 1 and 2. However it provides vital additional information, particularly for the analysis of basic inputs.
Further information is collected on the components of the import figures considered so far:

- $\mathbf{m}$ = imports by branch of production, n vector;
- $\mathbf{x}^M$ = amounts per branch of indigenous products directly or indirectly replaced by imports, n vector;
- $\mathbf{p}^M$ = amounts of indigenous basic inputs replaced by imports, m vector.

Indigenous commodities are indicated below by a superscript D and imported commodities by a superscript M. The commodity flows are distinguished as follows:

- $\mathbf{A} = \mathbf{A}^D + \mathbf{A}^M$: division of the input coefficients matrix into indigenous and imported inputs;
- $\mathbf{y} = \mathbf{y}^D + \mathbf{y}^M$: breakdown of final consumption into indigenous products and imports;

the breakdown can be made separately for each item of final consumption.

The basic equation (1) now takes the form:

$$11)\quad \mathbf{x}+\mathbf{m} = (\mathbf{A}^D+\mathbf{A}^M)\mathbf{x}+(\mathbf{y}^D+\mathbf{y}^M)=(\mathbf{A}^D+\mathbf{y}^D)+(\mathbf{A}^M\mathbf{x}+\mathbf{y}^M),$$

which can be divided into indigenous and imported commodity flows:

$$12)\quad \mathbf{x} =\mathbf{A}^D\mathbf{x}+\mathbf{Y}^D$$
and
$$13)\quad \mathbf{m} =\mathbf{A}^M\mathbf{x}+\mathbf{Y}^M.$$

Indigenous production can be determined from equation (12) by applying the method used in equation (4):

$$14)\quad \mathbf{x} =(\mathbf{I}\text{-}\mathbf{A}^D)^{-1}\mathbf{y}^D \iff \mathbf{x}=\mathbf{B}^D\mathbf{y}^D,$$

where $\mathbf{B}^D$ is now the inverse Leontief matrix of indigenous inputs.

The basic inputs contained in the GDP components can determined by dividing up equation (14) in the same way as (9):

$$15)\quad \mathbf{p} = \mathbf{PB}^D\mathbf{y}^D=\mathbf{PB}^D(\mathbf{y}^{DC}+\mathbf{y}^{DG}+\mathbf{y}^{DI}+\mathbf{y}^{DV}+\mathbf{y}^{DE}) = \mathbf{PB}^D\mathbf{y}^{DC}+\mathbf{PB}^D\mathbf{y}^{DG}+\mathbf{PB}^D\mathbf{y}^{DI}+\mathbf{PB}^D\mathbf{y}^{DV}+\mathbf{PB}^D\mathbf{y}^{DE} = \mathbf{p}^{DC}+\mathbf{p}^{DG}+\mathbf{p}^{DI}+\mathbf{p}^{DV}+\mathbf{p}^{DE}.$$

There is no analytical tool of the inverse Leontief variety for imports separately. Since there are no simultaneous dependent variables in the imports equation (13), it is an explicit function. The indirect effects of imports can be included in the analysis only in conjunction with the indigenous commodity flows, as in Sections 1 and 2. The separate effects of imports can be determined as the difference between the results of the total analysis and of the separate analysis of indigenous commodity flows. (This is true of input/output analysis in general: indirect effects cannot be determined directly from the formulae but only as

the difference between total effects and direct effects.)
Equation (9) is rewritten in the form:

16) $\mathbf{p} = \mathbf{PBy} = \mathbf{PB}(\mathbf{y}^{C}+\mathbf{y}^{G}+\mathbf{y}^{I}+\mathbf{y}^{V}+\mathbf{y}^{E}-\mathrm{m})$
$= \mathbf{PBy}^{C}+\mathbf{PBy}^{G}+\mathbf{PBy}^{I}+\mathbf{PBy}^{V}+\mathbf{PBy}^{E} -\mathbf{PBm}$
$= \mathbf{p}^{C}+\mathbf{p}^{G}+\mathbf{p}^{I}+\mathbf{p}^{V}+\mathbf{p}^{E} -\mathbf{p}^{M}.$

The inverse Leontief matrix **B** and the final consumption vectors **y** in equation (16) now also contain imported inputs.

In equation (16), the result **P** comprises the basic inputs used in Finland, i.e. the same as in equation (15), which contained only indigenous commodity flows. This is because on the right side of equation (16) imported indirect basic inputs are subtracted – in other words:

17) $\mathbf{p}^{M} = \mathbf{PBm}.$

What imported indirect basic inputs actually comprise demands closer interpretation. In equation (17), both the basic input coefficients **P** and the coefficients in the inverse Leontief matrix have been estimated on the basis of Finland's economy. The imported indirect basic inputs (17) can therefore be interpreted in two ways:

- Imported indirect basic inputs = how much imports offset the need for indigenous basic inputs - in other words, how much more basic inputs would be required if imports were replaced by indigenous production.
- Imported indirect basic inputs = the use of basic inputs in other countries caused by imports if the production methods applied are exactly the same as in Finland.

Thus even if imported indirect basic inputs are purely calculated amounts, they bear two different very reasonable interpretations.

The result of equation (16) is rewritten as:

18) $\mathbf{p}+\mathbf{p}^{M}=\mathbf{p}^{C}+\mathbf{p}^{G}+\mathbf{p}^{I}+\mathbf{p}^{V}+\mathbf{p}^{E}.$

$\mathbf{p} + \mathbf{p}^{M}$ in equation (18) is the sum of indigenous and imported indirect basic inputs, and the right side shows how this is distributed over the various GDP components. The imported indirect basic inputs to the GDP components can be determined as the difference between equations (18) and (15):

19) $\mathbf{p}^{M} = (\mathbf{p}+\mathbf{p}^{M}) - \mathbf{p} = (\mathbf{p}^{C}+\mathbf{p}^{G}+\mathbf{p}^{I}+\mathbf{p}^{V}+\mathbf{p}^{E}) - (\mathbf{p}^{DC}+\mathbf{p}^{DG}+\mathbf{p}^{DI}+\mathbf{p}^{DV}+\mathbf{p}^{DE})$
$= (\mathbf{p}^{C} -\mathbf{p}^{DC}) + (\mathbf{p}^{G} -\mathbf{p}^{DG}) + (\mathbf{p}^{I} -\mathbf{p}^{DI}) + (\mathbf{p}^{V} -\mathbf{p}^{DV}) + (\mathbf{p}^{E} -\mathbf{p}^{DE})$
$= \mathbf{p}^{MC}+\mathbf{p}^{MG}+\mathbf{p}^{MI}+\mathbf{p}^{MV}+\mathbf{p}^{ME}.$

4 Analysis of groups of household consumer goods

Intermediate consumption by non profit institutions can be eliminated from the private final consumption vector $\mathbf{y}^{C}$ to leave the value at producer's prices of the goods, by branch of production, which make up household consumption expenditure. Household consumption expenditure is otherwise recorded by group of consumer commodities at purchaser's prices. Let this be vector **c**.

There are no directly corresponding elements in vectors $\mathbf{y}^{C}$ and **c**: for example, the group household appliances includes, at producer prices, products of the branches manufacture of wood products, manufacture of metal products and manufacture of textiles. In addition to these, the group of consumer goods at purchaser's prices includes trade margins on furniture and indirect taxes.

However, drawing up the input/output tables involves constructing a conversion matrix $\mathbf{A}^{C}$, which converts the basket of consumer goods at purchaser's prices to products by branch at producer's prices:

20) $\mathbf{y}^{C} = \mathbf{A}^{C}\mathbf{c}.$

The basket of consumer goods can be further broken down into indigenous and imported products:

21) $\mathbf{y}^{DC}+\mathbf{y}^{MC} = (\mathbf{A}^{DC}+\mathbf{A}^{MC})\mathbf{c}=\mathbf{A}^{DC}\mathbf{c}+\mathbf{A}^{MC}\mathbf{c}.$

By combining equations (15) and (21), we can now determine the indigenous basic inputs in the groups of household consumer commodities:

22) $\mathbf{p}^{DC}=\mathbf{PB}^{D}\mathbf{y}^{DC} =\mathbf{PB}^{D}\mathbf{A}^{DC}\mathbf{c},$

and similarly the matrix of indigenous basic input coefficients of consumer commodities:

23) $\mathbf{P}^{DC} =\mathbf{PB}^{D}\mathbf{A}^{DC}.$

Equations (16) and (20) yield the indirect indigenous and imported basic inputs:

24) $\mathbf{p}^{C} =\mathbf{PBy}^{C} =\mathbf{PBA}^{C}\mathbf{c},$

and the matrix of basic input coefficients:

25) $\mathbf{P}^{C} =\mathbf{PBA}^{C}.$

5 Summary of formulae

The formulae for the various basic inputs are as follows:

Basic input coefficients by branch
Cumulative coefficients

$\mathbf{P}$ = coefficients of indigenous direct basic inputs by branch;

$\mathbf{P}^{XD} = \mathbf{PB}^{D} = \mathbf{P}(\mathbf{I}-\mathbf{A}^{D})^{-1}$
coefficients of indigenous direct and indirect basic inputs;

$\mathbf{P}^{X} = \mathbf{PB} = \mathbf{P}(\mathbf{I}-\mathbf{A})^{-1}$
direct and indirect coefficients of indigenous and imported basic inputs.

Additive coefficients:

$\mathbf{P}$	direct
$\mathbf{P}^{XD}-\mathbf{P}$	indirect indigenous
$\mathbf{P}^{X}-\mathbf{P}^{XD}$	indirect imported

Total:

$$\mathbf{P}^{X} = \mathbf{P}+(\mathbf{P}^{XD}-\mathbf{P})+(\mathbf{P}^{X}-\mathbf{P}^{XD})$$

Basic inputs in GDP components

$$\mathbf{Y} = [\mathbf{y}^{C},\mathbf{y}^{G},\mathbf{y}^{I},\mathbf{y}^{V},\mathbf{y}^{E},\mathbf{Y}^{D}] = [\mathbf{y}^{DC},\mathbf{y}^{DG},\mathbf{y}^{DI},\mathbf{y}^{DV},\mathbf{yD}^{E}\mathbf{Y}^{D}]$$

$$\mathbf{P}^{Y} = [\mathbf{p}^{C},\mathbf{p}^{G},\mathbf{p}^{I},\mathbf{p}^{V},\mathbf{p}^{E}\mathbf{P}^{DY}] = [\mathbf{p}^{DC},\mathbf{p}^{DG},\mathbf{p}^{DI},\mathbf{p}^{DV},\mathbf{p}^{DE}]$$

hence

$\mathbf{P}^{DY}$	$=\mathbf{PB}^{D}\mathbf{Y}^{D}$	indigenous basic inputs in GDP components
$\mathbf{P}^{Y}$	$=\mathbf{PBY}$	indigenous and imported indirect basic inputs in GDP components
$\mathbf{P}^{MY}$	$=\mathbf{P}^{Y}-\mathbf{P}^{DY}$	imported indirect basic inputs in GDP components

Basic inputs in household consumption expenditure

Basic inputs:

$\mathbf{P}^{DC}$	$=\mathbf{PB}^{D}\mathbf{A}^{DC}$	indigenous basic inputs
$\mathbf{P}^{C}$	$=\mathbf{PBA}^{C}$	indigenous and imported indirect basic inputs
$\mathbf{P}^{MC}$	$=\mathbf{p}^{C}-\mathbf{p}^{DC}$	imported indirect basic inputs

Basic input coefficients:

$\mathbf{P}^{DC}$	$=\mathbf{PB}^{D}\mathbf{A}^{DC}$	indigenous basic input coefficients
$\mathbf{P}^{C}$	$=\mathbf{PBA}^{C}$	indigenous and imported indirect basic input coefficients
$\mathbf{P}^{MC}$	$=\mathbf{p}^{C}-\mathbf{p}^{DC}$	imported indirect basic input coefficients

6 Changes to the input/output model

In the formulae given above we have disregarded the additional problem that results from direct use of basic inputs in final products. Of course, direct basic inputs in final products can be added later to the final consumption groups, but this runs counter to the basic logic of input/output analysis and entails extra calculations. In the subsequent calculations, therefore, the following changes have been made to the basic structure of the input/output model based on the national accounts.

The direct consumption of energy by housing included in household consumption expenditure – in the form of both basic inputs and intermediate consumption measured in FIM – has been transferred in its entirety to the housing ownership branch.

The total output, intermediate consumption and basic inputs of public services and non profit institutions have been transferred from final products to the columns and rows of the input coefficient matrix. Sales of commodities (as negative amounts) and the link with total output remain in the corresponding final use columns. This also makes it possible to establish the connection between the total output of these branches and consumption expenditure determined as a GDP component.

However, there is still one type of energy use which cannot be linked to use by any branch - i.e. direct purchases of fuels for private vehicles. In the calculations these are added later to household expenditure consumption.

ANNEX 3

BRANCH CLASSIFICATION

Basic classification

1 Agriculture
2 Forestry
3 Fisheries
4 Extraction of ores
5 Other mining and quarrying
6 Abattoirs
7 Dairy production
8 Milling and baking
9 Manufacture of sugar, chocolate and confectionery
10 Other food manufacture
11 Manufacture of feedstuffs
12 Manufacture of beverages
13 Manufacture of tobacco products
14 Manufacture of textiles
15 Manufacture of clothing
16 Manufacture of leather and fur products
17 Manufacture of footwear
18 Sawmills, planing and impregnation of wood
19 Manufacture of other wood products and building materials
20 Manufacture of non metal furniture
21 Manufacture of pulp, paper and board
22 Manufacture of paper and board products
23 Graphics and publishing
24 Manufacture of fertilisers and pesticides
25 Industrial chemicals and synthetics
26 Manufacture of pharmaceuticals and toiletries
27 Manufacture of other chemical products
28 Manufacture of oil and coal products
29 Manufacture of rubber products
30 Manufacture of plastic products
31 Manufacture of porcelain and glass products
32 Manufacture of other ceramics and stone products
33 Manufacture of iron and steel
34 Manufacture of other metals
35 Manufacture of metal products
36 Manufacture of machinery
37 Electrical appliances
38 Manufacture of vehicles
39 Manufacture of instruments
40 Other manufacturing
41 Supply of electricity, gas and heat
42 Water purification and distribution
43 Construction
44 Civil engineering
45 Wholesale and retail trade
46 Restaurants and hotels
47 Rail transport
48 Other land transport
49 Water transport and supporting activities
50 Air transport and supporting activities
51 Transport services
52 Telecommunications
53 Finance and insurance
54 Real estate and business services
55 Personal services
56 Housing
57 Public services
58 Other activities

Main groups of branches (in brackets: basic classification categories)

1 Agriculture and fisheries (1,3)
2 Forestry (2)
3 Mining and quarrying (4, 5)
4 Food
5 Tecloleafoo (14-17)
6 Wood processing (18-23)
7 Chemical industry (24-30)
8 Manufacture of ceramics, and glass and stone products (31,32)
9 Metal industry (33-39)
10 Other manufacturing (40)
11 Electricity, heat and water supply
12 Construction (43, 44)
13 Transport (47-52)
14 Private services (45, 46, 53-55, 58)
15 Public services (57)
16 Housing (58)

ANNEX 4

ENERGY CLASSIFICATION

Basic breakdown of energy

1 Motor petrol
2 Other petrol
3 Diesel
4 Light fuel oil
5 Heavy fuel oil
6 Liquid gas
7 Natural gas
8 Coal
9 Coke
10 Peat
11 Fuel wood
12 Industrial waste wood
13 Black liquor
14 Blast furnace gas
15 Coke gas
16 Biogas
17 Refinery residuals
18 Other residuals
19 Industrial reaction heat
20 Nuclear power
21 Hydroelectric power
22 Electricity, net imports
23 Heat, net
24 Electricity, net

Main groups of primary energy

Imported energy (1-9, 20, 22)
Indigenous primary energy (10, 11, 21)
Recovered energy

ANNEX 5

BASIC TABLES

Table 1. Specific energy consumption and specific emissions by branch, 1993 - energy in TJ/FIM million, emissions in tonnes/FIM million

	Imported energy	Indigenous primary energy	Recovered energy	Total primary energy	SO_2 1 000 t	NO_x 1 000 t	CO_2 (foss) mill. t	CO_2 (bio) mill. t	Value added FIM mill.
1 Agriculture	2,349	0,529	0,072	2,950	0,214	1,362	155,2	55,0	11 838
2 Forestry	0,326	0,053	0,000	0,379	0,011	0,475	24,0	6,3	9 277
3 Fisheries	0,557	0,006	0,000	0,562	0,021	0,389	39,8	0,0	966
4 Extract. ores	5,235	0,848	0,026	6,110	0,505	0,878	188,8	2,9	297
5 Other mining and quarrying	2,880	0,305	0,010	3,195	0,515	0,817	155,2	1,1	1 390
6 Abattoirs	1,269	0,178	0,017	1,464	0,186	0,188	64,9	2,6	2 461
7 Dairy prod.	1,941	0,652	0,039	2,632	0,454	0,383	157,4	7,2	1 835
8 Mill., baking	1,289	0,171	0,012	1,472	0,105	0,207	68,0	1,2	2 608
9 Manuf. of sugar, chocolate and confectionery	2,568	–0,062	–0,017	2,488	0,650	0,519	175,6	–2,0	1 224
10 Other food manufacture	1,704	0,261	0,041	2,005	0,259	0,299	109,4	2,9	1 950
11 Manufacture of feedstuffs	2,971	0,520	0,027	3,519	0,689	0,459	191,3	1,9	530
12 Manufacture of beverages	1,139	0,357	0,016	1,512	0,277	0,252	99,5	1,5	2 488
13 Manufacture of tobacco products	0,344	0,064	0,005	0,413	0,054	0,071	20,2	0,6	490
14 Manufacture of textiles	1,604	0,196	0,012	1,812	0,169	0,212	83,8	1,3	1 541
15 Manufacture of clothing	0,445	0,064	0,004	0,514	0,043	0,081	23,6	0,4	1 154
16 Manufacture of leather and fur products	1,283	0,115	0,008	1,407	0,261	0,192	71,3	1,2	183
17 Manufacture of footwear	0,521	0,068	0,006	0,594	0,037	0,079	24,6	0,7	324
18 Sawmills, planing and impregnation of wood	1,787	0,409	2,080	4,276	0,265	0,485	235,2	101,9	2 971
19 Manuf. other wood prod. and building materials	1,880	0,376	0,295	2,551	0,335	0,370	127,0	31,2	3 140
20 Manufacture of non metal furniture	1,110	0,151	0,245	1,506	0,113	0,217	59,5	19,5	1 314
21 Manufacture of pulp, paper and board	8,055	1,969	9,850	19,874	1,625	1,813	469,4	1000,9	13 820
22 Manufacture of paper and board products	4,678	0,905	0,174	5,757	0,783	0,905	333,3	19,7	1 655
23 Graphics and publishing	0,488	0,090	0,006	0,584	0,054	0,092	24,3	0,7	7 192
24 Manufacture of fertilisers and pesticides	1,935	0,041	1,676	3,652	0,481	0,192	81,9	–1,9	685
25 Industrial chemicals and synthetics	7,948	1,554	3,428	12,930	1,295	1,188	588,2	14,1	3 362
26 Manufacture pharmaceut. and toiletries	0,819	0,104	0,010	0,933	0,186	0,165	56,3	1,1	1 663
27 Manufacture other chemical products	0,909	0,132	0,010	1,051	0,162	0,159	54,0	1,1	1 458
28 Manufacture oil and coal products	6,656	–1,179	17,335	22,813	1,366	2,533	1492,4	–19,4	1 331
29 Manufacture rubber products	1,994	0,356	0,029	2,379	0,316	0,330	119,2	3,3	498
30 Manufacture plastic products	0,775	0,124	0,004	0,904	0,071	0,091	28,9	0,5	2 672
31 Manufacture porcelain and glass products	3,656	0,251	0,006	3,913	0,130	0,356	163,9	0,7	906
32 Manufacture other ceramics and stone products	4,830	0,267	0,046	5,142	1,094	0,237	326,0	0,8	2 259
33 Manufacture iron and steel	8,522	0,465	2,367	11,353	1,175	0,776	911,3	1,0	4 877
34 Manufacture other metals	5,722	0,705	1,121	7,547	0,974	0,571	245,7	1,4	1 642
35 Manufacture metal products	0,948	0,135	0,007	1,091	0,079	0,142	45,4	0,8	5 391
36 Manufacture of machinery	0,516	0,088	0,008	0,613	0,060	0,090	27,2	0,7	11 790
37 Electrical appliances	0,356	0,064	0,004	0,424	0,037	0,050	16,6	0,4	9 142
38 Manufacture of vehicles	0,287	0,052	0,004	0,344	0,036	0,050	15,0	0,4	1 837
39 Manufacture of instruments	1,011	0,150	0,010	1,171	0,156	0,173	57,5	1,2	4 254
40 Other manufacturing	0,369	0,051	0,004	0,424	0,038	0,057	17,7	0,5	1 169
41 Supply of electricity, gas and heat									10 019
42 Water purification and distribution	1,135	0,361	0,078	1,575	0,087	0,110	39,6	14,7	1 315
43 Construction	0,714	0,060	0,005	0,779	0,075	0,530	47,9	0,5	13 205
44 Civil engineering	1,108	0,050	0,002	1,160	0,091	0,978	71,8	0,2	7 793
45 Wholesale and retail trade	0,833	0,122	0,008	0,963	0,079	0,220	47,4	1,4	40 139
46 Restaurants and hotels	0,947	0,164	0,010	1,121	0,092	0,171	47,4	1,8	7 262
47 Rail transport	2,476	0,276	0,012	2,765	0,171	1,550	129,8	1,5	2 472
48 Other land transport	2,603	0,008	0,000	2,611	0,063	2,760	190,9	0,0	14 493
49 Water transport and supporting activities	0,909	0,009	0,001	0,918	0,358	1,234	68,0	0,1	3 459
50 Air transport and supporting activities	11,550	0,162	0,013	11,724	0,201	1,318	831,1	1,5	1 497
51 Transport services	0,245	0,041	0,003	0,289	0,026	0,094	14,7	0,4	4 968
52 Telecommunication	0,391	0,052	0,003	0,447	0,035	0,212	22,8	0,5	10 371
53 Finance and insurance	0,270	0,042	0,004	0,315	0,029	0,090	17,5	0,6	17 388
54 Real estate and business services	0,405	0,049	0,004	0,458	0,033	0,193	25,4	0,5	25 646
55 Personal services	0,814	0,115	0,008	0,937	0,074	0,265	48,7	1,7	12 659
56 Housing	4,359	1,321	0,055	5,736	0,509	0,647	256,1	78,3	41 109
57 Public services	0,651	0,132	0,011	0,793	0,096	0,138	42,3	2,6	86 475
58 Other	0,983	0,298	0,012	1,294	0,115	0,146	57,8	17,7	9 593
Average	1,664	0,315	0,455	2,434	0,219	0,462	109,3	44,4	425 428

Table 2. Total energy and emission coefficients of commodities, 1993 - energy in TJ/FIM million, emissions in tonnes/FIM million

	Primary energy			CO_2 (foss)			SO_2			Total output FIM mill.
	Dir.	Indig. indir.	Import indir.	Dir.	Indig. indir.	Import indir	Dir.	Indig. indir.	Import indir.	
1 Agriculture	1,494	0,634	0,424	78,6	31,5	20,8	0,59	0,18	0,10	23 370
2 Forestry	0,340	0,086	0,068	21,5	4,6	3,6	0,31	0,03	0,02	10 343
3 Fisheries	0,433	0,191	0,202	30,6	11,0	10,5	0,23	0,07	0,05	1 255
4 Extract. ores	3,134	0,565	0,347	96,8	28,8	18,3	0,57	0,17	0,08	579
5 Other minining and quarrying	1,680	0,642	0,415	81,6	36,0	21,4	0,57	0,25	0,10	2 643
6 Abattoirs	0,264	2,217	0,536	11,7	113,0	26,4	0,06	0,77	0,13	13 659
7 Dairy prod.	0,415	2,741	0,638	24,8	141,5	31,0	0,11	0,96	0,15	11 637
8 Mill., baking	0,626	1,014	0,412	28,9	52,4	20,6	0,11	0,34	0,11	6 135
9 Manuf. of sugar, chocolate and confectionery	0,834	1,292	0,935	58,9	67,5	47,5	0,34	0,45	0,26	3 650
10 Other food manufacture	0,543	1,074	0,945	29,6	54,8	47,3	0,13	0,34	0,26	7 195
11 Manufacture of feedstuffs	0,652	1,354	0,886	35,5	71,0	43,7	0,19	0,46	0,22	2 860
12 Manufacture of beverages	0,829	0,616	0,358	54,5	33,6	18,3	0,25	0,21	0,09	4 537
13 Manufacture of tobacco products	0,206	0,243	1,085	10,1	10,2	53,8	0,05	0,06	0,31	983
14 Manufacture of textiles	0,761	0,506	1,737	35,2	24,0	80,5	0,13	0,12	0,33	3 670
15 Manufacture of clothing	0,261	0,311	0,947	12,0	15,0	44,5	0,05	0,08	0,19	2 274
16 Manufacture of leather and fur products	0,606	0,452	1,451	30,7	22,8	69,1	0,17	0,14	0,34	425
17 Manufacture of footwear	0,273	0,485	0,841	11,3	22,6	39,6	0,04	0,12	0,18	706
18 Sawmills, planing and impregnation of wood	1,349	0,623	0,135	74,2	38,7	7,1	0,19	0,37	0,03	9 417
19 Manuf. other wood prod. and building materials	1,115	0,841	0,469	55,5	43,7	22,9	0,26	0,25	0,10	7 181
20 Manufacture of non metal furniture	0,639	0,728	0,678	25,3	36,8	35,8	0,11	0,19	0,14	3 095
21 Manufacture of pulp, paper and board	6,195	1,885	0,833	146,3	66,2	36,9	0,90	0,42	0,18	44 335
22 Manufacture of paper and board products	2,261	2,122	1,180	130,9	65,4	45,8	0,56	0,40	0,23	4 213
23 Graphics and publishing	0,256	1,183	0,561	10,7	46,2	23,6	0,05	0,31	0,11	16 391
24 Manufacture of fertilisers and pesticides	1,376	1,369	1,487	30,9	64,7	67,7	0,23	0,31	0,29	1 818
25 Industrial chemicals and synthetics	4,644	1,102	1,751	211,3	55,1	79,2	0,76	0,25	0,35	9 360
26 Manufacture pharmaceut. and toiletries	0,437	0,497	1,140	26,4	23,1	52,9	0,14	0,12	0,23	3 549
27 Manufacture other chemcal products	0,472	0,405	2,449	24,3	20,0	104,8	0,12	0,10	0,47	3 243
28 Manufacture oil and coal products	2,407	0,513	2,101	157,4	30,8	108,3	0,33	0,11	0,65	12 617
29 Manufacture rubber products	1,080	0,521	1,349	54,1	25,3	65,0	0,25	0,11	0,29	1 097
30 Manufacture plastic products	0,402	0,639	2,424	12,8	29,3	111,3	0,06	0,14	0,45	6 010
31 Manufacture porcelain and glass products	1,962	0,483	0,973	82,2	24,1	44,6	0,19	0,13	0,18	1 807
32 Manufacture other ceramics and stone prod.	2,264	0,997	0,665	143,5	58,5	34,0	0,55	0,33	0,15	5 131
33 Manufacture iron and steel	3,496	2,196	1,642	280,6	159,2	91,3	0,53	0,39	0,33	15 838
34 Manufacture other metals	1,564	1,583	1,961	50,9	57,8	75,3	0,28	0,33	0,42	7 926
35 Manufacture metal products	0,451	1,159	1,236	18,8	77,7	72,7	0,07	0,23	0,23	13 023
36 Manufacture of machinery	0,263	0,565	0,907	11,7	35,2	53,7	0,05	0,12	0,18	27 455
37 Electrical appliances	0,159	0,352	0,913	6,2	18,3	45,3	0,03	0,09	0,18	24 367
38 Manufacture of vehicles	0,174	0,299	0,496	7,6	15,2	24,3	0,04	0,08	0,10	3 621
39 Manufacture of instruments	0,478	0,506	0,905	23,5	29,6	50,0	0,11	0,11	0,19	10 429
40 Other manufacturing	0,205	0,490	0,957	8,6	23,0	44,8	0,04	0,12	0,19	2 422
41 Supply of electricity, gas and heat	0,000	0,724	0,577	0,0	31,3	29,7	0,00	0,18	0,16	35 700
42 Water purification and distribution	1,178	0,280	0,122	29,6	13,8	6,6	0,12	0,09	0,03	1 758
43 Construction	0,255	0,758	0,640	15,6	43,2	34,5	0,15	0,20	0,13	40 387
44 Civil engineering	0,546	0,752	0,567	33,8	46,6	31,0	0,37	0,28	0,12	16 563
45 Wholesale and retail trade	0,550	0,401	0,225	27,1	22,2	11,6	0,13	0,16	0,06	70 209
46 Restaurants and hotels	0,425	0,583	0,271	18,0	30,8	13,8	0,08	0,19	0,07	19 151
47 Rail transport	1,747	0,358	0,297	82,0	20,3	16,2	0,79	0,14	0,07	3 913
48 Other land transport	1,779	0,250	0,236	130,1	13,8	12,5	1,36	0,08	0,06	21 268
49 Water transport and supporting activities	0,411	0,302	0,523	30,4	16,9	30,0	0,55	0,11	0,22	7 732
50 Air transport and supporting activities	3,278	1,223	1,269	232,4	80,0	77,6	0,31	0,20	0,24	5 354
51 Transport services	0,134	0,491	0,609	6,8	28,9	33,7	0,04	0,11	0,15	10 690
52 Telecom.	0,325	0,284	0,172	16,6	16,5	9,5	0,13	0,11	0,04	14 264
53 Finance and insurance	0,201	0,272	0,116	11,2	13,7	5,8	0,06	0,08	0,03	27 246
54 Real estate and business services	0,214	0,448	0,250	11,9	21,6	12,5	0,08	0,12	0,06	54 764
55 Personal services	0,570	0,303	0,221	29,6	15,0	11,0	0,16	0,09	0,05	20 831
56 Housing	4,300	0,192	0,093	192,0	10,0	4,8	0,72	0,06	0,02	54 835
57 Public services	0,447	0,275	0,187	23,8	14,7	9,5	0,11	0,09	0,04	153 621
58 Other	0,786	0,363	0,192	35,1	18,8	9,7	0,13	0,12	0,04	15 779

Table 3. Energy and emission intensities of groups of household consumer commodities, 1993 – energy in TJ/FIM million emissions in tonnes/FIM million

	Primary energy		CO_2 (foss)		SO_2		Consumption expenditure FIM mill.
	Indig.	Import. indir.	Indig.	Import. indir.	Indig.	Import. indir.	
1 Food	1,423	0,538	73,9	27,1	0,465	0,144	41 898
2 Beverages and tobacco	0,372	0,168	20,7	8,7	0,115	0,045	18 434
3 Clothing and footwear	0,439	0,921	22,2	43,4	0,125	0,189	12 149
4 Housing	3,893	0,216	175,2	11,3	0,683	0,056	64 917
5 Furniture	0,744	0,871	35,9	42,1	0,186	0,177	5 400
6 Household appliances	0,476	0,927	24,3	46,5	0,126	0,184	3 767
7 Other household equipment	0,466	0,472	23,3	22,8	0,129	0,105	20 078
8 Private vehicles	0,382	0,553	19,9	29,9	0,115	0,123	7 571
9 Running costs for private vehicles	4,942	0,656	350,1	35,1	3,165	0,165	19 039
10 Transport services	2,407	0,529	160,1	30,3	1,175	0,135	6 874
11 Telecommunications	0,501	0,184	27,1	9,8	0,195	0,039	4 159
12 Radio, television etc.	0,291	0,815	14,9	40,5	0,087	0,173	3 029
13 Other leisure	0,600	0,362	30,7	17,7	0,177	0,085	15 089
14 Books and periodicals	0,999	0,444	41,6	18,9	0,259	0,092	6 958
15 Restaurants and hotels	0,815	0,284	40,5	14,9	0,229	0,075	20 838
16 Other goods and services	0,656	0,529	31,3	24,8	0,176	0,117	12 021
Total	1,896	0,430	98,9	21,7	0,584	0,104	262 220

Table 4. Energy and emissions represented by the various GDP components

	Primary energy, PJ		CO_2 (foss), mill. t		SO_2, 1 000 t		FIM mill.
	Indig.	Import. indir.	Indig.	Import. indir.	Indig.	Import. indir.	
Private consumption	514	115	26,70	5,82	156,6	27,7	275 254
Public consumption	100	25	5,29	1,25	27,7	5,4	112 184
Investment	56	53	3,26	2,87	20,0	11,0	71 194
Exports	492	150	19,52	7,46	94,1	32,7	159 438
Imports	0	–338	0,00	–17,30	0,0	–75,7	–133 449
Statistical error	–22	–5	–0,78	–0,12	–5,3	–1,1	–2 296
Total GDP	1 140	0	53,99	–0,01	293,3	0,0	482 325

Table 5. Energy and emission intensities of the various GDP components - energy in TJ/FIM million, emissions in tonnes/FIM million

	Primary energy		CO_2 (foss)		SO_2		FIM mill.
	Indig.	Import. indir.	Indig.	Import. indir.	Indig.	Import. indir.	
Private consumption	1,866	0,419	97,0	21,1	0,569	0,101	275 254
Public consumption	0,889	0,220	47,2	11,2	0,247	0,048	112 184
Investment	0,791	0,742	45,8	40,3	0,281	0,155	71 194
Exports	3,088	0,943	122,5	46,8	0,590	0,205	159 438
Imports	0,000	2,536	0,0	129,6	0,000	0,567	–133 449
Statistical error	9,391	2,145	341,7	50,1	2,305	0,487	–2 296
Total GDP	2,364	0,000	111,9	0,0	0,608	0,000	482 325