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**ENERGY USE OF PRIVATE HOUSEHOLDS BY PURPOSES  
OF FINAL CONSUMPTION**

Submitted by the Federal Statistical Office of Germany<sup>1</sup>

**Introductory note**

The consumption of energy is of critical importance in the context of utilising our natural environment. **a specific** environmental problem. It is rather a cross-section indicator which may provide information on a variety of environmental problems, such as pressures on landscape, ecosystems, soils, waters, and ground water, which are caused by the extraction of energetic raw materials, the creation of air emissions and of wastes, and the consumption of cooling water in the context of transforming and consuming energy sources. Last but not least, the consumption of non-renewable raw materials is important with regard to preserving the bases of life for future generations. At the same time, the use of energy is of crucial importance for the economic process because nearly every economic activity (production, consumption) is connected either directly or indirectly with the consumption of energy.

This means that the use of energy and the economic reasons for such use have to play an important part in Environmental-Economic Accounting, as this system deals especially with the interaction between economic activity and the environment. This is why it is our goal to provide comprehensive data on energy flows as part of the German system of Environmental-Economic Accounting. This will enable us to offer different kinds of data which may serve as starting points for analyses and which refer to the different phases of the economic process.

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Our data supply may provide answers to the following questions:

- What is the level of **direct** energy consumption of the industries (homogeneous branches) regarding their production and of private households regarding their consumption (**economic activity**)?
- What is the level of energy consumption, taking account of all stages of production, (**cumulated** energy consumption) for the production of **products**?
- What is the level of energy input, referring to the relevant **final uses**?

As is indicated by its very name, Environmental-Economic Accounting is an accounting approach; that is an approach of secondary statistics integrating the available information into a comprehensive and consistent methodological framework.

The first of the aspects mentioned before, that is presenting direct energy consumption, may be obtained directly from the accounting database as explained before. The other two aspects deal not only with the energy consumption connected directly with a specific production or consumption activity. They rather refer to examining the total energy content of individual goods, that is, the total energy used in all previous stages of production together has to be calculated (cumulated energy consumption). At the level of the overall economy, the data needed for this purpose can be obtained only by applying an input-output model approach.

In the following, I will first explain the concept of calculating direct energy consumption within the accounting framework as far as is necessary for understanding the presentation in general. In the second section, I will describe how the cumulated energy consumption is calculated by means of the input-output approach. In the last section, some important results will be shown.

### Direct energy consumption

The Federal Statistical Office regularly compiles an input-output table of energy flows or, to be more precise, an **energy flow table** showing the use of energy in physical units (Joule), broken down by types of energy sources.

Chart 1

### Energy flow table

	Input by 58 industries	Ó	Categories of final use	Ó	ÓÓ
Energy sources (Output by industries)					

The energy flow table is fully compatible with the monetary input-output table (IOT) which shows the entire economic interactions in monetary units. Compatibility refers in particular to the definition of homogeneous branches, although it also means that all other issues of the presentation concept are compatible, too and, in addition, data sources and calculation methods are closely coordinated.

Chart 1 shows the general structure of the energy flow table. The energy flow table shows the uses of the total supply of primary and secondary energy in a breakdown by types of energy source.

Primary energy sources are raw materials (coal, mineral oil, natural gas) and natural energy sources such as water power and solar energy. Nuclear fuels are included here, too. Primary energy sources are in part used directly for energetic purposes (for example, part of coal and natural gas), while another part is transformed into other energy sources. Secondary energy sources are energy sources that have been created through processes of transforming primary or secondary energy sources. They include, for instance, coal briquettes, mineral oil products, electricity, steam, and remote heating.

The total energy supply shown in the energy flow table comprises the domestic production and the imports for the individual energy sources. What is desired now is to combine the data on the total supply and the use of energy sources presented in physical units with the data of the input-output table (IOT) shown in monetary units. For this purpose, the same breakdowns must be used for the use side of the physical flows and for the representation of the use of goods in the IOT. The energy flow table shows for the individual energy sources (rows) their use (columns) as intermediate goods (58 homogeneous branches of the IOT) and as goods of final use (final consumption of households, final consumption of general government, capital formation, exports). In the context of final uses, energy is consumed in the categories "final consumption of households" (for example the use of heating oil, gas, electricity, or fuel), "exports" (exports of energy sources), and "capital formation" (only change in stocks of energy sources); no energy is consumed in final consumption of general government.

So, the energy flow table shows which energy sources are directly used for what purpose and to what extent. Every type of energy source may clearly be allocated to a homogeneous branch or a homogeneous product group of the IOT. Thus it is possible to allocate the energy sources in physical units to the output of the homogeneous branches as shown in the input-output table. For example, for the product group "mineral oil production", those energy sources are represented which belong to the mineral oil products, such as motor fuel or heating oil.

The direct results of the energy flow table already offer interesting opportunities of analysis, especially if combined with the data of the monetary IOT. The data allow in particular to illustrate the main issue of Environmental-Economic Accounting, that is the connection between economic activity and environmental pressures, which in this context are examined from the aspect of energy use. By means of the energy flow table, the energy used can directly be allocated to the goods produced or to the consumption activities. It is very important to know how much energy is used for what production or consumption activities because that information is a good basis for policy measures aimed at reducing energy consumption (how much energy is used for what economic activity). Also, those data can serve as a basis for assessing the impact of such measures, both with regard to the target variable energy consumption and also concerning the indirect economic effects (what production or consumption activities are affected to what extent by the measure?).

Direct energy consumption can directly be influenced by the acting persons. For instance, private households may reduce their energy consumption by using low-energy equipment, applying heat insulation, reducing the room temperature, and driving their cars more economically or less often. In production, companies can directly reduce their direct energy consumption by modifying their production processes.

In addition to absolute data on direct energy consumption, ratios may be calculated, such as direct specific energy consumption in the individual homogeneous branches (energy use in physical units in relation to value added in monetary units).

### **Indirect energy consumption**

In this section, I will explain the calculation of indirect energy consumption, which allows to examine also the second and third problem mentioned above. Here the focus is on cumulated energy consumption, that is the total energy consumption caused by the production of a good or the goods of final use.

This way of examining things is based on the knowledge that energy quantities used for intermediate purposes will indirectly serve the purposes of final use, too. Energy used in this way is either needed for the production of goods of final use or for the production of intermediate goods, which – after undergoing one or more stages of production – will also be integrated in the goods of final use.

Indirect energy consumption can be calculated with the help of the input-output table. In the following, I will outline the basic elements of how to calculate indirect energy consumption for final use by means of the input-output model and what opportunities of analysis are provided by those data.

With regard to final consumption of households, calculating indirect energy consumption means calculating not only the amount of energy directly consumed in the consumption process (example: the quantity of fuel consumed in car driving). What is also calculated is the total amount of energy consumed for producing goods for consumption of households at the various stages of production (e.g., the total energy consumed in producing a car and its components). This opens up additional opportunities of analysis permitting both to apply energy reduction measures more efficiently and to estimate more precisely the effects of such measures.

Such computations may be performed in a similar way for other types of materials. The Federal Statistical Office has already published such data for the emission of greenhouse gases and acidification gases, which are created in the course of certain production processes (especially the consumption or transformation of energy sources).

The main starting point for the calculation is the energy flow table in physical units presented earlier. It is linked with the monetary input-output table. What is used here is especially the interconnection of industries shown in the monetary input-output table. Input-output tables show the direct economic interactions between the producing sectors and the final use of goods for a specific period. So, they are suited for model calculations which – under certain assumptions – can also illustrate the indirect economic interactions in the spheres of production and use of goods.

The monetary input-output table is structured according to the following pattern shown in chart 2.

Allocating the energy quantities of intermediate use to the goods of final use is performed by means of the matrix of the Leontiev inverses. Basically, that matrix can be derived from the monetary IOT through an algorithm.<sup>2</sup> In a model, using the interactions shown in the table, the entire production is allocated to the goods of final use. In combining the Leontiev coefficients on the one hand and the information on

direct input of primary energy to the homogeneous branches from the energy-flow table as well as the information on the proportion of the final uses in relation to the total output of the homogeneous branches

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<sup>2</sup> For details of the calculation method see: Stahmer, Carsten: "Direkter und indirekter Energiegehalt der Güter der letzten Verwendung" in: Reich, Utz-Peter/ Stahmer, Carsten (ed.): Input-Output-Rechnung: Energiemodelle und Methoden der Preisbereinigung, Frankfurt/Main 1981, pp. 71-113.

Chart 2

<b>Input-output-table</b>			
	<b>Input by 58 industries</b>	<b>Categories of final use</b>	
<b>Output by 58 industries</b>			
<b>Gross value added</b>			
<b>Value of Production</b>			
<b>Imports</b>			
<b>Total input</b>			

from the monetary input-output table on the other hand the total intermediary (indirect) input of primary energy for final uses is obtained by product groups.

Calculating the energy content of goods of final use is an ex-post analysis of the economic processes. Using input-output tables for the additional calculation of the amount of energy used in the preceding stages of production to produce a product (to put it more precisely: a homogeneous product group) is a step towards a model calculation; that step involves making a number of assumptions.

These assumptions include in particular the following:

- The goods are produced with linear technology, that means the relation between inputs and the amounts of goods produced is assumed to be constant.
- For any individual good of a homogeneous branch (homogeneous product group), the average input structure of that homogeneous branch is assumed.

As far as domestic primary energy is transformed into secondary energy (for example, crude oil into motor fuel) or a secondary energy source is transformed into another secondary source (for example, crude petrol into domestic fuel), double counts will occur if the indirect effects are included. This can be avoided only by excluding secondary energy of domestic production. In this context, imported secondary energy can be treated as quasi primary energy because primary or secondary energy is not included if it had been used in other countries to produce secondary energy which was later exported to Germany.

What has not been included yet is energy input in foreign countries which was directly or indirectly necessary to produce German imports (energy sources and other goods). For a comprehensive

representation of the energy consumption caused by final use, however, it is necessary to cover that part, too.

Energy input abroad can be determined only if information on the production relations in those countries is available. To get such information, imports would have to be subdivided by countries of origin. Then, to those imports direct and indirect energy inputs would have to be assigned, following the method described earlier, and using as a basis the country-specific input-output tables and country-specific energy flow tables.

At the best, such data are available in some few cases only. Therefore, the assumption is made that input structures and the relations between energy input and produced goods are identical in Germany and abroad. This means that the energy contents of imported goods are estimated on the basis of the German input-output table and the German energy flow table. Primary energy input abroad for the production of German imports, that has been estimated in that way, has now to be added to the total direct energy supply (primary energy from domestic production and imported primary and secondary energy). This will result in the total primary energy supply for final use, or the energy content of goods of final use.

Allocating the indirect energy consumption to the individual categories of final use is done by product groups, according to the use structure of the monetary IOT. Cumulated energy consumption by product groups is determined as the sum of direct and indirect energy consumption.

Another way of presenting energy consumption by final consumption of households is using the breakdown by purposes of final consumption of households. Here, direct and indirect energy input for final consumption of households by product groups is allocated to the purposes of final consumption of households. This is done with the help of a monetary matrix of "product groups (homogeneous branches) by purposes of final consumption of households". The result is direct and indirect energy consumption by purposes of final consumption of households. Cumulated energy consumption is obtained by adding up direct and indirect energy consumption.

## **Results**

Table 1 shows the energy flows at the level of the overall economy from production through to the final use categories. As regards direct energy consumption, the total supply of primary energy amounts to 15,147 petajoules, 29% of which were produced

**Table 1:**

**Primary energy  
Germany 1995**

Specification	Direct	Indirect	Cumulated	
	Petajoule		Total supply =100	
Domestic Production	4 328	0	4 328	23,0
+ Imports	10 819	3 677	14 496	77,0
Total supply	15 147	3 677	18 824	100,0
- Intermediate Consumption	10 128	- 10 128	0	0,0
Final uses	5 018	13 805	18 824	100,0
- Exports	1 044	4 248	5 292	28,1
Domestic final uses	3 974	9 558	13 532	71,9
Private consumption	4 141	6 005	10 145	53,9
Public consumption	0	1 451	1 451	7,7
Gross capital formation	- 166	2 102	1 936	10,3

within the country (domestic production) and 71% imported. A total amount of 10,128 petajoules was used for production (intermediate consumption), while the remaining part was used immediately for final use purposes (5018 petajoules). A total of 1,044 petajoules were allocated to exports (exports of energy sources), 4,141 petajoules to the final consumption of households and -166 petajoules to capital formation (changes in stocks of energy sources). If, however, indirect energy consumption is also taken into consideration, the total supply of energy increases by the energy contents of the goods imported (excl. energy sources) of 3,677 petajoules to a total of 18,824 petajoules, 23% of which were produced within the country and 77% imported. Here, intermediate consumption is fully allocated to the final use

Table 2:

**Primary energy use for private consumption  
Germany, 1995**

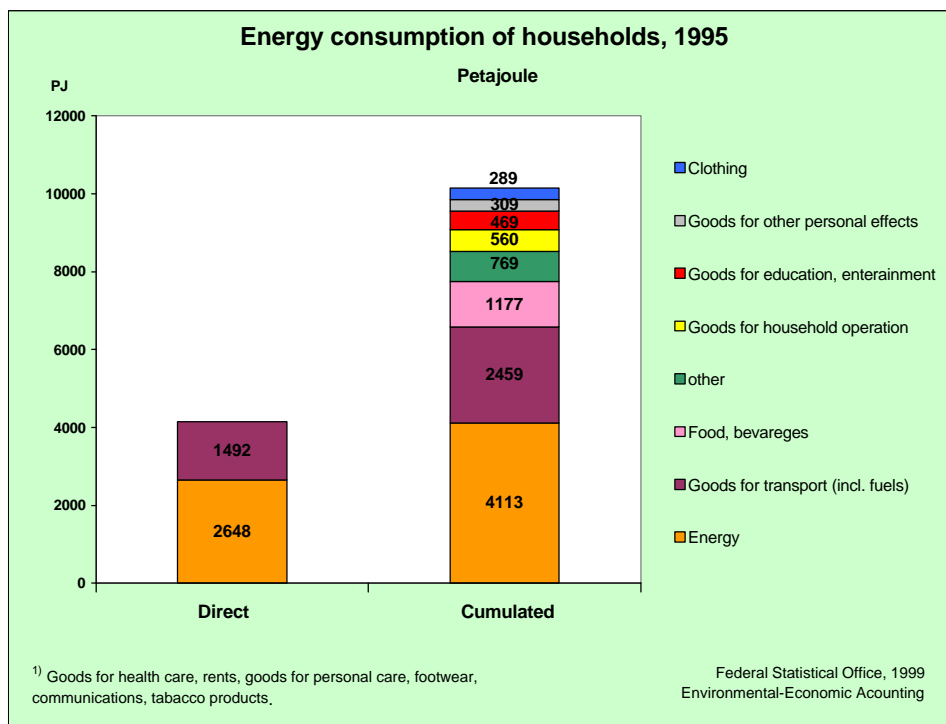
Serial number	Industries	Direct	Indirect	Cumulated	
		Petajoule			per private consumption of households (Kilojoule/DM)
1	Agricultural products		137,8	137,8	5 201
2	Forestry and fishery products, etc.	91,6	16,0	107,6	39 609
3	Electric power, steam, hot water	629,1	1321,3	1950,4	52 491
4	Gas	879,5	50,3	929,8	71 384
5	Water		0,0	0,0	.
6	Coal, products of coal mining	106,8	20,1	126,9	86 359
7	Products of mining (excl. coal, crude petroleum, natural gas)		2,8	2,8	12 194
8	Crude petroleum		0,0	0,0	.
9	Chemical products (incl. nuclear fuel)		378,7	378,7	13 390
10	Refined petroleum products	2433,6	356,1	2789,7	50 046
11	Plastic products		45,0	45,0	5 653
12	Rubber products		21,7	21,7	4 475
13	Stones and clays, building and constr. materials, etc.		28,1	28,1	7 679
14	Ceramic products		18,4	18,4	7 175
15	Glass and glass products		15,8	15,8	10 039
16	Iron and steel		0,0	0,0	.
17	Non-ferrous metals, semi-finished products thereof		0,0	0,0	.
18	Foundry products		0,0	0,0	.
19	Products of drawing plants, cold rolling mills, etc.		0,8	0,8	5 250
20	Structural metal products, rolling stock		0,0	0,0	.
21	Machinery and equipment (excl. electrical)		4,1	4,1	2 796
22	Office machinery, automatic data processing equipment		2,3	2,3	1 993
23	Road vehicles		338,1	338,1	3 223
24	Ships, boats and floating structures		3,0	3,0	3 843
25	Aircraft and spacecraft		0,3	0,3	2 293
26	Electrical machinery, equipment and appliances		74,4	74,4	2 641
27	Precision and optical instruments, clocks and watches		19,1	19,1	2 377
28	Tools and finished metal products		52,1	52,1	5 379
29	Musical instruments, games and toys, sports goods etc.		40,3	40,3	3 036
30	Wood		2,6	2,6	5 391
31	Wood products		106,2	106,2	3 075
32	Pulp, paper and paper board		4,7	4,7	15 684
33	Products of paper and paper board		36,5	36,5	6 347
34	Products of printing and duplicating		0,9	0,9	3 632
35	Leather and leather products, footwear		33,2	33,2	3 019
36	Textiles		89,3	89,3	4 561
37	Wearing apparel		109,1	109,1	2 623
38	Food products (excl. beverages)		627,5	627,5	4 500
39	Beverages		117,0	117,0	3 701
40	Tobacco products		20,8	20,8	800
41	Building and civil engineering works, etc.		0,0	0,0	.
42	Installation and building completion works		12,3	12,3	2 228
43	Services of wholesale trade, etc., recovery		105,2	105,2	1 381
44	Services of retail trade		500,8	500,8	2 566
45	Railway services		101,3	101,3	12 397
46	Water transport services, services of ports, etc.		3,7	3,7	4 252
47	Communication services		47,8	47,8	1 015
48	Other transport services, n.e.c.		209,5	209,5	4 392
49	Banking services		74,8	74,8	4 035
50	Insurance services (excl. social security funds)		61,0	61,0	963
51	Real estate renting services		241,8	241,8	650
52	Market services of hotels and restaurants, homes, hostels		202,6	202,6	3 105
53	Market services of education, research, culture and publishing services		90,0	90,0	1 865
54	Health and veterinary market services		26,0	26,0	1 107
55	Other market services, n.e.c.		63,9	63,9	1 090
56	Services of central and local government		71,0	71,0	2 292
57	Services of social security funds		0,0	0,0	.
58	Services of private non-profit inst., domestic services		98,4	98,4	1 448
59	Total	4140,6	6004,6	10145,2	5 658

categories so that the total supply now corresponds to final uses. All in all, 54% of primary energy consumption for final use purposes were caused by the consumption of households, 28% by exports and the proportion of public consumption and capital formation comes to 18% all together.

Table 2 illustrates the use of primary energy for the final consumption of households in a breakdown by product groups. Some of these product groups are of particular importance to the total consumption of energy. These groups include electric power, steam, hot water (1,950 petajoules), gas (930 petajoules), refined petroleum products (2,790 petajoules), food products (628 petajoules), and services of retail trade (501 petajoules). The relation between energy consumption and the final consumption expenditure of households, which is shown in the last column of the table, should be of interest, too. The average energy consumption per DM of the final consumption expenditure of households amounts to 5,700 kilojoules. As for some product groups, however, this relation by far exceeds the average value. This first of all applies to energy sources as coal (86000 kilojoules per DM), gas (71,000 kilojoules per DM), electricity (52,000 kilojoules per DM), refined petroleum products (50,000 kilojoules, per DM) and forestry and fishery products (40,000 kilojoules per DM). For other products, too, values are indicated which are clearly above average. These products include chemical products, glass products, paper, and railway services. The values indicated for most of the services, however, are by far below the average for all product groups.

Chart 3 illustrates the primary energy input for consumption of households in a breakdown by purposes. As regards direct energy consumption, almost two thirds of the consumption can be allocated to using energy (in particular heating oil, gas, electricity) and one third to goods for transport (especially petrol). Cumulated consumption is more than twice as large as direct consumption. Here, too, the above-mentioned uses play a dominating role, with their share amounting to nearly two thirds. As far as energy sources and goods for transport are concerned, however,

Chart 3



transformation losses (e.g. in power generation) and, for instance, the energy used in automobile manufacturing are as well covered in this context. Due to their indirect energy contents, however, other uses, whose overall proportion amounted to 35%, contributed also considerably to the total energy consumption of households. Food products hence accounted for 12% of total consumption, while the share of goods for household operation was just under 6%, and goods for education and entertainment made up almost 5% of total energy consumption.