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END-USE OF ENERGY IN NORWAY 1978-2000

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PREFACE

This publication is written as a contribution to a symposium on end-use heat demand taking place in Ohrid (Yugoslavia) in september 1982. The symposium is convened by the Economic Commission for Europe (ECE). Experts, invited by the Governments in the different countries, have been requested to submit relevant material on this topic. The views expressed are those of the authors and do not necessarily represent those of the Norwegian political authorities.

Central Bureau of Statistics, Oslo, 5 November 1981

Juul Bjerke

FORORD

Dette notatet er skrevet som et bidrag til et symposium om etter-spørselen etter energi til ulike formål. Symposiet skal holdes i Ohrid (Jugoslavia) i september 1982, og det holdes i regi av Economic Commission for Europe (ECE). Ekspertene som er invitert av de ulike lands regjeringer, har blitt bedt om å levere relevant materiale om dette emnet. Forfatterene står selv ansvarlig for arbeidet.

Statistisk Sentralbyrå, Oslo, 5. november 1981

Juul Bjerke

END-USE OF ENERGY IN NORWAY

1. Introduction

The Norwegian Central Bureau of Statistics has worked out resource accounts. Systems of energy, fish and land accounts have been developed. The energy accounts contain information on reserves, extraction and use of energy, including surveys of energy end-use.

The accounts are developed to constitute a base for resource budgeting, which will be an instrument for the political authorities to implement and evaluate resource policy. The work has been financed by the Ministry of Environment, which is responsible for the coordination in this field. The most important results from the work have been presented in a publication from the Bureau (Statistical Analyses no. 46: Resource accounts), and the use of the accounts for resource budgeting has been described in a report to the Norwegian Storting (No. 102 (1980-81)).

This paper on end-use of energy is based on the energy accounts.

2. End-use of energy 1978

The energy accounts give detailed surveys on energy consumption in households and different industrial sectors, the use of energy being distributed by 140 sectors in the background material. The surveys showing for what purposes the energy is used are less detailed, but give new and interesting information. In figure 1 net use of energy (outside the industries which are extracting or converting energy) is distributed by end-use categories.

The end-use categories or purposes are divided in 4 major groups:

- Feedstocks (oil) and reduction (coal and coke)
- Transport (including mobile machinery)
- Electricity - specific purposes (stationar machinery, electrolyses, light etc.)
- Heat

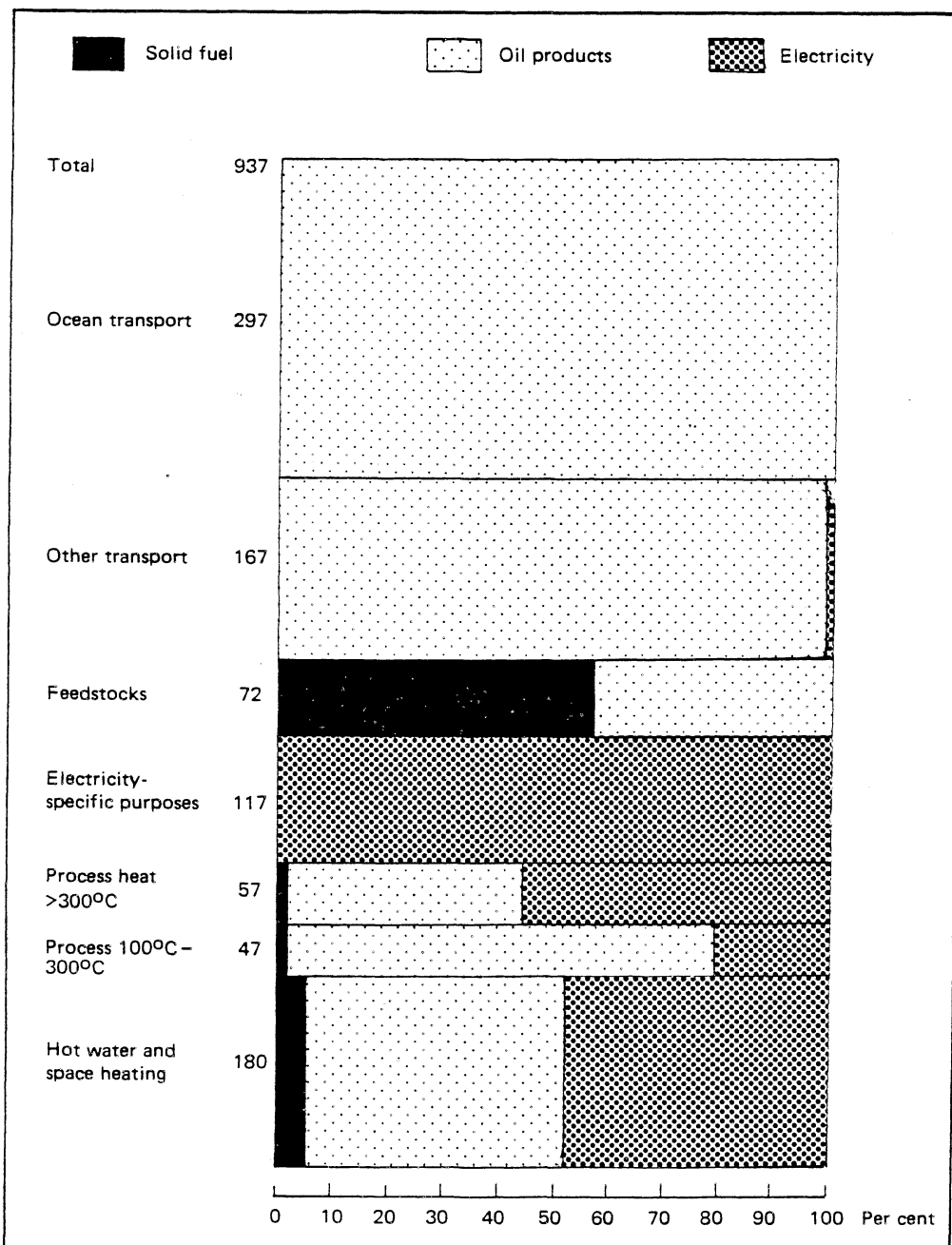
Electricity - specific purposes are purposes which need use of electricity, or where it would be unacceptable expensive to use other energy sources, for instance light or stationar machinery. Electrolyses needs electricity too, and is accordingly classified as electricity - specific. In this case, however, it is possible to use oil for the same kind of purposes by means of other kinds of processes.

The heat purposes are further divided by different temperature intervals:

- Process $>300^{\circ}\text{C}$
- Process $100\text{--}300^{\circ}\text{C}$ (included cooking)
- Space heat, hot water ($<100^{\circ}\text{C}$).

Energy for heating is classified by the temperature needed for the actual process (process - temperature), and not by the temperature by which the heat is actually delivered.

Figure 1. Use of energy outside the energy sectors, by purpose. 1978. PJ



The total Norwegian energy use (net) was 937 PJ in 1978, of which ocean transport used 297 PJ. The remaining 640 PJ was distributed according to end-use as follows:

Feedstocks (oil) and reduction (coke and coal)	11 per cent
Transport	26 " "
Electricity - specific use	18 " "
Heat: Process >300°C	9 " "
Process 100-300°C (included cooking) ..	7 " "
Space heat, hot water (<100°C)	28 " "

The use of energy for electricity - specific purposes is comparatively large in Norway, 18 per cent. The importance of electricity - specific use of energy in Norway is among others due to the energy intensive manufacturing as production of aluminium, using (low priced) hydro electricity. More than 99 per cent of Norwegian electricity is hydro electricity.

About one half of the energy used for heat purposes in Norway 1978 was electricity. At present it is considerably more expensive to use oil than electricity for most heat purposes, as oil prices were doubled in the period 1979-1981. The oil used for heating may theoretically be substituted by electricity. In Norway we used about 3,4 million tons of oil for such purposes in 1978. Theoretically this amount of oil could be substituted by about 30 TWh electric energy. For comparison the net consumption of electricity in Norway is about 80 TWh per year, and it is obvious that a rapid substitution from oil to electricity would represent a problem for the supply of hydro power. A substitution from oil to electricity anyway represents a problem in planning the future energy system.

Practically, the possibilities for substitution from oil to electricity are less than indicated above. This in particular concerns in manufacturing, where such a substitution in some cases needs large investments. If oil is going to be substituted, it may be more actual to use other energy sources than electricity. In Norway, almost all use of coal until the last years has been for reduction purposes. This is about to change, and the cementary manufacturing for instance is now substituting oil with coal. In the sawing and paper industries parts of the oil consumption are substituted by wastes from the production.

3. Changes in the energy end-use structure the last years

Table 1 shows net consumption of energy in Norway in the period 1976-1980. The energy is distributed by energy for feedstocks, transport and other purposes (electricity-specific and heat).

Table 1. Use of energy in Norway. 1976-1980. PJ

	1976	1977	1978	1979	1980	Average annual change Per cent
TOTAL	926	943	973	974	965	1,0
Ocean transport	321	333	297	287	289	-2,6
Domestic use	605	609	640	687	676	2,8
Feedstocks	60	55	72	85	94	11,9
Transport	152	163	167	172	167	2,4
Other purposes	393	391	401	430	415	1,4

The large increase in energy used for feedstocks the last years is due to the development of a Norwegian petrochemical manufacturing. This industry uses liquefied gases (NGL) as feedstocks.

The use of energy for transport has leveled off the last years. The reason for this is both increasing oil prices and other problems in industries using much energy for transport, for instance fishing.

Energy consumption for other purposes than feedstocks and transport as a whole increased until 1979, but is now decreasing. We have not yet reliable calculations distributing the energy between heat and other purposes since 1978, but there is no doubt that the total consumption of energy used for heating has decreased since 1979. This is the case even if we take into account that 1979 had an extremely cold climate. It is, of course, the use of oil which is reduced. In the first half of 1981 the sale of kerosene for heating was for instance 36 per cent lower than the sale in the same period last year. This indicates that those who most easily are able to substitute oil with other energy sources now are about doing it.

The use of electricity has increased, but the increase is about the same as usual the last years. There are good indications that we besides substituting oil with electricity, are using the energy in more efficient and economic way than earlier.

4. End-use heat demand in the future

To illustrate some aspects concerning future end-use structure in Norway, we have estimated the energy demand for different purposes in the years 1990 and 2000.

Different models have been used. In industries producing goods (manufacturing, mining and quarrying, agriculture and construction) most of the heat is used in the production processes. The quantity of goods produced, which can be measured by the gross value of production, determines the heat demand. The growth of the gross value of production has been calculated by an economical model called MSG (Multi Sectoral Growth model). The growth of economical activity is based upon the long term program from the government (Report to the Norwegian Storting No. 79 1980-1981)¹⁾. The resulting heat requirements in the industries producing goods are shown in table 2 for the years 1990 and 2000. It should be remarked that improvements in technology may reduce the heat demand compared to the figures in the table.

In manufacturing, mining and quarrying etc. (table 2) nearly 80 per cent of the heat demand is process heating. In households and service industries (trade, private and public services etc.) most of the heat is used for space heating. The amount of space heating is linked to the amount of dwellings and buildings. To estimate the heat demand in these sectors we have used a physical model developed by The Norwegian Institute of electricity supply²⁾. In this model input comprises a lot of physical parametres describing the mass of buildings in Norway. Output consists of the energy requirement for different end-use purposes as space heating, hot water, cooking, light etc.

Input for the simulation presentated in this paper is among others an increase in floor space from 174 million m² in 1978 to 235 million m² in 2000. This gives an average annual increase of 1.4 per cent from 1978 to 2000. The corresponding annual increase from 1960 to 1978 was 3.0 per cent.

1) Different alternatives of economical activity is given in Annex II.

In this report we have used the middle alternative.

2) The model is called EFI-ENERGI.

Table 2. Heat demand in industries producing goods. 1978-2000. PJ

ISIC	1978				1990	2000			
	Total	Process >300°C	Process 100- 300°C	Hot water and space heating	Total	Total	Process >300°C	Process 100- 300°C	Hot water and space heating
11 Agriculture	5.0	-	-	5.0	5.7	6.1	-	-	6.1
2,3 Manufacturing, mining and quarrying	115.0	57.0	41.0	17.0	129.8	131.6	67.4	46.0	18.2
31 Manufacture of food etc.	13.0	-	11.0	2.0	14.7	15.5	-	13.1	2.4
341 Manufacture of paper etc.	19.2	-	18.6	0.6	20.7	21.1	-	20.5	0.6
351 Manufacture of industrial chemicals	12.1	7.5	1.7	2.9	12.7	11.5	7.1	1.6	2.8
37 Manufacture of basic metals	33.9	31.6	2.3	0	42.4	46.1	42.9	3.2	0
Other manufactur- ing, mining and quarrying	36.8	17.9	7.4	11.5	39.3	37.4	17.4	7.6	12.4
5 Construction	2.0	-	-	2.0	2.4	3.0	-	-	3.0

Table 3 shows the theoretical need for space heating as a result of increasing floor space, indoor temperature, better insulation etc.

Table 3. Theoretical space heat requirement. PJ

	1978	1990	2000
TOTAL	165	197	198
In dwellings	110	131	128
In other buildings	55	66	71

A part of the theoretical space heat requirement in 1978 was covered by heat from occupants, lights, electrical appliances, cookers etc. (25 per cent). The net space heating demand which has to be provided by a heating system is shown in table 4. The heat requirement of hot water and cooking, given by the model, is also shown in the same table.

Table 4. Total heat demand in dwellings and other buildings¹⁾. PJ

	1978	1990	2000
TOTAL	160	177	165
Space heating	124	132	116
In dwellings	80	88	75
In other buildings	44	44	41
Hot water	32	38	40
In dwellings	25	28	29
In other buildings	7	10	11
Cooking	6	7	9
In dwellings	3	3	4
In other buildings	3	4	5

1) Not included buildings in manufacturing, mining, quarrying and agriculture.

Table 5 shows the total heat demand in Norway for the years 1978, 1990 and 2000 (table 2 and table 4 added).

Table 5. Total heat demand in Norway. PJ

	1978	1990	2000
TOTAL	284	315	306
Agriculture	5	6	6
Industry, mining and quarrying ...	115	130	132
Construction	2	2	3
Social and personal services etc..	54	58	57
Private households	108	119	108

The use of energy for electricity-specific purposes and for non-energy purposes can be estimated in a similar way as energy for heating purposes. This has been done to complete the illustration of projecting the end-use structure in Norway.

The use of energy for domestic transport has been calculated by the Institute of transport economics.¹⁾

The resulting end use demand 1978-2000 is summed up in table 6. The total end-use demand increases 1.3 per cent per year from 1978 to 1990. From 1990 to 2000 the annual increase falls to 0.3 per cent. The table also shows that according to the model low temperature heat demand increases until 1990 and then falls to the same level in 2000 as for 1978. This is among others due to better insulation in dwellings and other buildings and to the increase in "free heat gain" from electricity-specific purposes.

1) Otto Chr. Hiorth, 1979, Energi for innenlandske transporter 1970-2000. (Institute of transport economics).

Table 6. End-use demand 1978-2000

	1978		1990		2000	
	PJ	Pct.	PJ	Pct.	PJ	Pct.
TOTAL END-USE DEMAND	640	100.0	745	100.0	770	100.0
Heat:						
Low (<100°C)	180	28.1	196	26.3	183	23.7
Intermediate (100-300°C)	47	7.3	52	7.0	55	7.1
High (>300°C)	57	8.9	67	9.0	68	8.8
Portable fuels	167	26.1	177	23.8	184	23.9
Electricity (excluding thermal uses)	117	18.3	152	20.4	179	23.2
Feedstocks and reduction .	72	11.3	101	13.6	101	13.1

Figure 2. End-use demand 1978–2000. PJ

