ENERGY FORECAST COMMITTEE

ENERGY FORECAST FOR ICELAND
1982 - 2000

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1 INTRODUCTION

This report forecasts total energy production in Iceland and imports for the remainder of this century, in terms of primary energy sources, that is, hydro, geothermal and oil products. This energy forecast is a summary of earlier forecasts that deal with the individual sources. These earlier forecasts are:

Oil products 1980 - 2000, March 1980
Space heating 1980 - 2000, December 1980
Electricity 1981 - 2000, April 1981
Geothermal heat 1982 - 2000, March 1982

Higher and lower total forecasts are presented and it is assumed that the actual energy consumption will be somewhere between these levels. In arriving at the higher limit, it was taken for granted that electricity and geothermal usage will be consistent with the higher forecasts found in previously published reports of the Energy Forecast Committee. For oil products on the other hand, only one forecast has been prepared, and it was used in both the higher and lower total forecasts.

2 ENERGY FORECAST 1982 - 2000

In this report hydro and geothermal energy is presented in terms of oil equivalents, which is an accepted practice in most leading industrial countries and many international bodies concerned with the subject. On the other hand the United Nations and the Nordic countries other than Iceland present their energy statistics in terms of energy content of the various sources. Table 1 below shows the energy forecast; the figures are oil equivalents in thousands of tons annually. Import of energy is in the form of oil products only.

Table 1 Annual production and import of primary energy. Forecast; oil equivalents in thousands of tons.

Year	Hydro		Geothermal		Oil	Total	
	Lower	Higher	Lower	Higher		Lower	Higher
1980*	714	714	440	440	542	1696	1696
1985	865	979	580	640	542	1987	2161
1990	1000	1230	700	810	542	2242	2582
1995	1150	1690	820	1060	550	2520	3300
2000	1320	2190	940	1460	560	2820	4210

* Actual data.

The lower forecast assumes that there will be no further expansion of energy intensive industries - while some growth of this sector figures in the higher one, both for hydro and geothermal sources. The Committee believes that actual energy consumption will lie somewhere between these levels, but future development of energy intensive industries hinges primarily on government policy.

Figures 1 to 4 illustrate the energy forecast. In 1980, hydro accounted for 42% of the total primary energy use in terms of oil equivalents, geothermal for 26%, and petroleum products for 32%. The century-end figures are 47%, 33% and 20% respectively in the lower forecast, but 52%, 35% and 13% in the higher one.

Appendix 2 shows the same energy forecast where hydro and geothermal are expressed in terms of energy content, and in appendix 3 the forecast is broken down into consumption classes.

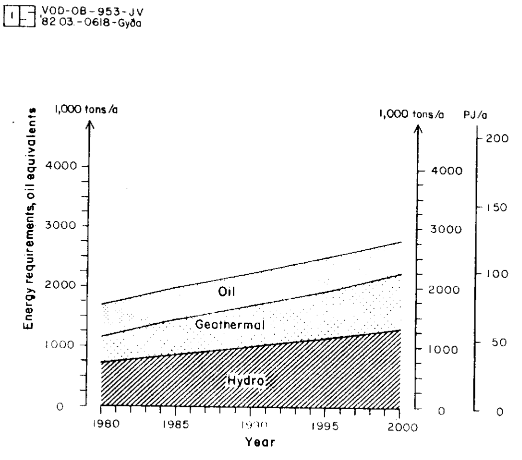

Figure 1 Primary energy requirements until 2000, lower forecast. Hydro and geothermal expressed in terms of oil equivalents.

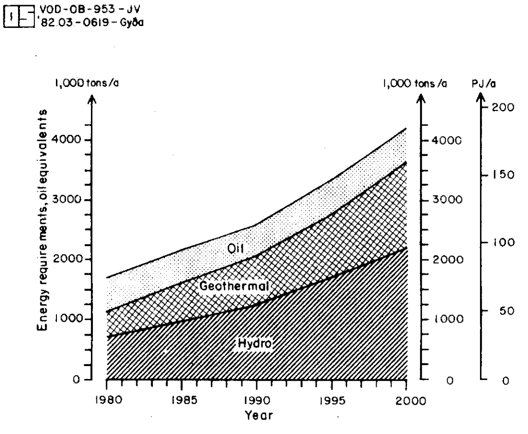

Figure 3 Primary energy requirements until 2000, higher forecast. Hydro and geothermal in oil equivalents.

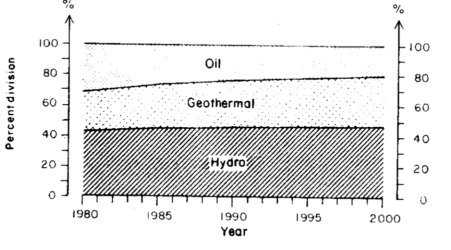

Figure 2 Percent contribution of primary energy sources until 2000, lower forecast. Hydro and geothermal in oil equivalents.

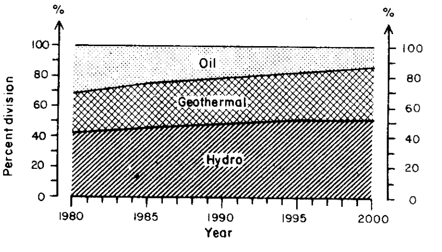

Figure 4 Percent contribution of primary energy sources until 2000, higher forecast. Hydro and geothermal in oil equivalents.

3 ELECTRICITY FORECAST

The Energy Forecast Committee's forecast of electricity production is based on the Economic Development Institute's forecast of population in Iceland for the years 1980 to 2000, its regional distribution and estimated manpower trends over the period. Assumed in the forecast is continuing economic growth, resulting in rising energy consumption per worker. It is further assumed that energy consumption per worker will increase at roughly the same rate as in recent years, with similar forecast from the other Nordic countries also considered. Moreover, the effect of conservation efforts is taken into account in the estimated energy consumption per worker, and in the estimate of residential and commercial electricity use.

The electricity forecast does not include sales of secondary or surplus energy since it is irrelevant to decision-making in the field of power system expansion planning. All consumption of electricity for space heating is included, whether used as direct resistance heating or electric water-borne district heating. While it is assumed that electric vehicles will play some role in the final decade of the century, the forecast does not distinguish their energy consumption from other categories, such as residential, commercial and industrial requirements; since it is unlikely that electricity sales to motorists will be metered separately.

There are two electricity forecasts, a higher one and a lower one. The lower one assumes that the industry sector can employ all additional workers likely to seek employment in this sector of the labour market, until the year 2000, without further development of energy intensive industries. According to the higher forecast, industry other than energy intensive will account for three-fourths of the manpower increase in question, and new energy intensive industry for one-fourth. The Committee believes that the realised industrial consumption of electricity will be somewhere between the cited levels.

The Committee emphasizes that the electricity forecast does not cover the energy requirements of new industries that may develop, on government initiative, beyond what is necessary to meet the economic premises of the forecast.

Table 2 below shows forecasted electricity demand until the end of the century expressed in terms of energy content in PJ/a.

Table 2 Electricity generation forecast in PJ/a.

Year	Lower	Higher
1980	11.3*	11.3*
1985	14.1	15.8
1990	16.3	19.8
1995	18.6	27.0
2000	21.3	34.7

* Actual data

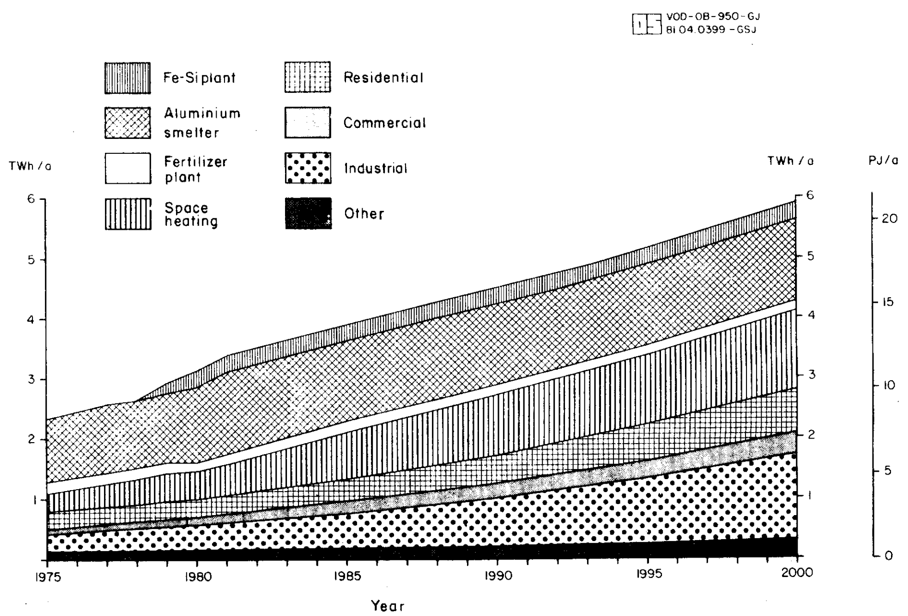

Figure 5 Electricity generation forecast until 2000 with no growth of energy intensive industries.

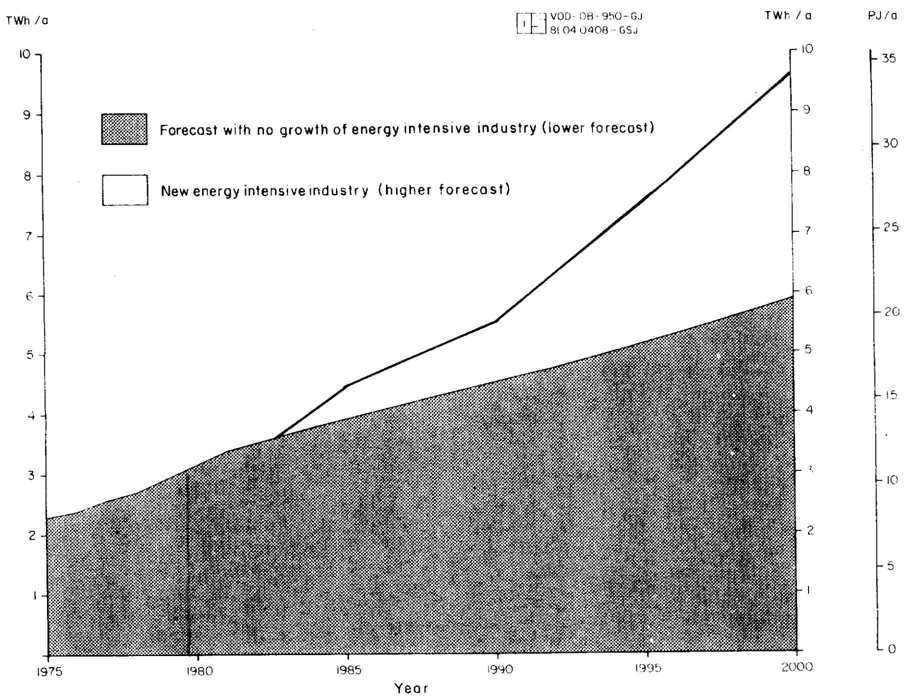

Figure 6 Electricity generation forecast until 2000 with new energy intensive industries absorbing a quarter of the net additional industrial labour force in the same period (1500 man-years).

4 GEOTHERMAL FORECAST

To date, space heating has been the primary use of geothermal energy, accounting for up to 90% of the utilization. Energy requirements for this purpose are the easiest to forecast as they grow more or less in proportion to the total heated space.

For a long time, geothermal water has been used in Iceland for greenhouses and swimming pools; expansion in this sphere is currently relatively slow and steady. The possibility of developing big greenhouse complexes has been debated on occasion in recent years. There is also notable interest in utilizing geothermal heat for soil heating in agriculture. Another possible line of development involves the use of geothermal water to maintain optimal temperatures in hatchery pools. Although the geothermal requirements of such operations today are comparatively small, it is conceivable that they may show strong growth in coming years.

There has been industrial use of geothermal energy in Iceland for some time, mainly involving drying but lately also distillation. Certain small enterprises use geothermal heat for drying stockfish products. There is a great uncertainty about the usage of geothermal energy in industry and fish farming; the gross figure by century's end could be anywhere between less than 4 PJ/a and 25 PJ/a.

The harnessing of geothermal energy for electric power production is not considered in this part of the report, but that factor is included in the electricity forecast. It is probable, however that the geothermal power station at Krafla will remain in service by 2000, and that co-generation of heat and electricity, now in evidence at Svartsengi plant, will have expanded.

World utilization of geothermal energy is limited today, and when harnessable geothermal energy is to be estimated, a fundamental question that arises concerns a reference temperature level. A common choice is the average temperature of the earths surface or approximately 15° C, but the Icelandic preference is for 5°C, which is close to the annual mean temperature in inhabited regions of the country. Figures on geothermal utilazation in the present forecast are based on the latter reference.

The figures in the geothermal forecast, given in Table 3 below, show energy content in PJ/a, based on the 5° C reference. The lower forecast assumes little growth of new industries making use of geothermal sources, while the higher one assumes that there will be some development in that sphere.

Table 3 Geothermal production forecast, energy content in PJ/a (Reference temperature 5°C).

Year	Lower	Higher
1980	21.4*	21.4*
1985	26.4	28.5
1990	31.2	35.8
1995	36.1	46.8
2000	42.6	64.3

* Actual data

Figure 7 shows the geothermal output until the year 2000.

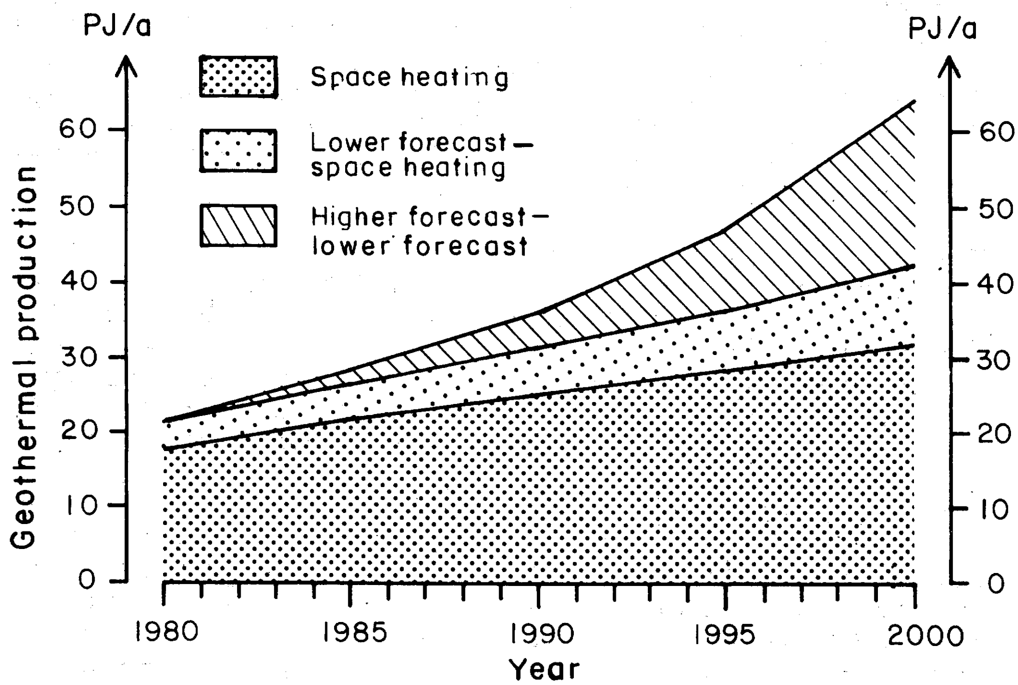

Figure 7 Geothermal production forecast until 2000, excluding production for electricity generation.

5 OIL FORECAST

The Committee assumes various changes in the pattern of oil consumption over the remainder of the century, this will by no means happen automatically, but rather as a consequence of the following steps to conserve oil:

1. Use of domestic energy sources (geothermal, hydro) to conserve 160,000 tons of oil annually in space heating (figures from 1973).

2. Curbs on the capacity growth of the fishing fleet, on engine horsepower in fishing vessels and on fishing effort, with the aim of bringing these factors to a level that will allow the maximum sustainable yield of the principal fish stocks to be harvested at minimum cost to the national economy. These measures would bring the fishing fleet's oil requirements in 2000 to some 150,000 tons - that is, roughly the present level - instead of the 270,000 tons that are conceivable if current trends where to continue.

3. General use of smaller and more fuel-efficient automobiles in the future, along with imports of electric cars on a notable scale in the 1990ies, would save 60,000 tons of auto fuel in 2000, in comparison to the 1978 level of average engine fuel consumption remaining unchanged to the turn of the century.

4. Increased energy efficiency in the operation of fish reduction plants, leading to 30,000 tons savings in 2000 compared with 1978.

This forecast assumes no replacement of oil imports with domestic synthetic fuels for the remainder of this century.

Conversion from oil to coal in certain industries has also been debated; a plan to that end will probably be carried out at a state-owned cement plant before the end of 1984. As this factory uses some 13,000 tons of oil annually, it would be logical to shift that energy consumption from oil to coal in the forecast. This has not been done; for one thing, no experience in the use of coal in this factory is available as yet, and for another, the cited factor is relatively trivial (just over 2% of the oil consumption). Further comments on coal use are found in Appendix 1.

Table 4 and Figure 8 show forecasted oil consumption until 2000.

Table 4 Oil consumption forecast in PJ/a.

Year	Oil use
1980	23*
1985	23
1990	23
1995	24
2000	24

* Actual data

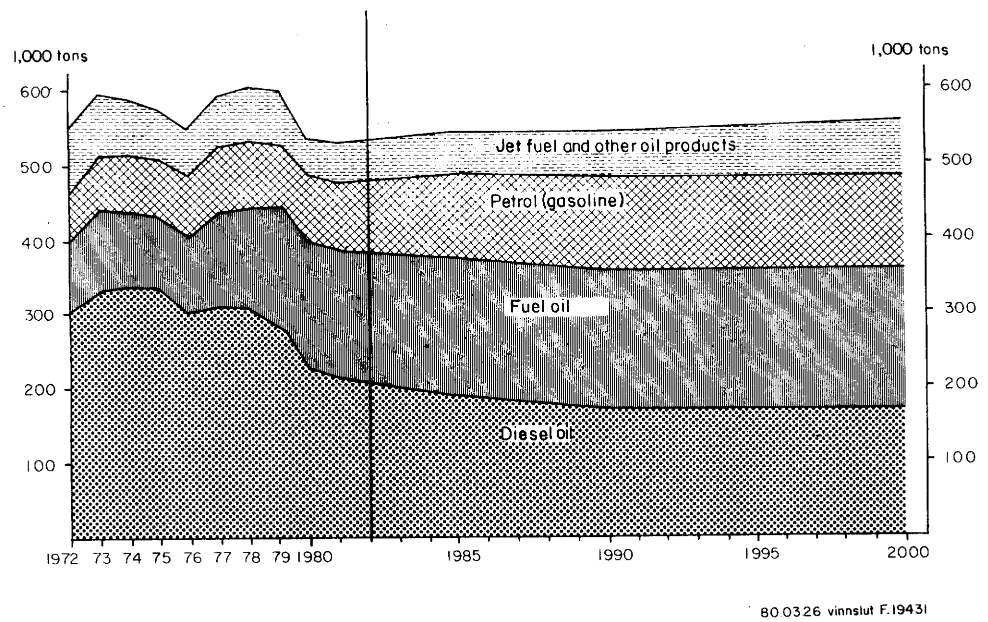

Figure 8 Oil consumption 1972-1981 and forecast until 2000.

APPENDIX 1

Coal consumption

Coal was the leading energy source in Iceland during the early decades of this century, but this role passed to oil after World War II. In the recent past, the importance of domestic energy has increased steadily. While coal consumption was minimal in the 1970s, the outlook now seems to be for growing reliance on this source, involving existing industries as well as new ventures. The following users are likely to be of greatest significance for the remainder of this century.

1. Icelandic Alloys. In ferrosilicon smelting plants, electricity accounts for about 55% of the energy requirements and coal and coke for about 45%. In 1980 the company purchased some 29,000 tons of the cited fossil fuels (about 860 TJ) - while the electric consumption came to around 970 TJ.

2. Icelandic Aluminium Company. This plant requires sizable quantities of petroleum coke and bitumen in the form of carbon electrodes, though the importance of this feedstock is smaller than in the alloy production.

3. New energy intensive industries using coal and coke may be developed in the remainder of the century. A silicon reduction plant that most probably will rise at Reydarfjördur for instance, would need some quantities of coal.

4. State Cement Works. It has already been decided to convert this plant from oil to coal. The coal consumption will be about 20,000 tons annually; the current use of oil is 13,000 tons, containing about 540 TJ.

It is conceivable that the consumption in Iceland of coal and coke may be around 70,000 tons, or 2 PJ/a in the next few years (Icelandic Alloys and The State Cement Works). This level may prove to represent less than 3% of the total consumption of primary energy when hydro and geothermal are counted in terms of energy content. Coal and coke are not included in the energy forecast, though they perhaps should be; currently, use of these sources is on a relatively small scale and largely limited to the ferroalloy smelter. The Energy Forecast Committee feels that an attempt to predict coal/coke use in the period under study is still not timely, while pointing out that it now seems logical to include the role of these sources at the ferroalloy plant (estimated to be a little over 1 PJ annually, two furnaces) in the 1982-2000 energy forecast.

APPENDIX 2

Energy forecast with hydro and geothermal expressed in terms of energy content.

In the foregoing main text, the energy forecast was presented exclusively in terms of oil equivalents (in tons). This appendix gives the result when hydro and geothermal are expressed in terms of energy content rather than oil equivalents (see table A-2-1).

Table A-2-1 Annual production and import of primary energy. Forecast with all sources expressed in terms of their energy content, PJ/a.

Year	Hydro		Geothermal		Oil	Total	
	Lower	Higher	Lower	Higher		Lower	Higher
1980*	11.0	11.0	23.0	23.0	23	57	57
1985	13.3	15.0	32.9	35.0	23	69	73
1990	15.3	18.8	39.8	44.4	23	78	86
1995	17.6	26.0	44.7	55.4	24	86	105
2000	20.4	33.8	51.2	72.9	24	96	131

* Actual data

Comparison of Table A-2-1 with Tables 2 and 3, shows that the electricity figures in Table 2 contrast with those on hydro energy, and that the geothermal forecast in Table 3 is not consistent with Table A-2-1. The reasons for these discrepancies are that hydro plants do not account for all electricity generation, and the geothermal forecast excludes geothermal steam used by electric power stations.

Figures A-2-1 to A-2-4 are comparable with Figures 1 to 4, except that those in the appendix series show energy content, not oil equivalents. Examination of the two sets will reveal that hydro energy rates higher when measured as an oil equivalent than in terms of energy content. The reason for this is the low efficiency inherent in the generation of electricity with oil.

As the figures show, oil accounted for 40% of the gross energy consumption in 1980 in terms of energy content, geothermal for 41% and hydro for 19%. Forecasts for the end of the century are 25%, 54% and 21% in the lower forecast, but 18%, 56% and 26% according to the higher one. The energy production in 1980 totalled around 57 PJ/a, corresponding to 16 TWh/a. The lower forecast puts the figure for the year 2000 at 96 PJ/a (27 TWh/a), while the higher one predicts 131 PJ/a (36 TWh/a).

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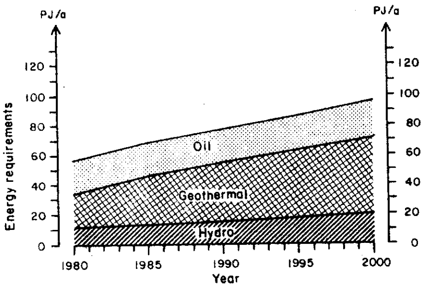

Figure A-2-1 Primary energy requirements until 2000, lower forecast. All sources expressed in terms of energy content.

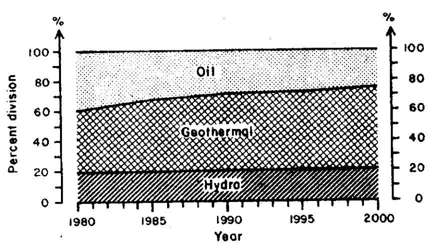

Figure A-2-2 Percent contribution of primary energy sources until 2000, lower forecast. All sources expressed in terms of energy content.

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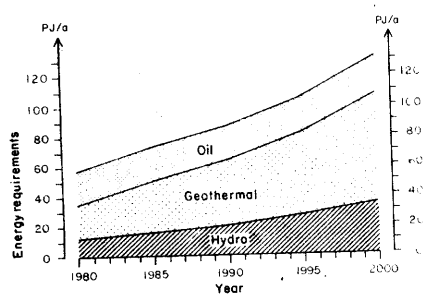

Figure A-2-3 Primary energy requirements until 2000, higher forecast. All sources expressed in terms of energy content.

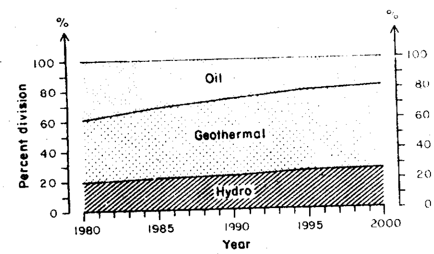

Figure A-2-4 Percent contribution of primary energy sources until 2000, higher forecast. All sources expressed in terms of energy content.

APPENDIX 3

Breakdown of energy consumption

A simple breakdown of the energy consumption is given below; it lists seven specified consumption classes, plus transmission and distribution losses. There is a ninth item, "other" including miscellaneous other use. Table A-3-1 presents the breakdown for 1980 in oil equivalents, while Table A-3-2 gives energy content figures. The levels forecasted for the years 1985, 1990, 1995 and 2000 appear in Tables A-3-3 to A-3-10.

<u>Table A-3-1</u> Breakdown of energy consumption in 1980 by end-use energy forms and main consumption classes. Oil equivalents in 1,000 tons/a.

	Electricity	Geothermal	Oil	Total
Space heating	90	360	64	514
Residential	60	-	-	60
Industrial:				
General	85	21	126	232
Energy intensive	380	-	-	380
Commercial	26	-	-	26
Fisheries	-	-	162	162
Transportation	-	-	170	170
Other	30	23	10	63
Losses (Transmission and distribution)	63	26	-	89
Total	734	430	532	1696

<u>Table A-3-2</u> Breakdown of energy consumption in 1980 by end-use energy forms and main consumption classes. Energy content in PJ/a.

	Electricity	Geothermal	Oil	Total
Space heating	1.4	17.4	2.8	21.6
Residential	0.9	-	-	0.9
Industrial:				
General	1.3	1.0	5.5	7.8
Energy intensive	5.8	-	-	5.8
Commercial	0.4	-	-	0.4
Fisheries	-	-	7.0	7.0
Transportation	-	-	7.3	7.3
Other	0.5	1.5	0.4	2.4
Losses (Transmission and distribution)	1.0	1.5	-	2.5
Total	11.3	21.4	23.0	55.7

Table A-3-3 Breakdown of energy forecast for 1985 by end-use energy forms and main consumption classes. Oil equivalents in 1,000 tons/a.

	Electricity	Geothermal	Oil	Total
Space heating	160	450	14	624
Residential	80	-	-	80
Industrial:				
General	120	26	110	256
Energy intensive*	510	43	-	553
Commercial	30	-	-	30
Fisheries	-	-	160	160
Transportation	-	-	240	240
Other	40	33	10	83
Losses (Transmission and distribution)	90	45	-	135
Total	1030	597	534	2161

* According to the higher forecasts.

Table A-3-4 Breakdown of energy forecast for 1985 by end use energy forms and main consumption classes. Energy content in PJ/a.

	Electricity	Geothermal	Oil	Total
Space heating	2.4	21.9	0.5	24.8
Residential	1.2	-	-	1.2
Industrial:				
General	1.8	1.2	4.7	7.7
Energy intensive*	7.9	1.8	-	9.7
Commercial	0.5	-	-	0.5
Fisheries	-	-	7.0	7.0
Transportation	-	-	10.2	10.2
Other	0.6	1.8	0.4	2.8
Losses (Transmission and distribution)	1.4	1.8	-	3.2
Total	15.8	28.5	22.8	67.1

* According to the higher forecast.

<u>Table A-3-5</u> Breakdown of energy forecast for 1990 by end use energy forms and main consumption classes. Oil equivalents in 1,000 tons/a.

	Electricity	Geothermal	Oil	Total
Space heating	190	510	1	701
Residential	100	-	-	100
Industrial:				
General	160	30	110	300
Energy intensive*	630	110	-	740
Commercial	45	-	-	45
Fisheries	-	-	160	160
Transportation	-	-	260	260
Other	45	46	10	101
Losses (Transmission and distribution)	120	55	-	175
Total	1290	751	541	2582

* According to the higher forecasts.

<u>Table A-3-6</u> Breakdown of energy forecast for 1990 by end-use energy forms and main consumption classes. Energy content in PJ/a.

	Electricity	Geothermal	Oil	Total
Space heating	3.0	25.0	0.1	28.1
Residential	1.5	-	-	1.5
Industrial:				
General	2.4	1.5	4.6	8.5
Energy intensive*	9.7	4.7	-	14.4
Commercial	0.7	-	-	0.7
Fisheries	-	-	6.7	6.7
Transportation	-	-	11.2	11.2
Other	0.7	2.6	0.4	3.7
Losses (Transmission and distribution)	1.8	2.0	-	3.8
Total	19.8	35.8	23.0	78.6

* According to the higher forecast.

Table A-3-7 Breakdown of energy forecast for 1995 by end-use energy forms and main consumption classes. Oil equivalents in 1,000 tons/a.

	Electricity	Geothermal	Oil	Total
Space heating	230	580	1	811
Residential	120	-	-	120
Industrial:				
General	210	39	100	349
Energy intensive*	920	260	-	1180
Commercial	60	-	-	60
Fisheries	-	-	160	160
Transportation	-	-	270	270
Other	50	70	10	130
Losses (Transmission and distribution)	160	60	-	220
Total	1750	1009	541	3300

* According to the higher forecast.

Table A-3-8 Breakdown of energy forecast for 1995 by end-use energy forms and main consumption classes. Energy content in PJ/a.

	Electricity	Geothermal	Oil	Total
Space heating	3.5	28.3	0.1	31.9
Residential	1.8	-	-	1.8
Industrial:				
General	3.3	1.7	4.4	9.4
Energy intensive*	14.2	10.8	-	25.0
Commercial	0.9	-	-	0.9
Fisheries	-	-	6.7	6.7
Transportation	-	-	11.9	11.9
Other	0.8	3.4	0.4	4.6
Losses (Transmission and distribution)	2.5	2.6	-	5.1
Total	27.0	46.8	23.5	97.3

* According to the higher forecast.

Table A-3-9 Breakdown of energy forecast for 2000 by end-use energy forms and main consumption classes. Oil equivalents in 1,000 tons/a.

	Electricity	Geothermal	Oil	Total
Space heating	260	650	1	911
Residential	150	-	-	150
Industrial:				
General	280	50	90	420
Energy intensive*	1230	520	-	1750
Commercial	70	-	-	70
Fisheries	-	-	160	160
Transportation	-	-	290	290
Other	62	120	13	195
Losses (Transmission and distribution)	200	64	-	264
Total	2252	1404	554	4210

* According to the higher forecasts

Table A-3-10 Breakdown of energy forecast for 2000 by end-use energy forms and main consumption classes. Energy content in PJ/a.

	Electricity	Geothermal	Oil	Total
Space heating	4.0	31.9	0.1	36.0
Residential	2.3	-	-	2.3
Industrial:				
General	4.3	2.1	3.8	10.2
Energy intensive*	19.0	22.0	-	41.0
Commercial	1.1	-	-	1.1
Fisheries	-	-	6.7	6.7
Transportation	-	-	12.5	12.5
Other	1.0	5.5	0.8	7.3
Losses (Transmission and distribution)	3.1	2.8	-	5.9
Total	34.8	64.3	23.9	123.0

* According to the higher forecast.

If the tables in the appendix are compared with Table A-2-1, a certain inconsistency will come to light - that total consumption in energy content is given as somewhat higher in the earlier table. The reason is that the electricity generation is broken down on the basis of hydro, geothermal and oil sources with the following efficiency assumed: hydro to electricity 1.0, geothermal to electricity 0.1 and oil to electricity 0.35. In the final tables, however the consumption is given as electricity, geothermal and oil. Consequently, the electricity consumption shows up here higher than in the foregoing hydro figures, while the geothermal and oil requirements come out lower.