Synthetic Fuels

Lectures of a Course held at the Joint Research Centre, Ispra, Italy, May 7-11, 1984

Edited by

G. E. Beghi

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INTRODUCTION TO THE ISPRA COURSE

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The main characteristic of any primary source is the degree of ease with which its energy can be converted and transported. From this point of view, petroleum-based fuels are most convenient and they are indispensable in our present society. Attention has been focussed in recent years on possible ways of obtaining liquid and gaseous fuels from alternative sources. These fuels which can be produced from non-petroleum sources, but with the same attractive characteristics of easy conversion and transportability, are called synthetic fuels, or synfuels.

The importance of the transport of energy in the energy systems, and of the synthetic fuels, from this point of view, is the motivation for a course to be held at the Joint Research Centre Ispra which has been active in the field of energy problems since its beginning. These problems are the main objectives of the research and development programme of the JRC including various activities, from experimental work to theoretical studies, together with different actions for the dissemination of information.

The Course gives a review of the present state of synfuel production technologies from the two main primary energy sources considered to-day: coal and biomass.

Coal is an important primary energy source, because of availability and reserves, but a conversion is useful. It may have a significant sulphur content and it produces dust when burned. When it is converted to gas or liquid fuels, combustion produces substantially less air pollution. Furthermore, moving gas or oil through a pipeline is cheaper than transporting coal.

Biomass is considered a sources of synthetic fuels for other reasons: biomass resources are renewable and may provide a valuable alternative source to petroleum. Some of the processes for converting biomass are well-known, for instance fermentation to produce alcohols suitable for car engines.

While basic technologies for most of these conversion processes are already available, and it is technically feasible to replace petroleum-based fuels, synfuels are not yet competitive

G. E. Beghi (ed.), Synthetic Fuels, 1–2.

and there are problems of a different nature hindering their penetration and wider application in the energy system.

Nevertheless in the long term synthetic fuels can be expected to make a contribution to the energy requirements and in some cases transition phases have already begun.

The main conversion processes using coal and biomass as primary energy sources are described, for the production of both gaseous fuels (low energy gas, methane, etc.) and liquid fuels (alcohols, synthetic hydrocarbons, etc.).

In addition to the state of the art of the production processes, the Course gives information on practical experience in the use of synfuels, particularly in automobile engines and on some aspects of environmental pollution.

The prospects of synthetic fuels depend strongly on local situations: the first element is economic competitivity but aspects other than the purely economic can be important, such as the availability of primary sources, needs and the energy policy.

The Course does not aim to arrive at conclusions, the goal is to give updated and reliable data, which will enable each participant to make his own evaluations and assessments for his particular situation. It is an opportunity to collect information on technologies and their potential development and to discuss these with experts; these discussions on the current status and problems could be helpful in the evaluation of the prospects of synthetic fuels in the energy system and of their practical applications.

The Ispra Course is organized in cooperation with KFA-Jülich, Project Management for Energy Research (PLE), Federal Republic of Germany and thanks are expressed to Dr. N. Stump. We should like to acknowledge the contribution of other services of the Commission of the European Communities: Directorate Alternative Energy Sources, Directorate General XII - Science and Research (Dr. G. Imarisio) and Directorate Coal, Directorate General XVII Energy (Dr. S. Furfari)

It should be mentioned that in addition to the contributions of the experts in each area, the discussions among participants and lecturers are also important in ensuring the satisfactory outcome of the Course.

GENERAL STRATEGY FOR ENERGY IN THE EUROPEAN COMMUNITY

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1.ENERGY SITUATION IN THE COMMUNITY

1.1 Consumption

Since 1979, energy consumption in the Community has decreased each year to the extent that in 1983 the lowest level of demand since 1975 was reached. This trend of falling consumption must be placed in the economic context of virtually zero growth in the Community's real gross domestic product in 1982, a fall in the index of industrial production and an unemployment rate equivalent to about 10% of the total labour force. Since 1979, there has been a dissociation between energy consumption and real economic growth. Figure 1 shows that setting the ratio of energy consumption to the gross domestic product (GDP) at the value of 100 for the year 1979, it consequently falls to 94 in 1980, 91 in 1981, 88 in 1982 and 86 in 1983 (the forecast for 1984 is also 86). The parallel index for oil consumption per unit of GDP (1979 = 100) moves to 91 in 1980, 83 in 1981, 79 in 1982 and 75 in 1983 (the forecast for 1984 is 74). A study by the Commission services of the reasons for changes in final energy use in the periods 1973-1979 and 1979-1981 in 7 of the Community countries suggests that a large part of the changes can be ascribed to genuine increases in energy efficiency rather than simply to changes in the level of economic activity and in economic and industrial structures.

Table I and Figure 2 show that the largest falls in demand have been registered in the oil sector. The share of oil in the gross inland consumption of energy was 52.3% in 1980 but fell to 47.1% in 1983. A long way has been covered since 1973 when the figure was 61%.

G. E. Beghi (ed.), Synthetic Fuels, 3–33.

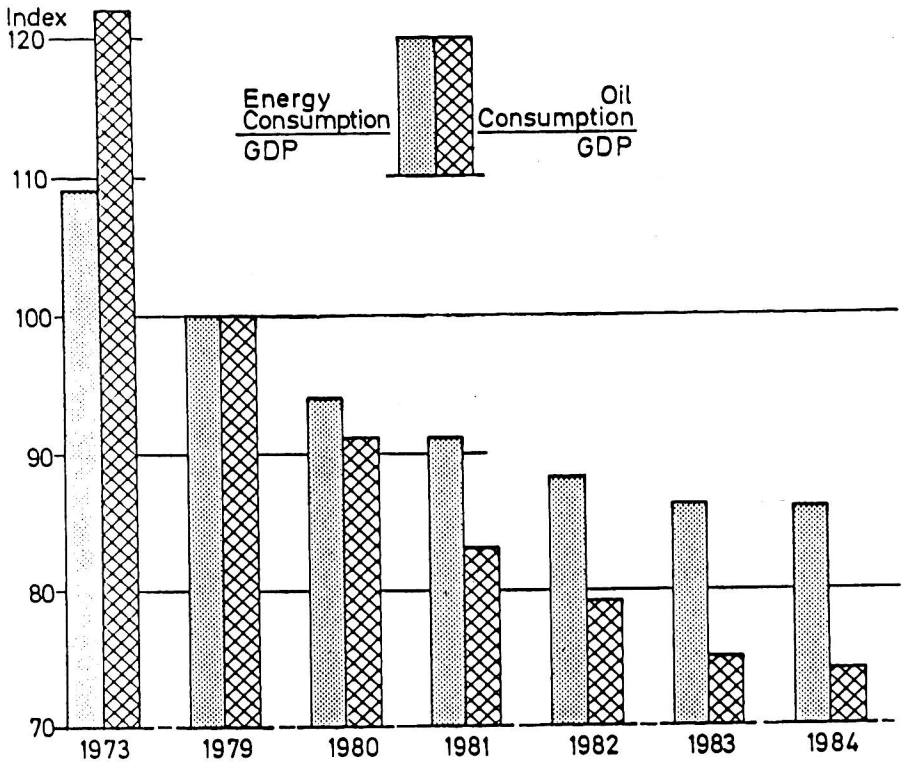

Fig.1 Ratio of: $\frac{\text{Energy-Consumption}}{\text{Gross Domestic Product}}$ compared to the Ratio of

: $\frac{\text{Oil Consumption}}{\text{Gross Domestic Product}}$ (Ratio settled to 100 in 1979)

Table I
Gross inland consumption of energy in the Community

	1980		1981		1982		1983*	
	Mtoe	%	Mtoe	%	Mtoe	%	Mtoe	%
Hard coal and equiv.	189	20.1	186	20.5				
Lignite and equivalent	33	3.5	34	3.7	216	24.5	207	23.7
Crude oil and equiv.	494	52.3	452	49.7	430	48.7	410	47.0
Natural gas	163	18.0	166	18.2	158	17.9	162	18.6
Nuclear energy	43	4.5	57	6.2	64	7.2	78	8.9
Hydro & others	15	1.6	16	1.7	14	1.6	14	1.6
Total**	944	100	910	100	883	100	873	100

*Forecasts
**Including other fuels

The other main features of the changing primary energy balance at Community level are:

- a decline in solid fuel use as a whole since 1979 (principally as a result of the contraction of output in the steel industry) but stabilisation in solid fuel use in power stations. Overall solid fuel use is now around 7% below its 1973 level;

- a doubling in the contribution of nuclear power since 1979 and a quadrupling since 1973, nuclear now accounting for the equivalent of 8.9% of total primary energy demand (78mtoe) and for 27% of the inputs to electricity supply. The result has been a marked divergence in the growth rates of nuclear and solid fuels as substitutes for hydrocarbons in electricity generation.

  a decline in the use of natural gas since 1979, reversing the high rates of growth of gas demand throughout the 1970s. The fall in gas use was particularly marked in 1982 and since then there has been a limited recovery. But gas demand is still 6% below its 1979 level.

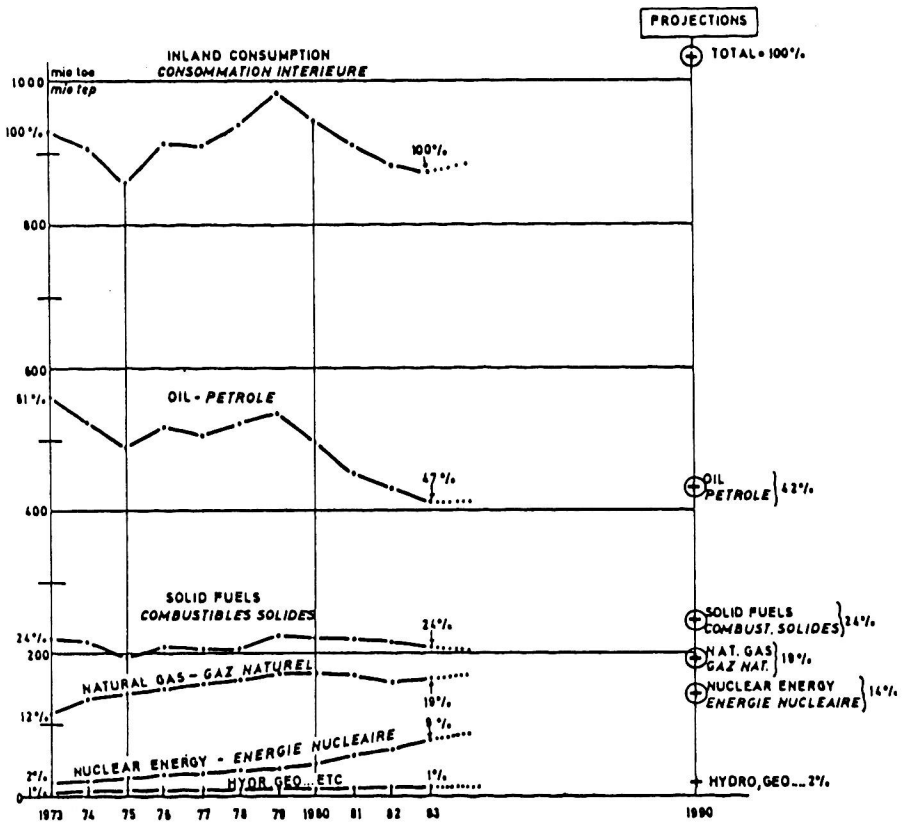

FIGURE 2

EUR-10: Main Trends in the Energy Balance
Principales tendances du bilan énergétique

1973—1990

1.2 Supply

For the fourth successive year indigenous energy production in the Community has increased. Net energy imports have therefore fallen even more quickly than energy demand (down to less than 42% of gross primary energy demand compared with 55% in 1979 and 64% in 1973). (Table II and Figure 3).

Over the same period there has also been an important increase in indigenous oil supply of over 41 mtoe or 46%, essentially from the North Sea, which has helped to reduce net oil imports to 59% of their 1979 level. In 1973 practically all Community oil was imported. In 1983 the Community was producing 2.6 mbd or over 30% of its own oil requirements, mainly from the North Sea.

Table II
Energy supply in the Community (Mtoe)

a.= production
b.= net imports

	1980		1981		1982		1983*	
	a.	b.	a.	b.	a.	b.	a.	b.
Solid fuels	185	47	187	42	182	46	174	37
Oil	91	438	102	358	118	326	130	287
Natural gas	129	41	125	43	116	44	119	47
Primary electricity	57	1	70	2	78	2	92	2
TOTAL	462	527	484	445	494	418	515	373
Share (%)	46.7	53.3	52.1	47.9	54.2	45.8	58.0	42.

In 1973 nuclear provided 7.5% of the inputs to electricity production and met less than 2% of inland energy demand. By 1979 the figures had risen to 13.3% and 3.8% respectively. In the past four years there has been a "quantum leap". In 1983 nuclear provided over 27% of the inputs to electricity and met nearly 9% of inland energy demand.

Natural gas production in the Community in 1983 was around the same level as in 1973, having declined from its peak during the mid-late 1970s

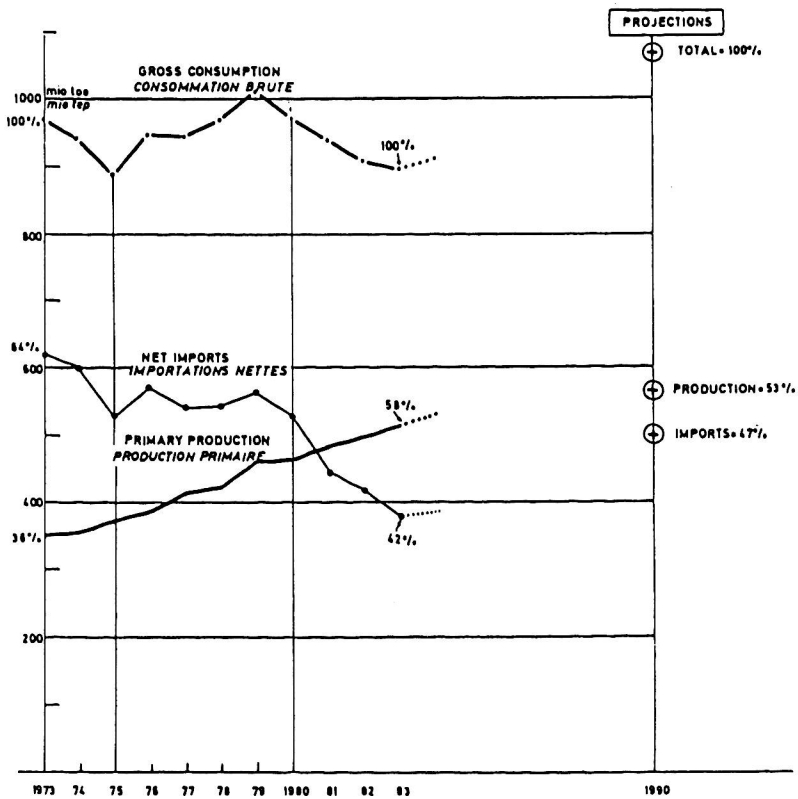

FIGURE 3

EUR-10: ENERGY: Gross Consumption, Primary Production and Net Imports

Consommation brute d'énergie et approvisionnements

1973—1990

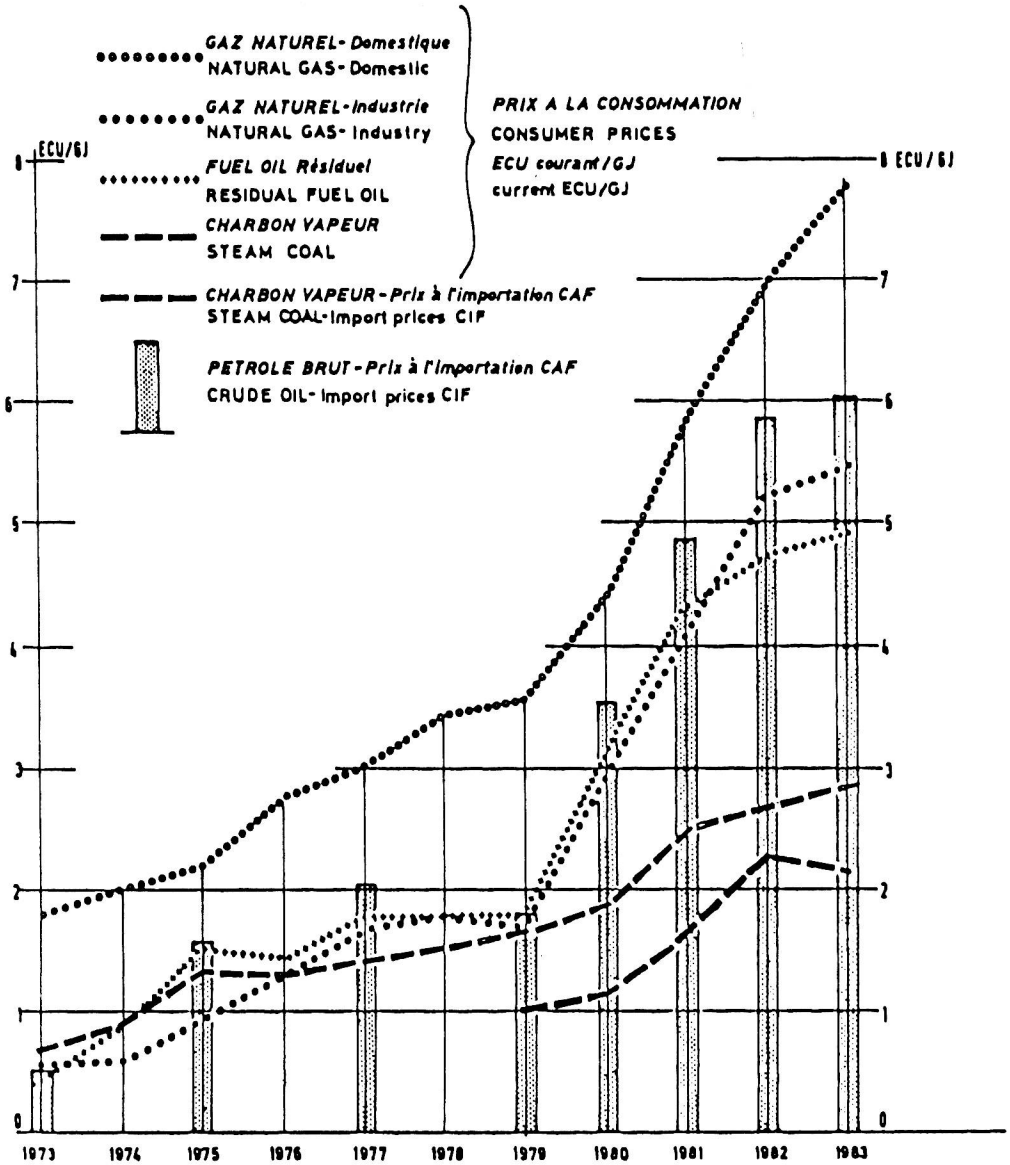

FIGURE 4

EUR-10 : Energy Prices - *Prix de l'énergie*

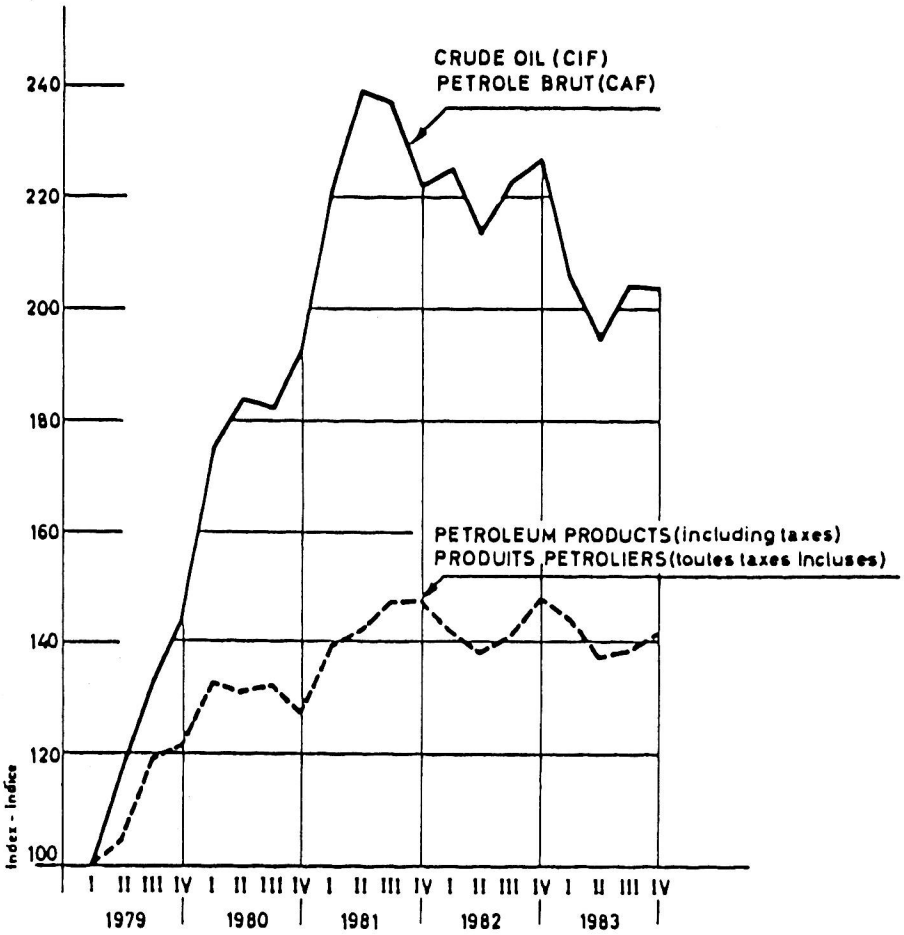

FIGURE 5

Real Oil Price Indices*
Indices des prix réels du pétrole*

* Calculated as follow: The weighted sum of consumer oil prices or crude oil imports prices in current ECU for 4 member States (F, D, I, U.K.) is deflated by the weighted sum of the ECU deflators for the same 4 member States
NB: Weights are based on the 1982 structure of consumption/imports

Calculés comme suit: la somme pondérée des prix au consommateur ou des prix du brut importé en ECU courants pour 4 pays membres (F, D, I, U.K.) est déflatée par la somme pondérée des déflateurs de l'ECU des mêmes pays.
N.B.: La structure de la consommation ou des importations 1982 est le pondérateur

The share of solid fuels and nuclear as inputs to electricity generation is up to around 74%, compared with 61% in 1979 and less than 54% in 1973. Moreover the share of solid fuels, nuclear and hydro and other minor sources together has risen to 79%, while that of oil and natural gas has fallen to 21%, compared to 42% in 1973. The main figures are set out in Tables III and IV which also include figures for 1973 and the forecasts for 1990 discussed later.

As far as the introduction of new and renewable energies is concerned, progress so far has been very slow. Their total contribution to the Community's inland energy consumption in 1979 was 14 Mtoe or 1.4%. In 1983 the figure was still 14 Mtoe, equivalent to 1.6% of a lower total consumption. In each of these years, moreover, virtually the whole of this contribution came from hydro electricity, which provides nearly 5% of total electricity supplies in the Community as a whole and around 11% in France and Italy. These figures make no allowance for the limited use of, for example, solar collectors and heat pumps in the Community (whose contribution is reflected only in reduced energy demand and not in the supply figures themselves) and they therefore understate the real contribution of new and renewable energies and new energy technologies. But even allowing for the statistical imperfections, it is clear that new and renewable energies will find an increasingly important place in the Community's total energy supplies only at a later stage and then only as a results of sustained efforts in R, D&D and in the commercialisation of new technologies.

1.3 Energy price trends.

The most significant developments in energy price trends are as follows: (figures 4 and 5)

(i) since 1979 there has been a sharp divergence in the trends in prices for oil, on the one hand, and coal on the other. The price which the Community has to pay in national currencies for its crude oil imports is now 3 times as high as in January 1979 in nominal terms and twice as high in real terms, despite a fall of 25% in the average dollar price of imported crude from the peak in early 1981. The price of key oil products (pre- and post-tax) has continued to increase in nominal ECU terms since 1980. On average the nominal 1983 prices of residual fuel oil and gas oil (ex-VAT) and heating oil (tax paid) were over 2.5 times those of 1979. Steam coal prices, on the other hand, increased by only 1.5 times. The price advantage of steam coal over competing oil products widened significantly during 1983;

(ii) the real prices of the main oil products in the four largest Community Member States are now generally higher than in January 1980 although somewhat below their peaks of 1981.