European Communities

EUROPEAN PARLIAMENT

Working Documents

1984-1985

21 May 1984

DOCUMENT 1-224/84/B

Report

drawn up on behalf of the Committee on
Energy, Research and Technology
on the development of advanced reactors

- Part B: Explanatory statement

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PE 89.172/fin./B
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English Edition

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EXPLANATORY STATEMENT

1. Introduction

The oil crisis and the present economic context have highlighted the need for a rational use of energy. To this end, the objectives must be careful selection of energy sources, more efficient transformation of one form of energy into another, more efficient heat insulation and the recovery of heat from some thermodynamic processes.

It follows that in the decades to come both industrialized and developing countries will have to cope with a series of problems in obtaining various forms of energy.

This is a delicate subject for various reasons, including the high degree of dependence on oil from third countries, the lack of diversification in the supply areas and the constant growth in demand for energy in the developing countries as a result of demographic growth, industrialization and urbanization.

On the other hand, our planet still has a wealth of energy sources and at the same time receives an abundant and uninterrupted flow of energy from the sun.

It is thus evident that, far from being due to the threat that the immense energy sources at our disposal will be depleted, the precarious supply situation is due primarily to the difficulty of developing quickly more efficient technologies for exploiting alternative sources and, often, to the fact that it is impossible to protect supplies because of political and economic tension.

To cope with the supply problems that began in 1973, the industrialized countries have mainly followed a strategy of gradually replacing oil with other fossil fuels.

The Community's dependence on energy imports began to increase substantially in 1950 with a few exceptions due to the exploitation of North Sea oil and gas.

The European Community currently consumes the energy equivalent of 900 million tonnes of oil a year, 45% of it being imported and the remaining 55% produced in the Community. Oil accounts for more than 75% of all the energy imported.

These are the figures for the Community as a whole. The situation is far from good when we consider that the Community depended on imports for 55% of its energy in 1973.

Individual Member States show wide variations from the Community average, and some are particularly vulnerable.

In recent decades oil has assumed importance in the energy balance of the more industrialized countries because it can be put to a variety of uses, is easy to transport and store. In addition, until ten years ago, oil was a really cheap source of energy with reserves being intensively exploited on a large scale.

The twentieth century has certainly seen oil triumphant. The more developed countries, that have experienced the 'oil civilization' and undeniably enjoyed unprecedented prosperity as a result, have been trapped into dependence on a source of energy that they cannot control and that, despite everything, continues to be the driving force behind their economies.

As a result, the Community's energy strategy has been to intensify the energy savings policy which so far has produced good results.

But paradoxically one of the sectors that has been less than brilliant since 1973 is nuclear energy.

Ever since the 50s people have become aware of the fact that fossil fuel resources are limited and bound to become rare and expensive. It was then that the American Administration launched its 'Atom for Peace' programme with the objective of reducing dependence on external sources of energy through specific use of the atom.

At the same time Western Europe was becoming more and more dependent on energy imports; oil dependence was increasing rapidly, particularly in the countries that were in the process of creating the Europen Community.

For example, in 1950 Italy depended on external sources for 60% of its energy supplies and France for 30%. The signing of the Euratom Treaty in 1957 represented an important step in the development of new energy sources and made a significant contribution to the reconstruction and pacific growth of our continent.

The original reasons for developing nuclear energy are as valid today as they were then. Research into alternative energy sources (solar and geothermal, energy, wave power, etc.) was prompted by the same reasons as research in the nuclear sector, which it complements rather than replaces. Experience in the past decade has fully confirmed the importance of diversifying sources of energy.

However, the development of nuclear energy policies has been paradoxical in the past decade. Before the oil crisis in 1973, large numbers of electricity generating nuclear plants were ordered throughout the world on an economically competitive basis. Almost all the nuclear plants now in service (50,000 MW in the European Community, 65,000 MW in USA and 18,000 MW in Japan) were ordered before 1973.

Not only did nuclear energy rapidly capture a share of the market, most of the industrialized countries also pursued the development of advanced nuclear reactors and the study of fuel cycles vigorously; they did so in knowledge of the fact that uranium resources were limited and had therefore to be used more rationally and that sooner or later nuclear energy could be used for non-electric applications (process heat, metallurgy, the production of synthetic fuels) in order to husband the oil and gas normally used in those applications. We should not forget that electricity accounts for only some 30-35% of the energy consumed.

Between 1971 and 1973 high temperature reactors with a total capacity of 8,000 MW were ordered in the USA and techniques for reprocessing and storing waste were already being developed and gradually applied.

The oil crisis in 1973 once again highlighted the fact that oil reserves were not endless and that overdependence on it and on energy imports in general was undesirable for any country. Even the United States, then dependent on imports for only 17% of their energy requirements and with ample energy reserves including coal, were concerned and launched their independence project. The EEC, which in 1973 depended on imports for 55% of its energy, was even harder hit.

Logically, the 1973 crisis should therefore have further encouraged the development of nuclear energy. Interest in nuclear energy increased and it suddenly became a better economic proposition than fossil fuels.

In fact, not all the expectations placed in nuclear energy were fulfilled and the rapid expansion then foreseen for nuclear energy in the more industrialized countries came to nothing. Here it is worth mentioning some factors that undoubtedly helped to slow down the development of nuclear energy. They explain the apparent paradox that the oil crisis slowed down rather than accelerated the development of nuclear energy. One of the main causes is the economic climate prevailing in the past ten years. It would be unfair to blame the oil crisis for all the setbacks, but it undeniably helped to trigger off a worldwide process of economic recession from which we are only now beginning to emerge.

Figure 1, based on EUROSTAT figures[1], shows the trend of oil prices and the trend in unemployment during the same period.

The economic recession and energy savings which have perhaps been the most important practical reaction to the oil crisis, combined with a slowing down of the growth in demand for electricity, have certainly not encouraged the construction of nuclear plants. In many cases, they have instead led to the cancellation of orders already placed.

A second factor is public opposition to nuclear energy. The so-called nuclear controversy initiated by ecological movements at the beginning of the 70s had an important political impact. Increased concern with safety and the environment led to more complex licensing procedures in many countries and made the time needed to complete nuclear power plants longer, and what is worse, unpredictable.

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[1] See Annex 1

In addition, governments and public alike became increasingly aware that the development of nuclear energy for peaceful ends could increase the risk of a proliferation of nuclear weapons. It was against this background that the world international fuel cycle evaluation programme (INFCEP) was launched between 1978 and 1980 following a Carter Administration recommendation. The European Community also took an interest in this and Parliament appointed Mr Protogene Veronesi as its rapporteur.

Partly because of their different supply situations, each country with an energy policy reacted to world events with a different approach to the question of nuclear energy. And that is one reason why there are differences on the world scene today.

With the exception of France, the rate of construction of nuclear power plants has not come up to the expectations of the 70s. In the USA in particular so many orders have been cancelled in the past 10 years that there are fewer GW on order today than there were 10 years ago (Figure 2)[1].

The cancellation of some 110 GW has already cost 10 billion. No orders have been placed since 1978.

In the European Community (Figure 3)[2] on the other hand, orders for nuclear power plants were placed at a much slower rate than in the USA and thus there were not the same mass cancellations.

In this situation it was not just water reactors, i.e. those already commissioned, that suffered but also advanced reactors whose development got off to a rapid start at the beginning of the seventies. With the exception of fast breeders in Europe, that decade saw an abrupt halt in HTGR research and development programmes for the reasons given above.

The experience and skills so far acquired in the HTGR research programmes could therefore be irretrievably lost, to the detriment of the European strategy in which energy independence is a prime objective.

To cope with the possibly rapid deterioration of the Community's hydrocarbon supply situation after the year 2000, nuclear fission must maintain and if possible increase its contribution to the Community's energy balance in the first part of the next century.

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[1] See Annex II

[2] See Annex III

There is no need to reiterate that the Community's dependence on imported uranium could impede implementation of a proper nuclear energy policy and in the end bring about its premature decline.

This is a risk the Community cannot afford to take since:

(a) thermonuclear fusion has not yet proved its technological feasibility. In any case it could probably not be exploited commercially much before the end of the first half of the next century;

(b) no matter how great the contribution of renewable energy sources (solar energy, geothermal energy etc.) and coal to the Community's energy balance in the first part of the next century, it would be irrational to expect it to compensate for a drop in supplies of <u>both</u> hydrocarbons <u>and</u> nuclear energy.

In this context consideration should be given to the alternative of fast super-converter reactors and high temperature reactors (HTR) that <u>use the fuel more rationally</u> and, in the case of the latter, offer the possibility of producing synthetic fuels and process heat in addition to electricity and so turn Europe's important source of energy to the best use.

II. <u>Development of advanced reactors</u>

The nuclear reactors currently in operation are mostly light water reactors (PWR or BWR)[1]. The fuel they use is enriched uranium (about 3% of uranium 235): the enrichment process leaves unused large quantities of depleted uranium (uranium with a low fissile uranium 235 content) which superconverters can use up entirely. For instance, the depleted uranium produced in a single year by the EURODIF enrichment plant could feed <u>100</u> 1,000 MWe <u>fast reactors</u> for 50 years. Superconverters also need plutonium to function. This is produced in large quantities by thermal reactors (with the reactors currently in operation and under construction Western Europe will have 25 tonnes a year).

Fast reactors thus produce energy from a by-product of the PWR or BWR fuel cycle that accumulates continuously and by the end of the century will have the potential for producing electricity for several centuries.

The advanced reactors considered promising from an economic point of view (in Western Europe and the United States) are helium-cooled graphite moderated high temperature reactors (HTR) and sodium-cooled fast breeders (SNR or FBR).

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[1] PWR = Pressurized Water Reactor
BWR = Boiling Water Reactor

Other types of reactors previously considered, particularly advanced gas-cooled reactors (AGR) and heavy water reactors (HWR) have not come up to expectations.

Canadian efforts to create heavy water electricity generating plants of the CANDU type deserve mention; AECL has exported some plants of this type to India, Pakistan and Argentina.

The success of advanced reactors alongside LWR reactors, in which the whole world has a stake, depends not only on the time they will need to reach technical maturity but on many other parameters.

Of all the possible strategies, the best, given a specific trend in electricity requirements, is to satisfy them at the lowest cost and with minimum supply difficulties, taking account of existing electricity generating plants. In concrete terms, this means reducing to a minimum the total cost of building the plants, of the fuel cycle and of their operation and maintenance.

As for the HTR, one of its characteristics in addition to those mentioned below is that it can use thorium, the fertile element most abundant in nature.

Moreover, this second generation of thermal reactors has advantages in that they are safe, may be located in the vicinity of towns, are easy to operate and maintain, have a flexible fuel cycle and above all offer access to new markets because of their ability to produce very high temperatures (950° C) useful for such applications as methane reforming, the Brayton cycle (gas turbine), process steam and the thermochemical production of hydrogen.

II.1 Fast breeders

A. General

Although a single reactor can use uranium efficiently (with at least 60 times the efficiency of a thermal reactor), the total energy output of uranium in a combined system of fast and thermal reactors will depend on the ratio of thermal reactors to fast reactors at any moment. The output will increase as the installed fast reactor capacity increases by comparison with the total installed nuclear power. In a combined system of light water-cooled thermal reactors and sodium-cooled fast reactors, the maximum output is achieved when the proportion of fast reactors is of the order of 50 to 70% of the total.

The proportion of fast reactors needed to attain the maximum uranium energy output decreases as the performance of the fast reactors or thermal reactors improves.

From this it can be deduced, firstly, that the improvement of thermal reactors is still an important objective (the HTR could help towards this).

Secondly, this highlights the fact that the construction of enough fast reactors considerably to improve the total energy output of uranium requires a considerable length of time (at least 20 years). In fact, the installation of fast reactors depends mainly on the rate at which plutonium is produced by the thermal reactors and fast reactors themselves.

Considering the Community's present uranium supply situation, the objective of fast super-converters should be to meet the Community's increased electricity requirements during the first quarter of the next century and at the same time gradually reduce its annual uranium requirements.

It follows that:

The complex and costly fast breeder programmes are amply validated and justified by the following arguments:

- the plutonium produced by fission in termal reactors can be used most economically in fast breeders;
- fast reactors are capable of converting non-fissile uranium, making better use of existing uranium resources;
- using fast breeders, the quantity of energy obtainable from known uranium reserves is considerably greater than all the fossil energy reserves put together;
- fast breeders do not depend on imports of natural uranium and are not affected by related supply difficulties;
- the cost of the electricity produced by fast breeders is totally unrelated to the price of uranium or fluctuations in that price; the cost of the uranium enrichment phase is also saved.

Current thinking is that liquid sodium is the most suitable coolant as it provides good heat transfer.

Sodium however also has certain unfavourable chemical properties: it reacts violently with water and has limited compatibility with other materials. Since it becomes radioactive in the reactor, there is an intermediate non-radioactive sodium circuit in addition to the steam generating circuit.

B) Achievements in the Community

In the past 25 years most of the Member States of the Community have devoted considerable energy to developing liquid metal-cooled fast super-converter reactors and have allocated vast financial resources for the purpose. Even today the cost of developing these reactors accounts for some 20% of the total cost of research, design and development in the energy sector.

Important technical objectives have been achieved as a result: various experimental and prototype reactors have successfully been constructed and commissioned and a large (1,200 MWe) power plant is almost completed. The results are unparalleled anywhere else in the world.

The following table summarizes reactor projects completed or under consideration, broken down by country or group of countries.

The dates given in brackets are the scheduled commissioning dates.

Country	Experimental and test reactors	Prototypes (200-300 MW)	Demonstration plants (1200 MWe)
United Kingdom	DFR(1963)	PFR (1974)	CFR Project not yet approved
France	Rapsodie (1967)	Phenix (1974)	Super-Phenix[1] (1984)
FRG	KNK II[4] (1977)	SNR 300[2] (1986)	SNR 2[3] Project not yet approved
Italy	PEC (1986)		

[1] In collaboration with Italy, the Federal Republic of Germany, Belgium and the Netherlands.

[2] In collaboration with Belgium and the Netherlands.

[3] In collaboration with France, Italy, Belgium and the Netherlands.

[4] In collaboration with Belgium and the Netherlands.

The table shows that the Member States have tended to cooperate on the construction of demonstration plants.

Major cooperation agreements have been concluded between research organizations and industry (electricity, design and construction companies) in various Member States.

C) Achievements outside the Community

Outside the Community too, most of the industrialized countries have seriously committed themselves to the fast super-converter sector.

In the USA the 200 MWth EFFBR experimental plant functioned from 1963 to 1972 and provided a valuable series of experimental data on various reactor systems. The 62.5 MWth EBR-II experimental reactor has been in operation since 1965, and in 1980 construction of the 400 MWth FFTF experimental reactor was completed. Given its power, it will in practice function as a demonstration plant.

Construction of the Clinch River breeder reactor (CRBR) was halted by the Carter administration and the prospects for this demonstration project are still uncertain.

In Japan the JOYO experimental fast reactor with a design power of 100 MWth (spring 1983) has been in operation since 1977.

The design for the 300 MWe prototype reactor MONJU has been completed and a decision was recently taken to go ahead with construction.

Preliminary plans are being drawn up for a larger demonstration reactor and construction is planned to start one year after MONJU has been commissioned. A series of pre-commercial reactors will then be constructed, similar in size and design to the demonstration reactor.

In the USSR design and construction of fast reactors is an essential feature of the national energy programme. Two experimental reactors are at present in operation, the 600 MWth BOR 60 and the 10 MWth BR-10.

The BN-350 demonstration reactor has operated successfully at a power of 350 MWe since 1973 and is being used for seawater desalination. The second 600 MWe demonstration reactor, the BN-600, has been in operation since 1981 and plans are now being drawn up for the commercial fast reactor, the BN-1600 MWe. Consideration is also being given to the possibility of increasing the power of the BN-600 reactor to 800 MWe.

II. 2. High-temperature gas-cooled reactors

A) Main technical features

The high-temperature gas-cooled reactor (HTGR) is the logical follow-up to the Magnox carbon dioxide-cooled graphite moderated reactor.

This was the first industrially successful reactor in Western Europe in the 50s. It was developed and industrialized in France and the United Kingdom and was exported to italy, Spain and Japan.

Today there are 32 commercial Magnox reactors in operation in Western European with a total installed power of 9 GWe. The oldest have operated satisfactorily for 25 years.

The more recent Magnox reactors, constructed at the end of the 50s and beginning of the 60s, incorporated a primary containment of pre-stressed concrete which was subsequently adopted for both the AGR (advanced gas-cooled reactor) and the HTGR.

The AGR, also derived from the Magnox, was developed and marketed in the United Kingdom and operates at sufficiently high temperatures (600° C) for a conventional and thus high efficiency (38 to 40%) steam cycle to be used. There are 10 of these reactors in operation or under construction in the United Kingdom with a total power of 6 GW.

The technologies developed for the Magnox and AGR as well as the long experience gained in operating them formed the basis for the development of the HTGR which, in other words, is not an entirely new reactor.

It is not surprising that Western Europe first successfully developed the HTGR with the DRAGON project (the Dragon reactor constructed in the United Kingdom came into operation in 1964) and the AVR (constructed in Germany and went critical in 1967). A parallel project in the United States led to the construction of the Peach Bottom reactor which came into operation in 1967.

The high-temperature reactor differs from the Magnox/AGR by virtue of two major innovations, i.e. it uses ceramic fuel dispersed in a graphite matrix and a chemically inert coolant (helium). The research and development programmes carried out in the 60s confirmed the validity of the HTGR concept and allowed a system to be devised that, apart from being promising from the economic point of view, had and still has intrinsic safety features that are unrivalled.

Its key feature is the fuel particle with a diameter of from 0.4 to 0.6 mm.

The particle may be uranium, thorium or plutonium carbide or, preferably, their oxides and is coated with carbon and silicon carbide deposited pyrolitically which make it particularly robust and impermeable to the fission products generated inside.

An HTGR reactor contains thousands of millions of these particles linked together in graphitized compacts and in graphite fuel elements which are by nature good heat conductors and of a considerable strength which, incidentally, increases with higher temperatures. The helium coolant which is chemically inert and has excellent properties from the point of view of heat exchange, can be raised to very high temperatures (750°C and even 1,000°C) without the maximum temperature at the centre of the fuel particle exceeding 1,300 to 1,500°C, whilst the graphite structures remain at intermediate temperatures of between 800 and 1,200°C.

By comparison, the temperature of the coolant in a light water reactor (about 350°C) is far below the maximum temperature at the centre of the fuel element (up to 2,000°C) and the maximum temperature at the hottest points of an HTGR is in effect much lower than in a light water reactor.

In conclusion, the operating temperature of an HTGR, although high, is far below the limits at which the completely ceramic core could begin to lose its geometric and structural properties, and a disaster involving an HTGR core is practically inconceivable.

The essential design and safety features of an HTGR can be summarized as follows:

- use of a pre-stressed concrete containment with possible redundancy of the load-bearing elements. This essential component is thus very safe;
- the coolant undergoes no phase change in either normal conditions or in the event of an accident;
- low exposure of the workers to radiation. Helium is inert and does not react with the materials in the primary circuit;
- transparency of the coolant so that the primary circuit can be inspected visually during maintenance operations;
- the core can be designed and optimized in the light of economic conditions and the availability of fissile and fertile material. The conversion factor and the burn-up can be varied within wide limits. The burn-up may exceed 100,000MWd per tonne. The reactor can function on an open uranium/plutonium cycle using slightly enriched uranium (e.g. 6%), or on a closed uranium/thorium/uranium 233 cycle (however, techniques have to be developed for reprocessing the thorium fuel), or on an open plutonium/uranium cycle (in this case the reactor behaves as an optimum plutonium burner). This underlines the potential of the HTGR for using natural uranium resources rationally.

  From the point of view of core geometry, reactors with both conventional prismatic fuel and spherical fuel elements have been constructed and successfully operated.
- the behaviour of the fuel and of the primary containment in the event of an accident is characterized by very slow and in principle predictable transients.

  The quantity of fuel exposed following rupture of a coated particle is trivial, and millions of elementary particles have to rupture before appreciable quantities of fission products are released into the primary circuit.
- accidental malfunctioning gives rise to slow and limited transients because of a highly negative reactivity coefficient, the lack of neutron absorption or moderating effect by the coolant, and the great mass and thermal capacity of the moderator.

All these characteristics make the HTGR an ideal candidate to occupy sites near densely populated and highly industrialized areas.

B. Achievements in the Community

The Dragon project. The first experimental HTGR was constructed in the United Kingdom under the auspices of OECD/NEA. The European Community contributed about 48% of the project's funds throughout the 17 years of its operation (1959-1976). The Member States and the Community itself also helped by providing numerous scientists and engineers. The reactor (20 MWth) was constructed in the record time of 4 years and operated practically without interruption from 1965 to 1975 (coolant exit temperature 750°C).

The project developed and very successfully tested coated particle fuel elements for both thorium and slightly enriched uranium cycles and found engineering solutions to the problem of containing, purifying and handling the coolant (helium).

The AVR. Built at Julich (Federal Republic of Germany), this 15 MWe (about 45 MWth) reactor had a core composed of fuel particles about 6 cm in diameter (the so-called pebble bed).

It was initially designed for a temperature of 750°C and operated without any major interruption until 1967. Since 1974 it has been functioning at an exit temperature of 950°C showing that there are no major problems in increasing the temperature to about 1,000°C as far as the core is concerned.

The THTR 300. Construction of this 300 MWe prototype began in Schmehausen (Federal Republic of Germany) in 1973 for the HKG consortium. Construction of this reactor, designed (like the AVR) round a pebble-bed core, has been considerably protracted and it is still not complete.

Part of the reason for this delay was the long and complex licensing procedure which called for changes in the components and systems design from time to time. However, the project is now nearing a rapid conclusion. In September 1983 the reactor was loaded with fuel and has now reached the first criticality stage.

A zero power experimental programme is now under way and a gradual increase in power is planned for the second half of 1984.

The project was initiated in 1973 as a joint action within the meaning of Chapter V of the EURATOM Treaty.

C. Achievements outside the Community

Peach Bottom. This reactor was constructed by General Atomic in the United States and was managed by Philadelphia Electric from 1967 to 1974. With a power of 40 MWe and designed around a conventional prismatic fuel core, it proved so reliable that American electricity producers became seriously interested in the HTGR as a rival to the light water reactor.

Fort St Vrain. In 1968 the Public Service Company of Colorado ordered a 330 MWe reactor constructed by General Atomic using the experience gained at Peach Bottom. The reactor went critical in 1974.

Unforeseen difficulties unconnected with the basic construction principles considerably delayed its entry into service. The plant is functioning at 70% of its 1976 nominal power and the authorizations needed for it to function at 100% have already been obtained.

III. CONCLUSIONS

III.1. Fast breeders

To cope with the persistent and increasingly rapid deterioration in the Community's hydrocarbon supply situation after the year 2000, the contribution made by nuclear fission to the Community's energy balance must be maintained and if possible improved in the first half of the next century.

The Community and the Member States must therefore retain the option of making fast breeders available as soon as possible to electricity producers on a commercial basis.

It will thus be possible to gain experience and form an opinion of the fast superconverter reactors to be used in comparison with alternative strategies.

This will entail successful continuation of the demonstration programmes now under way, consolidation of the industrial infrastructures needed both for the reactors and for the fuel cycle and, most importantly, public acceptance of the technologies involved, which means that adequate solutions must be found to the problems of safety, radiological protection and the ecological effects.

Since the development of fast reactors in the Community has now reached the industrial phase, the Community must play a support role based on its current activities in the nuclear sector and consisting mainly of facilitating and speeding up acceptance of the technologies involved by reinforcing its efforts to protect the public and the environment, ensure that nuclear energy is used for purely peaceful purposes and eliminate technical obstacles.

The above shows how important it is to develop and commission fast breeders at the right time.

It would be wrong to underestimate the number and difficulty of the problems still to be resolved.

In many ways these problems are more complex than those encountered when introducing the existing thermal reactors. In particular the need to coordinate the reactors with the corresponding fuel recycling stages right from the beginning puts the political, economic, industrial, technical and ecological problems in a new light.

The problems and the action needed

The main problems so far identified can be summarized as follows:

(i) the compatibility of fast reactors with the use of nuclear energy for purely peaceful purposes;

(ii) the acceptability of the technology from a safety and environmental point of view;

(iii) the recycling of fuels in fast reactors;

(iv) the technical obstacles arising from differences in norms and codes governing design, manufacture and inspection.

The present Community strategy for developing fast reactors centres round the following two activities:

(a) action to increase coordination and collaboration between national programmes, taken by the Fast Reactor Coordinating Committee[1] and its working party on safety and construction codes and norms;

(b) implementation of the Joint Research Centre's research programme (direct action programme) on the safety of fast reactors and plutonium fuel.

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[1] The committee was set up by the Council in April 1970 with the task of drawing up and implementing programmes for the broadest possible coordination and collaboration between the various programmes using the most suitable procedures and formulating any appropriate suggestion to that end.

III.2. The HTR

Prospects for marketing the HTGR to produce electricity suffered a severe blow between 1974 and 1976 when the 8 GWe of reactors ordered from General Atomic between 1971 and 1973 by American electricity producing companies were cancelled.

As mentioned in the introduction, the nuclear energy crisis that followed the 1973 oil embargo undeniably did not facilitate the introduction on to the market of a new generation of reactors.

Research and development of the HTGR continued however both in Europe (mainly in the Federal Republic of Germany) and in the United States and Japan.

Interest in the HTGR is currently sustained by the potential it has for energy applications other than electricity, deriving entirely from the possibility of producing thermal energy safely and economically at high temperatures (1000°C and above).

As we have seen, the reactor itself does not need any further major development since the ceramic core already offers an adequate performance.

On the other hand, the downstream user processes still have to undergo a long period of development, especially as regards materials, in the light of the market possibilities already identified.

These possibilities are mainly as follows:

- process heat for chemical and metallurgical applications,
- the production of synthetic gas (e.g. synthetic methane) and synthetic liquid fuels (e.g. methanol) using solid fuels as the source material.

This latter application is of particular interest to the Community which not only imports solid and gaseous fuels but also possesses large deposits of solid fuels (e.g. Belgium, FRG, France, United Kingdom).

These solid fuels can be used for two purposes:

- to produce liquid or gaseous fuels that can be transported and used with existing infrastructures;
- to eliminate, through thermochemical processes, impurities such as sulphur and harmful products such as nitrogen oxides that would be produced if the solid fuels themselves were used for combustion.

The HTGR could thus help gradually to improve the Community's energy balance and reduce the harm caused to the environment by the combustion of solid fuels.

B. The role of the European Community

Between 1959 and 1976 the European Community gave financial aid for HTGR research and development in Europe and promoted coordination of activities in the various Member States. When the Dragon project was completed (1976) the role of the Community in research and development ceased completely. Today the Community plays only a minor management role in the HKG joint action (THTR 300).

Given the potential importance of the HTGR in the Community's long-term energy strategy (in particular reducing energy dependence, exploiting indigenous solid fuel resources, reducing environmental pollution) it is to be hoped that the Community will promote it more vigorously.

The Community should gradually take action by:

- organizing meetings and perhaps financing studies to determine the possible future role of the HTGR in the Member States;
- devising R & D programmes and if possible including them in the Community's framework programme for science and technology;
- encouraging (politically and subsequently financially) undertakings and bodies that are continuing the work on the HTGR and its applications.

ANNEX I.

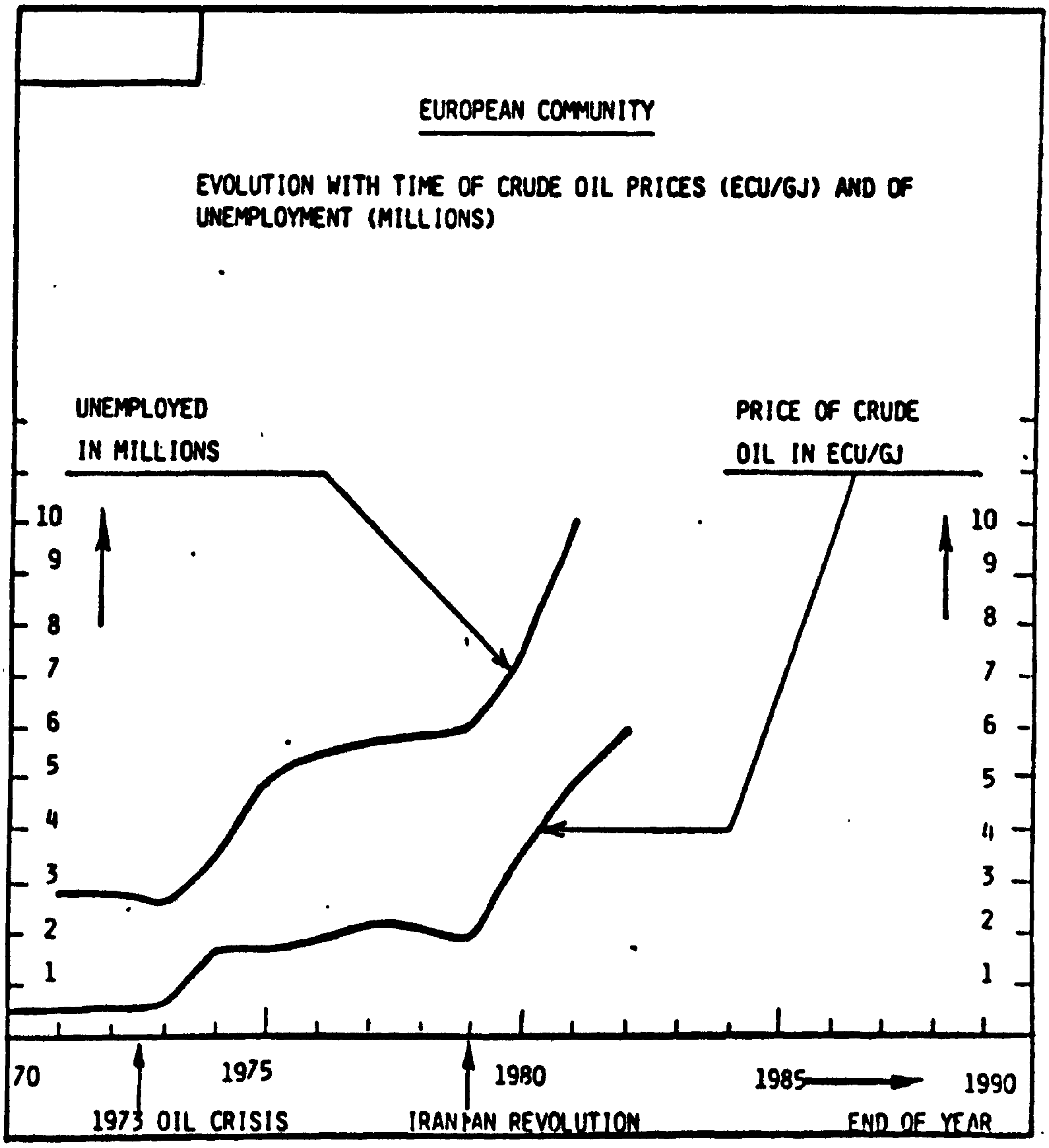
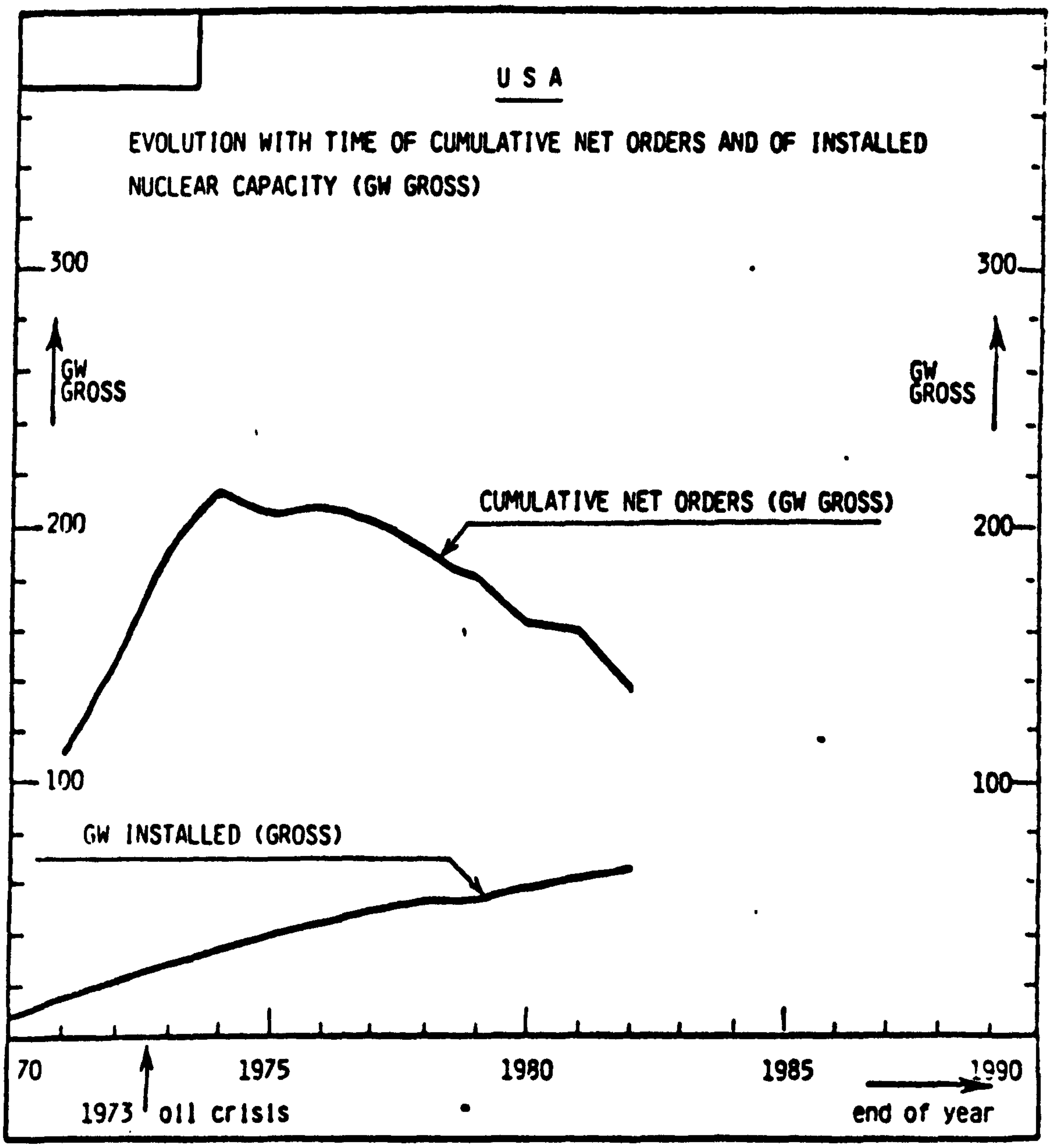


Figure 1.


U S A
EVOLUTION WITH TIME OF CUMULATIVE NET ORDERS AND OF INSTALLED NUCLEAR CAPACITY (GW GROSS)
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CUMULATIVE NET ORDERS (GW GROSS)
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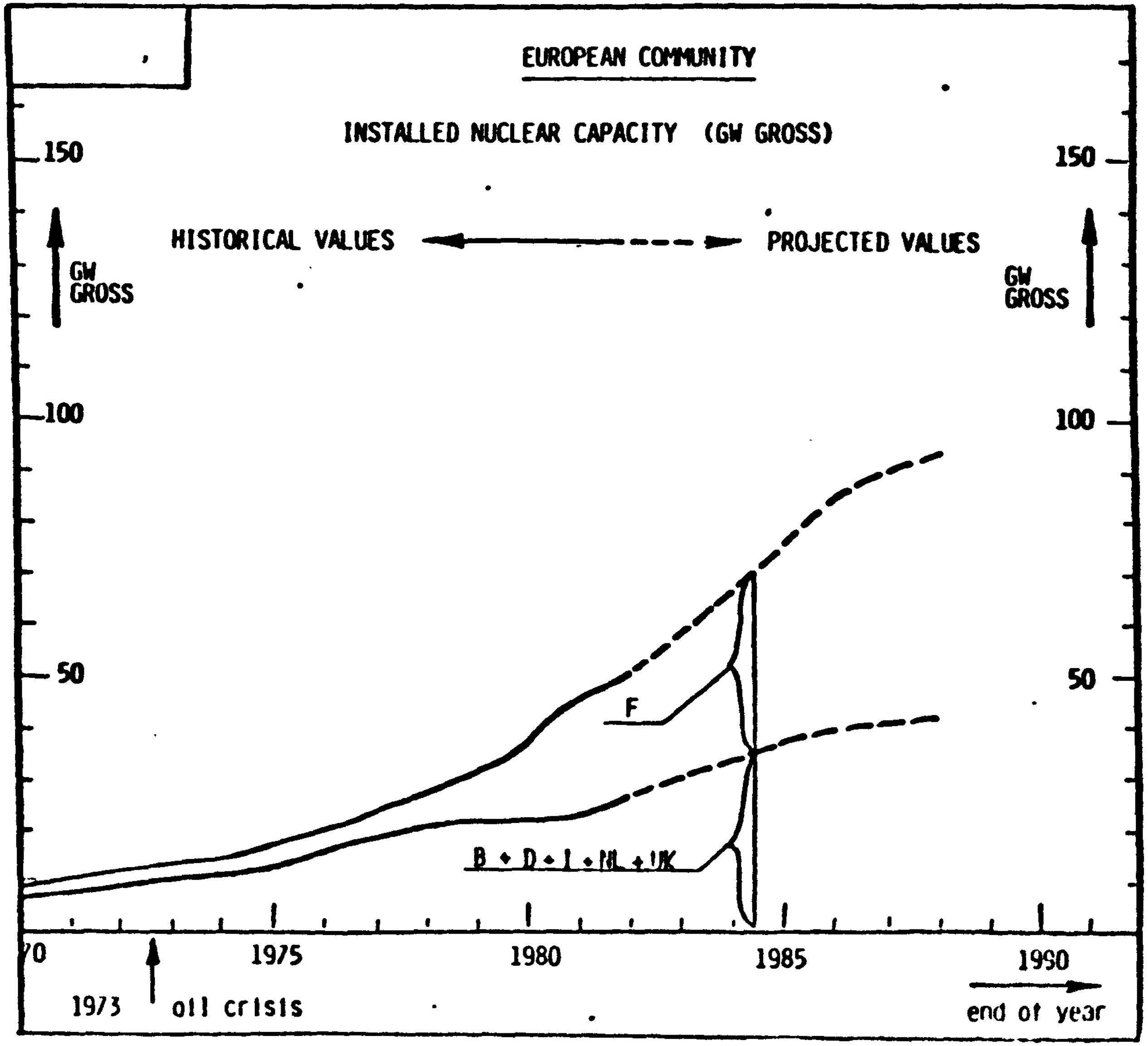
Figure 2.

Figure 3


EUROPEAN COMMUNITY
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F
B + D + I + NL + UK
70
1975
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1973 oil crisis
end of year

MOTION FOR A RESOLUTION (Doc. 1-691/82)

tabled by Mr VAN AERSSEN, Mr MÜLLER HERMANN, Mr MERTENS,
Mr MALANGRE, Mr BROK, Mr Karl FUCHS, Mr RINSCHE, Mr SCHNITKER,
Mr MAJONICA, Mr SAYN-WITTGENSTEIN, Mrs RABBETHGE, Mr LEMMER,
Mrs LENZ, Mr AIGNER, Mr HELMS, Mr VON HASSEL, Mr LUSTER,
Mrs WALZ, Mr WEDEKIND, Mr Ingo FRIEDRICH and Mr JANSSEN VAN RAAY
on behalf of the Group of the European People's Party
(CD-Group)

and by Mr SELIGMAN and Mr BATTERSBY

pursuant to Rule 47 of the Rules of Procedure

on further construction of high temperature nuclear reactors

The European Parliament,

A. Having regard to the common energy policy objectives for the period up to 1990 or 2000,

B. Having regard to the resolutions adopted by the European Parliament on the need to develop further generations of nuclear reactors such as high temperature reactors and fast breeders,

1. Supports, in the interests of a common EEC energy policy, further construction of the high temperature reactor at Hammschmehausen and of the fast breeder at Kalkar;

2. Calls on the Commission to examine to what extent bridging loans can be made available by the EEC to the builders of these installations;

3. Instructs its President to forward this resolution to the Commission and the Council.

MOTION FOR A RESOLUTION (Doc. 1-839/82)

tabled by Mr VANDEMEULEBROUCKE

pursuant to Rule 47 of the Rules of Procedure

on further construction of fast breeder reactors

The European Parliament,

A Having regard to the continually rising cost of experimental and prototype fast breeder nuclear reactors, and the decision of the Federal German government not to contribute further public funds to the Kalkar reactor,

B Having regard to the resolutions of the European Parliament emphasizing the potential of alternative energy sources (solar, bio-mass) for meeting energy needs within a far shorter time-scale than is forecast for the fast breeder,

1. calls on the Commission and the Council to revise their energy policy stance, and in particular to abandon any commitment to the fast breeder or other high-cost nuclear technology with uncertain prospects (high temperature reactors, nuclear fusion);

2. considers that for EEC financing and loans of all kinds priority should go to alternative energy development, and energy conservation, over such nuclear technology;

3. instructs its President to forward this resolution to the Commission, the Council and the governments of Member States.