European Communities

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Report

drawn up on behalf of the Committee on Energy and Research

on the proposal from the Commission of the European Communities to the Council (Doc. 1-433/81) for a decision adopting a research and training programme (1982-1986) in the field of controlled thermonuclear fusion

Rapporteur: Mr M. SASSANO

English Edition

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By letter of 24 August 1981 the Council of the European Communities asked the European Parliament to deliver an opinion on a proposal from the Commission of the European Communities for a decision adopting a research and training programme (1982-1986) in the field of controlled thermonuclear fusion.

The President of the European Parliament referred this proposal to the Committee on Energy and Research as the committee responsible and to the Committee on Budgets for an opinion.

On 20 October 1981 the Committee on Energy and Research appointed Mr SASSANO rapporteur.

It considered the draft report at its meetings of 22 September 1981, 27 October 1981, 27 January 1982 and 25 February 1982. At the meeting of 25 February 1982 it unanimously adopted the motion for a resolution and the explanatory statement.

The following took part in the vote: Mrs Walz, chairman; Mr Normanton, vice-chairman; Mr Sassano, rapporteur; Mr Adam, Mr Beazley, Mr Bombard (deputizing for Mr Pattison), Mr Calvez (deputizing for Mr Galland), Mr Flanagan, Mr Karl Fuchs, Mr Kellett-Bowman (deputizing for Sir Peter Vanneck), Mr Ghergo (deputizing for Mr Müller-Hermann), Mr Linkohr, Mrs Lizin, Mr Markopoulos, Mr Meo, Mr Moreland, Mr Phlix, Mr Petronio, Mr Protopapadakis, Mr Rinsche, Mr Rogalla, Mr Sälzer, Mr Seligman, Mr Travaglini (deputizing for Mr Pedini), Mr Veronesi.

The opinion of the Committee on Budgets is attached.

C O N T E N T S

A.

The Committee on Energy and Research hereby submits to the European Parliament the following amendments and motion for a resolution, together with explanatory statement:

TEXT PROPOSED BY PARLIAMENT	COUNCIL TEXT
PROPOSAL FOR A COUNCIL DECISION	
AMENDMENT N° 1	
Recital N° 2	Recital N° 2
Complete as follows:	Whereas, in view of the considerable efforts needed to reach the application stage of controlled thermonuclear fusion, which could be of benefit to the Community, particularly in the wider context of the security of its long-term energy supplies, the various stages of development of the work hitherto undertaken in this field should continue on a joint basis;
'attaching great importance to the strategy of concentrating effort on the Tokamak line and sizeable effort on two alternative lines in magnetic confinement, the reverse field pinch and stellarators, given a periodic reassessment of the reactor relevance of these lines compared with that of the Tokamak'.	
AMENDMENT N° 2	
Recital N° 3	Recital N° 3
	Whereas the scientific progress achieved in this field in recent years in the Community and the rest of the world illustrates the need, particularly for Tokamak systems, to construct larger and more complex devices and to concentrate in particular on the development of plasma heating techniques
'..., attaching greater importance to experiments relating to ignition with compact devices having a high magnetic field;	

ANNEX

AMENDMENT N° 3

Paragraph 1	Paragraph 1
After the first subparagraph add the following:	1. The subject matter of the programme to be executed shall be: (a) unchanged (b) unchanged (c) unchanged (d) unchanged (e) unchanged (f) unchanged (g) unchanged
The work referred to in (b) must be pursued having regard to progress elsewhere in the world in order to establish a position for mutual technical exchanges whenever cooperation in a larger international framework takes place;	

AMENDMENT N° 4

Add the following new paragraph 5a:

In consultation with the Consultative Committee of the Fusion Programme, the Commission may draw up proposals for the supply of fuel to fusion reactors with particular attention to the definition of the mission of the proposed tritium laboratory;

MOTION FOR A RESOLUTION

embodying the opinion of the European Parliament on the proposal from the Commission of the European Communities to the Council for a decision adopting a research and training programme (1982-1986) in the field of controlled thermonuclear fusion

The European Parliament,

- having regard to the proposal from the Commission of the European Communities to the Council (COM(81) 357 final),
- having been consulted by the Council, (Doc. 1-433/81),
- having regard to the report of the Committee on Energy and Research and the opinion of the Committee on Budgets (Doc. 1-1080/81),
- recognizing the need to safeguard the Community's long-term independence in the field of energy,
- whereas a lasting solution to the energy problem would help to ensure political, social and economic stability for the Community as a whole,
- whereas thermonuclear fusion is one of the few possible solutions which could contribute to the achievement of that objective,
- whereas the extent to which the Community has succeeded in coordinating work in this field is a striking example of collaboration among all the Member States for the attainment of a common objective;
- whereas it is particularly important in an enterprise of this nature that efforts should be made by all the Member States, and whereas the Community dimension of this objective should justify further coordination of activities by all Member States as well as fruitful collaboration between the European Economic Community, the international scientific community and other nations, particularly the United States of America;
- having regard both to the steady progress and results hitherto achieved by the Community in the field of thermonuclear fusion, in particular with Tokamak, as a consequence of which Europe now occupies a leading position in this sector, and to the numerous scientific and technological problems which must still be solved in order to develop and utilize a source of energy based on thermonuclear fusion,

- aware of the increasing volume of financial and human resources necessary for such development,

- whereas it is therefore essential, for the reasons given above, that the utmost priority should be attached to techniques which can provide proof as soon as possible of the scientific feasibility of controlled thermonuclear fusion,

- whereas constant monitoring of the project by the European Parliament is necessary given the considerable financial, scientific and technical risks involved;

- whereas, it is the duty of the European Parliament to request that the controlled thermonuclear fusion programme should be developed as far as possible over the next few years, in order to ensure the possibility of generating electric energy by thermonuclear fusion within as short a period as possible,

1. Applauds the high degree of Community integration achieved in this field by the Commission with the aid of the institutions with which it has been associated;

2. Noted with satisfaction the progress achieved in implementing the fusion programme and that the JET Joint Undertaking is in accordance with the plans submitted when the undertaking was set up in 1978.

3. Endorses the recommendations of the Fusion Review Panel to:

   (a) pursue efforts aimed at proving scientific feasibility;

   (b) pursue the programme following the Tokamak route towards a demonstration reactor, both by completing the first stage of this programme (the JET programme with its extensions) and programmes in support of the Tokamak confinement system;

   (c) continue the studies for the implementation of the second stage of the Tokamak programme (NET) and the technological developments necessary in order to carry out this project;

   (d) continue the studies on alternative confinement systems which may be used in a reactor, preferably in collaboration with fusion programmes carried out in other countries, praticularly in the United States,

   (e) keep under continuous review current and future results of European and world activities, with a view to deciding whether to go ahead with the implementation of the second stage of the programme;

4. Recommends, as regards activities other than JET, and as suggested by the Panel, the pursuit of research and activities relating to other Tokamaks inasmuch as they are fully justified in terms of the strategy of the programme and the search for ever wider international collaboration in this field;

5. Considers, furthermore, that it would be advisable, given the scientific difficulties involved in the fusion process, for the Commission to frequently consult a permanent scientific panel made up of senior experts appointed by the Member States;

6. Considers insufficient, however, the attempts made so far to exploit the possibilities of achieving ignition through small devices with a high magnetic field;

7. Attaches importance to the strategy of concentrating effort not only in the Tokamak line but also a sizeable effort on two alternative lines in magnetic confinement, reverse field pinch and stellerators, provided there is a periodic reassessment of the reactor relevance of these lines compared with that of the Tokamak;

8. Invites the Commission to consider proposals for new or novel experiments not included in the Commission's proposal or in the recommendations of the Fusion Review Panel, so that these may be judged technically against the general objectives of the fusion programme and existing work on the programme, and for future fuel needs;

9. Expresses the hope that during the implementation of the programme the Commission will communicate to Parliament proposals for new or novel experiments not included in its proposal which contribute to the attainment of the programme's objectives;

10. Recommends that the development of the programme should be increasingly geared as far as possible towards industrial participation particularly as regards the solution of technical problems with the aim of speeding up the practical application of future scientific inventions;

11. Calls on the Commission and the Council given the extremely long periods required for development work, to ensure that financing is assured also for other major national projects (such as fast breeders, high temperature reactors) once the existing programme (1982-1986) expires without this involving an unduly heavy burden on the Community budget;

12. Wishes the European Parliament to consider annually to what extent financial and technical adjustments to the programme are necessary;

13. Recommends a further strengthening of international collaboration, in particular with the United States, and the pursuit of cooperation on the INTOR project within the framework of the IAEA;

14. Invites the Commission to make proposals to foster fusion technology by encouraging the mobility of scientific and engineering specialists and through the establishment of a European Institute of Technology;

15. Calls on the Commission to use all the means at its disposal without delay to stimulate public discussion on nuclear fusion and its political, societal and social repercussions;

16. Approves the Commission's proposal for a research and training programme (1982-1986) in the field of controlled thermonuclear fusion, subject to the adoption by the Commission of the European Parliament's amendments, pursuant to Article 119(2) of the EEC Treaty and, having regard to the European Parliament's budgetary powers, calls for the Commission's proposal, thus amended, to be adopted as soon as possible by the Council.

B.

EXPLANATORY STATEMENT

I. INTRODUCTION

1. Energy supply is of central concern to modern economics; there is no need to recite the social and industrial upheavals which have resulted from the various stages in the energy crisis since 1973. Naturally enough, effort has been largely concentrated on finding solutions to the short and medium term, solutions which emphasize the need for massive energy-saving measures, which aim to increase energy supply from conventional non-oil sources and which foresee a growing (if not yet crucial) role for alternative sources of energy such as solar power.

2. In the longer run, i.e. into the next century, some foresee a society much less energy dependent than today. Others point to the benefits an abundant supply of energy can bring. The main candidate to provide such a long-term source of power is nuclear fusion.

3. Fusion is the ultimate form of solar power - it is the reaction that powers the stars (including the sun). Atoms of light elements are fused together under intense heat and pressure to create heavier elements, releasing massive amounts of energy at the same time. The reaction that should be easiest to achieve on earth is the combination of two isotopes of hydrogen, deuterium (D) and tritium (T), to give helium. Herein lies the attraction: the raw materials (deuterium and lithium) are amongst the most abundant on the planet (and the reaction is arranged so that tritium is 'bred' from a blanket of lithium around the reactor core) and the waste product is stable and non-radioactive.

4. A controlled fusion reaction has not yet been achieved. Although hardly ten years passed between exploding the atomic bomb and the commercial use of the equivalent (fission) reaction, thirty years have already passed since the first hydrogen bomb explosion. Commercial use of that (fusion) reaction is still at least twenty years away. The essential technical problem is to generate a very hot plasma (about 100m°C) and to contain or confine it (probably in a complex magnetic field, although other techniques are being tried). Laboratories have not yet managed to achieve simultaneously temperatures and density which are high enough with confinements which are long enough. The hope is that the new generation of machines might get some way towards generating some energy in return for the energy consumed. Later machines would be needed to achieve self-sustaining reactions.

5. The eventual utilization of an energy resource based on nuclear fusion, if it proves possible, will be the result of research and development work undertaken over several decades, in the course of which thousands of physicists and engineers will have had to solve many particularly complex physical and technical problems. Given the extent of the human and financial resources necessary for the achievement of this objective, the task must inevitably involve international collaboration, in particular among all the Member States.

6. The European Community, above all aware of the need to seek solutions safeguarding its energy independence in the long term, and in view of the fact that fusion-based energy constitutes one of the potentially more attractive solutions, has since 1958 pursued a research programme in the field of controlled thermonuclear fusion.

7. The work carried out by Member States engaged in research on fusion has thus been linked with the coordinating action of the Community itself, through both financial contributions and the direct participation of Community officials.

8. The Community dimension of this work is explained by:

   - the scale of the financial and human resources which must be made available;
   - the duration of such activities;
   - the considerable importance attached to this potential source of energy in all the Member States;
   - in the event of success, the opening up of a vast market for European reactors.

9. Furthermore, the coordinating action of the Commission has made it possible to avoid duplication and ensure maximum concentration of the financial resources available. The significant and frequently decisive contribution made by the Community in the field of controlled thermonuclear fusion is illustrated by the substantial progress so far achieved in Europe in the field of plasma physics. This progress has placed European activities in a leading position.

10. The projected strategy for building a demonstration reactor includes, as in the past, the development of devices based on the Tokamak principle. To this end the Community has underway a series of experiments carried out in various Member States with devices of the Tokamak type. As it is still not certain that this type of device will be capable of producing reactors for the generation of electric energy, further research is considered necessary, through international

collaboration, on what are judged to be the most promising alternatives. International cooperation, therefore, should be further stepped up, in particular with the United States and on the INTOR project within the framework of the IAEA.

11. Clearly, much remains to be done before fusion energy can be utilized. This implies an increasing volume of financial and human resources which can and must be supplied by the Community alone. We should bear in mind that research activities on the eventual utilization of a source of energy generated by nuclear fusion will probably be the main technical challenge facing Europe in the coming years - and a challenge from which Europe should not draw back.

12. In addition, the work undertaken in Europe has not been wholly satisfactory as regards the studies of plasma behaviour close to ignition. Your rapporteur considers that these experiments are of the utmost importance, particularly in view of the leading position already occupied by the European Community. They will make it possible to confirm certain theories concerning plasma physics on which current projects are based and the validity of which has yet to be proved.

    The greatest attention should therefore be paid to these experiments and priority given to the development of those techniques which may demonstrate within as short a period as possible the scientific feasibility of controlled thermonuclear fusion by magnetic confinement.

13. When so much needs to be done to achieve a fusion reaction at all, it is difficult to draw up a list of costs and benefits, especially on environmental questions. Because of the energy that has to be supplied, malfunctioning will probably lead to the reaction stopping of its own accord. There should be no highly radioactive waste, and the main problems would seem to be the possibility of a fire in the fuel blanket and the disposal of irradiated parts of the reactor structure. In his paper, 'The social aspects of nuclear power', C.M. Braams suggested that the most concrete conception of a fusion reactor might be characterized as follows:

    (a) a deuterium-tritium reactor,
    (b) based on the Tokamak principle (Tokamak is an acronym in Russian for 'current and magnetic chamber'),
    (c) operated in an electric power station,
    (d) in which careful management of tritium is necessary and where materials which become activated must be safely stored for possible re-use,
    (e) of which the disaster potential could be 100 times less than that of a fission reactor,
    (f) which has no military application,
    (g) which, as far as available raw materials are concerned, is competitive with other nuclear or fossil fuel energy sources, and
    (h) the cost of which will be on the high side.

SECTION II: PROGRESS TOWARDS ACHIEVING FUSION POWER

14. Substantial progress is being made in fusion research. The main line of development concerns machines known as Tokamaks. These are very effective at compressing and confining the plasma (i.e. the gaseous raw materials so hot that their atoms shed their electrons). This property derives from their toroidal form: hence, the Joint European Torus, JET. The application of neutral beam injection has allowed plasma temperatures to be pushed up to around 80°mC. So-called open machines have achieved even higher temperatures but with less success in confining the plasma: new concepts for the magnetic 'mirrors' plugging the ends of the plasma cylinder are being tried. The cylindrical form of such machines would lend itself better to the eventual application of fusion power to the production of electricity. Other techniques such as inertial confinement (in which lasers, for example, bombard a fuel pellet) show promise but are at an earlier stage of their development.

15. It is clear therefore that the pursuit of fusion power is going to take some time - probably at least another twenty years - and is going to be expensive. The 1982-86 programme, on which the Parliament has been consulted, is estimated to cost around 1500 MECU; the Community will contribute around 680 MECU of this total. The USA is spending at a rate about 30% higher than Europe, even excluding its substantial effort on inertial confinement. Japanese expenditure is fast catching up with Europe's. The next generation of machines (after JET) will inevitably be larger and more complex and a prototype power reactor more complex still - it has hardly been necessary yet to tackle many aspects of a practical design which are going to cause severe difficulties in development.

16. The further one progresses in a project the more difficult it is to draw back, the sunk investment is so large. One should therefore be certain about the strength of the long-term commitment to solving what is almost certain to be the major scientific and technical challenge for Europe in the rest of the century. It will certainly be asked if such expenditure is worthwhile, given the progress still to be made. Although it is at present impossible to calculate with any precision the costs and benefits of the development of fusion power, the potential prize (i.e. abundant and economic energy supply with acceptable environmental effects) is so desirable as to justify the massive spending and scientific uncertainty.

SECTION III: STRATEGY

17. The programme on which Parliament has been consulted is in effect the whole of the European effort in the fusion field. There is thus a concentration at Community level of policy making which is probably unmatched in any other sphere apart from agriculture. The programme must thus not only include projects which are desirable in themselves but also have an overall balance and strategy.

18. European effort is heavily concentrated on Tokamak machines; the JET machine being built is the largest of these. Tokamak machines certainly offer the best chance of achieving a self-sustaining fusion reaction. What is less certain is whether this layout will permit the construction of a practical power reactor: the torus is so compact and so surrounded by magnetic field coils that space for the fuel blanket and for devices to abstract the heat may be inadequate.

19. Careful thought therefore has to be given to the ultimate objective of the programme. Is it to press forward as rapidly as possible with the achievement of a self-sustaining reaction, and sort out the practical problems subsequently? Or is it to work more directly, if more slowly, towards a final power reactor?

20. The European effort has hitherto been weak on non-Tokamak approaches to fusion and, despite the Commission's efforts, it has not yet been possible to launch an effective programme in the field of fusion technology. The balance to be drawn between the two objectives will affect the amount of effort which should be devoted or diverted to correcting these weaknesses.

21. The usual difficulty of having a democratic review of large and highly-technical projects is compounded in this case where the programme encompasses virtually the whole European effort on the subject. The Commission has arranged for a report to be made by a group of eminent scientists and engineers familiar with but not associated with the programme. The report of this European Fusion Review Panel discusses the three stages on the road to fusion power, namely:

    scientific feasibility
    technical feasibility
    commercial feasibility

22. The Panel recommended the following strategy for the Community:

- to pursue a substantial programme following the Tokamak route towards a Demonstration Reactor. To complete the first stage of this programme (the JET project with its extensions) and carry out programmes in support of the Tokamak confinement system;

- to pursue the development of the technology required to build the second stage of the Tokamak programme (NET), guided by conceptual design studies;
- to investigate alternative confinement systems with reactor potential preferably in collaboration with other world fusion programmes, in particular the USA programme;
- to review the results of JET and similar experiments being carried out elsewhere towards the end of the 1980's and decide whether to go ahead with the construction of the second stage of the Tokamak programme.

23. The Panel also made the following points:

(a) 'That the relatively narrow approach of the present European programme entails some vulnerability, which is partially offset by international cooperation'.

The US, for example, devotes as much money to inertial confinement as to Tokamaks, together with substantial amounts on mirror machines (20%) and on heating and technology (12%).

The Panel thought JET and NET technology should receive about 80% of the available funding and alternative confinement systems about 15%.

(b) 'Although the plasma physics aspects of the fusion programme are well covered, there is already considerable backlog in the equally important fusion technology programme. In particular, systems aspects related to operation and maintenance have received inadequate attention'.

and

'Although contacts between fusion and fission research and development exist at some laboratories such contacts appear infrequent and insufficient'.

There is no doubt that much greater effort is needed on the so-called 'technology' aspects of the programme. The Commission is right to stress this point.

The involvement of industry would bring considerable expertise and be of benefit in the long term. The Commission's proposal envisages the awarding of various contracts to industry, and this practice should be extended as far as possible. Similarly, the implementation of the proposed 1982-86 programme should make it possible to establish a proper balance between the scientific and technical aspects of the programme.

(c) 'The European effort in inertial confinement studies is small and does not even allow a sufficient evaluation of the work being carried out in other parts of the world'.

Inertial confinement is the only real alternative to magnetic confinement. It is worrying that Europe's position is so weak. Nor is this a field in which there has hitherto been much international collaboration, due to the military applications of some of the technology; this may now be changing. Budgetary constraints rule out a major effort in this area, and the Commission proposal includes a small increase. It may be that more ought to be done.

(d) The Panel also pointed out that tritium handling would be a crucial aspect of fusion technology. The USA was setting up a civilian laboratory dedicated to tritium at Los Alamos. The panel recommended that a test facility be set up in Europe. The Commission proposal appears not to mention this possibility.

(e) The Panel also pointed out that final decisions on the form of the next generation machine (NET) could not be taken until certain experiments involving tritium had been carried out on JET. After some time these will render the load assembly unusable, and are therefore left until last in the experimental programme. There will thus be a gap of several years in the Community's fusion programme. Studies on eliminating this gap are urgently needed, but the Commission proposal appears not to address the problem.

Other observations by the Panel concerning collaboration, management and personnel are included in subsequent sections.

However, the next section of this report considers that part of the programme which can be devoted to the development of experiments intended to demonstrate rapidly the scientific feasibility of controlled thermonuclear fusion using the Tokamak system.

Ignition experients

Scientific justification

24. One of the principal objectives of research programmes relating to controlled thermonuclear fusion is the achievement of so-called ignition conditions in which the temperature of the thermonuclear plasma is self-maintaining without the need for a system of external heating.

The attainment of this objective, in itself of the utmost significance, requires that not merely theoretical but also experimental studies should be made of the behaviour of plasma close to ignition conditions.

Given that the current European programme does not provide for research actions leading to such studies in the near future, your rapporteur endorses the recommendations of the Fusion Review Panel for the pursuit and stepping up of such experiments.

25. Such studies have hitherto been effectively undertaken with devices having a high magnetic field which, thanks to the limited cost of their construction, constitute at present the most promising type.

These devices have been conceived on the lines of toroidal devices which are compact and have a high magnetic field, of which ALCATOR A of the MIT has been a prototype and FT of Frascati and ALCATOR C are the current forms and natural development.

Given the successes achieved so far by the high magnetic field approach, including the current record values of the 'NTE' and 'NET' parameters recently obtained on FT and the even more recent results obtained with ALCATOR, such as those concerning the intensity of the magnetic field, many experts consider it possible to obtain plasmas for thermonuclear use by utilizing techniques which are already partially established.

26. These devices are relatively inexpensive as compared with the so-called large devices which, in terms of their functioning, are largely based on costly techniques for the auxiliary heating of plasma, such as the injection of neutral atoms or heating through radio frequencies, the feasibility of which for high-power transmission remains to be proved.

Objectives of these experiments

27. As stated above, one of the principal objectives of this type of experiment should be to study the plasma in conditions close to those of ignition, or even directly under ignition conditions.

This would make it possible to establish, for example the possibility of utilizing the alpha particles (helium nuclei) produced by the reactions of leuterium tritium fusion for the heating of plasma. Another important objective would be to study the behaviour of plasma when subjected to extremely high magnetic field intensity and current.

In addition, tritium technology could be progressively acquired.

28. In more general terms it will be possible, according to experts working in this sector, to attain a series of significant objectives for thermonuclear plasma physics which are not covered by the current experiments proposed under the European strategy, at least not for the immediate future. In particular:

- study of the transport and laws of scale in collisional systems with thermonuclear implications;
- study of chemical heating and its effective possibilities;
- study of adiabatic compression as a means of reducing the time needed for obtaining plasma systems with thermonuclear implications;
- study of adiabatic compression as a means of multiplying the effect of auxiliary heating applied before actual compression;

Significance of the experiment and its importance at international level

29. The attainment of all or even some of the objectives briefly described above will constitute an important step forward for the fusion community, above all for those centres currently engaged in the development of so-called large devices, just as the results obtained so far with the compact devices built up to now (ALCATOR in the USA and FT in Europe) have been particularly useful for devices having a relatively low magnetic field.

Emphasis should also be laid on the possibility of developing a way of achieving fusion with high fields which would appear likely to complement the line pursued with large devices.

30. The achievement of these objectives should represent a first practical step towards the development of advanced fuel cycle reactors, i.e. without using tritium and thus drastically reducing or even virtually eliminating the production of neutrons.

The pursuit of these experiments may also lead to the development of a reactor suitable for testing the materials to be used in future fusion reactors.

31. Considerable international interest in this type of experiment exists and the idea of the possibility of fusion with compact devices has been accepted for some time. In particular:

- in the United States two groups are involved in the planning and construction of compact devices with a high magnetic field;
- in the USSR work is going forward on a project for a compact device with a high magnetic field and high adiabatic compression for the heating of plasma;
- in the European Community the importance of a device having an extremely high magnetic field has been affirmed in the document on which the European Parliament has been asked to deliver an opinion.

IV. COLLABORATION

32. The advantages of collaboration have obviously been accepted already by the Member States in that the current and proposed programmes constitute a pooling of European effort. Projects of this magnitude are natural candidates for joint programmes at a European level. It is perhaps significant that Europe is in a strong position (e.g. on toroidal confinement) where a common approach has been agreed, and in a weak one (e.g. on inertial confinement) where there has been no such common effort.

33. Future stages in the development of fusion power are going to be even more expensive. The Panel estimated that worldwide expenditure up to the point of putting a power reactor into service might be 100 billion ECU. The pressure for collaboration with the USA, Japan and the USSR (on projects such as INTOR) is therefore strong. However, there are difficulties in collaboration, such as slow decision-making procedures and the risk of withdrawal of one partner to leave the other in a disadvantageous position. Collaboration works best where there is real inter-dependence of effort.

34. Two avenues of collaboration are open at the moment (the one does not necessarily exclude the other):

- the INTOR project for a machine to follow the JET generation. As this is still at the study stage the cost of pursuing the design of a European machine in parallel is not large and worth the reduction of risk. It can also be argued that having two or three machines can be an advantage, scientifically:
- exchange of information etc., especially with the USA, as a way of reducing the vulnerability of the European programme. In particular, a 'package' can be envisaged which balances the strong European position on reversed field pinch and Stellarator machines with the US strength in mirror machines. Collaboration is already underway on materials and large coils.

The remaining areas of weakness in the European programme would then be:

- technology;
- inertial confinement.

V. ORGANIZATION AND STAFF

35. Hitherto the organization of the European collaborative effort on fusion research has run smoothly, apart from the long delay by the Council in reaching a decision on the site of the JET project. In view of the size of the latter project, it has been granted a special status and a separate administrative structure. The Panel recommends that the staff responsible for the management of the fusion programme in Brussels should be increased and that a Fusion Technology Steering Committee be set up, to oversee the development of the next stage. Parliament notes that the Commission intends to follow these recommendations by the Panel which it itself endorses.

36. Although the Commission proposal refers to the problem of the age of staff, no solutions are put forward. The average age of staff working on fusion R & D is about 45, and rising at about one year a year.

In other words, in 15 - 20 years, at the crucial stage of implementing fusion power, 30-40 years of experience will suddenly disappear. Efforts have to be made now to encourage a new generation of scientists and technologists to enter the field and gain some experience. There is scope here for scholarship schemes and increased cooperation with universities.

VI. CONCLUSIONS

37. In the light of the progress achieved in research aimed at developing controlled nuclear fusion, your rapporteur, while applauding the excellent work carried out so far by the Commission organs and the associations and endorsing the recommendations of the Fusion Review Panel, considers that the Community should concentrate its future action in the following areas:

- in the field of magnetic confinement, which is the sole field in which the Community is heavily engaged, every effort should be made to maintain the leading position achieved by the work undertaken in past years. In this area, particular importance should be attached to the rapid development of JET;
- the rapid undertaking of experiments aimed at demonstrating scientific feasibility, a step considered essential for stepping up work on the subsequent demonstration of technological feasibility; the devices which today seem most likely to produce plasmas close to the ignition stage, both in terms of the excellent results achieved to date and the reduced costs of construction, are devices with a high magnetic field. Given that a specific project (IGNITOR) already exists, the Commission is asked to envisage a rapid assessment of the scientific feasibility and validity of the experiments proposed;
- the development of heating techniques through the injection of neutral atoms and radio-frequency systems;
- the setting up of at least one laboratory for the manipulation of tritium. Given that current European studies are devoted to the development of a deuterium-tritium reactor, it is particularly important to obtain the necessary know-how concerning the fuel to be used;
- further examination of the various problems relating to fusion technology, while continually taking account of all the results and experience which will be progressively acquired;
- the pursuit of international collaboration on alternative lines and a definition of next generation devices.

OPINION OF THE COMMITTEE ON BUDGETS

Draftsman: Mr KELLETT-BOWMAN

On 19 October 1981 the Committee on Budgets appointed Mr Kellett-Bowman draftsman.

The committee considered the draft opinion at its meeting of 25 February 1982 and adopted it with 18 votes in favour, none against, and two abstentions.

Present: Mr LANGE, chairman; Mrs BARBARELLA, vice-chairman; Mr KELLETT-BOWMAN, draftsman; Mr ABENS, Mr ADAM (deputizing for Mr LALUMIERE), Mr ANSQUER, Mr ARNDT, Mr BALFOUR, Mr BARBAGLI, Mr BONDE, Mrs BOSERUP, Mr BROK (deputizing for Mr RYAN), Mr CROUX, Mr GEORGIADIS, Mr GOUTHIER, Mr JACKSON, Mr ORLANDI, Mr PRICE, Mr SIMMONDS and Mr SIMONNET.

1. Introduction

1. The present Commission programme proposal is designed to replace the programme for 1979 - 1983 adopted by the Council on 13 March 1980[1]. This revision is provided for in Article 3 of the same Council decision.

According to the Commission, the new JET programme represents a natural evolution of the programme which was envisaged when the JET joint undertaking was established in 1978[2]. The overall duration of the programme remains 12 years and the scientific and technical objectives remain essentially unaltered.

2. Objectives of JET during the five-year programme. The programme proposed has three overlapping phases:
- completion of the construction of the torus in its basic configuration (June '78 - April '83)
- extension of JET to full performance (January '82 - June '87)
- the operational phase, up to the end of 1986 (April '83 - December '86).

The overall costs of this programme for the years 1982 to 1986 will at current prices amount to approximately 442m ECU, 80% of which is borne by the Community.

3. The objectives of the general fusion programme exclusive of JET are: general physics and technology projects in fusion research related to JET objectives and post-JET projects (NET etc.) and in the long term the attempt to determine whether energy can be produced at competitive prices from nuclear fusion reactions between light atomic nuclei.

These research projects for the years 1982 - 1986 which will take place for the most part in national research laboratories with varying contributions from the Community (25 - 45%) and in which non-members of the Community such as Sweden, Switzerland and Spain will participate, will cost an estimated 1,062 million ECU at today's prices.

Average Community participation at present amounts to approx 32%.

The Committee on Budgets is required to examine the basic financial aspects and in particular the cost-effectiveness of the programme.

4. In its resolution on 1981 draft budget[3] the Parliament had given particular priority to those policies which

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1 OJ No L 72, 19.3.1980, p. 18
2 OJ No L 151, 7.6.1978, p. 8
3 OJ No C 313, 1.12.80, p. 42

- can be more effectively and/or economically implemented by the Community than by the Member States (paragraph 21 a)
- possess a genuine Community dimension and go beyond the national interests of individual Member States (paragraph 21 c).

Parliament also asked among other things for these policies to be streamlined by:

- carrying out precise assessments of the real impact of the expenditure programmes, particularly by means of costs-benefit analyses (paragraph 22 a)

- systematic and regular monitoring of the scope of these programmes and of their cost-effectiveness (paragraph 22 b).

It is generally accepted that the present Community project fulfils the first two requirements made by Parliament. In extending the programme particular care must be taken to ensure compliance with the last two principles.

II. Summary of the Commission proposals and the financial implications

5. In its proposed programme the Commission gives a detailed account of the present state of thermonuclear fusion research and Community developments in this field to date. It is the task of the committee responsible, in this case the Committee on Energy and Research, to judge the technical aspects of those developments.

In Chapter II the Commission also gives a comprehensive survey of the financial volume of the 1979-83 Community programme together with that of other world programmes (see Survey, page 24, of Commission proposal). The JET project costs for the old and new programme phases are summarized by the Commission in Table IV and attached to this opinion in Annex I. A survey of the overall budget for the fusion programme proposed for 1982-1986 (Sweden, Switzerland and JRC excluded) in 1982 prices is given in the table in Annex II (see Table VI of the Commission proposal).

6. The data furnished by the Commission is complicated by the overlapping programme and financing phases and the various types of layout adopted; they include appropriations (JET, fusion programme exclusive of JET, associations programme etc.) which are not always easy to distinguish or to put into perspective. Your draftsman has therefore tried to clarify the financial system by drawing up a survey of his own:

(1) Overall calculation

The total costs of the fusion programme for the years 1982-1986 amount to

442.3 m ECU for JET
1,062.0 m ECU for the General Programme
1,504.3 m ECU

The total Community contribution for the period 1982-1986 amounts to 680 million ECU in round figures.

This amount breaks down as follows:

355 m ECU* for JET (80%)
325 m ECU* for the General Programme (**rounded:**32%)
= 680 m ECU*

The figures given in the proposal for a Council decision are indicative estimates.

Taking into account unused appropriations from the present programme of

35 m ECU* for JET
67 m ECU* for the General Programme
= 102 m ECU*

there is a real financial requirement of

320 m ECU* for JET
258 m ECU* for the General Programme
i.e. 578 m ECU* for the whole programme

(2) Itemized calculation

a) The overall costs of the 1982/86 JET programme are estimated by the JET Council at 442.3 m ECU in commitments; 80% of this is financed by the Community (= 353.8 or 355 m ECU in round figures). These figures are based on tables I and II in the Annex. The situation regards payments is the same, as can be seen from the Commission's multiannual schedule in the financial record sheet:

Overall payments at July 1982 prices	480.0 m ECU
of which 80% Community share	384.0 m ECU
Community contribution for 1978/81:	125.8 m ECU
plus the payments due in subsequent years on commitments entered into during this period:	20.1 m ECU
	529.9 m ECU
minus payments for commitments from previous programmes	- 176.1 m ECU
	353.8 m ECU

Deducting the unused appropriations from the previous year's programme amounting to 34.9 m ECU, the real financial requirement runs out at 318.9 m ECU.

* All figures rounded

b) The overall costs of the fusion programme exclusive of JET for 1982/86 amount to 1,062 m ECU.

The Community share is on average 32%	= 344.9 m ECU
deducting payments for commitments from allocations in the 1979/83 programme for 1982 and 1983	22.6 m ECU
Total	322.3 m ECU

This sum of 322.3 m ECU was rounded off in the programme proposal to 325 million ECU.

Deducting 66.9 m ECU in unused appropriations, the real new financial requirements work out at 255.4 m ECU.

III. Commentary and criticism by the Committee on Budgets

7. It seems that the Community fusion programme has - together with the JET project - become one of the least controversial Community programmes. This at any rate is what the Council's budget figures in the 1982 draft budget seem to imply; the Commission's proposals have been adopted with only relatively minor cuts and the increases in the new programme have been entered in Chapter 100 pending its adoption[1]. The need to find cheap sources of energy for the future and inability of any individual State to bear the enormous costs involved by itself have resulted in a Community project being launched, the total dimensions of which - particularly in financial terms - cannot yet be fully assessed. It is all the more important for the European Parliament and in particular for the Committee on Budgets to follow and monitor this development very carefully.

Funding so far

8. The Commission is to be criticized for failing to provide an accurate survey of cost trends this far for the general fusion and JET programmes.

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[1]

Programme exclusive of JET (in million ECU)

	payments	commitments
Commission	54.515	114.015
Council	49.665	63.665
	+ 2.5 (Chap.100)	+ 27.5 (Chap.10)

JET (in million ECU)

	payments	commitments
Commission	83.2	83.2
Council	66.7	66.7
	+ 16.0 (Chap. 100)	+ 16.0 (Chap. 100)

The only way to obtain a general picture of the situation is to draw up a table of the appropriations so far approved in Council regulations:

Costs exclusive of JET		Costs of JET	
1976 - 80:	124 m ECU	1978	102.4 m ECU
1979 - 83:	190.5 m ECU	1979 - 83:	145 m ECU
1982 - 86:	325 m ECU	1981 revision:	195 m ECU
		1982 - 86:	355 m ECU

The difference between estimates and actual costs or expenditure is hard to assess; the Commission should draw up a detailed survey of this. One source of particular confusion is that unused appropriations from earlier programmes are omitted from the estimates of appropriations given in the regulations.

Cost increases as a result of inflation and the extension of the programme

9. Inflation has become a very important factor in the overall implementation of the thermonuclear fusion programme leading to escalating costs, especially during the construction phase of the JET project. Thus, as a result of the Council practice of 'fixing' the estimated programme appropriations in the regulations - a practice which the Parliament has repeatedly criticized - Regulation 80/318/Euratom for the 1979-83 programme had to be revised in May 1981 and the fixed appropriations of 145 m ECU increased by 50 m ECU to 195 m ECU.

10. The question arose in this context whether appropriations with sliding-price clauses should not be replaced by fixed appropriations. But Community considerations are decisive here according to Commission representatives: if invitations to tender for projects were issued with fixed price conditions, Community countries with high rates of inflation would no longer be in a competitive position and would have no chance of being awarded contracts. Thus it can be pointed out that cost-effectiveness suffers when sliding-price clauses are introduced for all Member States in the interests of realizing a genuine Community project. The decision over which option to choose can only be a political one.

There can be no doubt that given an average rate of inflation in the Community of approx. 12% programme costs will continue to rise sharply.

11. But inflation is not the only source of rising costs: a research programme lasting several years will bring to light new scientific problems which need and/or merit research; this research requires support which in turn means a considerable increase in the total funding required.

The Commission describes this in Section IV of its proposal (page 33 ff). The proposal also mentions the new plant which could be built after the JET demonstration plant (Next European Tokamak, NET) and many new projects for large items of equipment in which the Community would like to participate.

During the design and research phase of such a large-scale project lasting many years, many new areas of research come to light which sometimes have to be sponsored. It is, however, important not to allow this evolution to get out of hand nor to let research spread too far afield, otherwise overall costs might get out of control. In fact - where some projects are concerned - sponsoring entails subsequent costs which cannot be fully assessed in the initial stages. To take an example, large new items would require capital expenditure of about 234 m ECU at January 1982 prices; but the current programme proposal, following the recommendations of the Programme's Consultative Committee, allocates a total of 156 m ECU to cover possible construction during the 1982/86 period. The Community would provide about 45% or about 70 m ECU of this sum. The subsequent costs for the years 1987-88 would run to approx. 80 m ECU, according to Commission estimates.

The ultimate full cost of the JET project - to which the Community has contributed approx. 68 m ECU to date can probably not yet be fully assessed.

12. Another problem, which is closely related to the question of cost-effectiveness to be examined by the Committee on Budgets is that - because of their duration or delays - some research projects may be overtaken by events and the funds may therefore have been wasted. Vast injections of funds may therefore be necessary in order to carry out revised programmes.

The Committee on Energy should also devote more attention to this problem.

Staff

13. Particular importance should be attached to staffing if the programme is to run smoothly. The regulations originally fixed the number of staff for the programme exclusive of JET at 113 and at 150 for JET. The new proposal provides for a reduction of the number of staff for the programme exclusive of JET to 110 and for a gradual increase in the number of staff for JET from 150 to 180. This was clearly intended as a response to current staff requirements since according to the Commission only 107 posts in the fusion programme exclusive of JET have been filled to date, and 20 of these employees are working in Brussels at the Fusion Directorate, steering the programme. The other scientists and technicians are working in national laboratories.

14. The number of research staff on the JET project was increased because of the high average age of the staff (approx. 45 years old) and the need to train a new generation of young scientists. According to the Commission, on 30 September 1981 the staff numbered 124.

The high age of research staff is a well-known problem, which has been discussed on numerous occasions in connection with the Joint Research Centre (JRC)at Ispra[1]. The Commission should adopt a comprehensive solution to the problem.

In this connection the proposal by the Advisory Committee on the Fusion Programme, that the activities of the Joint Research Centre in the area of fusion research should be included in the plans and programmes should be adopted. The ACFP also suggests a further reduction in the number of Euratom staff[2] employed in the associations and paid by them at considerably higher rates.

The fixing of programme appropriations

15. The Council of the European Communities continues to ignore Parliament's strictures - reiterated over many years - and insists on 'fixing' the appropriations provisionally allocated to each programme. The absurdity of this procedure is particularly evident in the case of the fusion programmes: as we have mentioned before, the 1979-83 programme for the JET project had to be revised by the Council on 19 May 1981. Furthermore, the appropriations given in the regulations are in any case not a true reflection of genuine financial requirements because an additional sum totalling about 100 m ECU in unused appropriations from the previous year's programme is available for the JET programme and for the programme exclusive of JET.

The Council must be urged to refrain once and for all from this absurd practice of fixing appropriations in proposals for regulations; these appropriations can only be provided for and fixed in the annual budgetary procedure.

[1] Most recently in the Committee on Budgetary Control's report on the budgetary control aspects of the Joint Research Centre establishment at Ispra (Doc. 1-59/81)

[2] See addendum to COM/81/357 final.

IV CONCLUSIONS

16. The Committee on Budgets calls on the Committee on Energy and Research as the committee responsible to make a detailed examination in its report of the technical aspects of the Commission's current and new research programmes, particularly on the basis of the report by the Fusion Review Panel, in order to ensure that there is continuous monitoring of the effectiveness of the funds through systematic examination of the scope and usefulness of these research activities. In this connection the committee would also refer to paragraph 12 of its opinion.

17. The Committee on Budgets calls on the Committee on Energy and Research to take acount of the following points in the resolution contained in its report:

- Calls on the Commission to carry out cost-benefit analyses where possible in the context of this major research programme to ensure that the substantial appropriations allocated to this project are used efficiently: draws attention in this connection to the costs which have escalated dramatically since the project started, and to the total appropriations necessary for all related research activities;
- Urges the Commission to concentrate all the appropriations on the main research projects and to coordinate all available facilities, particularly those at the Joint Research Centre at Ispra, and warns against any dispersion of the Community's efforts;
- Urges the Commission to draw up a general programme as soon as possible in order to solve the problem of the lack of mobility and/or high age of research staff and to reduce further the number of Euratom staff working for the associations;
- Calls on the Council to accept at last the text of the regulation proposed by the Commission instead of deciding again to 'fix' the appropriations and the number of staff for this research programme:
  calls at this stage for the conciliation procedure to be initiated if the Council should deviate from the text proposed by the Commission in Article 2.

TABLE IV: JET Project Costs with future expenditure in 1982 prices

Basic performance construction:	commitments	226.75	85.45	-	312.2
	payments	163.9	148.3	-	312.2
Extension to full performance:	commitments	-	164.9	1.1	166.0
	payments	-	147.7	18.3	166.0
Operational phase (to end of 1986):	commitments	-	192.0	-	192.0
	payments	-	184.0	8.0	192.0
Total	commitments	226.75	442.35	1.1	670.2
	payments	163.9	480.0	26.3	670.2

TABLE VI

Proposed 1982-1986 budget of the Fusion Programme[1], at price level 1982
(all figures in MioECU)

Activity	1981 Total expenditure (estimated)	1982/86 Total expenditure (forecast)	Rate of COM participation	COM contribution 1982/86	Unused appropriations from preceding programmes (2)	New tranche requested
JET (3)	76.7	442.3	80%	353.8	34.9	318.9
Associations, (4) running costs	111.5	613.0	25%	130.6*	19.9	110.7
Support of JET (5)	7.9	34.0	45%	15.3	4.0	11.3
Normal priority actions	10.2	56.0	45%	25.2	40.0	55.4
Possible new large devices						
TORE SUPRA	2.7	)				
FTU	-	)				
ASDEX UPGRADE	-	) 156.0	45%	70.2		
RFX	-	)				
STELLARATORS	-	)				
NET & Technology (6)	16.8	190.0	≃ 36%	68.0	0.0	68.0
Management & Mobility	1.9	13	100%	13	3.0	10
Total	227.7	1504.3	≃ 45%	676.1	101.8	574.3
				JET 353.8 G.P.(7) 322.3	JET 34.9 G.P. 66.9	JET 318.9 G.P. 255.4

* To the 130.6 MioECU should be added 22.6 MioECU (see part D, 5.1.2) already committed prior to 1982 within the programme 1979-83 for the years 1982 and 1983. Therefore the total Community contribution for 82-86 will be: 130.6 + 22.6 = 153.2 = 25% of 613.0.

Foot-notes to Table VI

(1) Sweden, Switzerland and JRC excluded.

(2) Provisional figures, as the expenditure in 1981 is not yet known. Include 3.0 MioECU which constitute the provisional positive balance from third States contributions to the Fusion Programme (JET excluded) as from 1976 to 1981.

(3) Commitment budget of JET, as decided by the JET Council (see enclosed Opinion, part C)

(4) NET-Technology excluded. In order to obtain price level 1982, the 1981 expenditure for running costs of Associations and normal priority actions, as well as the 1981 estimates for the possible new large devices, have been raised by 9.94% which corresponds to the rise of consumer price index in the EC weighted according to the apportionment of expenditure for the Community Fusion Programme in the member States.

(5) Covers only work pursuant to Article 14 of the JET Statutes.

(6) Covers the activity of the NET group up to next programme revision only. The Community participation of about 36% to NET and Technology is a weighted average. (See Table V)

(7) G.P.: General programme, which means Associations (NET-Technology included) and Management and Mobility.