Commission of the European Communities

Evaluation of the R&D programme in the field of Non-Nuclear Energy (1985-1988)

(Volume 1)

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Authors: Sir H. BONDI (Chairman)
F. AMMAN
A. JAUMOTTE
Ch. MARNET
J.J. PALOMARES
R.J. UFFEN
P. WALDTEUFEL

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INTRODUCTION

This report is an evaluation of the Community Programme in the field of Non-Nuclear Energy (1985-88).

We were appointed as an independent panel by the Commission and carried out our task between autumn 1987 and summer 1988. We come from several scientific and professional fields, and this has permitted us to take a very broad view of the evaluation. We found useful to ask the Commission to retain a group of consultants to analyse some general characteristics of the programme in more detail. A summary of their findings is at Annex B.

We based our evaluation on several sources of information, notably :

- interviews with programme managers, with staff from several units in the Commission, with contractors, with potential users in Member States, and with the Management and Coordination Advisory Committee (CGC) delegates,
- questionnaires sent by post to all contractors,
- documents and literature on the programme and on the energy field.

We are grateful to all those who kindly provided us with information and views.

Following the terms of reference provided by the Commission, our evaluation covers the scientific and technical achievements of the programme as well as its dynamics, its potential impact, its management and its international environment.

The programme we evaluated had an amount of 175 Mecu allocated to it covering the following fields :

A. Development of Renewable Sources of Energy :

1. Solar Energy
2. Energy from Biomass
3. Wind Energy
4. Geothermal Energy

B. Rational Use of Energy :

1. Energy Conservation
2. Utilization of Solid Fuels
3. Production and utilization of New Energy Vectors
4. Optimization of hydrocarbon production and use
5. Energy Systems Analysis and Modelling.

The main objectives of the programme were to develop advanced energy technologies to :

- increase the range of energy sources
- increase the effiency of energy use and production
- reduce long-term dependence on imported fuel
- counter environmental pollution
- enhance the capability and competitivity of European industry in energy related areas.

Panel Membership

Sir Hermann BONDI (UK) (Chairman)
Master, Churchill College
Cambridge

Prof. Fernando AMMAN (I)
Institute of Energy Economics (IEFE)
University Bocconi
Milano

Prof. André JAUMOTTE (B)
Ecole polytechnique
Université Libre de Bruxelles
Brussels

Dr Chrysanth MARNET (D)
Stadtwerke Düsseldorf A G
Düsseldorf

Mr Juan José PALOMARES (E)
Oficina de coordinación, de Investigación
y Desarrollo Electrotécnico
Madrid

Prof. Robert J. UFFEN (CAN)
Department of Geological Science
The Queen's University
Kingston-Ontario

Dr Philippe WALDTEUFEL (F)
Ministère de la Recherche et de la Technologie
Paris

The group of consultants consisted of :

Centre de Sociologie de l'Innovation
(Prof. Callon, Dr Laredo et Mr Mauguin)
F-Paris

GMV Conseil
(Mr Crance et Mr Paulat)
F-Vaucresson

Université de Namur
(Mr Vinck et Melle Warrant)
B-Namur

Centre d'Economie des Ressources Naturelles
(Prof. Giraud)
F-Paris

EVALUATION OF THE R & D PROGRAMME IN THE FIELD OF NON-NUCLEAR ENERGY (1985-1988)

1 - SUMMARY

1.1. First, we are very pleased that the Community has an Energy R & D programme. The lowering of the oil price has in no way diminished the crucial dependence of Europe and its prosperity on imported energy, and the effort to diminish this and to minimize the buffetting of the economy of Europe by external events rightly involves an appreciable R & D programme. Moreover, we feel the objectives of DG XII's energy R & D programme should (and, it seems, are) somewhat wider, relating to other objectives of the EC. Industrial competitiveness in hardware relating to energy production, conversion and use seems to be an obvious consequence of the stated aims, for one could hardly feel successful in diminishing Europe's external energy dependence if this were replaced by dependence on an externally produced item. Once our industry is competitive in energy items in the internal market, it will plainly strive to be so externally.

Rightly, the non-nuclear energy R & D programme is wide, involving as it does projects on the rational use of energy and on minimizing its environmental burdens, on fossil fuels, on renewables, and one modelling. While we ourselves have, in the time available, only been able to examine some aspects,we feel that these were representative, and are greatly reassured by the work of our consultants whose wide and skilled probing we found most helpful. Our work related to DG XII's NNE programme but clearly there are connections with DG XVII's work on demonstration projects across an ill defined boundary.

1.2. We are very favourably impressed by the technical quality of all the projects we have seen. In every case the targets set have been of value and of attainable nature, the teams have been competent and well coordinated, enthusiastic and capable. Naturally there have been minor variations in this quality, but this is only to be expected.

This uniform high quality is a tribute to project selection and management. Excellent as its output is, we feel it necessary to point out that this process of project selection takes a very great effort on the part of very many people and causes some of the delay. However, we are aware of the essential need in a Community not only to choose well, but to be seen to choose carefully and well. Though the balance is fine, we do not suggest that the method of choice should be abbreviated.

1.3. There are, however, two aspects of the start-up of projects that cause us serious concern. The slowness and heaviness of the Commission's administrative procedures means that there are massive delays between approval of a project by the DG and completion of the contractual procedures. We regard this as a major and serious handicap. First, it means that the start-up is substantially delayed for all cautious or impecunious contractors, while competing science and technology elsewhere progresses. Secondly, it means that at the time the evaluation has to be carried out for decision-taking for the next round, quite number of projects have been under way for a relatively short time so that it is difficult to judge the contractor's performance. Third, we are keenly aware of the problems faced by programme managers and by contractors as a result of these substantial delays.

We firmly believe that the effectiveness of Commission programmes is compromised by these delays. Recognizing the need to ensure that money is spent properly, we yet feel that the Community would get better value for money if the delays to finalization of contracts and to payments been received were reduced by simplifying administrative procedures or, if this were truly proved to be impossible, by hiring staff adequate in quantity and quality to go speedily through essential procedures.

This administrative complexity seems to us to be unnecessarily great. We fully agree with the following paragraph from our consultants' report : "While such a process is adequate for a procurement policy, where the buyer wants to be sure to get the exact product or service he pays for, it does not warrant R&D support : in that case, the EC no longer buys a good, but helps financially other parties to increase their research effort either by themselves or preferentially with others. The only effective contractual requirement should then be that the contractor does actually spend the contractual amount of money (including both his share and EC support) on the agreed theme; legal procedures, accordingly, should bear on monitoring conditions rather than on obligation of results." The management of this complexity is furthermore made particularly difficult by the three separate DG's involved having different and unlinked computer systems.

A further cause of concern is that while experienced contractors do not find it over difficult to comply with submission procedures,they are sufficiently daunting to prevent new ones coming forward in the numbers that would be expected. Naturally this can only be an impression; it would be hard to collect numerical evidence. This impression is shared by us and our consultants. We feel it right to draw attention to this point.

1.4. We have been very favourably impressed by the way the Commission has, with relatively modest amounts of money, managed to bring together a variety of industrial firms, university teams and staff from institutes to cooperate well and successfully. Sadly, European companies do not often cooperate of their own volition in R&D which fact much diminishes their competitive standing vis-à-vis U.S.A. and Japanese firms, as does the frequently less close connection with universities than is common in U.S.A. Indeed, we are pleasantly surprised by the success of DG XII staff in setting up such "clubs" of firms and university departments and ensuring their effectiveness. Where this has been achieved, we feel that the question whether it was appropriate for the subject to be pursued as a Community task is easily answered with a firm and clear "yes". There is less enthusiasm on our part for the (fortunately less common) case where the contract is with a single small group of researchers all in the same firm or university department. There will be cases where such a project is necessary within a wider Community project, but such work needs special justification, and coordination and dissemination must be assured. Educationally indeed DG XII has been most successful within the programme to lead people to think together and work together, but we regard it as essential to drive home the principles of such an attitude consistently and forcefully. Regrettably, there are still people about who believe they are "communautaire" if they have, wholly on their own, devised a project in every detail, and then invite others to join in carrying it out. We believe DG XII in this programme is very successful in establishing proper cooperative attitudes, but we hope that many contractors are right in being confident that these habits of cross border cooperation between different companies will, in the majority of cases, long survive the ending of Community support and management. The prognosis is good in cases where EC enforced cooperation has been lengthy.

In line with Community policy in the area of DG XII's responsibilities almost all the work done is at the precompetitive stage. However, from a European point of view it is most desirable that cooperation between firms begun in this manner is continued, so that a transnational effort in Europe, involving the resources of several firms jointly, is in competition with the American and Japanese giants. We are not clear what mechanism exists to stimulate, where necessary continuation of such cooperation begun in the precompetitive phase through into the commercial work though we are encouraged by this happening spontaneously in a few programmes (like amorphous silicon solar cells and perhaps combustion).

1.5. We were much impressed not just by the quality of the work being done on energy modelling and systems analysis, but by its central position in the whole programme. It ensures contacts and meetings with people engaged in its different components, and so is a major element in its cohesion. We are convinced that it must be a continuing effort for it will always be needed to evaluate the changing scene, and infer consequences for the rest of the programme, in addition to ensuring its cohesion.

1.6. The aims of the different sub-programmes seem to us well chosen and appropriate. We do not feel in many cases immediate progress to demonstration projects or to commercialization is to be expected, for many of the sub-programmes aim, rightly, to put Europe in a position where it can react speedily and effectively to an increase in price or a decrease in availability of imported fuel. The advance to commercialization is not to be expected unless and until such a contingency occurs.

The aim of improving the competitive position of European industry is readily served by sub-programmes on the rational use of energy, though again not much of the necessary investment will occur until energy becomes again more expensive.

Where the aim is to enable European industry to export, or at least avoid imports, of hardware or (through licensing or otherwise) of know-how, technical R & D cannot necessarily ensure success. Indeed we are a little disturbed by our being unable to identify a proper apparatus for such industrial strategic decision taking. We are not arguing that in, say the mass production of solar cells, Europe is no longer in a position to catch up with Japan, but we do not know where such a proposition would be discussed and decided. Europe's resources of skilled people are large, but finite, and we cannot expect to become a world leader in everything. The risk of squandering resources in hopeless areas is real, and these questions need study.

1.7. Again there are areas where good work is being done under the programme, but where it is obvious that this is only a modest part of the global effort e.g. in the utilization of heavy oils, or in enhanced oil recovery. We want to praise, not criticize, the work being done, but we do not find much evidence of its output being used to trade information with others, such as oil companies. Through trading of this sort, the likelihood of a commercially useful result emerging could be markedly improved. Undoubtedly that is a complex situation with an industry not used to public funding but with small oil companies anxious to utilize basic research done under Community sponsorship as they do so little themselves.

Accordingly we wish to command the steps taken in order to insure that the whole European research Community, including large oil companies, participate in the next phase.

Solid fuels present a particular set of programmes. The first task must be to make the burning of European coal, lignite and peat environmentally acceptable in an economical way. We discuss later in detail our attitude to the different ongoing programmes. Next, one must be clear that increasing the acceptability of imported coal considerably diversifies Europe's external dependence. The energetic marketing of coal to areas not used to it implies R & D in new techniques (water-coal mixtures). Concerning the pollution issue, there obviously is an important matter of norms and standards that are based on measurements if one wishes to have them respected. It might be useful to make sure that the matter of research aimed at measuring devices and procedures does not lie somewhere in the vacuum between the energy programme and the environment programme. Certainly this is a field for European cooperation.

1.8. While we are much impressed by the technical quality and by the management of the work under the programme, we feel that the time is approaching where the outlook should be widened, in two very different directions.

First the excellent engineering and science that is being carried out is beginning to need support from behavioural sciences and from economics. In many of the sub-programmes their future utility would be much enhanced by having experts from these fields integrated into the project team and also involved in EC management groups. Utilization is not just dependent on hardware skills, and a widening of the effort from engineering to include the social sciences would in many cases now be advantageous. This would be particular valuable in areas where decisions are taken by many people (efficiency of energy use). Experience shows that barriers exist inhibiting favorable decision taking when this is not centralized, as it is, on the supply fields. Therefore the inhibitions to the use of small generating equipment and particularly on energy saving measures are not purely technological and must be addressed otherwise.

Secondly, there is a tendency not to look sufficiently outside Europe. Too little is done to acquire firm knowledge of the work that is going on, (or the strategy behind it) even in our major competitors, USA and Japan. It is also well worth studying the efforts of the smaller ones like Canada, Australia, Sweden, etc.. The developing world in particular is of great potential importance for many of the projects.The developing countries seriously industrializing are virtually bound greatly to increase their coal consumption. The export of hardware or know-how (perhaps through aid programmes) could be of great help to European industry, to the country concerned through enabling it to burn coal more efficiently and with less environmental damage, and, by avoiding worse effects on the global atmosphere, help us all to live more agreeably. Indeed in many ways projects being carried out under this programme are valuable not just for Western Europe, and we see little evidence of the relevance of this being considered. Nor do we feel that enough thought is being given to the energy and environmental policies of our close neighbours in Eastern Europe. They will be important for us, and though this will not necessarily affect R & D projects we would feel happier if we could feel sure this matter had been considered.

Again, while we enjoyed the technical quality of all the work we saw, we wonder whether there is enough long range research in the programme. For example,we see it is as part of DG XII's job to bring radically new innovative technologies to sectors of the energy field modernizing themselves in a less revolutionary way. Such work will not inevitably yield usable results, but without it the programme will have less benefit. Knowledge gained by public funding must become generally available though sometimes persuasion and effort is required to achieve this. While we appreciate that significant efforts are being devoted to the dissemination of the valuable results obtained through conferences, publications etc, we feel that in some cases energetic marketing to the Community's industry and users is required.

1.9. In a forward looking organization the R & D component is of central importance. All other sectors should come to it with their future needs and problems, and should in turn receive from DG XII suggestions of technological projects of interest and importance to them.

Unhappily, we found a number of the other Directorate-Generals too thinly staffed to be able to concentrate on the future, with urgent present needs taking all their available effort. We find this worrying, and would hope the Commission can gradually remedy this. The more all parts of the organization think about the future, the more will DG XII be able to assume the central role that should belong to it; and the more DG XII can equip itself to deal with behavioural and economic questions as well as with engineering ones,the more it will be able to help all the others to face the future. To be more specific, it seems to us unusual that such a large undertaking as the Commission's Aid Programme does not carry with it (at say 1% or 2%) an R & D component whose natural home would be DG XII. With the pressing worries about the energy household of the developing world (and its environmental effects) some of this should be in the non-nuclear energy R & D programme.

The Commission has already a considerable and well-established success in the Common European Driving Cycles for motor cars. Other such efforts at commonality of measurement (and regulation) in energy may well require an R & D effort.

1.10. To sum up :

We are very positively impressed by the programme,by its management, and by what it is achieving for the cohesion of Europe, but we feel a broader perspective could in some respects improve the very real benefits it already offers.

2. GENERAL RECOMMENDATIONS FOR THE COMMUNITY PROGRAMME IN THE FIELD OF NON-NUCLEAR ENERGY.

2.1. In trying to assign overall priorities to the different portions of the EC's programme, we are keenly aware that it forms only a few percent of the total funded in Europe from public funds in the area of non-nuclear energy. It is therefore clear to us that we must look for those areas where Community funded research can make a special contribution. The main, but not the only criterion here is whether the project in question can benefit from being transnational, whether Europe can, in the field in question, do better by bringing together industries, universities and other public institutions in different countries under EC management. Naturally DG XII work is best placed at the precompetitive phase.Particular attention must be paid to the smooth transition of projects from DG XII to DG XVII's demonstration portfolio. Our suggestions for the future must be guided by the experience of the past, and by the consideration that the task of a research programme is the acquisition of knowledge. This acknowledge may suggest the ending of a programme, or its continuation, or its transfer to the larger arena of publicly funded demonstration projects or to purely industrial funding.

2.2. We feel that the objectives of DG XII's NNE programme should and indeed do include not only the lessening of Europe's energy dependence on the rest of the world, but also the improvement of competitive capability of Europe's industry, both by the encouragement of transnational cooperation and by strengthening industry-university links.

We judge that DG XII has achieved much in these aspects, with modest financial means, and this encourages us strongly to recommend a continuation of the NNE programme. We would hope however that it can be made even more effective by making it easier for new entrants to join the very well functioning transnational "clubs" and by reducing the disincentive to doing so by the heavy administration and the long delays before formal approval and before payments.

2.3. We are quite clear that **systems analysis and modelling** is most useful and helpful in the programme, and must be continued. It has the potential to increase the cohesion of the programme and this should be exploited. The current funding is barely sufficient for this activity with its present remit; if, as we propose, its remit is widened, somewhat larger funding will be required. We would like to suggest that in other areas of Commission work, such system analysis could also be employed to advantage.

2.4. In **renewable energies** we are particularly impressed by the programmes on **geothermal** and on **solar** energy (as regards the later, particularly the work on amorphous silicon). In both these programmes we are not only impressed by the progress made, not only impressed by the prospects,but we also very much like the transnational nature of the efforts, and the way the best people in Europe are brought together irrespective of location. Accordingly we recommend that the funding for these should be fully maintained and, if possible, increased.

Useful and transnational work is going on in **wind energy.** It has two main thrusts :

a) the provision of a source of energy for island and isolated communities where energy now is unduly expensive;

b) a contribution to the general production of electricity for the grid.

We would strongly support (a) (but solar energy also needs to be considered here), but hope that work in this field can soon be transferred to the demonstration stage. On (b) we feel it important for the new programme to be directed to establish economic viability in likely future circumstances, especially since big wind machines have at present a much higher cost per Kw than small ones.

Biomass is an important field, but it seems to us that its main benefits are in relation to agricultural policy and to aid to developing countries. We feel therefore that its call on DG XII's

NNE finances should be reduced but that DG VI and DG VIII should be involved in setting objectives and ensuring that enough money is available for this programme.

2.5. **Energy conservation** seems to us to be a most important area. More rational use of energy would not only reduce Europe's energy hunger, but would reduce the environmental burden and other undesirable side effects. Yet progress here is only very partially dependent on technical advances and those that are needed are generally not over expensive. Good examples are absorption heat pumps, the combustion project and fuel cells. On the other hand, economic, social and behavioural factors are decisive in this field (one need only consider the behaviour of drivers, or the reluctance of company boards to sanction energy saving measures).We recommend therefore continuation of the programme at a reasonable level of funding, but feel that to ensure its effectiveness energetic studies of the relevant economic, social and behavioural sciences must be included.

2.6. We welcome the work being done on **fossil fuels**, and are conscious that R & D in such mature areas cannot be cheap. Both for oil and gas, there is a vast area for research well ahead of industrial development. We gladly support transnational projects in this domain, which gather European competencies, while not duplicating the necessary research effort by large oil companies. Similarly the environmentally and socially acceptable utilization of Europe's resources of **solid fuels** seems to us to be a priority item, and we similarly give our strong support to transnational programmes in these fields in which the social and environmental factors are fully considered. The aim should be, on one hand, to improve the penetration of European coal into Community markets not used to them, and secondly to diversify Europe's sources of energy imports.

2.7. Given our strong support for so much of the programme, we are disturbed by the substantial cut proposed and trust that consideration of our report will strengthen its claims on the promised revision.

1. SOLAR ENERGY

1.1. INTRODUCTION

It is well known that quantitatively speaking, solar energy is the most important source of energy on earth, even though it is widely dispersed and therefore difficult to use in applications apart from the "natural" ones such as photosynthesis, etc., as it requires elements to concentrate and convert such energy.

From the point of view of collection/usage, this source of energy can be classified into three different groups with, in turn, different technologies for collection and use :

a) Passive solar energy

b) Thermal solar energy
- Low temperature
- Medium temperature
- High temperature

c) Photovoltaic solar energy

The activities of the DG XII in this field date back to the work carried out by the JRC in the early seventies which resulted in the first Solar Energy Programme (1975-1979, 18,7 MEcu); following this, a second Programme was implemented (1979-1983, 32,5 MEcu) and finally came the Non-Nuclear Energy Programme (1985-1988, 35,5 MEcu), the subject of this evaluation.

1.2. OBJECTIVES

Table 1 shows the evolution of the objectives of the various sub-programmes throughout the three R & D programmes already carried out.

The following aspects should be mentioned as significant :

- A certain continuity exists between the three programmes, progressing from basic research in the first programme to more experimental research in the third.

- As a result of this, at the beginning of the third programme, those lines of investigation, where a possible technico-economic viability is not clear, such as the high temperature (Eurelios Tower) and the Photochemical, or where the research is considered concluded as in the case of low temperature solar energy, were abandoned.

  In the Photovoltaic area, efforts are concentrated on investigating ways of reducing cost so as to become competitive, and the development of concrete applications commences by means of pilot plants. A new research path is opened in the passive use of solar energy.

- At all times the energy goal has had a greater weight than others such as economic, social or environmental objectives.
  Centering on the third programme the concrete goals are the following :

Three generic fields of action are established :

A) Solar Energy Applications in Buildings.

A.1. Passive solar system development (PASSYS).
Development of design tools and simulation models for passive solar heating system and development of test procedures for passive solar components.

A.2. Passive solar topics research (PASTOR).
Heat transfer and air movement, thermal comfort, auxiliary heating and controls, daylighting, planning and urban design.

B) Photovoltaic Power Generation.

B.1. Amorphous silicon solar cells (AMOR).
The programme was focused on new or improved preparation techniques with emphasis on efficiency,stability and low-cost potential.

B.2. Thin-film solar cells from alternative materials (ALTERNA).
Development of thin-film solar cells using alternative materials in case these turn out to be economically superior to amorphous silicon, at least for some applications.

C) Solar Radiation Data.

C.1. Solar radiation in microclimates.

1.3. COMPOSITION OF THE PROGRAMME

Table 2 shows the composition of the programme once the research proposals presented have been examined and approved.
The following should be mentioned as the most significant generic aspects of the programme :

- The projects approved and put into action cover the fields of action foreseen in the programme, some being amplified, as in the case of the passive solar programme in which, with very good judgment, two activities have been added, directed to the dissemination of the results obtained.
  In the same way the widening of the field of action in Photovoltaic energy to include the development of pilot plants for concrete applications, compensating, to a certain extent, the high level of basic research in this programme, should be considered as opportune.

- A very positive aspect is the high level of participation of the various countries in each of the lines of action undertaken.

  In nearly all cases, except in the subprogramme of pilot installations, it consists of a unique project with multinational participation with all the benefits deriving from this type of action such as the exchange of knowledge between countries, the homogeneity of work methods, avoidance of duplications of research, etc.

- From the economic point of view, the greatest effort has been concentrated in the photovoltaic energy programme, above all in the amorphous silicon project, although, in general terms it can be said that it is balanced between the different fields of activity.

1.4. ANALYSIS OF THE DIFFERENT SUBPROGRAMMES (*)

a) Passive Solar (Energy)

The subprogramme is composed of three projects (PASSYS, PASTOR and SOLINFO) shared by nearly all the Member States of the E.C. The general aspects of the said projects, such as objectives, number of contracts, etc. are shown as previously stated in table 2.

With these three projects it can be said that the different aspects to take into consideration for the good use of solar energy through passive systems are well covered, as they cover aspects from the design and validation of computer programmes which permit the evaluation of the economic viability of a passive system, up to the analysis of different systems including the monitoring of 60 installations gathering data such as construction details, architectural ideas and even the level of satisfaction among users.

One aspect to be taken into account in this type of project is the dissemination of results, as on this depends, to a large extent, the possible viability or not of the economic and research efforts carried out.

To cover this aspect the SOLINFO and ARCHISOL projects have been put into action in the way that, through them the results of other projects have been made known to collectivities such as architects, engineers, builders, planners, etc.

In the particular case of architects, some 3.500 professionals have been identified to whom, periodically, information on results achieved is circulated.

Thus, in general terms, it can be said that the passive solar programme has been well designed and is being carried out in an

* In this analysis, only projects in progress will be considered and not those in preparation.

adequate way, with excellent coordination and a satisfactory level of circulation of the results.

Nevertheless, attention should be drawn to a crucial aspectfor achieving the objectives. It would be ideal that with the information obtained, a set of regulations is drawn up at a community level for standards of construction, from the energy point of view, which could range from energy recommended guidelines to obligatory regulations in which case, without any doubt, the passive solar energy contribution would be significant.

b) Solar Radiation Data.

This programme is a continuation of the activity in this field, started in the first programme, in which projects started in previous programmes are completed, as is the case of the European solar radiation map to which the study of different European microclimates has been added.

At the same time the activities started in the 2nd programme on themes relative to the obtention of solar radiation data via satellite, are being concluded.
It is obvious that in order to make the most of any energy resource, especially in the case of solar energy, the knowledge of the existing resources is basic, thus the work undertaken to date must be useful, especially in respect to the analysis of economic viability of a chosen system of exploitation or in the selection of the site for its installation.
Nevertheless, the level of information currently available is more than sufficient to be able to tackle aspects such as those mentioned previously. Thus it does not seem advisable to continue this activity as even the programme of the study of microclimates, if considered interesting, should have been tackled by the different countries interested in a task of

coordination and homogenization, instead of being included in a Community R & D programme.

An important aspect to take into account, with respect to making the most of the effort involved, is the publication of the results, as in some way it should be ensured that these results reach those institutions which could potentially make use of them. Perhaps one way would be to request from the different national participants to take on the responsibility for disseminating the results throughout their own countries.

c) **Photovoltaic.**

As mentioned previously, economically, the photovoltaic programme represents the biggest effort in the solar energy programme. This subprogramme has been structured around three actions :

Amorphous silicon.

The project is aimed at developing a European option in the development of amorphous silicon cells compared to the alternatives of USA and Japan. The project is built around two companies, one French and the other German, which assume the role of industrializing and commercializing the product without, of course, moving away from the research aspects and a large number of research centres, in many cases in the universities, where partial aspects of the problem are analyzed.

Ten Member States from the Community participate in the project, which consists of 23 contracts from as many institutions.

The result has been very satisfactory as once the research phase has been concluded with positive results, the two participating companies will form a new company which will take charge of completing the innovation process with this product.

This could be a highly enlightening example of a very useful way of establishing actions within a programme such as non nuclear energy. That is to say, to create groupings of companies (in this case two), in which research centres join a concrete project, headed by one or various companies. In case of success, these very companies would go into production thus completing the innovation process. One aspect to take into account in projects such as the present, is to try to ensure the continuity of the action once the contract with DG XII has expired, perhaps by tying it to other community, national or multinational programmes, such as Eureka.

Thin-film solar cells from alternative materials (ALTERNA).

This action is aimed at developing technologies of thin film solar cells using alternative materials to silicon.

The operation has been subdivided into four subprogrammes in accordance with the different alternative materials to be studied. The programme is formed by 23 contracts with as many research centres integrated by the type of material to study, the coordination work being done by DG XII programme Manager, in each subprogramme of the different participating contractors.

The programme has a very marked basic research component and can only be evaluated from the point of view of acquired scientific knowledge, as economically or industrially all depends on the potential use of the results by some company. Apart from what has been said of the scientific knowledge acquired, a clear result must be the identification of multidisciplinary transnational groups with high scientific qualifications, to tackle investigations linked to concrete innovations with expectations of economic viability.

Photovoltaic pilot programme.

Despite the fact that in the first objectives of the third NNE programme the project in the field of development of pilot installations for the use of photovoltaic energy was not included, in our opinion this concept has rightly been included by the management of the programme,which in someway begins to compensate the existing imbalance between basic and experimental research within the photovoltaic programme.

This project composes 13 contracts carried out mainly by companies which have as a final objective the development of some equipment or system which covers some existing applications.

Although, as it has been said previously, the concept is well introduced, perhaps the topics of the different projects are not so consonant as they are completely independent projects, analysing, in many cases, partial aspects of a more generic problem.

In this sense it would have been more useful to identify concrete applications for the use of photovoltaic energy, such as rural electrification, water pumping, photovoltaic systems combined with other types of energy, etc. and to have tackled the problem as a whole, seeking the most viable technico-economic solution involving in each project various institutions such as in the previous programmes.

In relation with this aspect could be said that there are some contracts that cover, in a way, this emptiness.

1.5. EVALUATION OF THE PROGRAMME.

a) Scientific and Technical Achievements.

The scientific and technical knowledge achieved in the current programme could be classified as direct and indirect. In the first group this knowledge is quite different according to the subprogramme; thus in solar application in buildings two main blocks exist, one in which potent computer tools have been developed and tested, which permit, through simulations, the measurement of the energy contribution of solar origin in a building using passive concepts and systems, as well as the economic repercussions of these and therefore their economic viability. The other big block concentrates on the monitoring of a determined number of installations and collecting and publishing the results.

In the photovoltaic programme, a great step forward has been made in the amorphous silicon technology, creating the basis for the possible development of a European industry to exploit this technology.

On the other hand, in the laboratory the possibilities have been studied of new technologies for the production of thin film cells with materials alternative to silicon and very definitely directed to the production of cells at low cost.

On the side of indirect results, basically, two aspects should be mentioned : in the first place the contribution of programmes such as the present in which is not just a collection of national ones, this is being creation of a truly European technology, achieved through the participation in the same programme of research teams from different countries, and secondly, and as a direct consequence of the first, the interchange of knowledge between these research teams avoiding, with this, the duplication of research.

On the negative side it must be pointed out that since the beginning, the programme has had purely a general energy objective and therefore that research whose energy viability was not clear has been terminated, although it may be useful for some highly specialised purposes, for example, high temperature solar energy and photochemical energy.

It would be interesting to develop applications normally of high technology, different from those of electric generation, in which the characteristics of solar energy are an important differential in relation to the other energies. For example, in the case of thermal solar energy, the possibility of having a thermal source with a temperature higher than 1000° C, with no contamination should be used for different applications than electric generation; for example, development of new alloies, high power lasers, thermal shields, etc. However, the potential users of such applications should first demonstrate their interest and need through active financial participation before such a programme is undertaken.

In the same way, in the photovoltaic area it would be interesting to identify those applications in which the generation costs with photovoltaic systems were more in line with the conventional ones, and develop the system in a global sense, not only certain subsystems. Most of the applications for the supply of electricity to isolated installations, either domestic (isolated communities), industrial (agricultural installations, water pumping, etc.) could be in this situation.

b) **Practical and Commercial Relevance.**

The economic and commercial aspects of the subprogramme can be analysed, in principle, from 2 points of view. On the one hand is the energy input which can be derived, as a consequence of the programme, to the energy balance of the E.C., and on the other hand subsidiary aspects such as the creation of companies, generation of employment, interchange of technologies, etc. With respect to the first, it is practically impossible to quantify the energy contribution due to several factors :

On the one side, at the moment, there are no sufficiently developed statistical methods which would permit the measurement of the contribution of renewable energies in general.

On the other, the penetration level of the renewable energies is wholly conditioned by the current price of conventional energy sources, as well as by the political decisions taken in the different Member States. However, we could talk of a significant contribution to the Community consumption in the year 2000 with active and passive thermal solar energy. This contribution is based fundamentally on low temperature solar energy (hot water supply) and passive solar energy.
The development, or rather the contribution of passive solar energy, is heavily conditioned by the establishment, by the Member States, of specific regulations for the use of concepts and systems in the construction of new buildings.

In relation to the subsidiary aspects the amorphous silicon subprogramme is a good example as, if it bears fruit and develops an industry capable of competing with US and Japanese industries, it will have access to a potential market in the E.C. in a short space of time of some 40 Mw peak which, at a current cost of 8 Ecu/W peak, means a potential market of 320 MEcu. On the other hand it means the creation of an industry in the field of semiconductors with its benefits of creation of jobs, interchange of technology, etc.
Another aspect to consider in the photovoltaic programme is the important role which it can play in improving the infrastructure and conditions of life in the less favoured regions, with favourable effects on the depopulation of these

regions and on the conservation of the environment.

c) **Effectiveness of Management and Use of Resources.**

The following targets in the general management of the programme can be mentioned :

- Definition and preparation of the programme.
- Request for research proposals.
- Evaluation and selection of proposals.
- Control and follow up of the different subprogrammes.
- Evaluation of the subprogramme.

In general terms it can be said that the existing process as well as its management is highly satisfactory. However, some aspects which could bring about general improvement in such process are detailed below.

When designing a new programme, starting from the generic idea that an R & D programme like the present, one should try to coordinate, bond, contrast, etc. the different existing national programmes in the Member States : It would be interesting to know the objectives of these programmes from the protagonists; for example, through meetings of the people responsible for the different programmes with the management of the DG XII.

As regards the selection and evaluation of the proposals presented, much emphasis is placed on the object and research team, aspects which undoubtedly have great importance, but it is surprising that the results which they hope to achieve with the investigation are never analysed. In fact in the questionnaire to be completed to request financing, information on such results is not asked. This aspect would be very enlightening when selecting proposals as well as being a valuable element when evaluating the results of the research.

1.6. CONCLUSIONS AND RECOMMENDATIONS.

a) Objectives and Range of the Programme.

In general terms it can be said that the objectives foreseen in the programme have been covered in a satisfactory way having been, in some cases, rightly amplified, as in the case of the SOLINFO and ARCHISOL actions, without which the results of the subprogramme of passive energy would have had limited circulation. In the same way, the project of pilot plants in the photovoltaic subprogramme is well thought out but it is necessary to promote new projects, more adequate for the development of this line of action. With the projects undertaken in the third NNE programme and in the preceding programmes it can be said from the technology point of view that the situation is the following :

- The passive use of solar energy has been sufficiently studied, having developed information tools which permit the evaluation of the viability of a determined component of installation. Thus, at the moment, the work to develop is more in the area of the demonstration projects rather than research, and as a consequence looking at the new programme. The aim of a new programme should be acquisition of knowledge so that the penetration of this energy saving technology could become widespread whether through regulation action or otherwise. Only a programme with such an aim would be worthwhile.

- The same can be said of the "Solar radiation data" programme in which, at the moment the level of knowledge of energy sources of solar origin is very superior to the level of use which is made of the same, thus there is no sense in continuing this activity.

- Imaginative proposals for rising the spectral composition of sunlight should be supported provided interested users can be identified.

- In photovoltaic, the subprogramme of amorphous silicon can be considered an important success and should be continued giving opportunities to interested firms not yet involved. The way in which this project has been developed should serve as a guide to implement other actions directed to developing complete systems which satisfy a real need, such as those existing in the supply of energy isolated communities. This also has relevance to the Community aid programme.

  At the same time, the development of mixed systems, photovoltaic and another type of energy, either conventional or renewable, can contribute to find solutions for this type of Communities, as do some other renewable sources of energy.

b) Management.

On the whole, as already mentioned, the procedure used is correct and it is only necessary to point out the following :

- Establish better contact among those responsible for the DG XII and those responsible for the different national or sectorial programmes.

- Introduce as a criteria for evaluation the results to be obtained in the research.

2. ENERGY FROM BIOMASS.

2.1. NATURE OF THE PROGRAMME

The programme (20 million Ecu for the period 1985-88 - split among 123 projects) covers the following divisions :

I. (4.8 million Ecu) Biomass production and improvement of Productivity

II. (1.0 million Ecu) Harvesting, Transport, Storage, Drying.

III. - IV. - V. (10.3 million Ecu).

III : Biogas (small budget)

IV : Ethanol fuels and basic studies in Biological Conversion.

V : Ethanol. Pilot plants.

VI. (3.5 million Ecu) Thermal Biomass Conversion

VII. (0.4 million Ecu) Photochemical and Photobiological Processing for producing energy-rich compounds (concerted action on photobiology, photochemistry and photoelectrochemistry)

The programme can roughly be divided into :

a) Biomass production, harvesting and collection;

b) Biomass conversion.

2.2. ANALYSIS OF THE DIFFERENT SUB-PROGRAMMES.

I. Biomass Production and Improvement of Productivity.

Among the plants which have been shown to be most interesting are Jerusalem artichokes and Sweet sorghum.

Jerusalem artichokes are interesting for the rotation of cultures. Sweet sorghum poses, however, less problems and appears extremely interesting. Its culture requires fertilizers, but not pesticides, if one delays its sowing for a fortnight.

Experimental plantings have been made in West Germany, Italy and Spain (sowing 100 hectares).
Production seems to be approximately 70-100 tonnes per hectare fresh material) with a content of :

- sugar : 8 - 10 tonnes per hectare
- lignocellulose : 20 - 30 tonnes per hectare

One would need to achieve a productivity of 15 tonnes per hectare of sugar.

It would seem useful to increase the culture trials in the Community to be able to extract from them average production values which are statistically valid. On such bases, a strategy for the future could be prepared.

II. Harvesting

There exists good machinery for the large trees, but there is not good machinery for small trees and difficult terrain. Research and development directed to machinery would be interesting in cooperation with other programmes (agriculture, forestry, etc...) in order to obtain the necessary critical financial weight.

Transport

The programme includes one small concerted action for the pneumatic transport of cut biomass (over a distance of 1 km. as a trial).

Storage and Drying

Based essentially on past programmes. Only the warehousing and drying of sweet sorghum has received particular attention.

III. Biogas

This is an activity which has been almost abandoned as the biogas digesters are at the stage of being industrialized and commercialized. Some small activity has been retained, directed towards advanced digesters.

IV. Ethanol Fuels and Basic Studies in Biological Conversion.

The withdrawal caused by lead free petrol has not been ignored. Ethanol fermentation has been replaced by a special effort directed towards the development of several pilot plants. Bioethanol can be obtained from various plants (straw, wood, sugar beet, Jerusalem artichokes, sweet sorghum, etc...) either through acid hydrolysis or through enzymatic hydrolysis. Enzymatic hydrolysis will not be profitable for many years.

Effort has been concentrated on acid hydrolysis with the objectives of :

- reducing the price and reaching that of synthesised ethanol;
- extending the treatment to new basic materials, such as Jerusalem artichokes and sweet sorghum.

With sweet sorghum a production of 9 tonnes of bioethanol per hectare has been achieved. It should be noted that the market for bioethanol will remain modest for at least a decade.

VI. Thermal biomass conversion.

Gasification from air or oxygen for the production of synthesised gas was part of the first and second programmes. This action has been completed during the third programme. This has resulted in interesting conclusions from a technical point of view, but with no economic future. The programme has been virtually abandoned.

In contrast, there is a new interest in pyrolysis because :

- the investment is lower than for gasification;
- the installations are more compact;
- the operating costs are lower.

Significant results have been obtained with a limited budget. A pilot plant with a fluidised bed (using 1 tonne per hour of material) has been operated. This uses all types of agricultural waste (including the bagasse of sweet sorghum) and forestry waste.More than 150 modifications have been made to the installation in order to create a standard module for pyrolysis.

As a follow-up to this programme, and in co-operation with other departments, three major projects have been started in Southern Italy, Galicia and Greece. Two further projects are to be added in Catelonia and in Sarre.

This has, therefore, resulted in an agro-energy scheme, whose objectives are as follows :

a) to direct agriculture towards sweet sorghum, which appears particularly interesting, both for Northern and Southern Europe. It would be appropriate to conduct research into the varieties of sweet sorghum which maximalise production per hectare. Currently this production is around 70-100 tonnes per hectare.

b) to extract the sweet juice under pressure. The problem of stabilising this juice has not been fully mastered.

c) to use the bagasse of sweet sorghum, half as product paper pulp of good quality and half as a combustible liquid through a pyrolitic process which has been developed. This combustible - similar to bunker C oil - is usable in thermal installations, particularly in power stations.

The balance sheet of value achieved is approximately as follows:

-	Sugar	: 10 t/ha x 110 Ecu/t	=	1,100 Ecu/ha
-	Wood pulp	: 10 t/ha x 25 Ecu/t	=	250 Ecu/ha
-	Pyrolitic fuel	: 10 t/ha x 73 Ecu/t	=	730 Ecu/ha
				2,080 Ecu/ha

Approximately : 2,000 Ecu/ha.

The liquid fuel (oil and slurry) obtained by pyrolysis can be immediately utilised in existing steam boilers. It presents the following main characteristics :

Oil :	lower calorific value	6,100 kcal.kg
	specific gravity	1.2 t/m3
	viscosity (50°C)	600-900 cp
	S content	0.01 %
	ash	2 %
Slurry :	lower calorific value	4,500 kcal/kg
	S content	0.01 %
	viscosity (50°C)	600 cp

There are, therefore, two possibilities of using a plant like sweet sorghum, which appears to be the most favorable amongst the short rotation bushes, either for the production of bioethanol or for the production of sugar, paper pulp or liquid fuel. This second route is extremely interesting whilst waiting for the development of the market for ethanol. The programme relating to pyrolysis should be pursued in cooperation with the countries most advanced in this field, mainly Canada.

VII. Photochemical and Photobiological Processes

This small programme is of interest to numerous university groups (25). It had led to an excellent cooperation, which should be preserved.

2.3. EFFECTIVENESS OF MANAGEMENT AND COORDINATION.

The production and utilization of biomass requires cooperation, or at least coordination, between completely different scientific and technical disciplines : forestry, agriculture, harvesting machinery, transportation, biology, chemical and power engineering, economy, etc.

The use of biomass is heavily dependent on fuel prices, which have varied considerably during the period of the programme (1985-1988). For these reasons, the managerial task of such a programme is particularly difficult. In my opinion, it has been accomplished successfully. The results obtained are important for the Directorate-General VIII (Development) which could make use of the experience and test plans realised to solve specific problems in the developing countries.

2.4. EVALUATION

The quality of the research has been excellent. The participants have been well qualified and have carried out their projects with due regard to E.C. objectives.
The programme has created links between the teams, especially the university teams, which would not have existed without it, particularly the smaller and more isolated teams.

2.5. RECOMMENDATION

The policy of "freezing" land, which is in the process of being decided (covering 5 million hectares) will pose problems of using the land "freed" and of the future of the agricultural population. The utilization of "frozen" land for energy purposes is an interesting possibility. It is, therefore, important to assess the routes which are economically the most profitable.

The extent of market penetration will depend largely on the future supply price of biomass and the cost of conversion technologies. There is a need for further development to reduce costs and for developing integrated biomass utilization. The main objective of a future programme is the development of techniques for the production, conversion and use of fuels from biomass. The primary relevance of this programme is for agriculture policy. DG VI should therefore be involved in the setting of objectives and in making resources available.

The programme will be directed to :

Production of biomass

- research into short rotation forestry and alternative crops like sweet sorghum under various pedoclimatic conditions using a common methodology. The emphasis will be on problems of quality, standards and production costs.

Harvesting, etc.

- development of harvesting machinery with emphasis on the suitability of machinery.

Biological conversion

- R & D on acid and enzymatic hydrolysis of lignocellulose;
- basic research on photocatalysis and photochemical liquid cells for the production of fuels.

Thermal conversion

- pyrolysis processes at intermediate temperature, in cooperation with other countries, particularly Canada.

It is important to have in the programme integrated schemes, i.e. pilot projects incorporating production, harvesting, conversion and marketing as an integrated whole, for short rotation forestry and for other crops, like sweet sorghum.

3. WIND ENERGY

3.1. INTRODUCTION

Among the renewable energies, wind energy is the one which is closest to its viability threshold.

In the last ten years two events, which are worthy of mention, have occurred :

- On the one hand, in California, through tax benefits for the generation of renewable energies, wind energy is competitive with conventional energy, producing a spectacular increase in the installed power which is currently over 1.400 Mw.

- In the Community, the existence of such a market produces an important growth in the number of manufacturers and the types of machines. It must be born in mind that a great part of the installed power in California has been supplied from Europe.

On the other hand an important aspect to note is the ability of this type of energy to be able to compete successfully in price with conventional supplies in the supply of electricity to marginal markets, not-connected to the general grid, such as small insular systems with high electricity generation costs at the moment.

3.2. OBJECTIVES

Wind energy is included in the second research programme of non-nuclear energy (1980-83) in a modest way (the budget was 1,2 MEcu) with activity mainly directed at analysing the potential use of this energy, as well as collecting existing knowledge in this matter.

Thus the following projects were set up :

- Assessment of the technical and economic potential of wind energy in the European Community.
- Preparation of a Wind Atlas for the European Community.
- Study of R & D related problems interconnecting aerogenerators to the grid.
- Collection of data from the operation of existing aerogenerators.
- Instrumentation for monitoring of aerogenerators.

In the third NNE programmethe research funds available for this energy were increased considerably, with a budget of 18 MEcu, and with the following goal :

The general objective is the improvement of the technical characteristics of wind conversion systems, and the decrease of their cost. The subprogramme should also help to extend the considerable know-how which has recently emerged in Europe on small and medium size machines to sizes up to the megawatt range.

To achieve this objective, two lines of action were established :

- Wind energy technology R & D (WINNER)
  The purpose is to address generic R & D problems associated with wind energy conversion. Topics include aerodynamics, mechanics and electric conversion.

- Development of wind machines in the 1 Mw class (WEGA).
  Design and construction of innovative wind energy conversion system in the 1 Mw class.

3.3. STRUCTURE OF THE PROGRAMME

Table 1 shows the composition of the programme once the research proposals had been studied and approved.

The following aspects should be noted :

- In general terms it can be said that with the approved projects under way, the fields of action foreseen in the objectives of the subprogramme are covered.
- Between them the Technology R & D and WEGA projects cover 78 % of the total investment in projects.
- Fundamentally these two actions are directed at analysing, developing and improving the wind turbines in general, or one of its elements in particular.
- As to the participation in the different projects, two of them, the European Wind Atlas and European Wind Energy penetration study, have clearly multinational participation as nearly all Member States are integrated in them, while the rest are more or less isolated actions with their own ends.

3.4. ANALYSIS OF THE VARIOUS PROJECTS (*)

a) **European Wind Atlas.**

This project started in 1981 as a collaboration between 9 countries, increasing to 11 in 1986 and had as a goal the elaboration of the European wind atlas.

As with any sort of energy, basic for its possible commercial exploitation is the knowledge of resources available. In this sense this project should, and in fact already is, contributing to the development of wind energy in the European Community. Another important aspect to note is the relatively low cost of the project showing an efficiency in the means at its disposition in relation to others in other types of energy.

(*) In this analysis, only projects in progress will be considered and not those in preparation.

(b) European Wind Energy Penetration Study.

The intention is to provide the different Member States with a tool which - in the absence of national data - makes it possible for them to evaluate the extent to which wind power can technically and economically be fitted into the national power production systems, in order to :

- Serve as background information in the energy political deliberation of the Community and the national governments.
- Serve as background information for utilities.
- Serve as guidance for wind turbine manufacturers' market analyses.

The guidelines consist of :

- Recommendations for technical and economic evaluations which form a background for harmonization of the studies in the different countries.
- Demonstration of the possibility to obtain the necessary wind turbine data and wind data where these are not available.

Ten companies participate in the project, one for each country, the latter being in charge of analysing the penetration of wind energy in the same one. The project can be very interesting as the level of penetration of wind energy in the Community will be a direct funtion of the level of penetration of such energy in each of the electric companies.

It should not be forgotten that generation with wind energy is quite different from that of other conventional sources. While with these the production units are of hundreds of Mw, with wind energy they are of hundreds of Kw, that is almost 1000 times less meaning that for similar production a very high number of generating units has to be used, producing a tangible disadvantage in the use of these systems.

c) Wind Turbine Experiment Project (in preparation)

The purpose of the Experimental Project is to operate 4-5 medium size wind turbines under various topographical and climatic conditions within the EC. The turbines shall supply information on production, operation and maintenance under these conditions. The operators (owners) of the turbines shall be the utilities, distribution companies or the like. The actual project covers the preparation phase of the Experimental Project. The preparation has concentrated on Specifications for Wind Turbines, Invitation to tender, Turbine Bid Evaluation and Technical Information for Proposers.

This action, as planned, can only supply limited information on the behaviour of a certain machine in several places, and it is not possible to integrate the results of the different installations due to the disparity of the conditions of the experiments, imposed by the very definition of the project.

In any case, in principle it does not seem that the results obtained in an experiment such as this could be of any relevant use.

d) Operational Data Collection and Studies (Data Base)

The European wind turbine data base Eurowin gives a survey of current European wind technology and wind turbine sites.

EUROWIN contains :

- manufacturer data with addresses, technical details, prices, etc.
- operator data such as local data, monthly data, tariffs, current costs, etc.
- Analysis data like average capacity factors, cumulative energy production, installed rated power, average operational time, etc.
- failure analysis data such as component failures encountered, causes and effects of the failures.

The result of this project will allow inquiries and comparison of wind turbine data and their sites according to various criteria.

A project like the present can serve to establish the current state as far as service and results of the existing machines within the Community, permitting the identification of areas not investigated, as well as serving to help those producers interested in generating wind energy as far as the supply of existing systems is concerned.

In any case the most important problem is, as in any data base, the necessary update which will represent certain cost.

e) **Technology R & D**

This project, second in importance as far as assigned budget, covers a whole series of technology aspects linked to the design of wind turbines.

The project is structured around the following themes :

- Aerodynamics of horizontal axis wind turbines.
  It consists of 3 projects whose aim is :
  To provide a coherent set of measured aerodynamic data accounting for axial and nonaxial flow, free stream turbulence and stall in high winds on three similar HAWT rotors with diameters 3m, 17m and 26m. These measurements are designed to quantify the relative importance of three-dimensional, unsteady and scale effects.
  Total budget : 871.000 Ecu.

- Wake effects.
  8 projects, carried out by as many institutes, analyse the effect of the wake of a wind turbine on the rest of the turbines in configuration, in wind parks.
  Total budget : 580.900 Ecu.

- Gust measurements and modelling.
  Formed of 4 projects and aimed at designing and validating a model which permits the measurement of the effects of turbulence on the dynamic response of the wind turbine structures.
  Total budget : 581.000 Ecu.

- Material testing.
  This is formed of 3 coordinated projects and its aim is the analysis of the critical structures from the point of view of fatigue in the wind generators.
  Total budget : 632.000 Ecu.

- Design criteria for wind turbines.
  Composed of 4 projects to analyse different basic criteria of the design of wind turbines in order to achieve maximum service.
  Total budget : 838.000 Ecu.

- Other actions.
  This action consists of 10 projects, normally independent of each other, in which a specified component of the wind turbine is studied or developed.
  Total budget : 1.206.000 Ecu.

As significant aspects, the following should be noted :

- In all the projects there is a coordination between the different research teams involved to interchange experiences and ensure the uniformity of unite criteria.
  This perhaps could be the most clear result of a project like the present one : the interrelation between research teams from different countries.

- Most of the projects are more or less theoretical studies and, although the scientific and technical qualifications of the research teams is high, and therefore from a scientific point of view the results are valuable, from the practical point of view, it is not clear what use will be made of the results. Probably a large part of the knowledge obtained will not transcend the academic area.

- It would be helpful if a company were linked to each of the projects to assume the evaluation of the developments carried out from an economic point of view.

f) **Development of MW-Size Turbine (WEGA).**

This is the most important project from the point of view of the investment made and is aimed at the development, construction and experimentation of three different wind turbines in the Mw range. An electricity company from the country where the machine is to be installed, participates in the project, and assumes the task of operating and maintaining the machine.

Without any doubt, from the point of view of electricity generation, for the production of wind energy connected to the grid, the companies tend to go for the size of machines of maximum power compatible with a good possibility of installation, operation and maintenance.

In this sense the objective is well chosen and the results will be useful in a medium-long term period. From an economic point of view, the costs per Kw of this sort of machine are well above those of the medium power machines (more than double), even though it is true that, with new developments and economies of scale when producing in series, it is hoped to reduce the costs drastically.

There might be some doubts about the need of developing three machines, although from the industrial point of view this is the most solid action of the programme.

3.5. EVALUATION OF THE PROGRAMME.

a) Scientific and Technical Achievements.

Seen as a whole, the programme is clearly designed and implemented from the point of view of the supply of wind systems.

That is to say a whole series of projects have been structured where the different existing problems in wind generation are analysed, taking the wind turbine as the central component.

Thus :

- A data base is developed and implemented in which the different types of existing wind generators are stored, their characteristics, functioning, etc.

- At a theorical-practical level all the most important aspects linked to the design of the wind turbines have been analysed, such as :
  - Gust measurements and modelling
  - Wake effects
  - Material testing
  - Aerodynamics
  - Design criteria

- Lastly, three wind generators in the Mw range are designed built and operated.

In a word, the project consists of offering a reliable system which can penetrate the market of electricity generation without having yet achieved costs, competitive with those of conventional energies.

Another way of approaching the objective of incorporating wind energy in the energy balance, and from our point of view the most efficient, would be from the side of the demand, that is : Carry out a segmentation of the market by type of application.

Thus, in a first approximation, four segments could be defined, each clearly differentiated.

1st segment : Very low power.

Basically directed at small agricultural applications, mainly water pumping, already operating, with adequate machines and with their own channels of industrialization and commercialization. In principle, no action is necessary on the part of the Community institutions.

2nd segment : Systems in isolated areas.

The possibility of covering small rural communities, without electricity, or insular systems as well as industrial installations of an agricultural or livestock type. In this case, it is necessary to develop solutions, not only the air turbine, which range from a system for an isolated house not needing a continuous supply, to the supply of a larger community, with a level of quality of service similar to the electric grid, using mixed equipment or storage systems.

3rd segment : Special applications.

Certain applications exist, such as desalination, which can function in a discontinuous way : when there is enough wind the plant functions and when there is not, it stops. In some way the wind energy is stored in the form of potable water.

4th segment : Connection to the general network.

The generic application is studied in the programme, with the fundamental problem of having to compete with cheaper systems, already installed in the companies. The criteria here is the saving of fuel and of investment in the parallel conventional production units.

In line with this strategy it would be useful to establish an R & D programme in which companies and research centres are integrated, and whose objective is the development of systems which meet the applications described in the 2nd and 3rd segments.

b) **Practical and Commercial Relevance.**

At the moment, from an economic view point, wind energy is at a pre-commercial level. In the Member States there is a significant installed potential power, and in some, such as Denmark, it has reached a considerable level of development, although it is true that the major part of the existing installations can be considered as experimental and for demonstration purposes. The step to a commercial level, if one thinks of installations connected to the network, would be to establish on a European level, a framework of incentives similar to those developed in California, which would allow the existing differential in respect to conventional systems to be compensated for.

In this sense, perhaps it would be useful to study the possibility of using projects such as the VALOREN programme, to supply these incentives for a transitory period, say until 1992, when a single market will be formed, with the object of propitiating a market capable of generating the economies of scale to permit the elimination of these current cost differentials. On the other hand, the development of systems capable of supplying energy to marginal markets such as those described beforehand, besides favouring and strengthening the development of depressed areas, could represent at a community level, a market of considerable size from the economic point of view. It could also be relevant to the Community aid programmes.

3.6. CONCLUSIONS AND RECOMMENDATIONS.

The third R & D programme in NNE, as refers to wind energy, has meant a consolidation of this line of research in the European Community in general.

An important research effort has been made in which nearly all member states have been involved, having established adequate communication channels between the existing research groups in this field.

Moreover, mainly from a theoretical point of view, the different technologies involved in the development of air generators have been analysed, specially studying aspects linked to reliability, availability and reduction in cost of these machines.

In the same way they have tried to involve the equipment manufacturing industries in some of the projects undertaken as well as the users, mainly electrical companies.

For all this, it can be said that we are in an optimum position to undertake new stages to allow wind energy, to be competitive with conventional energy, above all in certain applications, both from a technical and economic point of view.

In the new R & D programme in NNE it would be useful to take into account the following aspects :

- In relation to the project of studying resources, the European wind atlas for the moment is sufficient with the level of information it supplies, and more important would be to circulate it among potential users.

- It is important to finish the "European wind energy penetration study" as projected, ensuring that the expectations of use of wind systems existing in the community electrical companies is reflected in the study. This project can give valuable information in respect to the possible expansion of wind energy in the European Community.

The Technology R & D project has been interesting from the point of view of identifying research teams, establishing connections between them, through shared projects, analysing the different problems linked to the design of wind machines etc. However, in a new programme this type of action should be linked to concrete projects with the participation of a company to collect the research undertaken, and incorporate it in a concrete product or system.

Regarding WEGA Projects - once they have been completed - the results obtained, and especially to analyse the feasibility of this machine range from the economic point of view(generation costs). Further activities in this line would be influenced by this analysis. In any case the opportunity of descaling the machine to the level of power at minimum cost must be considered.

Finally, it would be useful to start a new project directed at developing systems of energy supply for insular systems or isolated communities, which are not connected to the network, or developing systems for special applications such as desalination. This applies to several of the renewable energy sources.

4. GEOTHERMAL ENERGY.

4.1. INTRODUCTION

The whole of the Crust of the Earth may be considered to be a source of geothermal energy. Over geologic time a very large store of heat has accumulated in the rocks. It is the energy source which causes volcanoes, builds mountains and moves continents. The temperature increases with depth : the geothermal gradient, normally 35715 C/km, may be as high as 100°C/km

The exploitation of geothermal energy began at Larderello, Italy (1902), and has grown to the present E.C. capacity of 500 MWe. This is about 10% of the World installed capacity, which has growing more rapidly in the U.S.A., Japan and Indonesia than in Europe. In addition, the direct application of geothermal hot water to space heating and agriculture is about 600 MWt, mostly in France and Italy, which is also close to 10% of the installed World capacity.

A geothermal reservoir consists of a hot fluid, a geological formation able to store the fluid and an impermeable cap rock. Geothermal reservoirs are frequently classified as "high enthalpy" (dry or wet) or "low enthalpy", depending on the temperature and thermal properties of the fluids permeating the rocks. The research has also shown that geothermal reservoirs may be engineered by fracturing deep-seated "hot dry rocks" (HDR) and by subsequently circulating surface water through them to extract heat.

The E.C.'s first stage in geothermal energy research and development began in 1975 with the broad aim of evaluating the existing and potential geothermal resources of Member States by giving financial support for the compilation of the large amounts of heat flow and temperature data that were available from various National organizations. By 1979 these data were used to prepare an "Atlas of Subsurface Temperatures" which contains extremely valuable temperature maps for depths from 500 to 5000 m.

A follow-up of this work started in 1983 by editing the "Atlas of Geothermal Resources in the E.C.", giving the locations, depths, extents and physical and chemical properties of known geothermal aquifers. This work will be published soon.

The third research stage began in 1985. Its purposes included extending the knowledge of specific geothermal reservoirs; improving the techniques of management and exploitation; and the development of the technology for extracting the heat from hot-dry-rocks at greater depths. This involved detailed examination of the physical and chemical properties of reservoirs; deep drilling techniques and instrumentation; brine and corrosion studies; geophysical monitoring and exploratory wells and initial economic assessments.

4.2. CURRENT ACTIVITIES.

During the third stage, 1985-89, the E.C. allocated 21 MECUS to 70 geothermal projects, many of which were concerned with improvements to existing technologies but many were novel in concept, requiring fundamental research, coordination of activities and shared risks. Attention was given to broader geological aspects. Tectonic structures quite often delineate different heat flow provinces. For example, the precambrian rocks underlying north-west Scotland were originally part of the Canadian and Greenland shields. The geothermal gradients are much lower than those of the younger Corneibian granite batholith of south-west England. Again, the Dogger low enthalpy aquifer of the Paris Basin is quite different from the high temperature anomaly of the Soultz area of the Upper Rhine Valley.

Hydrothermal fluids are frequently highly saline and so are good electrical conductors. Thus geo-electric exploration methods may be used to investigate a geothermal reservoir. Fractured or hot rocks reduce the speed of seismic waves. Consequently seismic tomography may be used to identify geothermal targets.

Two test sites which had been established at Travale, Italy, and on the Island of Milos, Greece, were used to modify the existing geophysical techniques, already in use for mineral and hydrocarbon exploration, for the peculiar conditions of geothermal exploration. This involved multinational collaboration between twelve teams from universities within the E.C. Exhaustive examinations were made of magnetic, electrical, magnetotelluric and seismic methods.

The structures of the volcanic zones of Olot, Spain, and Milos, Greece, have been studied using modern refraction seismic surveys.

Several E.C. projects have been concerned with thermal ground water reservoirs in the Triassic sedimentary basins of France, the F.R G., the U.K. and Denmark. These generally include low enthalpy reservoirs developed for space heating and agriculture. The red-bed sandstones often contain highly saline brines which present problems in the chemistry of reservoir development, in corrosion of equipment and in the disposal of brine into the environment. Geochemical studies are being used to predict the corrosive potential of the ground water in the F.R.G., Holland and Belgium.

Over time a reservoir may be reduced in temperature, pressure and rate of flow because of chemical changes in the reservoir during exploitation. The reinjection of brine after heat extraction is being studied in France as a potential means of disposing of it while helping to maintain aquifer pressure.

Mathematical modelling of reservoirs (e.g. the Mafete field, Italy) is being used to anticipate future conditions due to pressure changes and water-rock interactions. A novel combination of several disciplines (sedimentology, geochemistry, geothermometry and hydrodynamics) is being used to model the evolution of the Dogger aquifer using the available information from about 50 "doublets" (a combination of a production well and an injection well).

Electricity production from high enthalpy geothermal brines is normally achieved by "flashing" the brine to steam. Much of the usable energy is lost in the rejected hot water and the efficiency is low. So the "total flow" method is being developed in which the hot brine is allowed to expand through the nozzles of an impulse turbine to drive a generator. The gaseous exhaust phase then flows through a heat exchanger. The development of a prototype 200-500 KWe machine of this type with a target of 45% efficiency is being supported by the E.C.

The most novel, but highest risk research is in the field of hot-dry-rocks. Cold water is pumped down an injection well through any fractures present through another well to a power plant at the surface before being returned for another circulation through the system. To extract heat from igneous rocks like granite, requires the existence of natural joints, shears and tension cracks, or the rock must be artificially fractured. Temperatures high enough for space heating can be found at depths of less than 3 km over wide areas of Europe but if electricity production is sought, temperatures greater than 170°C will likely be required so that depths of 5 - 6 km may be necessary.

The key E.C. project is at the Cambourne School of Mines, south-west England in the Carnmellis granite which forms part of the extensive Corneibian granite batholith. Another promising development is under way in the Upper Rhine Valley at Soultz-sous-Forêts.

By 1985 the Cambourne School of Mines had demonstrated promising flow rates between three wells at depths of less than 3 km but at temperatures less than 100°C. Microseismic monitoring had shown that a large fracture system existed, extending downwards to depths of more than 4 km which was unexpected. At first much of the water had been "lost" to deep storage but by hydrofracturing with a gel rather than water, since 1985 flow recovery has been near 80%. It has since been established that the in situ stress field is anisotropic.

The next endeavour would be to create and tap a reservoir at a depth of about 4.5 km. Considerable progress has recently been made at the Soultz Project which is a French-German feasibility study of an area 20 km north of Strasbourg. The project is sited in an old known oil field where 1300 m of sedimentary rocks overly granite. A temperature anomaly is known to exist, possibly because of the natural radioactivity of granite.

One hole has been drilled 1800 m, well into the granite, after a few month's lost time due to an accident in drilling. The region is being assessed as a possible hot-dry-rock pilot project from either the granite or the overlying porous sandstone. There exists a nearly major demand for space heating as well as for electricity.

Stress release within a reservoir may create cracks and small faults,generating seismic noise which can be monitored. This has proved useful for studies of the hydraulic fracturing of wells. Experiments are under way at Le Mayet de Montagne in central France to investigate the possibility of stimulating pre-existing fractures between two 800 m deep bore-holes.

4.3. EVALUATION

The Quality of the research has been excellent. The participants have been well qualified and have carried out their projects with due regard for E.C. objectives. Most of the 70 projects are on schedule. About 30 had been completed by the end of 1987 and the remainder will likely be completed by the end of 1988. There has been good progress in the collection of basic data; the management of both high and low enthalpy reservoirs;reinjection and the control of hot saline brines; the testing of geophysical methods; and the drilling of moderately deep holes into hot geological formations.
Much of the work on high and low enthalpy reservoirs has immediate relevance to commercial utilization but the work on hot-dry-rocks is not likely to have practical utilization for another decade or two.

However there are "spin-offs" which are applicable to hydrocarbon exploration in deep geological structures.
There are no fundamental reasons why deep holes cannot be completed with existing techniques. The method of detection of helium in boreholes which has been developed at Soultz and the techniques for in situ stress determination by caliper logs and packers should have immediate wide application. So also should the corrosion and scaling studies.

We have found little evidence of unnecessary duplication or wasted effort. The E.C. staff have planned, organized and monitored the programme effectively with a minimum of bureaucratic interference with the scientific activities. There has been an appropriate and effective use of external consultants. However, in the initiation of new projects there still remain some apparently unnecessary delays in funding, after approval has been given.

Since the beginning there has been an admirable focussing of effort from data collection, through fundamental research, to field testing and to technical evaluation at the "pilot-plant" stage.

At the E.C. level considerable national cooperation has been achieved. Nations such as Italy and France, which have been involved in geothermal exploitation for many years, have shared their knowledge and experience. International teams have now been established where none previously existed and, if encouraged and preserved, should be the instruments for future rapid exploitation of geothermal resources when economic or strategic necessity arises.

There has been established a system of "Contractor's Symposia" where common problems are discussed; knowledge and experience are shared; projects are subjected to peer review, and research priorities are identified.

e.g. "The Proceedings of the First E.C. Workshop on Geothermal Hot-dry-rock Technology" May 1986, to which Japanese and U.S.A. experts were invited with considerable mutual benefit.

Geothermal exploitation has the potential to reduce the E.C. dependence on imported petroleum and to contribute to the goal of energy self-sufficiency. In general the methods are environmentally more benign than the burning of fossil fuels. Problems with the treatment of saline brines are manageable through the process of reinjection. Long-term environmental effects appear to be less hazardous than those of radioactive waste disposal, acid rain or the "greenhouse" effect.

4.4. CONCLUSIONS and RECOMMENDATIONS.

The compilation of basic geothermal data and evaluation of existing resources is essentially complete and any additions may be left to Member States to gather, with advice available from other members. The excellent avenues of cooperation should be preserved and sufficient E.C. funding provided to maintain the viability of the research teams which have been established. Means should be sought to make more widely available, those reports which deal with scientific and technological achievements at the "pre-competitive" stage in an effort to improve the transfer of technology.

The research and development of "dry" high enthalpy resources has reached the level of sophistication that it may be left to Member States and further E.C. funding could be terminated. However, the work on "wet" high enthalpy resources should continue to receive E.C. funding because of the importance of brine and corrosion studies to the E.C. environmental policies.

The development of low enthalpy resources has also reached the level where the nations hosting the resources, and most likely to benefit from their exploitation, should fund future development. The E.C. could withdraw, gradually, from the funding.

There will be a renewed need for basic research into the nature of deep geologic structures because of the E.C. renewed interest in hydrocarbon resources as well as the geothermal resources. Common interests such as seismic profiling and the understanding of in situ stresses still require fundamental research and the application of modern data processing techniques. It is surprising that the oil industry does not appear to be using seismic tomography (perhaps it is considered proprietary) or attenuation measurements. On the other hand, the oil industry has great experience with hydrofracturing and the stimulation of three-phase reservoirs, for enhanced recovery.

In the fourth E.C. stage it should be advantageous to have more industrial participation along with the Universities and the Research Institutes.

It is in the field of "Hot-Dry-Rock" where E.C. efforts should best be concentrated. Admittedly it is expensive, and risky, in that the technology is still primitive and the fundamental science is incomplete. Furthermore, the economic feasibility is still quite doubtful. However the time-scale for its development and evaluation is comparable to that for the probable return of high hydrocarbon prices and E.C. shortages. Thanks to the efforts at Los Alamos in the U.S.A. and at the Camborne School of Mines, England, in drilling and fracturing, hot-dry-rocks is poised to take great strides. First drill a bore-hole to a hot enough depth; then measure the stresses in situ; stimulate a fracture zone; from a second partially drilled well map the fractures using seismic tomography and monitoring; direct the second well into the fracture zone and hydrofracture with a high temperature gel.

Hot-dry-rocks need a pilot project but it is probably too expensive a risk for a single State. In the past, National funding has greatly exceeded E.C. funding of geothermal development, so it would be appropriate for E.C. to concentrate its available funds in this area in the next stage. Great care will be required in selecting the site for such a cooperation project. Perhaps the E.C. should fund the research, field studies and well-logging while the drilling should be funded by the host country (which will "own the hole"). Major decisions will likely have to be made within a year or so.

We find the proposed combination of Geothermal Energy with Deep Geology to be both logical and prudent and should be given high priority in funding by the E.C.

5. ENERGY CONSERVATION

5.1. The promotion of the rational use of energy plays an essential role in the energy policy of every industrialized system, included the European Communities. A few remarks on the effects of energy saving on the economic system and on the barriers that prevent the individual economic agents to operate more efficiently in that direction are useful in the present context to evaluate the effectiveness of the R&D programme in Energy Conservation and the directions in which it could be further implemented.

The relevance of a rational use of energy, which in general goes with a decrease in energy consumption for a given level of production or of comfort, cannot be properly evaluated if one considers only the direct marginal costs of saving a unit of energy as compared to providing an additional unit; as a matter of fact the savings in total costs incurred by the economic system as a whole that accompany the decrease of the energy intensity are often much more relevant than the direct cost savings. The environmental marginal costs connected to the energy consumption, as to other human activities, are increasing with the total consumption, because one has to cope with a given capacity of the environment to recycle the pollutants; their fraction that has to be abated to keep an acceptable environmental quality must therefore increase with the total quantity produced and the related marginal costs, with a given technology, increase too. A somewhat similar argument applies to the prices of the energy sources, especially to oil : the total global demand has effects on the prices, that therefore cannot be considered as given; when evaluating the advantages of actions directed towards a more rational use of energy at a macroeconomic level one should compare the investments costs for saving energy not simply with the marginal costs of the oil saved, but with the overall impact of the economy of the oil price change due to higher consumption. Finally the substitution of scarce raw materials, which are mostly imported, with technology and investments allows to make better use of the industrialized countries own resources, at present not fully employed.

The examples given above refer to the externalities, that is to the costs that are incurred by the society as a consequence of a given action and are not reflected as direct costs for the economic agent responsible of the same action. The fact that the costs as seen by the individual agent and by the society as a whole are not equal (or, which is equivalent, that the macroeconomic set of conveniences is different from the microeconomic set), implies that in the case of energy use (as in other cases) the market allocation mechanisms alone are not sufficient to guarantee the highest degree of growth and development to an economic system and that adjustments to them that reflect at the microeconomic level the macroeconomic set of conveniences can be very effective in widening the opportunities.

Among these adjustments of the market mechanisms the public funding of R & D in energy conservation finds undoubtedly its place, as it transfers to the Community at least part of the costs of development of new technologies energy saving; this is not, to be sure, a sufficient instrument to achieve the internalization of the externalities; the fiscal policy, for example, is another complementary instrument that can be adapted to the transfer of external costs connected to the use of the commodity in its price.

But there are other barriers to the achievement of an optimal level of energy intensity (that corresponding to the macroeconomic convenience) which have to do with various "frictional" effects, which would be present also if the externalities were all completely internalized. All the studies on energy conservation in industry find, for instance, that the time of return on investments required by a firm (not belonging to the energy sector or to very energy intensive sectors) to invest in energy saving equipment is

much shorter than the typical values considered acceptable for other investments. The reasons that justify this behaviour of the industrial agent are manifold, but the most important can be traced to the following two : the first has to do with the priorities in investments, as the entrepreneur tends to invest in equipment that improves the productivity, the product quality and the market share of his firm, all determinant factors of his success or of his survival in the market; moreover his competence and knowledge of the field allow him to evaluate quite accurately the level of uncertainty or risk of the investment, which therefore does not require to keep large margins for unknowns. An investment whose only justification is energy saving, on the contrary, affects a very small fraction of the added value of his firm, typically 5 to 10 %, and requires knowledge and competences that are not usually under his direct control : it is therefore reasonable that energy saving investments are not high in his priority list and are considered more risky than others, requiring therefore to be acceptable a much shorter time of return than usual. A second reason is connected to the fact that modification of processes to achieve energy saving often has as a side effect the introduction of elements of rigidity on other factors of production (like labour), whose share in the final costs is much higher than that of energy; the cost associated with such added rigidity is difficult to evaluate and the problem is that the advantages of the investment are proportionate to a small fraction of the total added value, the energy cost, while the risks are proportionate to a much larger fraction of the added value, for instance the labour cost. These arguments do not clearly apply with the same weight to firms of the energy sector or of very energy intensive sectors : the empirical evidence shows that these firms are the most prompt in adapting the energy intensiveness of their production processes to the relative costs of energy and equipment. Different are the barriers to the diffusion of energy saving equipment among final consumers : the deep-rooted customs on one hand and the deficiency of an established supply of reliable energy saving equipment on the other concur to lessen the investments devoted to energy conservation in the sector of the final consumption.

The preceding considerations on the barriers that slow down the implementation of all the rational actions in terms of energy conservation intend to show that the lack of technological solutions is not the most important among them; a programme whose aim is the promotion of energy saving and energy conservation should therefore seek the support of other disciplines, as a help in understanding the nature of the barriers that prevent the achievement of the objectives and in suggesting the possible ways to overcome these barriers. The presence of market barriers (examples are the reluctance to invest in energy saving apparatus and the effects of added constraints to the firm operations sometime linked to energy conservation measures), of psychological barriers due to individual preferences (the car driver behaviour, often considered "not rational", is generally regarded as the best example) and of institutional barriers (for instance old sets of regulations whose revision and modernization is not timely, to say the least) is there to remind that a purely technological approach is not generally sufficient to achieve the desired results and should be complemented by studies in economic and social sciences. It should be remarked that a wider approach at a system level, not limited to technological R & D at the component level, including the economic and behavioural aspects of the diffusion of energy conservation as research subjects, would also provide in perspective a useful hint on the priorities of intervention measured in terms of expected results and on the complementary instruments that have to accompany the technological R&D.

5.2. The R & D in Energy Conservation has had an important role in all preceding Non Nuclear Energy (NNE for short) R &D programmes of the Commission. The main lines of work in NNE1 and NNE2 programmes have been : buildings (in the domestic and commercial sectors); heat pumps; waste heat recovery; transport; industrial processes; energy storage; recycling of materials (in NNE1); production of energy from wastes (in NNE1). The objectives of NNE3 programme, being evaluated, have been regrouped in four main lines: buildings, industry, transport and energy storage.

The developments of improved insulation materials and techniques in buildings, of improved efficiency and effectiveness of energy-consuming equipment, of a better understanding of the behaviour of the buildings as integrated systems are the themes dealt with in NNE1 and NNE2; this line was supposed to continue in NNE3, but the budget limitations suggested to limit the field of intervention in the building area to the heat pump development.
Heat pumps have been the object of R & D within all the preceding NNE programmes: in NNE1 the action has been broad-scoped and mostly exploratory; NNE2 devoted resources to the performance improvements, to the development of new refrigerant mixtures and to studies and preliminary developments of absorption pumps. NNE3 actions are concentrated on the pursue of the development and of the achievement of better performances of absorption pumps; the agreement recently reached among the industrialized countries to reduce the use of freons requires to intensify the search for solutions not making recourse to conventional compressors.

The very ample field of heat recovery in industrial processes was touched upon in NNE1 and NNE2:technologies for residual heat recovery, use of residual heat to generate mechanical and electrical energy, improvement of heat transfer processes in industry, heat recovery in buildings are typical examples of subjects dealt with in the preceding programmes; NNE3 has concentrated on heat exchanger development.

As far as transport is concerned both NNE1 and NNE2 approach has been centered on development of new engines and improvement of performances of existing ones; in NNE3 all the efforts have been devoted to a very well coordinated research on the combustion process to achieve a much deeper scientific understanding of all the complex reactions taking place during combustion with the aim of a better control of performances and noxious emissions. This line of research is coordinated with a similar one dedicated to the combustion processes in stationary sources. It can be remarked that a system approach to the energy saving in transport has not been considered until now as a suitable field for the Community funded R&D in NNE programmes.

R & D on various industrial processes with the aim of improving their energy efficiency has been conducted in all the preceding NNE programmes; in NNE3 stress has been laid upon specific processes (like the combustion) and specific components (heat exchangers and unit operations).

Studies on energy storage, thermal, mechanical and electrical, were present in NNE1, mostly of exploratory nature; NNE2 concentrated on the development of electrical batteries with solid electrolytes, through a coordinated international collaboration, while giving some attention also to mechanical energy storage, which turned out to be of marginal interest. NNE3 has proceeded on the line of the advanced electrical batteries to a point which can be considered close to industrialization.

A line of work that started with the last programme, NNE3, is the R & D on fuel cells : first generation cells are already operating in prototype plants, but the second generation solutions, with expected efficiencies up to 60 % (as compared to the 40% achieved up to now), require intense research and development efforts, particularly in Europe where this field has not been tackled with the same attention as it has been done in the USA and Japan.

5.3. The NNE3 Energy Conservation subprogramme has assigned a total of 121 contracts, as of the end of February 1988, for a total amount of about 21,62 MECU, corresponding to an average cost of 178.670 Ecu per contract. The disaggregation into main lines of activity is as follows :

a. Absorption heat pumps : 12 contracts (3 of which multipartner and 4 associated) for a total amount of about 1,570 MEcu (average 130.818 Ecu/contract);

b. Industry-heat exchangers : 7 contracts (6 of which multipartner) for a total amount of about 1,330 MEcu (average 189.997 Ecu/contract);

c. Industry-heat transformers : 12 contracts (7 of which multipartner and 7 associated) for a total amount of about 0,992 MEcu (average 87.702 Ecu/contract);

d. Industry-fluids and components : 1 contract (multipartner) for a total amount of about 0,200 MEcu;

e. Industry-combustion in stationary sources : 11 contracts (all multipartner and 8 associated) for a total amount of about 1,897 MEcu (average 172.448 Ecu/contract);

f. New industrial processes : 21 contracts (17 of which multipartner and 8 associated) for a total amount of about 3,114 MEcu (average 148.284 Ecu/contract);

g. Combustion in mobile sources : 24 contracts (all multipartner and 16 associated) for a total amount of about 6,977 MEcu (average 290.723 Ecu/contract);

h. Electric energy storage : 11 contracts (10 of which multipartner) for a total amount of about 2,252 MEcu (average 204.764 ECU/contract);

i. Fuel cells : 22 contracts (13 of which multipartner and 3 associated) for a total amount of about 3,286 MEcu (average 149.348 Ecu/contract).

The priority effort in the Energy Conservation subprogramme is devoted to basic and applied research in the fields related to the combustion process, be it in stationary or mobile sources : this item accounts for a little more than 40% of the funds allocated until now. It has to be remarked that the Commission has succeeded in this particular case in involving all the European centres of excellence in the field, university, public and industrial research groups; the very nature of the subject, which is clearly at the level of precompetitive research, has brought together in this action the most important car manufacturers with a number of various research centres. One of the objectives was in fact to establish an active collaboration among the best scientists of the field in Europe to allow a systematic approach to the subject, approach that would have been impossible at a national level simply for the lack of human resources; this objective has been fully achieved and the European group that has been formed through the Community funding is now becoming the world leader. The scientific objectives of this line of work, which can be summarized :

a) in the development of a three dimensional computer simulation model for the design of a more efficient and less pollutant petrol and diesel engine;
b) in the preparation of a data base in the kinetics of the chemical reactions taking place in combustion; and
c) in the computer simulations of the chemical reactions in turbulent combustion, validated by experiments equipped with very sophisticated diagnostic tools;

are determinant to achieve an improvement in the noxious emissions without impairing the combustion efficiency. The first steps of the programme are proceeding as expected, but it must be recognized that the goal is very ambitious and it will take many years more to arrive at a satisfactory scientific understanding of such a complex process as combustion is; however combustion is so widely used in energy transformation equipment that an improvement in its basic knowledge is certainly of the utmost interest.

The actions related to fuel cells, absorption heat pumps and advanced electrical batteries are in some sense comparable to that in the field of combustion, these are areas where precompetitive research is needed to explore possible technological solutions before passing to industrial applications and in perspective all of them could have very wide use. In all three cases the Community funding has allowed the establishment of transnational collaborations that bring to the critical mass for producing good scientific results also those specialized groups, dispersed but of very high quality, that are typical of the relatively small European countries. The fuel cells action is complementary to national programmes and is concentrated on second generation cells which are expected to operate at much higher efficiency than the phosphoric acid cells : the molten carbonate fuel cells, the solid oxide cells and the solid proton cells. The work in heat pumps (the relative contracts go under the headings "Heat pumps" and "Industry-heat-transformers" has been concentrated in the development of absorption pumps, as more basic and applied research is needed for this solution that, among other interesting advantages as compared to the traditional mechanical heat pump, avoids the employ of freon, considered at least partially responsible for the ozone layer depletion and whose use, for this reason, should be limited as far as possible. The R & D in advanced electrical batteries started with the objective of developing batteries with energy and power density consistently higher than the conventional lead batteries, while keeping comparable cost levels, having in mind applications like the electric vehicle, where the present battery weight is an evident drawback. The international collaboration started in NNE2 programme and continued in NNE3 and, after a thorough study of possible solid electrolytes, arrived to a choice which has been further developed and is now close to industrialization; the energy and power density achieved are in line with the objectives, which were respectively factors of 1/5 and 1/2 as compared to the lead-acid batteries.

The other actions refer to more fragmented lines of research, like the heat exchangers (where an interesting issue is the high temperature ceramic heat exchanger), the recourse to spheroidal cast iron as a substitute to steel in high fatigue strength applications, energy saving advanced technologies in textile industry, improved design for glass kilns, etc. In some of them (it is the case of the technologies for the textile industry and of the glass kilns) there is an international collaboration, though limited in size; but most of these subjects are in areas close to competitive research, they are therefore of more specific interest of single firms and the diffusion of results presents problems of property.

5.4. The Energy Conservation subprogramme appears to proceed according to the objectives stated and approved; the limitations in funding has caused the cancellation of the line of research relative to energy savings in buildings and some other readjustment.

The scientific quality of the work is in many cases excellent, and in general appears to be good. A very high level of transnational collaboration is achieved in about four fifths of the subprogramme (in terms of funding); the rest deals with more specialized subjects whose interest is relatively less diffuse.

The R & D funding by the Commission of the European Community is an integration to that provided at the national level, which for the Community as a whole amounts to much higher sums dedicated to different aspects and sectors of R & D in energy conservation. It has however an important function in some definite cases, which should represent the areas of priority intervention of the Commission.

Perhaps the most evident of such cases is when a precompetitive research is highly specialized and can therefore profit from the synergies derived from the collaboration among centres of excellence distributed in different Member States; the Community funding in this instance, insofar as it brings effectively together these competencies otherwise dispersed at a scale which is insufficient for achieving the desired results, is necessary and cannot find efficient substitutes at the national level. Another case where direct R & D funding by the Community finds its justification is the promotion of lines of precompetitive research, considered prioritary, in countries where for a number of reasons they are not supported, while the related scientific and technical competences are available. In general an indirect R & D support, providing the resources for bringing together the experiences and the results of national groups, through meetings, workshops and topical conferences, is a certainly useful contribution by the Commission which would be difficult to substitute with national fundings. It appears less appropriate the funding of industrial research which is close to commercialization, as in this case the diffusion of the results is certainly more limited.

Very good examples of effective R & D actions, as measured with the above criteria, are the programmes on combustion, fuel cells, advanced batteries and absorption heat pumps. All these actions are relative to precompetitive research, of very high and wide interest, well conducted and managed; are based on ample transnational collaborations and would therefore be much more difficult, if not impossible, to organize without the Commission intervention. Some of them, particularly combustion and fuel cells, need certainly to be continued, with a readjustment of objectives, in the future NNE programme. The funding of the more fragmented themes should generally be left to the Member States' research agencies : it is however appropriate the Commission's support in the organization of topical meetings and conferences whose aim is the exchange of experiences and results among groups of different countries and, possibly, in exchanges of experts in view of the harmonization of the scientific and technical level within the Community.

A final remark has to do with the subprogramme principal objective, the more rational use of energy in all sectors of the economic systems (not only in industry) and with the most appropriate instruments to achieve it. We dispose of plenty of studies supporting the opinion that from the purely technological viewpoint the energy consumption in industrialized countries could be reduced by important amounts, without appreciable changes in personal comfort and with the same industrial output, through the recourse to various energy saving technologies, all presently well known and all fulfilling the condition of economic convenience. It is not an easy task to asses how well is founded this current opinion; but anyhow that leaves us with a dilemma, either the barriers to the diffusion of economically convenient energy conservation are not due to the lack of technological solutions, or, if there are technological barriers, the conventional methods of technological assessment are not reliable in their evaluation. As it has been very briefly outlined in section 1 of the present chapter, the problem of energy saving in a complex system, composed of a very large number of economic agents of different nature and with different values and capacities, cannot be efficiently approached taking into account only the technological aspects, that probably are of minor importance as compared to all other aspects.

The presence of market, psychological and institutional barriers that hinder the diffusion of energy conservation measures suggests to complement the financially much heavier efforts in technological research with a modest research effort in economic, social and behavioural sciences in order to analyze the response of the system to the different actions supporting an energy saving policy and to provide guidance on the choice of the most convenient actions in technological research; it would be of great help in the achievement of the objectives to dispose of systems view complementary to the component view, typical of the purely technological approach. This last remark, applies particularly to transport, where the dynamics of energy consumption remains quite high and where there is little room for diversification of energy sources.

6. UTILIZATION OF SOLID FUELS.

The chief tasks of the existing programme are to foster the developments of new methods for the combustion of low quality fuel (coals with high contents of impurities, lignite, peat) and for the general reduction of polluting emissions (SO_2, NO_x, dust) by cheaper methods than those now existing.

6.1 Method 1 : Water/fuel suspensions.

This process is bound to be energy costly, since the water has to be evaporated. The process as now developed is economically viable only in special circumstances. The costs could be somewhat reduced through the development of cheaper methods of preparing the fuel-water mixture. The main interest arises from cases where the fuel has a negative price (industrial wastes) or is difficult to burn otherwise (oil shales, peat) and this method promises to keep the pollution at an acceptable level.
There could also be interest in it as a method of introducing coal burning to areas only used to oil, because the fuel arrives in liquid form.

6.2. Method 2 : Fluidized Bed Combustion (F.B.C.)

This has many advantages, notably the ability to extract the sulphide and other impurities before the smoke leaves the combustion chamber. However, the difficulties need also to be mentioned :

- the success of the process depends on the quality of the limestone used, its origin and its porosity, with an efficacy of the sulfalour retention for a given ratio Ca/S at a given temperature (i.e. 850°C) that can vary by a factor of 5, which can be improved by additives (NaU, CaU2, Fc203) or the presence of alkaline ash;

- the erosion, corrosion and deformation of the limestone cannot easily be controlled.
- fine ash of high resistivity is produced in the form of a dust which therefore is difficult to contain with electrostatic filters.
- large amounts of waste are produced, which are difficult to store or dispose of in an economically and environmentally acceptable fashion.

Many different efforts are being made throughout the world to deal with these problems, and it is not easy to be well informed of them all. Three methods in particular are being pursued :

(A) the deep or bubbling bed (first generation) under atmospheric pressure,

(B) the expanded circulating bed (second generation) also under atmospheric pressure,

(C) pressurised F.B.C., still at the development stage.

With (A) the high Ca/S requirement (3 to 5) to achieve acceptable desulphurisation (80 %) is a grave disavantage, mitigated by (B) where the requirement is reduced to 1.5-2, but with 10-25 % higher investment costs.
Both (A) and (B) take much more about ten times space than conventional boilers so large outputs (over 300 MW) are hardly achievable. With a pressurised F.B.C. under 10-15 bars pressure the size disadvantage does not exist, but it appears difficult for any F.B.C. to limit NOx emissions to an acceptable standard. The Duisburg (B) Plant (90 MWcl) in operation has a NOx value lower than 2.00 mg/m3.

6.3. Method 3 : Integrated Coal Gasification Combined Cycle (I.G.C.C.)

This process was basically developed several decades ago but recently interest in it for electricity production has given it a new lease of life although it requires radically different power stations from existing ones (whole F.B.C. requires only modest changes). I.G.C.C. produces far less waste than F.B.C., produces valuable pure sulphur, responds well to changes in fuel and can be built up in modular fashion.

Many different types have been tried, but the MWe unit in the Mojave Desert is the most important one. It has produced, since it started up in 1984, excellent emission reductions (SO2 97%, NOX 90%, dust 99.9%) but the efficiency has not yet attained its forecast value of 40-43%.

Here (as in pressurised F.B.C.) the problem is the working of a gas turbine with the impurities contained in the synthetic gas, limiting its working temperature and life.

6.4. Recommendations

The Community has substantial, if expensive, resources of coal and also has lignite and peat. To replace some of the imported oil by imported coal is also valuable in diversifying the Community's external energy dependence. A solid fuel programme is therefore an essential part of the NNE Programme and we regard it as important to continue it, especially so that solid fuel combustion can meet the emission standards set.

The difficulty for DG XII's intervention in this field is that little research can be defined, but much development which however is generally linked to major installations of risk, high cost and long time scale.

Therefore we suggest the following areas in a programme (the financial volume of which could be moderately reduced from the present one) for DG XII financing and management.

(a) A major effort at data collection on existing undertakings, especially in regard to items like availability, reliability and component life, which are so important for market penetration.

(b) An appreciable R & D effort to develop better diagnostic tools for F.B.C. and also for I.G.C.C., especially but not exclusively to assist with improving gas turbine efficiency and life.

(c) To support current projects of our preferred types, Pressurised F.B.C. and I.G.C.C., both directly and also associated problems such as waste disposal.

(d) A gradual termination of other existing work, with full dissemination of results.

We would welcome support for imaginative and novel proposals to improve the exploitation of coal which are environmentally acceptable.

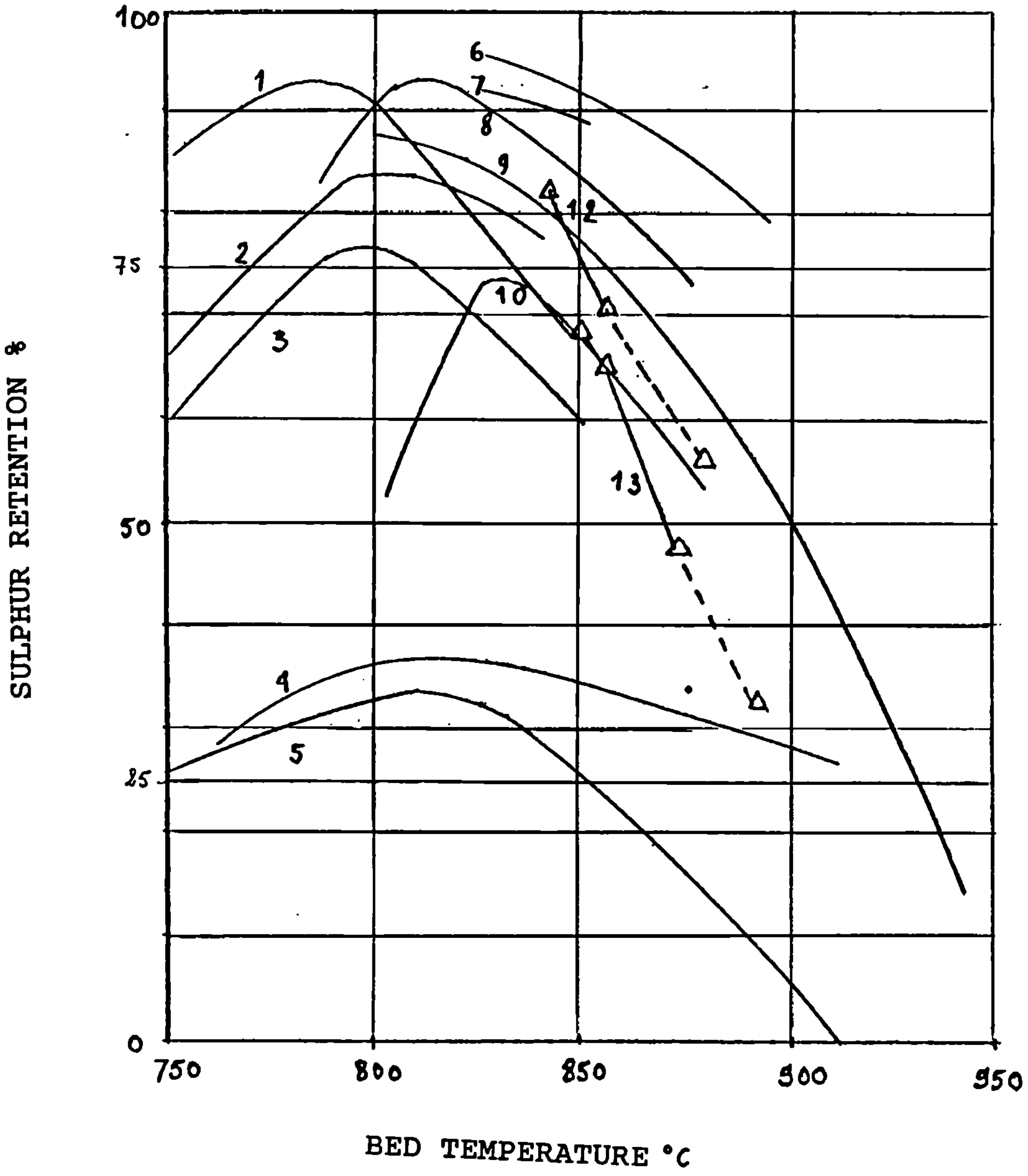


Figure 6. The sulphur retention vs. the bed temperature

1. König Ludwig, Mittelgut, Ca/S = 6 (3)
2. König Ludwig, Mittelgut, Ca/S = 2-3 (3)
3. König Ludwig, Nuss, Ca/S = 4.8 (3)
4. König Ludwig, Mittelgut, Ca/S = 0 (3)
5. König Ludwig, Nuss, Ca/S = 0 (3)
6. Wakamatsu, Ca/S = 5 (7)
7. Wakamatsu, Ca/S = 7 (7)
8. TVA, Ca/S = 2.3 (2)
9. Flingern, Ca/S = 2 (4)
10. B & W, Ca/S = 3 (8)
12. Chalmers, Ca/S = 2.7
13. Chalmers, Ca/S = 1.3

7. PRODUCTION AND UTILIZATION OF NEW ENERGY VECTORS :

7.1. INTRODUCTION

It seems likely that the world will continue to rely on liquid hydrocarbon fuels in the near future, especially for transportation. The greatest source is still crude oil and the currently relatively low prices may tend to erode memories of petroleum embargos, fuel shortages and rising prices. The new Energy Vectors sub-programme of the C.E.C. was introduced in 1985 to provide fresh approaches to the goals of security of supply and competitiveness. When consumption again approaches production capacity, the price of crude oil is likely to increase and alternative liquid fuels may suddenly be in significant demand within the E.C.

Concerns about the availability of liquid fuels are not at all new ! In the past, much effort has been devoted to the development of processes for the conversion of solid fuels like coal, oil-shale and tar-sands and of biomass, to liquid hydrocarbons. Converting coal into a liquid, transportable fuel requires either the addition of hydrogen to the coal's complex molecules (macerals) or the removal of carbon in order to improve the hydrogen/carbon ratio. Many methods of liquefaction have been proposed, tested and commercialized, beginning with the Bergius/Farben process in Germany in the 1920's. Variations of Fischer-Tropsch synthesis have been exploited throughout the world for over forty years.

7.2. CURRENT ACTIVITIES.

The New Energy Vectors research was a relatively late addition to the overall energy research programme. As originally proposed, it contained provision for the production of synthetic fuels from biomass; the generation of hydrogen for synthetic fuel production; and fuel cells. These were deleted, or drastically reduced, because the proposed funding was cut from 43 MECUS to 10 MECUS in 1986.

During the third C.E.C. research stage (1985-89) some 30 projects were funded. These are primarily concerned with the development of new or improved processes for the liquefaction of solid fossil fuels. A few projects deal with the conversion of natural gas to alcohols; with thermochemical biomass conversion; and the co-refining of coal and petroleum. Emphasis is being given to the development of new catalysts; to the byproducts of coal liquefaction and to system studies to evaluate new processes and new materials. In order to improve competitiveness the latter are including some economic analysis.

Many of the New Energy Vectors projects were late getting started (not until 1987) because of policy changes and financial restrictions, so many are still in the early stages of implementation and results have not yet been obtained or may not be ready to be reported.

7.3. EVALUATION

The quality of the research so far has been very good. The investigators are well-qualified and there is a good representation from universities, institutes and industries. Multi-national participation is the norm either through joint projects or by collaboration. The projects are being carried out on schedule and should be concluded satisfactorily by the end of 1989.

Regular, semi-annual topical meetings are held among contractors for the coordination of activities and the dissemination of results. A major symposium will be held 6 - 8 June 1988 in Saarbruken where common problems will be discussed, peer judgement will be exercised and priorities will likely be established.

Considerable progress is being made in cooperation between universities and industries of the Member States. e.g. the work on the selective production of alcohols from natural gas by G.E.R.T.H.

(Groupement Européen de Recherches Technologiques sur les Hydrocarbures). There is established collaboration on catalysts between institutions in France, Spain and the Netherlands where different, but complementary, approaches and equipment are used. The C.E.C. staff have planned, organized and monitored the research projects effectively, using expert consultants appropriately. There appears to be little duplication of effort or undesirable bureaucratic interference.

The research is applied in nature, some is quite basic but much is very close to the competitive stage of commercial exploitation. The academics involved appear to have close ties with industry so that the transfer of technology should be quick when the economic situation warrants it.

7.4. CONCLUSIONS and RECOMMENDATIONS

Because of relatively low petroleum prices there is no present urgency to press ahead with R & D on synthetic fuels. The Fischer-Tropsch process is available and has been well tested for over 40 years. However the research promises to improve the efficiency and competitiveness of the process substantially and economic exploitation could become attractive in appropriate circumstances.

We consider the Staff proposal for including synthetic fuels as part of the Hydrocarbon sub-programme to be appropriate for the period 1989-92. The basic research should be continued but at a reduced level, provided it is sufficient to preserve the capabilities of the collaborating institutions and so provide insurance against sudden socio-economic changes.

8. ENERGY SYSTEMS ANALYSIS AND MODELLING.

8.1. The economic models in general, and the energy models in our particular case, are a necessary tool for the planners and analysts; while much too often their function as a forecasting tool is over-emphasized, in fact what should be stressed is their usefulness in the analysis of complex systems. As the development of models requires and implies a thorough investigation of the system under study, the definition of the relevant factors influencing its parameters and the recognition of the relationships among them, such a study has the important result of bringing to light the detailed behaviour of the system when subjected to changes. Models are therefore necessary instruments in the decision making or in the policy making processes, helping to give coherent answers to the typical "what if" questions that are frequently met; it is sufficient to recall here as an example how useful and beneficial can adequate models be in the complex decision process that will eventually bring into being the Internal Market. The Energy Systems Analysis programme provides therefore tools that are widely needed not only in the Administrations of the Member States and in the Commission itself, but also in the utilities and firms of the energy sector; moreover it provides the necessary data bases for the different models relative to the Member States.

Depending on the objective of the specific study of interest the models can be oriented to the demand or the supply, can be dynamic or static, can be aggregated or disaggregated by sectors, can try to simulate the reality in a given moment in time, optimizing some parameter, or to model the future in different time horizons, long, medium and short term. Various models have been developed by national groups of experts, under the guidance of DG XII; the level of coordination appears to be exceptionally good and the various national groups operate as a team.

In this field the cooperation of national groups is important in the phase of model development, but becomes essential in the construction of the national data bases. Another very positive aspect of the cooperation among the national groups is the unification of the models devised for a definite task, avoiding their proliferation which would make any comparison or combination of the results practically impossible.

8.2. The R & D in Energy Systems Analysis has been part of all the Commission Non Nuclear Energy (in the following NNE) R & D programmes, starting from 1975; various models have been developed in response to different objectives : among them we find the model which goes under the name of HERMES, designed to integrate economy and energy at a sectoral level; the energy demand models, called STEM, MIDAS and MEDEE, respectively short, medium and long term; a supply model, EFOM, which focuses on the analysis of the energy production and consumption systems, integrated with the optimization of investments in the pollution abatement equipment. An important part of the activity of this section of the NNE R & D programme has been the creation of the data bases for the various models; it is convenient to remind here that the effort required to build up the data base is often, if not always, more demanding than that necessary for the creation or the operation of the model itself.

8.3. The NNE3 Energy Systems Analysis subprogramme has assigned a total of 54 contracts, as of the end of July 1987, for an amount of about 3,637 MEcu, corresponding to an average cost of 67.360 Ecu per contract; the contracts cover the years 1985-87 and the number of contractors is about one half of the number of contracts for the same activity.

The main areas are the following :

a. Hermes model : 18 contracts for a total amount of about 1,037 MEcu (average 57.601 Ecu/contract), relative to data base elaboration and model applications;

b. EFOM model and energy-environment integration : 14 contracts for a total amount of 1,057 MEcu (average 75.505 Ecu/contract), mainly relative to data base elaboration;

c. MEDEE model : 6 contracts for a total amount of about 0,457 MEcu (average 76.201 Ecu/contract), mainly relative to data base elaboration;

d. Indicators : 7 contracts for a total amount of about 0,410 MEcu (average 58.530 Ecu/contract), relative to the elaboration of energy indicators and energy streams, useful for the preparation of data bases;

e. Miscellaneous : 9 contracts for a total amount of about 0,677 MEcu (average 75.185 Ecu/contract) dealing with various subjects, like the cost effectiveness of new energy technologies, the completion of the MIDAS model, the energy system simulation for the EC countries, etc.

The list of the contracts shows that the priority efforts in the present 3rd R & D programme are directed on one side towards the completion of the HERMES model, its data base and its applications, on the other side towards the implementation of the energy-environment integration in the EFOM model. Each action is well coordinated, as the very frequent plenary area meetings of the contractors show:at least one each year (but the energy-environment group, whose activity started in the period considered, held 5 plenary area meetings); to these plenary area meetings a number of partial meetings have to be added. DG XII has also partially supported two conferences organized in 1986, in Paris and Milan, relative to economic and energy subjects.

The results of the Energy Systems Analysis R & D programme are currently published in scientific journals. Particularly relevant in the valuable report "Energy 2000" published in 1986 jointly by the Directorates General XII and XVII (Science, Research and Development and Energy); this report elaborates a projection of the Community's energy system to year 2000 using a long term demand model, MEDEE, an optimization supply model, EFOM, and an economic model, EURECA, to establish the necessary consistency between the economic variables, the price of imported oil and the other variables relating to the energy markets (EURECA, developed during the 1st NNE Programme, is a model that generates, as a function of time, values for the major macro-economic variables, like gross domestic product, private consumption, investments, etc., and describes the flows of imports and exports across the various countries; it consists of a module for each country and a linkage system). As it usually happens in this type of exercises the connections among the different parameters, brought to light by the models, give a much more relevant information on the system behaviour than the sheer forecasting.

8.4. The Energy Systems Analysis subprogramme appears to proceed in accordance with the guidelines that had been decided; it must be remarked that the work in the two main lines of work, the finalization of the HERMES model, the economy-energy interface, and the energy-environment integration, through the use of the EFOM model, is well advanced. The scientific community of the Member States is deeply involved both in the elaboration of the models and in building up the data base.

The energy models, products of the research in the Energy Systems Analysis programme, are currently used in various Directorates General of the Commission: the report on the cost of non-Europe, which has been prepared by DG II, is based on the HERMES model; the analysts of DG XVII derive their energy scenarios from the different models developed in this programme (STEM, MIDAS, MEDEE, EFOM and HERMES); the cooperation between DG XII and DG XVII has produced the already quoted report "Energy 2000"; the environmental problems connected with the energy system are being tackled by means of the model EFOM, an optimization model which takes into account the investments required to comply with the environmental regulations, and the analysis of the results is of interest of DG XVII; DG VII is conducting a COST action,n.307, regarding the rational use of energy in transportation, through the use of MEDEE. The national versions of these energy models are also being currently employed in national institutions and public administrations of various Member States; a version of the demand model MEDEE, MEDEE S, has found extensive application in Latin America and in some Far Eastern countries.

The interviews with a number of Commission officials and of members of the national groups taking part to this programme convinced us that the Energy Systems Analysis subprogramme performs a staff function with respect to other Directorates General of the Commission, besides providing to the national expert groups a very useful forum for harmonizing the development of the modelling tools employed in the Member States, the second function being strictly correlated to the first one but not more important or more strategic. In this sense this research programme appears to be a necessity for the operation of at least some of the Commission's services.

The connections of DG XII with other Commission's services through the development of suitable models might usefully be extended in directions that, in part at least, have already been taken into consideration in the future programme : the most important seams to be the one related to the interaction energy-environment, not limited to the emissions from large power plants and industrial boilers, with special attention given to the most dynamic sector in terms of energy consumption, namely the transportation sector. The CO2 issue, only in some aspects is, we are informed, tackled at the Community level. A deeper involvement of the Energy Systems Analysis subgroup in the study of the issue would be advantageous (emissions, CO2 cycles in the environment, climatic changes, their effects on agriculture and generally on land use). The Commission can usefully act as a coordinating agent among the European groups that are already working on it, in order to promote the best scientific connection at the global level. The Energy Systems

Analysis experience could be transferred also to other fields, different from energy, that would greatly profit from a systems approach at the Community level : to quote just a few of them, let us remind the waste problem (urban and industrial); the transportation system, for passengers and goods; the perspectives of agriculture producing material inputs to the industrial activity and the related effects on agriculture, industry and environment.

In conclusion the Energy Systems Analysis subprogramme appears to be scientifically sound and well managed; the connections with other Commission's services allow to make an in-house good use of the energy models that have been elaborated; the staff function to other Commission's services, based on the collaboration with the best qualified scientific groups in the Member States, could be usefully extended to other fields, different from energy, where a better insight could be gained from a system approach. The present level of funding of the subprogramme is considered barely adequate for the functions performed : it should be reconsidered, in the sense of a substantial increase, in the light of an extension of its objectives. It has to be remarked that the absolute level of funding of this type of activity is rather low, while the results can be of high relevance in terms of understanding the dynamics of complex systems and of bringing this understanding to the level of the policy makers.

9. OPTIMIZATION OF THE PRODUCTION AND UTILIZATION OF HYDROCARBONS.

9.1. Significance.

It is hardly necessary to say the hydrocarbons (HC below) are a major energy source for Member States, and for the rest of the world as well. Since there is no practical alternative to HC, at the present time, in the road transportation sector, this situation is bound to last several tens of years. Thus HC are of strategic importance.

Due to these facts, the HC energy resources clearly are a field for EC concern, and a significant theme for research-development activities. On the other hand, one is bound to ask whether, comparing of the research effort invested by the industry itself with national technical centres, means available within C.E.C. Research Directorate allow to carry out a research programme at a level achieving significance. To this question, the present evaluation exercise suggests a positive answer. Specific arguments are given below, in the course of reviewing the programme subsections; at that stage the following remarks are in order :

- the demand for a HC research programme under C.E.C. leadership originates from the industrial branch itself;

- the potential available for the programme within DG XII is considerably enhanced through the logical imbrication with demonstration projects supported by DG XVII.

9.2. History.

Until 1985, i.e. within phases 1 & 2 of the EC research programme, fossil fuels were not included in the research topics. Neither did hydrocarbons appear in the initial proposal for phase 3 submitted to the Council by the Commission. Indeed, the onset of a HC

subprogramme was decided by the Council, on the basis of a complementary proposal asked to the Commission. In turn the Council was guided by advices originated in oil industry : the French oil companies were very active in promoting hydrocarbons as an area for research at EC level.
In such a context the Commission, seeking to minimize further delays in order to warrant continuity with the on-going programme phase, choose to implement the subprogramme, directly along the lines recommended by the oil industry.

Nevertheless, the launching of the HC subprogramme took time, as is always the case when launching a new area. As of March 1988, on the basis of contract starting dates and durations, the halfway point has not yet reached; indeed a halfway general contractor meeting is scheduled for the autumn of 1988.

Obviously, an evaluation at this stage cannot cover the achieved results. Besides checking whether the programmed research processes according to schedule (which indeed is the case), one has to be content with an analysis of the subprogramme, a discussion of the relevance of selected areas, an assessment of the significance of the action for building the future.

9.3. Key figures

The ENN3 "Hydrocarbons" subprogramme covers four areas A - D :

A - Improvement of the knowledge of hydrocarbon fields
B - Utilization of natural gas
C - Utilization of heavy oil fractions
D - Research on matching of engine and fuels
with highest priority to A and lowest to D.

In answer to the call for proposals, 116 proposals have been received; 45 contracts have been warranted, including 21 for A, 8 for B, 10 for C, 5 for D. The EC contribution (total sum 15 MEcu) ranges between 51.000 Ecu and 800.000 Ecu, 16 contracts are at marginal cost : for the shared cost contracts the C.E.C. percentage ranges between 29% and 68 %.

Despite the strong input of the French oil industry in setting up the subprogramme, the contracts turn out to be well spread over the EC nations : 1 Belgium, 4 Denmark, 17 France, 7 Germany, 7 Italy, 1 Ireland, 3 Netherlands, 5 United Kingdom. A vast majority of contracts extends over 3 years.
The scanning of proposals was conducted in connection with DG XVII and conversely, to the extent that a few of them were switched between Directorates through agreement between programme managers (see Annex A).

9.4. Analysis

A - Improvement of the knowledge of hydrocarbon fields : this consists of two subsections A1 & A2.

A1 - Geophysical methods : There are 9 contracts, among which
- 2 deal with the interpretation of borehole logging data;
- 6 deal with seismic methods,the main emphasis being both on the development of local, near real time workstation techniques, and on work to build sophisticated non linear inversion schemes for 3D data;
- 1 deals with magnetic survey methods.

Most of contracts in this area go to universities and other public laboratories.
It may seem paradoxical that this research axis, aimed at a better efficiency in locating new oil fields, is assigned a top priority by the industrial sector; indeed, in times where oil is cheap and abundant, one expects such a concern to be exclusively of strategic nature.

Nevertheless an oil company cannot, within the equilibrium of its activities, neglect the exploration without endangering its very existence on the long run. Therefore, while an improved exploration efficiency represents for Europe a matter for long term strategy, it includes for industrial actors medium term, economic stakes as well.

The exploration activity is very expensive, due to the high percentage of unsuccessful attempts. It is widely recognized, for that reason, that investments in geophysical research present a large potential return. Why, then, do not large companies - with large research budgets - assume the research effort ?

The fact that geophysical data collection and processing is subcontracted to smaller companies (oil services) with smaller research budgets certainly contributes to the explanation.

This discussion points out an important aim of the C.E.C. programme, which concerns the changing of states of minds : the oil industrial sector, as a whole, should be brought to take in charge more vigorously research needs which are of major and direct interest to it, even if most of this research is best carried out in universities and other public organizations.

Now the public scientists will also have to modify their state of mind. Until now the C.E.C. programme has - rightly - set several of them to work in parallel; at the next stage the programme's job is to lead them to join forces.

A2 -Improved knowledge of the mechanics of fluids in oil wells:

There are 12 contracts, among which :

- 2 for studying the porous structure of reservoirs;
- 2 for studying the behaviour of oil-water fluids;
- 4 deal with various aspects of interaction between mineral and fluids;
- 2 concerned with the use of tensioactive materials;
- 1 deals with the use of polymers for stopping oil wells.

While the natural yield of oil wells ranges between 25-50 % of existing resources, research in area A2 aims at a more complete extraction from known reservoirs. The objective, mainly economic, is to decrease the cost of assisted recuperation methods. Its relevant time scale is mostly determined by the market price of oil.

Such issues are very much a matter of concern for oil companies; indeed, 7 contracts out of 12 go to industrial laboratories, including large companies. Still, the C.E.C. programme also allocates funds to university laboratories, particularly for basic topics such as characterizing materials and understanding physical mechanisms. It appears therefore that the programme ensures a well coordinated coverage of the field, from basic physics until pumping strategy, and that it is efficient in building the necessary research community. For the next phase, the proposed putting together of this theme and deep geothermy appears logical and appropriate.

B - <u>Utilization of natural gas</u>: There are 8 contracts, among which:

- 1 deals with gas purification;
- 2 deal with the development of methods for converting methane to various products;
- 5 deal with research aimed at direct catalytic oligomerization of methane.

While it is valuable to progress towards making various materials from natural gas, the fraction of the effort devoted to that end within an energy-oriented programme should be restricted, as indeed is the case.

On the other hand, the main action here (i.e. the 5 contracts mentioned on the last line) illustrate well the relevance of a research programme at EC level. A possibility to transform directly methane into a liquid fuel would bring major changes concerning fossil fuels at both the economic and strategic viewpoint, especially for Europe. Natural gas reservoirs are more abundant than for oil, and certainly spread more equitably throughout the world.

However, the industrial branch concerned with natural gas production happens to also be the oil industry, which is prioritarily concerned with oil. For illustration, natural gas coexisting with oil reservoirs is occasionally burned on the field; this has an adverse effect on the balance of carbon dioxide in the climatic system, and cannot be considered as rational use of energy...

Direct oligomerization of methane is a matter of basic research: it is typical that all five concerned contractors are university laboratories they are spread among 3 nations, and work in close cooperation). This research is risky, in the sense that there is a sizeable chance of failure. Alternatively it may achieve a breakthrough, in which case the relay to demonstration projects and implementation would definitely occur, with large and positive consequences.

C - <u>Utilization of heavy oil fractions</u> : There are 9 contracts, among which :

- 4 concern thermal treatments (including 3 which are linked together);
- 2 deal with catalytic processes (new products, recycling);
- 2 support the development of original methods.

While new oil extraction activities will provide an increasing proportion of heavy products, there is a growing trend among the users to favour the light products. The issue is therefore of prime importance for the industry (it is worth noting that all contracts in this subsection have been granted to private laboratories), and it has definite relevance for rational use of energy sources as well as concern for environment.

Thus there is a strong ground for supporting this research area within the C.E.C. programme; furthermore, the balance appears satisfactory between long term developments and progresses likely to be shortly brought to application.

While several large oil companies obviously conduct active research for upgrading of heavy crudes, they have not been present in this initial phase of the C.E.C. programme.
Particularly in this domain, it is nece.ssary in the future to broaden the programme concertation and community to a majority of the major actors, in order that the progresses resulting from the programme become indeed beneficial to Europe as a whole.

The last contract in subsection C, nearer in spirit to those of area D, is dealt with below.

D - Research on matching of engine and fuels:
There are 6 contracts (5 + 1), among which :

- 2 (in cooperation) deal with the possible addition of boosters to classical fuels;

- 4 (including 3 in cooperation) address the improvement of criteria and methods to assess the quality and energy efficiency of both light and Diesel fuels.

The first topic originates in growing trends for incorporating various additives with hydrocarbons; the second one is of obvious importance for the European oil industrial branch. Indeed the existing methods for assessing fuel efficiencies, which have been built a long time ago, have become inadequate. Such a research deserves without any discussion to be supported at C.E.C. level; the programme managing team was quite right to encourage and bring together proposals in this topic.

9.5. General comments

The ENN3 Hydrocarbons subprogramme is being carried out in close adequation with guidelines which has been set up for it. Main judgment criteria for allocating the grants (relevance of subject, relevance for European support, quality of proponent) were adequate and properly applied. The implementation of the programme achieves a satisfactory balance between long term and short term issues : it meets an encouraging success in bringing together a number of European laboratories for coordinated work.

In some domains, however, the programme suffers from the fact that important industrial partners did not decide to join in. Something had to be done about it; actually, it has been done; in the sense that the next programme has been prepared, as seen above, on a basis which gathers the widest possible interest from industrial partners.

It has been noted that the total number of contracts over areas A, B, C & D was 44 instead of 45. The last contract, very rightly, has been given to an investigation of research needs, in order to prepare in a rational and concerted way the continuation of the programme beyond its on-going phase.

The main result of this study is that the axes pursued by EC are confirmed : indeed the need is stressed for further EC research concerning techniques for exploration and reconnaissance (following A1), production techniques (following A2), natural gas development and conversion (following B), hydrocarbon conversion (following C), while specific continuations of area D may be included under the two preceeding headings.

In addition, the study points out other fields where research is needed : they concern mainly the technology of oil extraction, specifically drilling problems and offshore environment.

Indeed these additional fields are quite important and deserve a research effort at EC level; at the same time, it is to be stressed that first of all, one should keep on and build on the effort in areas covered by the 3rd programme. In most cases a single 4 year period is not enough to achieve the gathering of competencies necessary to get results; the actual benefits will appear only after a further phase has allowed to reassess the objectives more vigorously and to focus the efforts on projects (see Annex B).

A good example is offered by A1 area : While the 1985 call for proposal reads "Development of advanced geophysical analysis method ... by utilization of ... seismic and geophysical data ...", the commission draft for the next phase states : "integration of seismic and non seismic methods...". This evolution reflects both a progress in the formulation of the objectives and the intent that individual results obtained under the 3rd programme shall be brought together in order to progress further.
At the same time, the programme should definitely be kept open to new partners and new ideas. A way to achieve this is to direct a very moderate amount of money towards exploratory research : such issues as the possible use of biotechnological methods for enhanced oil recovery, or the a-biological creation of hydrocarbons, may deserve attention in this respect.

In conclusion, then, the "hydrocarbon" subprogramme offers good prospects for getting valuable results; it offers in addition an excellent basis for improvement of European research during the next phase of the C.E.C. programme.

INTRODUCTION TO ANNEX A

The panel was greatly helped in its understanding of the evolution of the Commission's aims and its methods of working by a series of interviews with members of the staff of DG's outside DG XII.

The informal minutes presented here record how the panel came to its appreciation of the situation and form the basis of several views expressed.

ANNEX A :

INTERVIEWS WITH MEMBERS OF OTHER DIRECTORATES-GENERAL

1. Evolution of the energy programme.

The term "Non-nuclear Energy" in the title of the programme was not very fortunately chosen, because one should not make a distinction between nuclear energy and energy in general.

Although nuclear energy plays a different part in different member countries of the Community, it will play a significant part in meeting energy requirements for some time to come. Whilst current political discussions show that some member countries look upon the era of nuclear energy as a transition period, it is all the more necessary to consider and deal with alternatives.

The renewed emphasis on Non-nuclear energy is linked to the first oil price crisis. In 1975 five fields were covered : solar energy, energy conservation, energy modelling and system analyses, geothermal energy and hydrogen. The first oil price crisis gave the particular impetus to the Community to investigate what research and development will be necessary in order to ensure adequate energy supplies for the Community and/or to submit proposals on how to ensure such supplies.

This was the basis for the First and Second Programmes in this field. The work of the Third Programme - which is now being evaluated - is the logical continuation of the earlier work but certain investigations have been shortened, enlarged or terminated as a result of the present situation. In this, the development of oil prices - oil is the "market leader" for the price of energy in general - always plays an important role. When the price of oil increased steeply, there was a strong incentive to search for alternatives in order to become independent of oil.

In this context, the use made of nuclear energy and of fuels of fossil origin for producing electricity was of special importance.

At the same time, possible processes for converting solid fuel - mainly coal and lignite - into liquid and gaseous hydrocarbons were investigated. Although existing processes already made it technically possible to convert solid fuel into the gaseous and/or liquid state, this investigation opened up a broad range of new possibilities.

At the beginning of this third programme, it was found possible to investigate sources of energy which had only lately come under review, such as solar energy, energy from biomass and garbage, wind energy, hydrocarbons and geothermic energy.

Solar energy	: A long term approach was chosen looking for new markets and creating a competitive industry in this field in Europe. The equilibrium price for photovoltaic energy-keeping in mind inflation-would be reached before 1995.
Energy from biomass	: There was a movement from energy farming towards energy from existing biomass and biomass wastes due to its environmental benefits and to the more competitive price.
Wind energy	: Wind energy potential was studied and the encouraging results made the wind energy programme adopted as a separate programme (before, wind energy was part of the solar programme).
Hydrogen	: The main aim was to obtain hydrogen by electrolysis more efficiently and to identify (and solve) problems like : safety, materials, storage, intermediate (non energy) use of hydrogen.
Geothermal energy	: This subprogramme was launched under Italian and French impetus. Once the American approach was seen incomplete as regards hot dry rocks, Europe started some new projects in Cornwall.

It was found possible also to examine such novel sources of energy in order to establish whether it is feasible to test them in demonstration plants with a view to eventually putting them into operation commercially on a larger scale.

2. DG II - Economic and Financial affairs.

One of the tools that has been used by DG II is the HERMES model. After some simulations with exploratory assumptions to test whether the model was suitable for its purposes, some useful conclusions have been reached, in particular for the assessment of the completion of the internal market.
It is not intended that the Community promotes research and development projects of national institutions or companies independent of the requirements of the member countries. An important feature of this sort of models is that they can be used as a basis for discussion among economists and energy experts : it is an interphase between energy and economy. The relationship between DG II and DG XII should, therefore, be seen in the light that, on the one hand, DG II points out possibilities of utilizing projects for the needs of the Commission and that, on the other hand, DG XII is going to elaborate the project and will make it available to the Commission, especially to DG II.

The liaison between the two Directorates-General was described as satisfactory. So as to attain greatest possible effectiveness, mixed committees should be set up consisting of, on the one hand, technical and scientific specialists and, on the other hand, experts on economics.

3. DG III - Internal market and industrial affairs.

It is important to assist medium and small companies with research grants from the Community insofar as such companies can contribute to producing energy by alternative means or to saving energy.

A solid knowledge is needed in order to get better standards and better calculations on energy needs.
Close links are established with ISPRA, but it would be worth to be coordinated also with the Non-Nuclear energy programme : there are many related fields in which R&D is needed.
The value of the link-up with DG XII is mainly that schemes for energy-saving methods of production and heat insulation methods which reduce energy requirements are being furthered. DG III submits questions on such matters and the Directorate is ready to assist with research and development projects in order to resolve the points at issue in co-operation with individual companies.

4. DG VI - Agriculture.

There is a need to reduce the energy requirements of agriculture and/or to produce energy from waste material coming to hand in agricultural operations. There are, therefore, links with the research and development projects for utilizing "biomass" and refuse. It is not so much a question of whether the existing agricultural problems can be resolved by massively promoting the production of biomass and refuse within the Community in order to produce energy.
DG VI, thus, puts questions to DG XII and, if DG XII has particular problems, DG VI is ready to consult and give advice.

5. DG VII - Transports

Motor traffic has increased greatly and will continue to increase. Efforts are being made to make traffic safer as well as to reduce the environmental nuisance caused by the emissions from the transport vehicles. In this connection, an effort is to be made to limit or reduce the problems caused by the individual traffic by substituting other means of transport. However, since the motor industry is a very major economic factor in the Community, research and development projects aiming at solving these problems are particularly important. DG XII should become more active in this field and to consult with DG VII on what research and development deserves particular support from DG VII's point of view. In continuing the programme, one should think not only of how to utilize the energy put in more efficiently but also how to make novel forms of energy available for transportation purposes. It is quite feasible that hydrogen technology will open new possibilities.

6. **DG VIII - Development.**

For the purpose of the implementation of a programme on the supply of solar equipment, some regular meetings have been held between DG VIII and DG XII. Furthermore, exchanges of points of view between both DG's are regularly carried out in the field of utilization of biomass.

7. **DG XI - Environment.**

With regard to the programme under analysis, air pollution could be considered as one of the most relevant aspects for the Directorate-General for Environment, Consumer Protection and Nuclear Safety.

In this field the existing Council Directive on the combating of air pollution from industrial plant, which requires the use of Best Available Technology for a large number of industrial activities, could represent a very interesting approach to sustained research efforts.

Air quality standards established in existing directives have as a primary goal the protection of human health. Ecological protection will constitute the objective of the future, therefore a great deal of work will have to be done before appropriate standards can be laid down, taking into consideration the different ecosystems existing in the Member States.

In both fields DG XII will be able to instigate investigations to provide a basis for issuing new directives and guidelines. It is clear that special instruments and methods of measurement will have to be developed in order to implement such legal provisions. This should be a field for further cooperation between the two Directorates-General.

Additional support should be given to research and development in the field of environment. There is a need for closer cooperation between DG XI and DG XII.

8. DG XVI - Regional policy.

Cooperation with DG XII is considered satisfactory but DG XII should confine itself more markedly to basic research and should not concern itself so much with promoting research relating to particular applications. Nevertheless, the programmes in the fields of decentralized energy supplies (solar and wind energy, etc.) are well suited to arriving at decisions on regional development. No absolutely applicable statements can, however, be made on the question of making qualified personnel available in the regions.
Thus, Palermo and Dundee may be mentioned as examples of regional centres at which the local universities produce outstanding scientific results.

9. DG XVII - Energy saving and alternative energy sources, electricity and heat.

There are, naturally, closer links with DG XII than is the case at the other Directorates-General.

The need for demonstration programmes is due to the fact that most of the research had failed to be commercialized. At present time, not all desirable contacts are established between this directorate and DG XII. Periodical meetings between both would be very useful to avoid overlaping fields.

On the other hand, a small number of R&D projects have a demonstration phase in DG XVII. Partly it could be solved allowing public access to DG XII's data contained in Sesame data base.

It was recommended that DG XII should concentrate more upon research and concern itself less with applications and/or pilot or demonstration plants.

10. DG XVII - Coal.

Concerning the use of solid fuel for generating electricity, two lines of approach are being pursued :
One possibility is to gasify coal and, then, to operate a combined cycle (gas turbine/steam turbine) process; this is suitable for larger plants with an output up to 600 MWe. The particular problem in this process is cleaning the hot flue gases. In this field, there is very good co-operation with DG XII. Converting coal by means of this process has the great advantage that emissions can be reduced substantially.
The other possibility is to use the fluidized bed combustion technology which can be employed for plants generating between 100 and 300 MW. Atmospheric as well as circulating fluidized bed furnaces have proved themselves in practical operation, whilst pressurised fluidized bed combustion is still at the demonstration stage.

There is still a rather long way to go, before the flew's technology can be employed commercially for major plants and/or for combined gas turbine/steam turbine processes.

There is a good co-operation with DG XII in this field : the projects for which DG XII gives assistance are sufficient.

11. DG XVII - Oil and natural gas.

Relationship and exchange of information between DG XVII programme (to support technological development in the sector of hydrocarbons) and DG XII programme (being evaluated) worked satisfactorily. DG XII participates in the advisory Committee of the DG XVII programme to give an opinion on the projects presented for support. In case a proposal submitted by a promoter does not suit DG XVII's programme, it is submitted to DG XII. DG XVII has been requested to comment on projects which were presented in the framework of "non-nuclear" R&D programme. Participation in respective conferences for dissemination of results is foreseen.

12. DG XVII - Energy policy, analysis and forecasts, and contracts.

Basic modelling tools are supplied by DG XII programme (Eva, Medee, Hermes).

In connection with policy models, the important point is that in drawing up such models and systems, one is compelled to make it clear what the various types of dependence are. This is the essential value of drawing up such models. The types of dependence must be seen not only in the technical field but also in their wider socio-economic aspects such as administration, policy and social acceptability. Working groups which draw up such models and forecasts must, under all circumstances, include representatives from all these fields and faculties. Working groups within DG XII should include economists as well as social scientists. In all other respects, co-operation with DG XVII is very good.

Introduction to Annex B

Annex B consists of the synthesis of the consulting group who helped the panel to carry out the evaluation of the DG XII Non Nuclear Energy programme.

We are very pleased to acknowledge the efficiency of the consulting group, and have indeed been astonished by the amount of work that he accomplished : within a small number of weeks, they managed to put together and analyse a data base for the programme contracts, to conduct and interpret an investigation of contractors through a questionnaire, and to carry out a number of highly informative, in depth studies bearing on the programmes' methodology and way of operation.

Although the brevety of time available for evaluation did not allow a full interaction between the panel and group, we received from the consulting group, on many issues, data and information which we found extremely useful. Such data have been incorporated into the panel report.

In addition, the consulting group addressed broad issues which go beyond the scope and terms of reference of the evaluation panel; corresponding conclusions have not been included in the panel report. In this respect, the report of the consulting group deserves to be read and studied as a separate document.

The conclusions are those of the consultants.

Evaluation of the

THIRD NON NUCLEAR ENERGY RESEARCH PROGRAMME

of the

COMMISSION OF THE EUROPEAN COMMUNITIES
(1985 - 1988)

SYNTHESIS OF THE CONSULTING GROUP REPORT.

CENTRE DE SOCIOLOGIE DE L'INNOVATION

Ecole Nationale Supérieure des Mines de Paris
60 Bd Saint-Michel - 75006 Paris - FRANCE.

April 1988.

In January 1988, the Centre de Sociologie de l'Innovation (CSI) was asked by the evaluation Unit of DG XII-H to assist the evaluation panel of the third Non Nuclear Energy research programme (NNE3) on "transversal aspects" of the on-going evaluation.

To accomplish this, the CSI proposed to focus on three main issues :

- the impact of NNE3 (through a mailed questionnaire to all contractants),
- the management perfomance of the programme (through both a survey of the available programme documents and interviews of programme actors),
- finally the evolution of international environment (through available literature),

The scientific and technical achievements are not under the scope of our study.

The CSI team (P. LAREDO & P. MAUGUIN) was joined by 3 specialized groups: GMV (P. CRANCE & P. PAULAT) a service company specialized in opinion surveys for the questionnaire management and analysis, the University of NAMUR (D. VINCK & F.WARRANT) for the management survey, and CERNA, Centre d'Economie des Ressources Naturelles de l'E.N.S.M. Paris (P. N. GIRAUD) for the world outlook. Significant contributions are also due to M. CALLON (CSI) and P. WALDTEUFEL (panel member in charge of liaisons with the consulting group).

The whole work had to be, and was, completed within a 3 months period (February to April 1988), in order to fit into the evaluation agenda. The reader should bear in mind this very tight schedule, which did not allow as extensive a study as would have been desirable.

We gratefully acknowledge encouragements from the evaluation panel, help provided by the Evaluation Division of DG XII-H (Mr L. MASSIMO, Ms C. de la TORRE) and the cooperation of every manager of the NNE3 programme.

In order to provide the evaluation panel with detailed, clearly organized material, we have built separate files according to the topic of interest and the data provenance : one for the impact survey, two for the international environment and three for the programme management. Very early in our work, it appeared necessary to describe, as a priliminary step, the content and dynamics of the programme : two additional files are dedicated to this task.

The following synthesis presents, in turn, the main conclusions inferred from each file; it ends with an overall appreciation on the programme and a series of open questions about possible future options.

SUMMARY

GLOSSARY

This glossary lists the main abbreviations used in this synthesis; most of them concern the contracts data base and the impact survey.

EC	European Community
CEC	Commission of the European Communities
MECU	Millions of European Currency Units
RD & D	Research, development & demonstration

NNE SUBPROGRAMMES

B	Biomass
C	Hydrocarbons
E	Energy conservation
F	Solid fuels
G	Geothermal energy
M	System analysis
S	Solar
V	New energy vectors
W	Wind

COUNTRIES

B	Belgium
D	Federal Republic of Germany
DK	Denmark
E	Spain
F	France
GR	Greece
I	Italy
IRL	Ireland
L	Luxembourg
NL	Netherlands
P	Portugal
UK	United Kingdom

ACTORS

LC	Large Company
SME	Small & Medium Entreprise
ENG	Engineering company
TRC	Technical research centre
UNIV	University or fundamental research centre

TYPE OF WORK

BASE	Fundamental research
CONCEPT	Applied research on new concepts at labo. level
PILOT	Pilots and prototypes
DEVPT	Industrial development
ACCOMP	Accompanying research (atlases, norms, technological transfer)

HORIZON
(potential economic application)

ST	Short term (< 5 years)
MT	Medium term (5 - 10 years)
LT	Long term (>10 years)

TYPE OF ASSOCIATION

ISOL	Isolated project
MPP	Multipartner project (either 1 contract with subcontractors or associated contracts)

THE PROGRAMME CONTENT SEEN THROUGH NNE3 CONTRACT DATABASE.

File 1 : CSI - P. Laredo, P. Mauguin et P. Waldteufel.

Objective : Analyse NNE3 data in order to characterize the programme.

Methods used : The main file was extracted from DIODON digitized system, completed with recent contracts previously missing, corrected and finally enriched by added specifications with the aid of the programme team. A separate file was built for multipartner projects.

MAIN CONCLUSIONS

The implementation of NNE3 to date consists of 690 research contracts, for a total CEC contribution amounting to 139 MEcu. Taking into account the contractors' share, and using a multiplying factor of 3 for the marginal cost contracts, the total cost of the programme is about to 350 MEcu, which may be interpreted as 850 full time researchers working over a 4 year period.

1. BULK FIGURES : Table 1 (a-h) : NNE3 bulk ratios.

(a) SP	(b) STATES	(c) ACTORS	(d) WORK	(f) END	(g) ASSOCAT.
B : 12%	B : 6%	UNIV:40%	BASE :22%	1985-87:16%	ISOL : 32%
C : 12%	D :19%	TRC :24%	CONCEPT:32%	1988 :20%	MPP : 68%
E : 16%	DK : 7%	ENG : 5%	PILOT :26%	1989 :58%	
F : 13%	E : 4%	SME : 5%	DEVLT : 5%	1990-91: 6%	
G : 13%	F :22%	LC :26%	ACCOMP :14%		
M : 4%	I :11%				
S : 18%	IRL: 3%				
V : 4%	NL : 8%				
W : 10%	P : 2%				
	UK :16%				

(e) HORIZON	(h) EUROPE
Short : 32%	Single Country :40%
Medium: 37%	EUROPE :60%
Long : 31%	

% of EC AID (a, b) — % of TOTAL COST (c, d, e) — % of EC AID (f, g, h)

11 - Participation of EC countries :

57% of the EC funds are attributed to the projects of 3 countries (F, D, UK), while the 5 "smaller" ones (E, IRL, P, GR, L) collect 11 %. The 3 leading countries are, with NL, the only ones to be more involved in fossil fuels and energy conservation than in renewable energies. The new subprogrammes, with the exception of Wind, start with a strong presence of the largest countries (solid fuels, n.e.v...); the smallest countries appear later, as the subprogramme become mature (solar, system analysis,..).

12 - Role of different actors :

The main actors of NNE3 are universities and large companies (66% of the total programme amount); SME (including engineering and research outfits) contribute to 10 % of it.

13 - Nature of work :

58 % of the total amount aims at development of new concepts and building pilots or prototypes, which reflects the maturity of the programme. That trend is confirmed by the average time horizon for expected economic outlets : 69 % of the total amount concerns short or medium term projects.

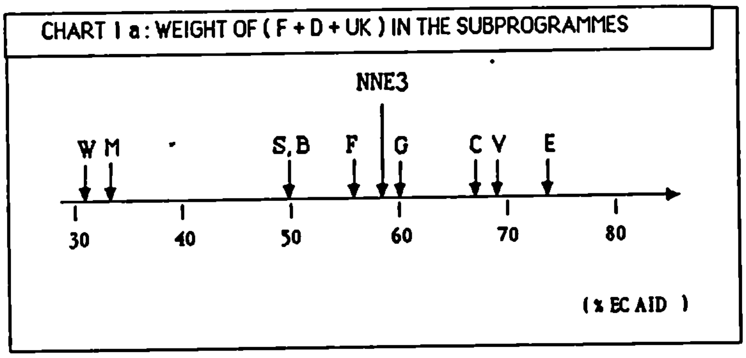
14 - European attitude :

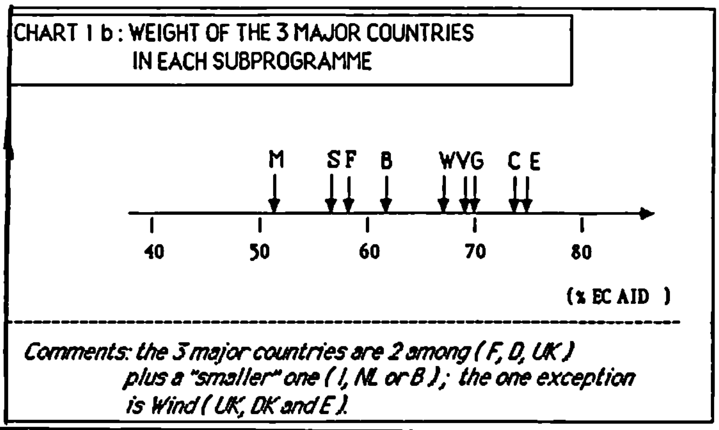
The multipartnership, a major feature of the programme (68 % of the total CEC aid), mainly implies actors belonging to distinct European countries; in this way, 60 % of the subsidy is devoted to European multipartner projects.

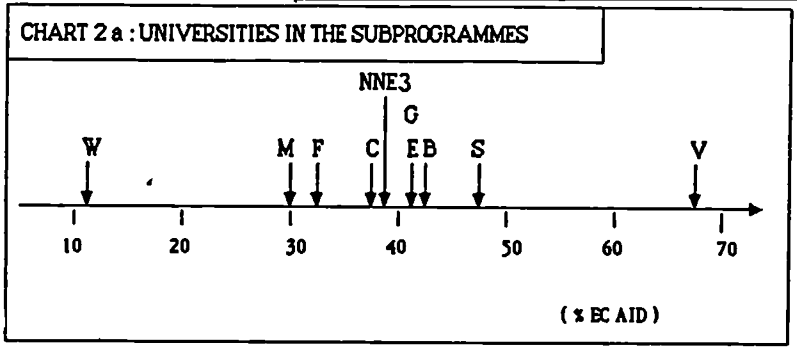
Summing up, a typical NN3 project might be centred on a new technology, and include two (British and German) universities, as well as a French Technical research Centre, a large Italian company and a SME from a smaller country.

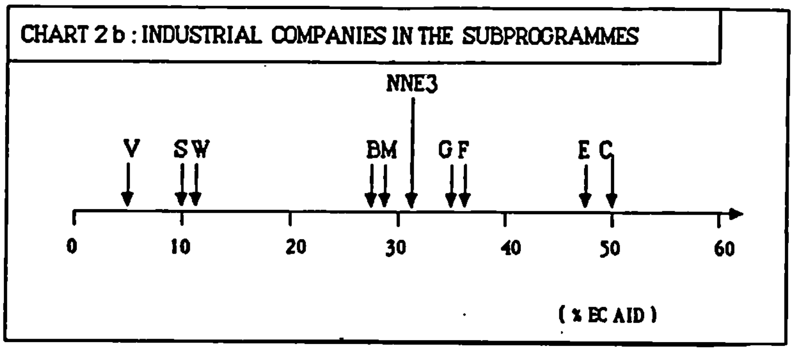
2. NNE3, A FEDERATION OF CONTRASTED SUBPROGRAMMES.

Beyond the bulk of the whole NNE programme, the following charts illustrate the diversity between the 9 subprogrammes, regarding the weight of different EC countries (chart 1), the role of different actors (chart 2), the nature of work (chart 3) and the multipartnership (chart 4).









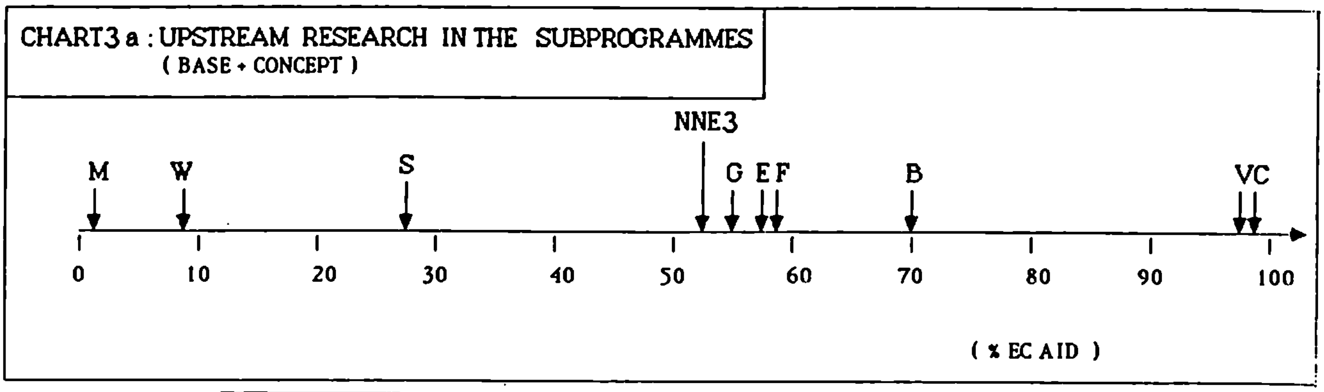


CHART3 a : UPSTREAM RESEARCH IN THE SUBPROGRAMMES
(BASE + CONCEPT)
NNE3
M
W
S
G E F
B
VC
0
10
20
30
40
50
60
70
80
90
100
(% EC AID)

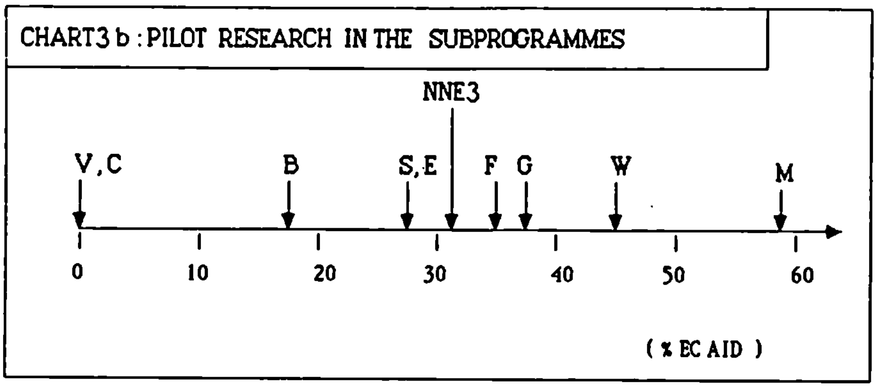


CHART3 b : PILOT RESEARCH IN THE SUBPROGRAMMES
NNE3
V, C
B
S, E
F G
W
M
0
10
20
30
40
50
60
(% EC AID)

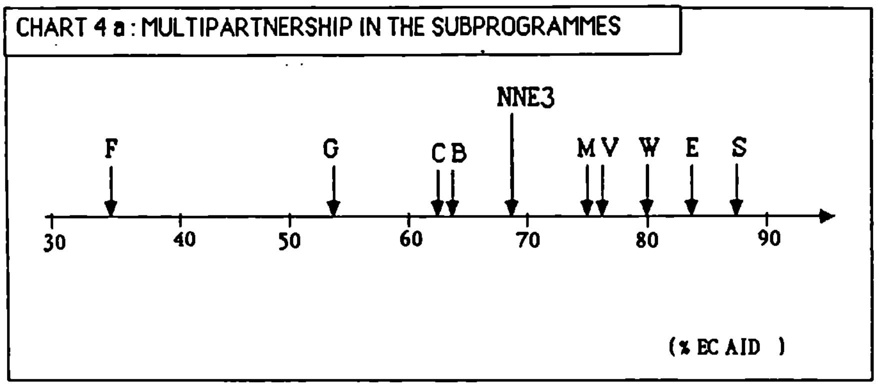


CHART 4 a : MULTIPARTNERSHIP IN THE SUBPROGRAMMES
NNE3
F
G
C B
M V
W
E
S
30
40
50
60
70
80
90
(% EC AID)

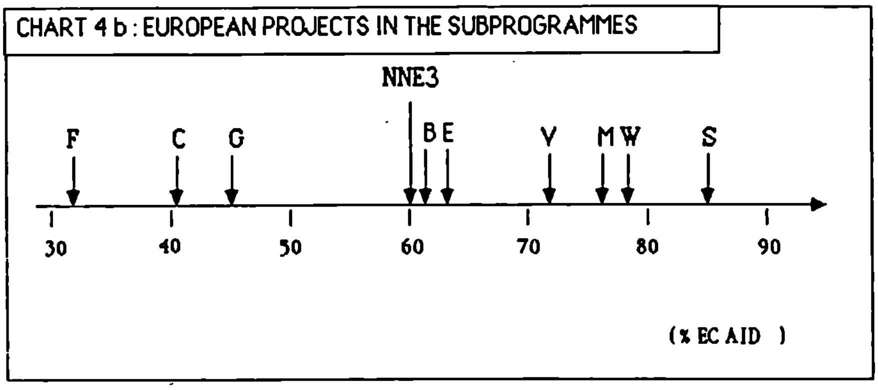


CHART 4 b : EUROPEAN PROJECTS IN THE SUBPROGRAMMES
NNE3
F
C
G
B E
V
M W
S
30
40
50
60
70
80
90
(% EC AID)

3. THE ROLE OF MULTIPARTNERSHIP : See table 2.

As shown by chart 4, multipartnership seems to be a unifying factor among subprogrammes (with the exception of Solid Fuels).

PROJECT

Number of PARTNERS	TOTAL FOR CLASS (MEcu)	Cumulative Percentage	Number of PROJECTS	Project AV.SIZE (MEcu)	D I F F E R E N T COUNTRIES	ACTORS (average number)
31 - 10	55	15,7 %	11	5,0	7,0	2,8
9 - 6	39	26,9 %	10	3,9	3,6	2,4
5	41,6	38,7 %	26	1,6	3,0	2,0
4	31,2	47,7 %	24	1,3	2,4	1,8
3 - 2	68	67,1 %	85	0,8	1,6	1,4
TOTAL N>1 (720 partners)	234,8	67,1 %	156	1,5	2,5	
N = 1 (265 actors)	115,0	32,9 %	265	0,6	1,0	1,0
ALL N values	349,8		421	0,83		

TABLE 2 : WEIGHT OF MULTIPARTNER PROJECTS.

31 - Involving more actors, focusing on less projects :
Totalizing related contracts and taking into account subcontractors, the NNE3 programme is now seen as a portfolio od 420 distinct research actions carried out by 700 distinct research teams.
Although smaller in number, the 160 multipartner projects (MPP) represent by and large the bulk of NNE3 : they concentrate 67 % of the money involved and 74 % of the research teams of the programme.

32 - MPP, as a European melting pot :

The average MPP draws an amount of 1,5 MEcu, 3 times larger than the average isolated project (0,46 MEcu), and associates 5 research teams coming from 3 different countries.

Research actions get larger as they become more European. The 11 projects involving more than 10 partners reach an average size of 5 MEcu; these 10 partners come from 7 different countries ! In addition to promoting European attitude, MPP also are a way of getting various types of actors to work together. Indeed, the 47 largest MPP (more than 5 partners) induce joint work between 2 to 3 types of actors (university, large companies, technical research centre...).

33 - Setting up MPP takes time :

Projects involving a large number of partners are in general typical of the mature stage of programmed action; in NNE3, they are mostly present in the oldest subprogrammes (renewable energies, system analysis), with the exception of the wind subprogramme which features 2 large prototype projects.

34 - MPP, towards technological breakthrough and transfer of technology :

Regarding simultaneously the nature of work and the criteria of association, there appears to be a significant discrimination of tasks between the isolated projects and the MPP : (see Chart 5 below).

a) Technological breakthroughs take mainly place in MMP :

37 of them concentrate 76 % of the total amount devoted to technological projects (pilots & prototypes); they involve an average of 5 distinct partners, mostly industrial groups associated with universities, from 2.5 different countries. They are the largest NNE3 projects (2 MEcu average);

b) Another domain for the MPP is the accompanying research, and more precisely, the studies promoting or inducing the <u>transfer of technologies</u> between different EC members. 84 % of that kind of research is conducted through large MPP (# 7 partners from 6 EC countries; majority of technical research centers and engineering companies; average amount of 1.9 MEcu).

The share of isolated projects is larger for both fundamental research (43 %) and industrial development (55 %). Actually, considering upstream research, isolated projects aim at exploring new scientific fields (0,5 MEcu average), whereas the <u>mastering of strategic competences</u> (57 % of fundamental research amount) is achieved in a European network through MPP (1.3 MEcu; 4 partners from 2.5 countries on average).

THE THEMATIC DYNAMICS OF NNE3

FILE 2 : CSI - P. Laredo and D. Vinck

Objective : Analyse the thematic evolution of NNE subprogrammes through time.

Methods used : File built through interviews of NNE3 programme managers, some NNE3 experts and some "key partners" of the programme (altogether 30 interviews) also using official NNE3 documents and contract database.

MAIN CONCLUSIONS

1. NNE3 : strategic approach and management only present at the "subprogramme level".

   Although the third programme changed the situation by creating a unique CGC and unique budget, it did not succeed in creating an integrated entity : each subprogramme has its own budget and no transfer has occured up to now (the only ones expected represent less than 1 MEcu). Optimizations have thus been attempted specifically within each subprogramme, and they are difficult to appreciate unless one takes into account separately the whole life of each subprogramme. When one does so, on the other hand, the main evolution lines appear very similar.

2. NNE subprogrammes : a focusing process on "technological projects" and "strategic knowledge networks" through a sequence of three distinct phases.

   Every NNE programme appears to undergo a focusing process which results in coordinated research actions which belong to two broad categories :

   - the "technological projects", aim at building pilots or prototypes, in order to test technical feasibility of new concepts prior to any industrial development;
   - the "strategic knowledge networks" gather European partners in transnational networks, in order to achieve the critical mass and master new fields of basic knowledge which are likely to initiate industrial research.

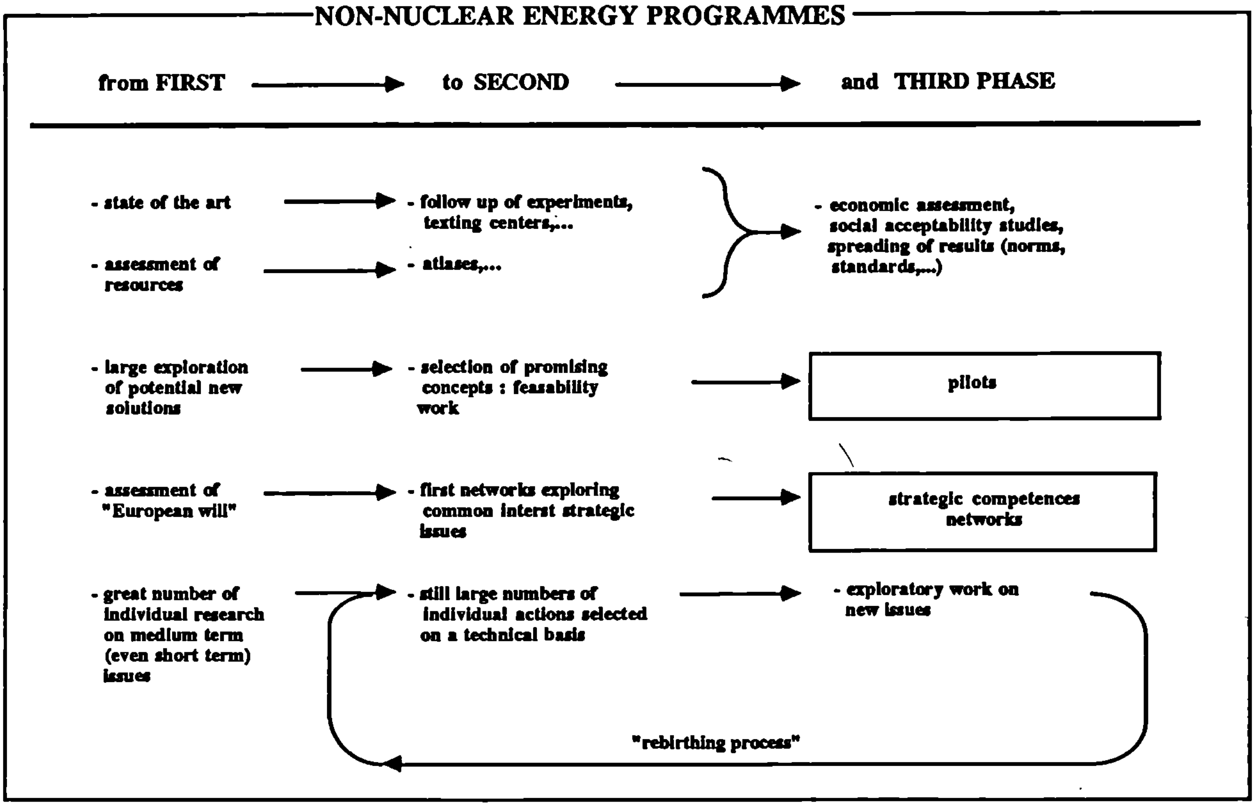
This focusing process usually extends over a long period of time (in any case greater than the time length of a usual European programme i.e. 4 years).

It consists of three distinct phases :

- the exploration phase begins by describing and assessing the state of the art; broad exploratory research work is conducted along the various S & T problems that have been identified. Meanwhile support is given to a large number of short term, individual actions;
- the structuration phase begins to concentrate actions on a restricted number of paths that are judged promising; along these paths, the programme organizes the research community in order to gather the necessary knowledge and know-how. A growing attention is given to resources assessment tools (atlases, instruments and methods);
- the maturation phase sees the full extent of this movement with the actual emergence of a limited number of "strategic knowledge networks" and "technological projects". Indeed, this phase can last quite a long time and extend over a period of two, even three European programmes, requiring a significant effort of economic assessment, social acceptability studies and spreading of results (through catalogs, norms, testing centres, ...).

Following this, the programme actions enter a fourth (industrial development) and often even a fifth phase (demonstration). The fourth phase appears in fact, with a few exceptions, not to be included in DG XII action, while a growing opportunity to cover is offered by the setting up of European projects within the EUREKA frame. The last phase is dealt with by DG XVII (through its demonstration programme).

Table 1 summarizes the observations made on the 9 subprogrammes; the focusing process model described above applies fully for the 5 older programmes,and remains detectable in at least 3 out of the 4 newer ones. This qualitative analysis finds its quantitative confirmation when considering the database (see file 1, second part) and, per "action", the share of the large and/or multipartners operations.



3. NNE programme : which thematic definition ?

It follows from the previous point that this focusing process - which spreads over a long period of time and which every "action" undergoes- should lead to a firmer definition of the thematic priorities than has been the case until now. Most likely, the reality of the next NNE programme will consist of a limited set of items (around 20 "technological projects" and "strategic knowledge networks") rather than a broad catalogue of over 100 scientific items such as the formal terms of reference of NNE3.

At the same time, science progresses, new ideas develop, new concepts are made possible through external technological discoveries,... Even within a given field that may appear fully "mature", new cycles are ready to start : combustion for the car industry is a good example of this endless process of rebirth. It thus seems necessary that an on-going programme does not close its doors to such new "emergent concepts". Indeed, there are two ways of providing for these opportunities : either keep a very broad definition of the field of the programme (which has been the case up to now) or allocate a share of the available funds for exploratory purposes; i.e. what is often called "wild research".

It seems logical, then, to move towards a clearer, more restricted definition of the main objectives, while a specific envelope should be set aside for exploratory research; in this way, the programme would become more transparent for outsiders (see problems encountered by contractors, file # 3). At the same time such a clarification may raise a problem of compatibility between "political" goals and "S&T" objectives : clean coal, for example, is a typical political goal, while MHD solutions for combined cycles appear as a possible S & T objective.

POTENTIAL EFFECTS OF THE NNE3 PROGRAMME.

File 3 : GMV - P. Crance and P. Paulat

Objectives : describe the contractors involved in the NNE3 programme and assess the estimated impacts of the NNE3 contracts.

Methods used : file built through the analysis of 341 answers to a mailed questionnaire to all contractors (636) complemented by 39 face to face and 10 telephone interviews.

MAIN CONCLUSIONS

The study of answers provides detailed information on three complementary issues :

a) characteristics of the contractor population;

b) the programme impact as seen by the contractors;

c) contractors' opinion on C.E.C. support and practices.

PART 1 : WHO IS DOING THE RESEARCH ?

11 - Mainly medium size teams in research organisms.

The contractors are mainly research organisms (70 %), linked to a university (53 %) or a government agency (23 %). Private companies represent only a fourth of the total; half of them qualify themselves as "engineering companies".

Within these organisms, 89 % of the teams concerned are specialized in R & D; they are, typically, medium size laboratories (21 researchers on average, with a large dispersion from 2 to 175) which in two thirds of the cases occasionally sell services outside (half of them at full cost). On average, these teams manage more than 11 projects per year. The suggested long term orientation is confirmed: when asked for the main purpose of their activity, the asnwer is "basic knowledge" for 67 %, the "development of new products" is the aim of only one team out of two which is, at the same time, in half of the cases, also engaged in fundamental research.

12 - "Specialized" teams.

The contracting teams largely appear as specialists :

- In energy : it represents more than 50 % of their activity for 65 % of them.
- In cooperation : more than 80 % of them are used to cooperate with outside partners in the course of their R&D projects, nearly always in Europe (77 %) and only half of the time (45 %) outside Europe (mainly USA).
- In public financial support : for more than 90 % of answers, subsidies appear necessary for research work; they think that two thirds of their projects could not be carried out without such subsidies and estimate public support to provide for 69 % of their total R & D expenses. At the same time, national public subsidies are seen as decreasing by 73 % of the contractors, while EC contracts, on the contrary, are seen as increasing by 70 % of them (of course, these are average figures which vary depending on the country and the type of actor).
- In EC contracts : they represent nearly a third of total public support, i.e. 22 % of total estimated R & D costs; to achieve this level, the contractors applied on average for 5.5 contracts and were successful in 80 % of cases (4.3 contracts signed on average). According to answers, contractual relations with other DG XII programmes exist in one third of cases, contracts with DG XVII in a fourth of cases.

PART 2 : THE ESTIMATED IMPACT OF THE NNE3 PROGRAMME.

One must first underline the fact that hardly one fifth of the contracts, to date, have reached their contractual term. It is, consequently, out of question to attempt in any way an assessment of the actual impact of NNE3. What is presented below therefore concerns the contractors' opinion about likely outcomes of on-going operations.

21 - a "leading project"...

For 3/4 of the contractors, the supported project is seen as a core activity; the total number of researchers involved is 5.7 (out of the average of 21 present in a team), which corresponds to 2.9 full time scientists. Actually one can estimate that EC support enables the number of researchers devoted to the supported project to be increased by one unit (full time). This effect is confirmed by the overwhelming percentage (90 %) who thinks that EC contracts "help to get results more rapidly".

22 - ... that fosters European collaborations ...

In 68 % of cases, the research implies European collaboration. This collaboration includes new links for 65 % of these contractors; it also opens new doors since, in 65 % of cases, the partners belong to organizations with a different status. Furthermore, the cooperation is an active one, as shown by the frequency of meetings,(every three months on average); finally it is seen fruitful, as the contractors intend in 88 % of cases to maintain it for other purposes.

Two main reasons are given to explain the interest of such collaborations (and, at the same time, to our opinion, emphasize the role of EC support) : cross-fertilization (i.e. exchange of competences), and increase of means (i.e. achievement of a critical mass).

23 - .. but remains way upstream of commercialization.

Half of the contractors think their research work will lead to a commercialized product within 10 years; within these, only half (one fourth of the total) already know their future industrial partner (their own organization in one case out of 10). This is consistent with the total percentage of projects which are expected to lead to applications for patents (28 %), or to influence European norms or regulations (25 %). This is in striking contrast with the expected academic production : 4,1 articles and 1,5 thesis dissertations per contract, on the average.

	S	B	W	G	E	F	U	C	M	ENN3
Number of people on the contract	4.9	5.5	4.2	8.4	5.2	7.7	5.5	5.8	3.3	5.8
Number of fulltime researchers	2.6	2.7	2.9	3.5	2.5	3.6	2.6	3.2	2.3	2.9
Number of theses	1.7	1.3	0.7	1.4	2	1.1	1.8	1.3	1.6	1.5
Number of publications	5.4	3.4	2.7	4.9	3.4	3.8	5.1	4.8	2.8	4.1
Commercialization (% of contractors)	60	56	46	50	62	80	46	56	22	57
Term for commercialization	4.6	5.4	2.6	5.4	4.6	4.4	7.7	6	2.2	5.1
Know your partner ? (%)	23	22	18	33	45	32	24	37	11	24
Intend to apply for patents (%)	25	29	16	10	38	40	36	36	0	28
Number of patents	1.5	1.2	1.3	0.7	3.7	1.5	2	1.4	0	2
Other known projects ? (%)	97	79	96	70	67	50	76	75	50	76

Notes : "Commercialisation" refers to the percentage of contractors who think the results may lead, in the end, to a commercialized product. The "term of commercialisation" refers to the number of years necessary before effective realization under the most favorable economic conditions; "know your partner" refers to the future partner who would industrialize the results.

"Know other projects" refers to the other projects supported by the CEC within the same subprogramme.

PART 3 : CONTRACTOR'S OPINION ON CEC SUPPORT AND PRACTICES.

31 - Financial support is the prime factor for contractors : 90 % say it "helps to get results more rapidly". Moreover, in 70 % of cases, they would not have undertaken the research at the same level without support; this is confirmed by their disagreeing (59 %) when asked about the EC support as a guarantee for quality.

32 - European collaboration comes next : 78 % think it is the best thing about EC contracts (see Pt II.2 above). It is worth mentioning the role of NNE3 management in this connection : the monitoring of contracts appears satisfactory to most of them. Contractors' meetings are highly praised (80 % attended at least one and unanimously think they are of high scientific level).

33 - As regards administrative practices, problems center on the starting period : it requires on average 17 man-days to prepare an application; afterwards, for 42 % of the contractors, delays of payments at the beginning are too long. One other aspect worth mentioning is that, for 68 % of answers, the interval between calls for proposals is considered to be too long.

34 - Concerning the nature of EC intervention, 4 contractors our of 5 prefer programmes defined by themes to programmes defined by criteria. This is backed by the fact that contractors make a clear difference between R & D and demonstration (only 42 % of them would like an automatic link between supports by DG XII and DG XVII). No clear opinion, however, is given as to whether DG XII ought to elect to support selectively the best teams as opposed to enhancing the general level of European research.

TO CONCLUDE : A EUROPEAN CLUB OF ENERGY RESEARCH

Putting together many answers leads us to describe the contractors' world as a kind of "club". What is the European energy research club as seen by its members ?

- First, an information network. On one hand, 36% of contractors were directly informed of the NNE3 CP, 18 % inquired themselves and 36 % were informed by government agencies : on the other hand, when asked about difficulties for newcomers, 43 % answered "not aware of the programme".

- Second, a place where you "learn the rules". This appears clearly when considering the percentage of successful applications of contractors (80 %, while the NNE3 programme rejected one proposal out of two) or referring to the administrative learning process described by contractors during interviews.

- Third, a place where you know each other. The older the programme is, the less newcomers you let in (31 % of "geothermy" against 88 % for "wind", for a 65 % average for the whole programme).

- Fourth, the gathering of an elite. Contractors' meetings are judged to be of high scientific quality.

- Finally a club generally fosters an image of its members : overwhelmingly here, it develops around "little teams with European connections" (90 % of them wish the EC to develop such teams and 78 % think it is the best result EC action can achieve).

Indeed, the contractors' club appears to be a major achievement of the NNE programme : it witnesses the success of the programme in creating an effective European network in energy R & D (though, in the long run, an effort may be necessary to ensure that such a club does not become a closed medium).

THE NNE3 ENVIRONMENT : THE WORLD ENERGY SCENE.

File 4 : CERNA - P.N. GIRAUD.

Objective : place the NNE3 programme into its international context.

Methods used : analysis of IEA and EC scenarios, of world energy research, development and demonstration (RD & D) data (source : IEA database covering the western world except France), of US and Japan R & D policies (sources : official national documents, AFME) and of EC documents on energy policy and on RD & D. Comparisons are made between the 3 main western poles : Western Europe, USA and Japan.

MAIN CONCLUSIONS

1 - NNE3 : a limited reference to the world scene.

One would expect a logical progression from world outlook to main objectives for energy policies, to RD & D priorities, each step requiring a careful analysis of what is done elsewhere. Although working documents using this approach have undoubtedly been established for various segments of the programme, there is as far as we know no official document describing the world R & D background against which position the EC programme ("Plan par objectif", October 1982, ref. XII-1165/82 done under contract by H. Durand). At the same time, there is quite a number of official documents on EC energy policies; the programme even actively participated to the ENERGY 2000 scenario which envisions the world energy outlook for the years 2000.

2 - Long term visions undergo large, short term fluctuations.

There exists, at a given time, a leading analysis for energy perspectives, as well as resulting research priorities. In the early eighties (1980-83) a majority of experts stresses the vulnerability of the western world, enhanced by a high estimated probability of an oil crisis within 10 years. Hence the research effort is focused towards finding new energy sources.

From 1984 on, the spectrum of a forthcoming oil crisis fades away (see the ENERGY 2000 study); the emphasis shifts from the political to the economic sphere. What matters, rather than the oil dependency, is the oil bill. Hence, research priorities undergo a change in favour of fossil fuels (especially coal) and the rational use of energy.

Beginning in 1986, the perspective changes again. Energy is seen as becoming an economic sector among others; this stresses the importance of energy as a factor for the competitivity of economy and industry (see for example the recent DOE survey on non energy benefits of energy R & D programmes), while the preservation of the environment becomes a growing concern. Accordingly, R & D priorities go to advanced technologies, new markets for equipment goods, as well as accelerating the integration of modern generic technologies into the energy aspects of production.

3 - <u>Converging visions do not hinder diverging RD & D policies.</u>

Table 1 summarises the above description; nevertheless, even if international experts at any moment agree on a converging vision, this does not prevent Japan and USA to account for the vulnerability of their energy supply due to a growing oil dependency, and pushing forward scenarios that give a fast growing share to new energy sources.

TABLE 1 - MOTIVES AND PRIORITIES FOR R & D

Time periods	1980 - 1983	1984 - 1986	Mid 1986 on
Global Energy vision	Dangerous oil	Stabilized oil	Commodity Oil
Primary objective for energy policies	Independence by increasing domestic supply	Savings on the cost of energy	Competitiveness & environment problems of energy technologies
R & D priorities	new sources : nuclear, syn. fuels & renewables	growing concern for traditional sources & energy conservation	standard industrial policy + safe nuclear + clean coal for environment.

a) The public effort for Energy RD & D decreased, from 10 MM $ in 1980 to just over 6 in 1984; since 1984, however, this level has been maintained. The decrease is mainly due to the USA (-60 % in 7 years from 5.6 to 2.3 MM constant 1986 $) while on the contrary Japan continuously increased its effort (+17% in constant Y). Western Europe, during that period, first increased its effort until 1982 then let it steadily decrease from 3.3 to 2.1 MM constant 1986 Ecu (-38% in 5 years). In 1986, the three poles reach comparable levels : 2 MM $ for EC (less France), 2.3 MM for USA and Japan.

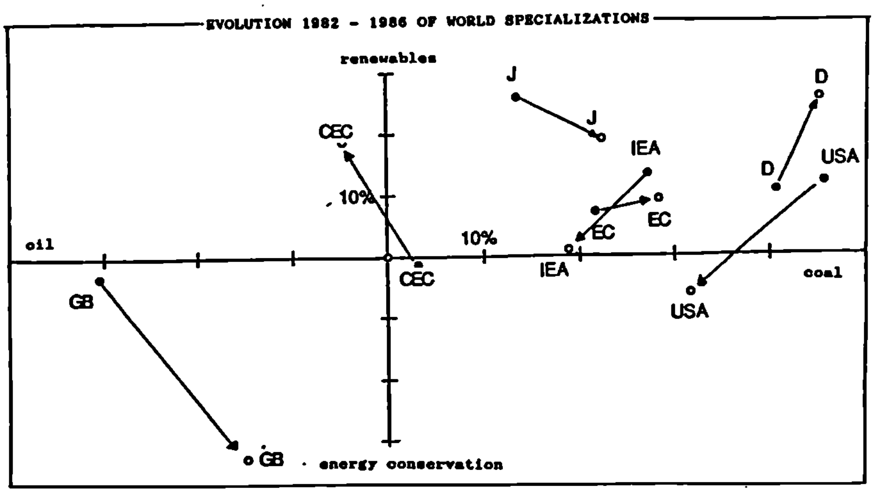
b) Nuclear RD & D prevails everywhere. It represents more than 70% of total RD&D of IEA countries; during the eighties only Japan increased its effort (over 80 % of total RD&D spending in 86), the decline observed elsewhere has been slower than the overall rate of energy RD & D.

c) Public R&D expenses on non nuclear energies are quite different among the 3 poles. In 1986 the overall public RD & D effort amounted to 1.7 MM$: 50 % for fossil fuels (4 times more for coal than for oil & gas), 23 % for Energy conservation and 27 % for renewables. The present situation results from diverging evolutions since 1980 : over this period Japanese effort was stable while EC one decreased by 22 % and US one by 70 %. In 1986, USA represented 42 % of the total effort way ahead of EC (32 %) and Japan (26 %).
Tables 2 - 8 and the chart below show the main facts about the public RD & D effort for the western world. Note however that these are not necessarily representative of the R & D effort when considered alone.

Table 2 : NUCLEAR PUBLIC RD&D SPENDING

	Total M$-86	advanced nuclear share 1980	1986	80-->86	conventional nuclear 80-->86
USA	1130	72%	34%	-79%	+ 9%
Japan	1800	34%	37%	+32%	+20%
EC (- France)	1370	42%	54%	0%	-38%

This chart describes the 1982-86 evolution for individual countries (Japan, USA, UK, FRG), European Community less France (EC), EC specific RD&D programmes (CEC) and IEA aggregations. The axes depict the degree of specialisation : first within fossil fuels (% RD&D public spending in coal minus % devoted to oil) second between renewables and energy conservation (% renew. - % en. conserv.).



Tables 3 - 5 : NON NUCLEAR ENERGY RD&D PUBLIC SPENDING, 1986 SHARES and 1980-->86 TRENDS

M$-86	USA	JAPAN	EC	Total	%
Oil	38	107	36	181	11%
Coal	256	203	187	646	39%
ECons.	220	18	151	389	23%
Renew.	177	99	164	440	27%
Total	691	427	538	1656	100%

86-SHARE	USA	JAPAN	EC	
Oil	21%	59%	20%	100%
Coal	40%	31%	29%	100%
ECons.	56%	5%	39%	100%
Renew.	40%	23%	37%	100%
Total	42%	26%	32%	100%

80-->86	USA	JAPAN	EC
Oil	-73%	17%	-55%
Coal	-68%	25%	-20%
ECons	-35%	-61%	-19%
Renew.	-82%	-25%	-16%
Total	-69%	-2%	-22%

Tables 6 - 8 : RENEWABLE ENERGIES RD&D PUBLIC SPENDING, 1986 SHARES AND 1980-->86 TRENDS

M$-86	USA	JAPAN	EC	Total	%
Solar PV	41	44	44	129	29%
Sol. C&H	11	4	27	42	10%
Sol. Ther	26	1	10	37	8%
Wind	25	2	40	67	15%
Biomass	43	11	21	75	17%
Geotherm	27	36	22	85	19%
Total	177	99	168	444	100%

86-SHARE	USA	JAPAN	EC	
SolarPV	32%	34%	34%	100%
SolarC&H	26%	10%	64%	100%
SolarTH	70%	3%	27%	100%
Wind	37%	3%	60%	100%
Biomass	57%	15%	28%	100%
Geotherm	32%	42%	26%	100%
Total	40%	23%	37%	100%

80-->86	USA	JAPAN	EC
SolarPV	-76%	200%	-24%
SolarC&H	-94%	ns	- 0%
SolarTH	-86%	-97%	-17%
Wind	-70%	ns	0%
Biomass	-40%	x 15	61%
Geotherm	-85%	-38%	-27%
Total	-82%	-25%	-16%

NOTES : all data are extracted from IEA "energy policies evaluation" reports ; 80-->86 trends shown in national currencies (constant 86 prices) to avoid exchange effects ; all 1986 US$ conversions were done by IEA on the basis of the average annual exchange rates.

d) These differences appear still larger when looking at the four main NNE components ...

- With respect to the average, EC and USA do not support oil & gas (5 % against 25 % in Japan) while Japan does not support energy conservation (5 % against around 30 % for USA and EC).

- The 1980-1986 evolutions put forward clear disincts priorities between USA with Energy conservation (only a 35% decrease) and Japan with fossil fuels (20 % increase); no such clear choices appear for Western Europe.

- In Oil & Gas, public effort does not appear significant when compared to industry effort (less than 200 M$); still, it is mainly the fact of Japan (60 % of total public support for the oil and gas R & D).

- In coal research with 31 % of total public effort, Japan has overtaken EC, but lies 10 points behind USA (40 %) whose effort is increasing again due to the starting up of both an important clean coal programme and of a significant MHD programme.

- Energy conservation has a strong support in the USA (56 % of total effort compared to 39 % for EEC). It appears as the major priority for the US department of Energy, which emphasizes its "non energy" effects. For DOE there are 3 main priorities: a) transport, b) generic technologies, c) industry; it is exactly the other way round for EC.

e) ... and are reinforced by the choices made for renewable energies.

- In spite of the 82 % decrease since 1980, US effort on renewables is still the largest (40 %) just ahead of EEC (37 %), Japan lies far behind (23 %) but concentrates on fewer areas (PV and Geothermy represent 80 % of total spending) than the two other poles (efforts evenly spread over 5 areas).

- Solar energy represents half of the efforts : the three poles make a similar effort on PV (around 40 M$ each); it is Japan's only significative effort in solar energy while, for EC and USA, Thermoelectrical and Heating & Cooling represent half the total solar spending.

- With around 20%, Geothermal energy comes second even if the efforts have decreased more than average everywhere. All 3 poles are present with Japan spending more (42 %) of the total 1986 effort : 85 M$).

- Biomass appears as a clear US priority (60 % of total effort) with increases nevertheless in both EC and Japan. On the contrary, Wind appears as EC main stronghold with a constant effort in the eighties.

f) In conclusion :

- The United States reckon their national energy potential (with coal and new energy sources) to be more than self sufficient in the long run, in spite of their growing oil dependency. In this context, the primary objective of their R & D policy is to ensure that technical knowledges exist and are available for every axis with potential economic interest.

- Japan, on the other hand, aims directly at reducing its energy dependency by promoting diversified sources; at the same time efforts are concentrated on a limited number of large projects which are oriented towards potential new markets, such projects cover without discontinuity every step from basic research to technological demonstrations (often requiring large scale pilots) and are seen as an important support for the development and spreading of generic technologies.

THE ENN PROGRAMME WITHIN ITS EUROPEAN ENVIRONMENT.

File 5 : CSI - P. Laredo.

Objective : position the NNE3 programme within the European energy R & D content.

Methods used : member states publications on their energy R & D programmes; interviews (11) of national representatives to the CGC and/or managers of national R & D programmes; similar method used for other CEC programmes alongside "keypartners" interviews (altogether 12 interviews in addition to panel ones). Considering the shortness of available time, only four countries were concerned.

MAIN CONCLUSIONS

1 - The absence of readily available information.

- we were not able to find within the programme a readily available, comparative data set (other than the IEA one to which the CEC contributes) which would have allowed us to quantitatively assess the EC R & D effort in relation with the whole European effort;
- the programme had no synthesis on the various national programmes, their orientations and their priorities.

2 - DG XII action : only a fraction of CEC action on energy RD & D

Even not taking into account nuclear research and other energy R & D efforts conducted by the CCR, NNE3 represents only a fifth of the total RD & D effort carried out by the EC on energy. The largest share is under the responsibility of DG XVII :

- technological developments projects in the hydrocarbons industry : 35 MEcu per year until the end of 1988; 3/4 of the grants (average : 0.83 MEcu on a 3 year period) go to "oil services" companies and 60 % to SMEs;

- basic research on coal : around 20 MEcu per year reserved for coal producing companies and dealing with all coal research aspects except combustion;
- pilot projects for coal liquefaction and gasification : between 15 and 20 MEcu per year for 4 years (35 MEcu for the years 1986 and 1987;
- demonstration projects on all energy related activities : around 250 MEcu for 4 years (1986-1989); in 1987, 87 MEcu were granted to 200 projects, 40 % for energy conservation, 31 % for renewable energies (well distributed on all sources), 19 % on solid fuels and 10 % on other fields (use of electricity, mini-hydraulics).

Finally, the EUREKA frame offers an alternative channel which allows private companies, possibly associated with public laboratories, to obtain public support for industrial development projects.

Three main aspects must, then, be taken into consideration :
- first, the DG XII programme is a minor line of CEC action toward RD & D in the energy sector, (as a consequence of the partition of missions among DG's) for industrial partners; this tends to reinforce its longer term specialization and "fundamental research " tendency;
- second, the overlapping areas with the demonstration programme, mainly at the "pilot" stage (f.i. deep drilling in geothermal energy, wind machines prototypes, ...); note that in such cases, contractors tend to differenciate strongly between both programmes, and underline the positive effect of following-up methods developed by DG XII (periodic exchanges, common set of tests, ...);
- finally, links between programmes do not appear to be very strong; and sociological studies indicate clearly that it is often the case with different bodies of the same administration whenever they address the same customers, in this case the energy equipment industry.

3 - The expectation from EC member states : help their national programme in pre-competitive stages.

We received two main statements about their EC research programme.

a) first it must build on, and enlarge the national programmes. The EC programme's role is to offer, in what are considered by each country as important R & D issues for its own future, two extensions : one by increasing public support (European money permits to do more, further and faster; see concurring opinion of the contractors); secondly, by opening an access to competences that are not nationally available (through the joint projects initiated by EC).

Stating this, member states are well aware that their own priorities may quite diverge from those chosen by their counterparts. When raising this question, we always got a similar answer : "in no case should a research theme that is important to us be excluded from the EC programme". At the same time, member states recognize that doing so, they entitle the others to bear the same attitude, with straightforward consequences: the officially defined EC programme then becomes a broad catalogue, including every scientific and technical theme, provided at least one of the member states has shown interest into it.

b) Second, the EC programme should not interfere with the market, i.e. should not through its interventions risk favouring one company against competitors. Although this opinion may not be shared by all the countries (especially those which do not have a national R & D programme), it is strongly advocated by many of them, who think that there are other mechanisms to support competitive research. This second criterion drives the programme way upstream of industrial development (especially when compared to the newer EC programmes such as ESPRIT).

4 - NNE programmes : a limited margin for action

NNE3 had to combine 3 main elements : the influence of non convergent policies of member states, the splitting of responsibilities within the commission, a positioning only in the pre-competitive stages, ahead of industrial research. This has logically driven the programme toward the mastering of technologies way ahead of the market (i.e. basic research + technological breakthrough). Under such conditions, one is tempted to define DG XII domain as restricted to "technological fundamentalism".

THE PROGRAMME MANAGEMENT

<u>**File 6**</u> : CSI - P. Laredo.

Objective : describe the existing management mechanisms and assess their actual use and performance.

Methods used : interviews of programme managers, members of CGC and administrative personnel of EC. Two specialized files (n°7 & n°8) have been built for the role of the CGC and the administrative processing of contracts.

MAIN CONCLUSIONS

PART 1 : THE EXISTING MECHANISMS ...

1 - <u>The role of political bodies in deciding the broad lines of the programme.</u>

The commission prepares, within the preexisting (programme) organization, proposals for future action. These proposals are then submitted for recommendation to the different instances, first consultative (CREST, ..) later political (the European Parliament) before the Council of ministers takes an official decision which defines the general orientations, the funds allocated and their breakdown by theme.

This negotiation process may have to go through iterative phases. This was indeed the case for NNE3, when the Council requested the commission to modify its initial proposal in order to incorporate a subprogramme dedicated to hydrocarbons.

The Framework programme for 1988-92 introduces an important evolution in the sense that, before any analysis of expected results of on-going research, it stipulates the financial amounts to be allocated to each EC programme.

2 - Management structures.

To allocate funds granted to the programme, three elements play a role in scientific management : an "advisory committee for the programme management" (thereafter referred to by the initials CGC), a programme team and a set of external sectoral experts.

- the executive management is in the hands of a small "task force", i.e. the programme team, which includes the different subprogramme managers and their assistants (at most 2 or 3 scientists).

- this task force is assisted by external experts (around 50) which are paid for the job they perform. They participate not only to the selection of proposals, but also and mainly in the scientific and technical follow-up : follow-up of each operation, animation of contractors' meetings, ...

- the CGC has been assigned 5 main missions and should, thus, give advice on : programming, selection of projects, evaluation, information and coordination with national programmes. The 24 members of the committee are nominated by member states and appointed by the Commission.

3 - Management tools.

The call for proposals (CP) is the main formal tool to communicate with the scientific and technical community at large. Because of the late start of the third programme (15 months elapsed between the end of the second programme and the beginning of the third), the Commission's choice for NNE3 was to issue one very large CP covering nearly all the themes of the programme and dedicated to the allocation of a vast majority of the available funds.

For the selection, the method used was as follows : assessment by the programme managers and their experts, examination by the CGC of choices proposed by the programme team, search for a common position of all delegations on each proposal, return of the proposals which did not gain acceptance to the programme team for further instruction, before reexamination by the CGC ...

While the scientific and technical preparation of contracts lies within the hands of the programme team, the writing of the contracts and their administrative acceptance lie with a specific directorate which also controls all the budgetary, administrative and financial information.

The follow-up is based on biannual reports and the holding of annual contractors' meetings. A financial control of the means engaged by any contractor for realizing his project can also be done at the contractor's office (80 per year for the whole of DG XII).

PART 2 : ... AND HOW THEY ACTUALLY WORK.

1 - the role of political choices in the evolution of the NNE3 programme.

It is worthwhile recalling that the thematic field of the programme was not restricted by the Council of ministers when they decided to cut down by half the funds allocated (from 380 to 175 MEcu); on the contrary they added a ninth subprogramme. Obviously this created difficulties for the programme strategy ...

2 - the main role of the CGC : the management of national compromises.

File 7 shows that the CGC unequally fulfilled the missions which were assigned to it. Out of the 5 tasks it had in charge, only two have been the object of an active interest :

- the selection of proposals,
- the preparation of the new programme.

The actual mechanisms developed to deal with these two activities lead us to qualify the CGC action as dedicated to the management of national compromises. In turn, this suggests that the CGC mainly fulfilled what sociologists call "hidden functions" :

a) create a mutual information flow between member states,
b) take into account the different national interests while promoting the first steps towards European scientific and technical collaboration,
c) contribute to the emergence of a "scientific and political" social group potentially ready to take charge of a voluntary common action. For an external observer, such aims are, considering the construction of Europe as the most important goal, just as important in the long run as official tasks assigned to the CGC.

3 - The programme managers : "jacks of all trades"

The role of the programme managers goes far beyond daily managing. Backed by their pool of experts who strongly adhere to the logic of a European policy, they in fact define the strategic choices, especially when implementing the general orientations into research objectives. This goes along with the methods adopted by the CGC which relies on the programme managers for all the strategic assessments and most of the actual operational choices.

We wish to underline two main aspects of this situation :

a) the assistance by external experts appears to be a really efficient S & T management tool;
b) considering the political choices made, the split of responsibilities developed between the CGC and the programme managers may appear as a rather logical and efficient solution.

4 - <u>The S & T follow-up : a major success of the NNE3 programme.</u>

One of the best achievements of the programme is without any doubt the quality and efficiency of the scientific follow-up by the programme team. It appears to be a major factor in promoting European S & T networks (see file n°3). It has been successfully complemented by "International conferences" which, at periodic intervals, present the EC supported R & D work in the context of the flow of world science.

5 - <u>Questions about the other management tools.</u>

Questions arise from the actors of the programme when it comes to the other tools :

- file 8 shows how heavy the processing of contracts appears, making it a real obstacle course;
- file 2 underlines the broadness of the main call for proposals when compared to the actual scope of maturing (sub)programmes which only focus on some of the mentioned themes; this in turn does not help to identify newcomers and foster their integration into the developing European networks.

Finally, let us stress the importance of information tools dedicated to an efficient management : we specifically refer to data bases gathering all the necessary administrative, financial and scientific information and offering all programme managers easy manipulation and processing facilities. The NNE3 programme obviously lacks such a tool. The reorganization under way of the computer system of DG XII (see file 8) may offer a good opportunity for improvement, provided programme teams are actually associated to its definition.

THE ROLE OF THE CGC

File 7 : Université de Namur - D. Vinck.

Objective : analyse the role of the CGC on the programme definition and management.

Methods used : work on the minutes of the CGC to :

1) examine active participation,
2) identify main themes treated and analyse the differing positions taken on each of them,
3) reconstruct the main "logics of action" and the alliance or opposition networks that developed within the committee.

MAIN CONCLUSIONS

The CGC ("Comité Consultatif de Gestion et de Coordination"), created in 1984, has been assigned 5 domains for advice : programming, selection of projects, evaluation, information and coordination with national programmes. It is made up of 24 members nominated by the member states (2 for each one) and appointed by the Commission.

It met 13 times between January 1985 and January 1988, sometimes with 2 or more sessions per meeting (total number of sessions analyzed : 18).

1 - <u>A limited core surrounded by a large number of outside experts.</u>

During its meetings the CGC has drawn a considerable number of persons : 228 persons have participated in an average of 3 sessions. Participation of Member states amounts to 2/3 of total participation with 142 persons. As expected official representatives account for the core of the participation : 23 persons and nearly 11 sessions on average per person. But it still only represents a third of the average composition of the CGC. The 119 national experts (average participation : 1.7 sessions) represent another third of the average CGC composition. The participation of EC members makes up the last third: 88 persons for 2.7 sessions on average. It is necessarily dominated by programme managers and their outside experts (33 persons mainly present during the selection process; average participation : 1.7 sessions).

2 - <u>A continuous interest focused on only two missions.</u>

Altogether 10 distinct discussion themes could be noted from the CGC minutes. The selection of projects clearly takes the largest share, being present in all but one of the meetings and being the core of at least half of them. Since the beginning of 1987, it has been overtaken by the preparation of the fourth programme. All the other themes appear to be marginal, especially two of them, evaluation and diffusion, that are directly linked with the official tasks assigned to the CGC. As refers to coordination with national programmes, it seems to have never been the object of a specific discussion.

3 - <u>Limited quantitative effects on the selection of projects.</u>

Near to 1500 proposals were received and went through the CGC following a precise rule aimed at reaching a consensus within the CGC : 1) each proposal is ranked by the commission prior to its passage before the committee either as A (to be accepted), C (to be rejected) or B (to be reconsidered); 2) if no objection is done by any member state, the advice of the commission is accepted; otherwise the proposal is systematically ranked B; 3) B proposals are studied by the commission, come back before the CGC with an A or C ranking and are only accepted when a consensus is reached (there are still some B proposals waiting from the first CP dating back in 1985 ..).

SELECTION OF PROPOSALS : CGC INTERVENTION
NNE'3 PROGRAMME

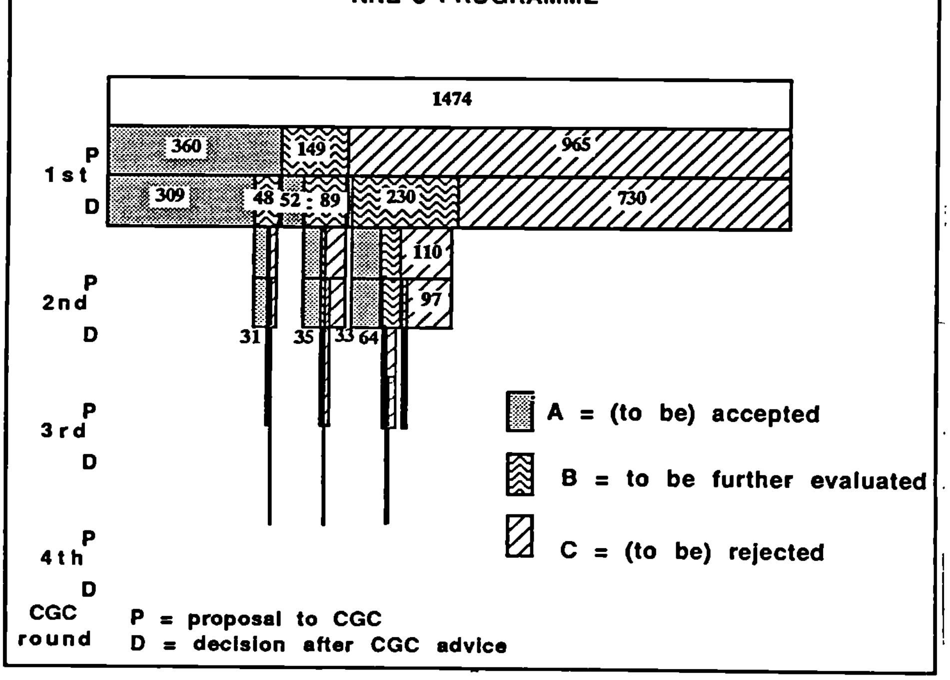
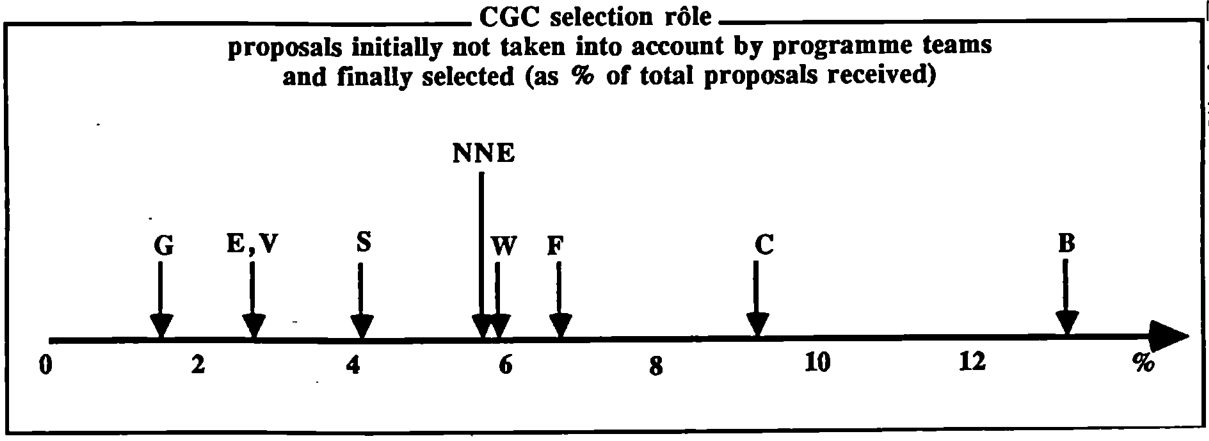


Table 1 summarises this process and highlights its time-consuming nature: nearly 20 % of the suggestions made by the commission were not initially accepted and altogether over 200 projects were added to the initial B category (mostly C proposals that member states did not want to be rejected before further appraisal).

Ultimately however, only 6.8 % of the proposals changed fate thanks to their passage through the CGC. In 80 % of the cases (5.6 % of total number of proposals) this concerns proposals not retained initially by the programme teams; Table 2 shows those figures to fluctuate significantly among subprogrammes. Therefore the process had limited quantitative effects; this is of course not saying it was unnecessary, neither that qualitative results were negligible.



4 - <u>The preparation of the fourth programme : a "transaction process"</u>

To prepare the fourth programme, the CGC developed a mechanism which may be assimilated to a "transaction process" geared towards the conciliation of national interests, which often conflict. As a first step (at the end of 1986), the programme team prepared, with the help of its experts and, in some areas - e.g. hydrocarbons -, backed by outside assessments) a list of research requirements. This first proposal covered over 100 research items; it was then discussed within the CGC in a series of meetings where each delegation gave its opinion and, progressively, a common position was negociated.

From the 4 meetings studied, three issues appear particularly significant:

- criteria for selection. This has been discussed at length (29 different points treated); in 9 cases out of 10, concurrent opinions were expressed, that do create a large consensus about general orientations : promote European connexions, put together public research and industrial companies, take into account environmental concerns, favour long term horizons;

- thematic priorities. Among the 103 items initially listed, 30 were endorsed without any comment; the remaining 73 gave rise to 192 statements from national delegations. For 37 items, opinions were unanimously positive, and emphasized satisfaction due to the fact that the theme under discussion was indeed part of the programme. For another 21 items, concurrent opnions were given on the negative side but were significative in only 4 cases (3 negative opinions or more). Finally 15 themes mobilized half of the positions taken by national delegations because of openly divergent opinions : positive and negative statements balanced one another except for 4 themes. Ultimately, the programme was left with a thematic definition including just under 100 different research topics ...

- repartition of funds between research areas : an agreement was easily reached to consider, rather than 9 subprogrammes, 4 main domains for research : energy conservation, renewable energies, fossil fuels, system analysis. However, the shares to be attributed to each of these areas have been the object of lenghty debates, still going on at the time this report was completed.

Summarizing then, the new programme is strongly oriented towards the bringing forward of European connexions; it should have a broad coverage, in order not to exclude any national research priority. This feature, as well as the fact that budgetary allocations to broad research areas tend to become the main object of debate and compromise, are largely consequences of the method itself, elected by the CGC.

ADMINISTRATIVE PROCESSING OF CONTRACTS.

File 8	: Université de Namur - F. Warrant
Objective	: describe the administrative processing of contracts and analyse the links between scientific and administrative functions.
Methods used	: review of the internal administrative literature and of consultance reports concerning CEC organization, interviews (15) of administrative managers.

MAIN CONCLUSIONS

The reader should bear in mind that this text describes a situation likely to change rapidly, following the decision of the Council of Ministers dealing with the administration of R & D contracts within the Commission (November 9th, 1986).

1 - Separated scientific and administrative processing channels.

Table 1 summarizes the flow chart of the administrative processing of a research contract.

This table first reflects a general principle found in most European countries, i.e. a splitting of tasks between :

1) the responsible for the commitment/payment (here DG XII),
2) the accountant (DG XIX),
3) the financial controller (DG XX).

Further, it shows a complete separation between the scientific and administrative steps for preparing contracts within DG XII. While the first lie within a scientific directorate (for NNE3, this is DG XII-E), the second are under the responsibility of the contracts division of DG XII-B. Accordingly, for each contract, there is a parallel processing with two "officers" in charge : the programme manager for DG XII-E (called in administrative language the "scientific officer") and a "negotiator" for the contracts division. This does not reflect a general rule : for BRITE and STD the technical and legal negociations take place through common meetings with the future contractor.

Within the contracts division,the 11 negotiators specialize by country rather than programme. This repartition follows from language problems; further, it enables to partly compensate the variations of workload due to the "Call for Proposals" procedure. Thus nearly all negociators deal with every programme. This does not facilitate concertation with programme managers; hence the requirement, recently expressed by the Director General of DG XII, to reinforce the function of "liaison officers" also attributed to the negociators.

Still, the basically dual structure for preparating the contracts is likely to remain a source of delays; the more so when considering the workload of nagociators, who deal, on average, with about 290 contracts every year.

2 - The future contract : a demanding "obstacle course"

Such a task separation, common to many national administrations, induces an involved, compulsory circulation of each proposal before it turns into a contract; no less than 11 movements between services have been noted (see table 1), out of which only two correspond to movements towards other DGs (endorsement by DG XX and registration by DG XIX).

TABLE 1 : FLOW CHART OF THE ADMINISTRATIVE PROCESSING OF A RESEARCH CONTRACT

Task	Fulfiller
acceptance & letting of contracts	approximate delay for commitment : 8 months
- first agreement	XII/DG
- blocking approved amount on DIODON	XII-B
- scientific negotiation, draft of technical annex	XII-E
- administrative, financial and legal negotiation	XII-B (N)
- draft contract	XII-B (N)
- forward	XII-E
- endorse	XX/FC
- register	XIX/AD
- sign	XII/DG
- send to contractor and internally	XII-B (N)
administrative attendance	approximate delay for a payment : 3 months
- payment of advance - periodic payments on reports - modifying contracts	*numerous interactions between* XII-B (G) *and depts of* XX & *XIX* *concerned by the orders to pay*
for example : - opening a file on the data processing system - registering the advance - preparing the order to pay	*all payments after advance only made after* ....XII-E (scientific officer) *has endorsed the verified expenditure (periodic report received and accepted).*
acceptance & closure of contracts	
- approval of final report	XII-E
- payment of retention guarantee	XII-B (G)
- if necessary recovery of taxes..	XII-B (G)
- .. or overpayments	XII-B (G)
- spot financial audits	XII-B (G) *or* XX/FC *for up to two years after last payment*

XII/DG : Director General, DG XII
XII-B (N) : DG XII Contract Division (Negotiators)
XII-B (G) : DG XII Contract Division ("Gestionnaires")
XII-E : DG XII Scientific Directorate
XIX/AD : DG XIX Accounting Department
XX/FC : DG XX Financial Control

Note : the 8 months approximate delay often includes a renegociation period, due to scientific decisions to foster modified proposals (especially with the purpose of joining some proposals together).

3. The consequences of a procurement approach.

The taylorian process observed on the preparation of contracts appears mainly linked to the fact that each contract requires at the same time a technical and a legal negotiation.

While such a process is adequate for a procurement policy, where the buyer wants to be sure to get the exact product or service he pays for, it does not warrant R & D support: in that case, the EC no longer buys a good, but helps financially other parties to increase their research effort either by themselves or preferentially with others. The only effective contractual requirement should then be that the contractor does actually spend the contractual amount of money (including both his share and EC support) on the agreed theme; legal procedures, accordingly, should bear on monitoring conditions rather than on obligation of results.

The discussions under way within EC for developing an "unified contract" adapted to R & D needs offer an opportunity to take this aspect into consideration.

4 - A systematic, time consuming financial control.

The basic financial control presently consists of checking every statement received; this weighty procedure is carried out by a special office of the contracts division. Within this office, the "gestionnaire" in charge processes each statement in turn, which requires following a strict standard procedure so that any file can be treated by any "gestionnaire".

Alternate methods could undoubtedly reduce this workload : DG XII, DG XIII and DG XVII proposed to develop a method based on "auditor certificates", wherein the auditor usually used by a company to certify its annual accounts would certify the truthfulness of each invoice (this was not, however, accepted by DG XX, because of financial rules).

Such simplifying steps would enable the Commission, as a counterpart, to increase the number and scope of "on the spot" audits. At the present time there are, for the of whole DG XII, only 80 audits per year, which are restricted to purely financial aspects.Indeed, when applied to a significative sample (around 10%), this methods offers a powerful management tool, for contracts where only the inputs can objectively be measured. Furthermore, "on the spot" audits might also be made highly useful for the scientific directorates, by providing at the same time elements for a scientific/technical evaluation.

5 - <u>A key issue : the data bank and processing systems</u>

DG XII has developed an automated system, DIODON II, that manages contracts inside the DG.

The interviews we conducted clearly point out 3 major problems :

- DIODON is not linked with the computer system in use at DG XIX;
- for more users, DIODON does not appear reliable (updating problems) and is difficult to access and manipulate;
- DIODON, since it is strictly oriented toward the administrative processing of contracts, does not include the relevant information for scientific follow-up and programme monitoring.

These drawbacks explain the priority put on the development of a new system called AMPERE to replace DIODON. Provided AMPERE takes into account broader finalities than the administrative processing of contracts, it offers an opportunity to vastly improve the working relationship between scientific and administrative bodies.

TO CONCLUDE

NNE3 : MANAGEMENT IN A CONSTRAINTED UNIVERSE

I - AN OVERALL APPRECIATION ON NNE3 MANAGEMENT.

An external observer cannot but be struck by the absence of explicit strategic analysis in NNE3 : we did not find any written document attempting, even in broad terms, to position the NNE3 programme within the international competition.

While such a lack appears, at first sight, as a matter for serious criticism, the detailed analysis of the programme and of its way of operation suggests a more balanced view. Indeed, it would be a mistake to infer from that situation that the programme is not efficient : one might, on the contrary, argue that there is a strong consistency between, on one hand, the external constraints which weigh on positioning of the programme and, on the other hand, the management mechanisms used to best deal with existing margins of action and achieve, within these constraints, the best possible results. See chart below.

NNE3 : the management of constraints

---------------- constraints	------------------>		results
External cons-straints(national policies, responsibility sharing within EC)	Actual objectives pursued by NNE3	The management of NNE3	The results of NNE3
limited margins for action : - non nuclear - precompetitive - complementary to diversified national strategies	maintain Europe within technological competition : - basic research - breakthrough areas	- no use for global stragegic survey - key role of the programme manager in running the programme - management of national compromises (CGC role)	- academic quality - interactive networks - promotion of a European research attitude

This chart begins with the "boundary conditions" of the programme, and helps to clarify how they induced consequences on actual objectives, management principles, and ultimately the nature of results. The contraints linked to the environment of the programme determin in a quasi mechanical way the selection of its objectives : maintain Europe within the technological competition, while focusing on possible new activities derived from major breakthroughs, provided they complement the national programmes.

Since the definition of aims and objectives derive from external constraints, two main functions are left to the programme :

a) the settlement of compromises between member states, which the CGC is managing;

b) the definition of research topics and the setting up of European networks addressing them : this has been the main task of the programme managers.

In such a situation, potential results cannot be assessed directly in terms of technical/economic impact; they are basically geared toward three goals : achievement of high academic quality (theses, articles,..), construction of inter-connected networks (associating industrial and academic research teams),promotion of European minded research attitudes. Although valuable results have certainly been obtained in many sectors of energy research, we believe, indeed, that these three goals are the only significant ones in a strategic sense that a programme is able to pursue under such constraints; on all three, information we have gathered upon the programme points to unequivocal success.

II - THREE ISSUES FOR FURTHER REFLEXION.

As a conclusion, we feel it useful to submit to the evaluation panel and the Commission, three tentative statements. They are presented in the order of narrowing fields of view.

II.1.EC NNE R&D actions may be near a turning point.

- On one hand, the programme has accumulated a portfolio of results;

furthermore most of the subprogrammes have come to, or are entering, what we termed the mature phase. In other words, with the terms of reference as they stand today, a programme such as EC/NNE may be approaching, in not very many years from now, the time where it will have completed its job.

- On the other hand, our survey of the world scene shows what is now at stake in energy research, rather than vulnerability to oil crisis, is the competitivity of industry on the global market. As a consequence one ought to shift from stimulating basic research ahead of every possible energy resource, to the selection of a few axes, for which the effort must then go all the way down to proving the technical/industrial feasibility,in the spirit of the japanese projects. Thus one wonders how to optimize the European research effort for energy in this new context. Although officially denominated "precompetitive", ESPRIT appears an example of EC research undertakings which, unlike NNE, address the industrial assessment of new technologies, uncluding the large scale pilots that it requires.

The alternative, then, is :

a) either to keep the boundary conditions of the programme more or less as they stand, in which case the question of the relevance and very existency of the NNE programme is bound to arise in a not very distant future;

b) or to move from "pre-competitive" to what may be termed "pre-industrial" R & D.

In the case where the latter decision is considered, it should definitely be based upon an in-depth strategic analysis (see the recent report to the Director General of DG XII by R. Chabbal), which would have to address both thematic and organizational issues. Considering the length of time necessary for this kind of work, it would be wise to undertake it soon. We stress that such an analysis ought to address, as well as thematic topics, organisational issues. The separation of tasks between DG XII and DG XVII is one of the major boundary conditions of the NNE programme; while it may have been well adapted to the context and concerns of the recent past, this organisation cannot be seen as optimal for setting up integrated projects.

II.2. The NNE4 programme should have an explicit strategy.

Here is a paradox within EC practices. On one hand, programme evaluation is a recognized procedure; on the other hand, it is difficult to identify clear objectives assigned to the NNE programmes. We believe that an explicit strategy ought to be elaborated, whatever the decisions for the future may be.

Our report emphasizes the focusing process experienced by most of the actions developed under the previous NNE programmes; while they are not numerous, most of them require continuation of EC support, if only to assess their effective technological potential. Besides, several of these projects will soon reach a turning point and require strategic analyses in order to assess the actual interest for Europe to engage further. Furthermore, in the context of the limited budget allocated to NNE4, one may doubt whether many significant items can be added to this list (we do not speak here of exploratory research effort, which might easily be dealt with by open calls for new ideas, with a small fraction of the programme amount specially set aside for it) : the Commission needs a basis for choices to be made.

This work should be one of the main concerns of new programme. While it appears as a natural responsibility of the CGC, it requires sizeable evolutions in both the Group's practices and the national visions with respect to the role of an EC energy programme.

II.3. R & D spending and monitoring need improved managerial tools.

We found the S & T monitoring of contracts to function very satisfactorly. Other than this, several aspects of the management could be improved with benefit, whatever the basic choices for the future orientations may be.

- The NNE programme experiences a natural tendency to create a closed research medium, i.e. a "club" of regular partners, while conversely potential new partners find difficulties in joining the programme. An efficient way to remedy this situation is to clearly specify the thematic definitions and judgment criteria; this applies particularly to calls for proposals or even calls for interest).

- The severest problem noted by contractors concerns the administrative aspects of the contracting procedure. The Commission ought to realize that R & D support cannot be assimilated to a procurement policy and devise accordingly a simpler contracting mode suited to R & D finalities. This, at the same time, would ease the involved "obstacle course" that each proposal has to go through before turning in an actual contract.

- Coordinated data on the monitoring of the programme are lacking; the building of a data base simultaneously embracing administrative, financial and scientific information appears, at the programme level, highly desirable (if only to insure the necessary transparency needed for sound periodic evaluations).

- Finally, there is a lack of adequate data pertaining to the activities of EC member states as well as major world competitors. Comparative analyses should be one of the main functional tasks required from the programme team : putting together and disseminating this kind of information might go a long way toward creating common attitudes amongst European countries.

Commission of the European Communities

EUR 11834 - Evaluation of the R & D programme in the field of Non-Nuclear Energy (1985-1988)

Sir H. Bondi, F. Amman, A. Jaumotte, Ch. Marnet, J.J. Palomares, R.J. Uffen, P. Waldteufel

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Finally, a number of recommendations are given for the future orientation of the programme and ways of improving their effectiveness.

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