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Institute FOR Prospective Technological Studies

JOINT RESEARCH CENTRE

COMMISSION OF THE EUROPEAN COMMUNITIES

EUR 15002 EN

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EXECUTIVE SUMMARY

1. The Institute for Prospective Technological Studies is an integral part of the Commission of the European Communities Joint Research Centre (JRC). It is currently sited at the JRC's main campus at Ispra, in Italy.

   The Institute's main tasks are:

   - monitoring new developments in science and technology;

   - strategic analyses of new areas of science and technology.

   Training of young scientists in techniques of prospective analysis is an important subsidiary task.

   The main instrument for fulfilling the first task is the Institute's European Science and Technology Observatory (ESTO). The second task is addressed by performing "prospective studies" for a range of clients, chiefly but not exclusively services of the Commission. The training function operates through the award of research fellowships enabling young European scientists to spend one or more years studying within the Institute.

2. 1992 was a year of consolidation rather than rapid development, with the numbers of both permanent staff and research fellows remaining constant. Major expansion awaits approval of dedicated research funding.

   ESTO, in particular, must await decisions on these matters before it can be developed to its full potential. For the moment it remains embryonic, with only the "Global Change Research and Policy" module operational. Development work on in-house information systems, particularly the European R&D projects data base QUI QUOD, continues and seems likely to attract sponsorship from potential clients elsewhere in the Commission. A small catalytic effort in the direction of producing new innovation indicators is also starting to show promising results.

Prospective studies are increasingly conducted within the framework of multiannual agreements with Commission clients. This considerably aids continuity and forward planning of resources. Such agreements were in force during 1992 with the Presidency's Forward Studies Unit and the Directorates General for Industrial Policy and Environment (DGs III and XI).

Studies undertaken during the year covered four main themes:

- energy (systems and technologies for the long term future);
- environment (industrial opportunities and constraints);
- transport (space markets, high speed trains);
- industrial competitivity (evaluation of EC strategies).

A start was made in structuring participation in the fellowship programme around specific projects. The first such project concerns long-term prospects for urban transport.

3. As mentioned above, staff numbers remained constant during the year. The Institute has 14 "permanent" staff, 4 of whom are in administrative/secretarial posts. In addition there were, at 31st December, a national expert on secondment and three post-graduate fellows.

1. INTRODUCTION

1.1 Background

The Institute for Prospective Technological Studies (also known as PROMPT) was created in 1989, following the new orientations and the new organisation of the JRC which were put into effect at the end of 1988. The official document which describes these changes for the JRC ("A new outlook for the Joint Research Centre" - COM (87)491), contains the following statements, relating to the new Institute for Prospective Technological Studies :

"prospecting, assessment, scientific watch and strategic analysis will assume a new significance in the context of scientific and technological developments.
This work will become an integral and essential part of the process of programming Community research. In particular, the scientific and technological watch function, which is virtually unknown in the Community, will be called upon to play a key role in the future alongside the prospective studies and technology assessment functions"
and
"the special feature of the JRC's role in this area is its ability to supply strategic analyses based on "inside knowledge" of the scientific and technical trends in the world of research".

Working from this base, and relying on the wide spectrum of scientific/technical knowledge available within the JRC, PROMPT supports a permanent system for information on and analysis of the state of science and technology in the European Community, and of its relative position world-wide. The activity includes the analysis of both the potential and the drawbacks of new technologies, the prospects for their application in various fields and the developments foreseen.

The focus of the Institute's activities is advanced, applied research, with priority going to the subjects covered by the Community Framework Programme and to those newly emerging technology areas which are potentially important for European society and industry.

The main functions of the Institute are to monitor, evaluate and alert, with the intention of providing information on strategic options and opportunities with a European dimension, in a form suitable for users within the Commission, for science planners and for European industry.

The permanent staff of the Institute remains small in number. It is, however, being complemented by temporary staff seconded from Member States, by visiting scientists and by research fellows. In addition, PROMPT relies heavily on contributions from outside, through formal contracts or collaboration agreements with national institutes and industrial firms and through networks of individual correspondents in various fields and countries.

1.2 The Year in Review

1992 was a mixed year for the Institute. On the one hand, there was considerable progress in consolidating and extending the "client base" among Commission services, a permanent antenna was established within the Forward Studies Unit in Brussels and some progress was made on developing the conceptual and IT bases of the European Science and Technology Observatory. There were also promising developments in the Institute-sponsored informal network on Literature-Based Innovation Output Indicators, with several national studies reaching completion and others getting under way.

On the other hand, the continued uncertainties regarding the Institute's future location and funding meant that this was, once again, a transition year. New recruitment was balanced by staff losses while delays in the start-up of the Commission's new Human Capital and Mobility Programme (the Institute's only source of Framework Programme funding) meant that, contrary to expectations, the year ended with no net increase in the number of grant-holders.

Against this background the strategy of concentrating on the satisfaction of specific client requests, rather than on the development of methodologies and tools, proved correct. Clients have generally expressed themselves well pleased with the work done and the Institute's reputation for producing rapid, succinct and appropriately-focused background papers has grown. The increasing volume of requests for studies is evidence that such work is appreciated.

At the same time the Institute aspires to be more than a study-office performing client-specific (and mainly one-off) reports. The Community's need for a comprehensive and continuous technology watch function, as envisaged in the original decision establishing the Institute (COM(87) 491), grows ever more apparent.

2. ESTO (European Science and Technology Observatory)

From the inception of the Institute it has always been accepted that one of its main tasks was to establish an observatory equipped to provide European decision-makers with a science and technology awareness service covering all the key areas of current and future policy concern. It was anticipated that operating this observatory (known as ESTO) would absorb roughly half the Institute's resources.

To date, however, no separate funding has been available for ESTO, with the result that it has still only an embryonic existence, on the margins of the specific studies for clients which provide almost all the Institute's current income. This situation will, hopefully, change in the near future. Indeed if PROMPT is to move from its present site, thus losing the intimate (if largely informal) scientific support structure available within the Ispra campus, substantial development of ESTO becomes a *sine qua non* of the Institute's continuing effectiveness.

Given this central role foreseen for ESTO in the future development of the Institute, every effort has been made to keep the concept active, notwithstanding the lack of specific funding. Information services within the Institute have been developed in such a way as to be readily adapted to the full ESTO project. In one area - global change - the observatory function is already operational, thanks to the sponsorship of the Forward Studies Unit and other Commission "clients". A small exploratory project in the development of innovation indicators is already showing promising results.

2.1 Information Systems

The collection, synthesis, storage, analysis and dissemination of a large amount of information in selected fields is an essential part of the activities of the Institute. Some of the tools for this activity have required further development for the effective execution of this function.

The most widely utilised tool is the direct on-line access to some 500 bibliographic and patent data bases. This is complemented by new techniques for structured searches and by a system for rapid document acquisition.

Direct access to information is also obtained through networks of correspondents, a procedure which will be strengthened in the future by the creation of antennae in key countries and regions. In October 1992 a PROMPT antenna was established in Brussels as a direct link with the Forward Studies Unit of the Commission.

Prompt makes extensive use of software tools for information processing. In particular, two systems have been created. The first, a data base named NOVA, is for storing the most recent information on scientific breakthroughs and technological innovations while the second

is an information system named QuiQuod or "Q^2", describing current R&D projects in the Community.

2.1.1 NOVA (Innovation Updates)

A pilot system for this information resource has been developed, including an input mask, a retrieval system and a basic "import/export" "from/to" text-file mechanism. In hardware terms this has been accomplished by linking a number of Macintosh PCs to the JRC Ispra ETHERNET network backbone and to the dedicated PROMPT server. In software terms a custom-made package, based on the "user-friendly" HyperCard Interface, was developed to facilitate access to the data records stored in the SYBASE SQL server. The software permits the input, retrieval and output of information stored according to requirements.

In the initial stages, the stored information will be primarily related to subjects that are currently studied by PROMPT, i.e. Global Change, Environmental Technologies, Renewable Energies, Nuclear Fission, High Speed Trains, Air Transport, Space Technology, Advanced Materials and Biotechnology. Consequently it is mainly our own staff who collect and enter the information in the NOVA data base. This means that a critical filter is applied to the vast amounts of publicly available information. The number of outside contributions, through collaboration agreements and formal contracts with networks of experts in science and technology, will continue to rise depending on financial resources.

Information input may be performed either on-line through a MAC PC or in batch-mode from any other type of PC, through the use of a common word processor application. Information retrieval may be performed on-line through the HyperCard interface and custom-made software which performs a free text search based on keyword combinations using Boolean and/or proximity operators.

The prospective use of the information contained in the NOVA data base is to provide a system for the analysis of innovations and/or scientific breakthroughs with the aim of studying their future evolution, impact and consequences.

2.1.2 R&D Projects Information System - Qui Quod (Q^2)

The Q^2 prototype information system has been designed, built and tested for data in the chosen sector of Advanced Materials. This system provides access to existing national R&D projects data bases, and enables the user to make integrated queries concerning the status of the projects. The scope of the Q^2 project is to obtain a clearer view of European R&D efforts in various research fields, and to include details

on project definition and progress, the institutions involved, budgets, staff resources and time scales.

The variety of available sources (national, regional, sectoral R&D data bases), their evident differences (structure, language, functionality) makes the use of support tools necessary. The pilot project, which consisted of the methodical interrogation, on one pre-specified field, of all the R&D project data bases in Europe, with the aim of identifying activities and expertise and the subsequent retrieval of the results, was concluded successfully. It involved identifying all R&D related data bases (project or person or institution based) in all Member States (including also those data bases which had wider geographical coverage) in all domains and then performing the retrieval, querying and comparison procedure for the whole set of R&D projects data bases in the advanced materials field. While we have reason to believe that the list so collected is not exhaustive, about 100 R&D-related, European-based data bases, were identified, of which 47 fulfilled the mandatory requirements (European, R&D project data bases). Of these, 27 were found to contain records in the chosen field of advanced materials.

By means of the comparison mentioned above, the harmonisation level of the R&D project data bases in the EC member countries was identified and the relative importance, completeness and compatibility of these data bases, in relation to PROMPT needs, were all assessed. The plausibility of a network of integrated national R&D data bases was also demonstrated. Other conclusions, more specific to each of the national data bases accessed, which will either enhance the harmonisation of the individual data bases as to their structures or provide some general rules to be followed so as to establish the homogeneity of the data contents of the national data bases, were also drawn. Despite the obvious difficulties in integrating the results of such a query, the inter-comparison suggests that the quality and quantity of the data thus accessed could generally satisfy PROMPT requirements.

What in effect has been developed at this stage is a manual which clearly describes what steps need be taken in order to retrieve the desired data from the multitude of different sources, in as harmonised a way as possible, using informatics tools whenever possible. The next phase would be to develop a user friendly and intelligent interface, in collaboration with other interested Commission services (Eurostat, DGXII-A2, DGXIII-D), that would cover the needs of the final user, independent of where the original information item was situated, and taking into account the differences of the existing and available R&D projects information systems documented using the above procedure. It is hoped that the final product of this project can be used to create networks of inter-linked European research data bases which improve communication between European researchers.

2.1.3 On-line data search and retrieval

The Institute has a well-developed bibliographical and data search service, with direct access to over 500 data bases and facilities for on-

line ordering of scientific reports, books and papers. Various automatic techniques have been developed to facilitate interrogation of data bases, particularly those containing data on patents, and to pre-treat information before downloading. This results in considerable cost savings.

2.2 Monitoring specific fields

As was noted above, the absence of a specific funding source for ESTO places severe limitations on the number of technology areas which can be monitored. In fact the only area in which anything resembling a full monitoring system has been implemented is that of global change, as described in the next section.

Since this activity grew out of a client-requested study (and remains closely linked to such studies) it may be seen as a model for future development of monitoring in specific fields. We are conscious, however, that transformation of prospective studies into observatory activities entails the risk of focusing on the priorities of yesterday rather than those of tomorrow. For this reason we insist that the core of observatory activity must be research which anticipates topics, rather than responding to them following client requests.

2.2.1 Observatory of Global Change Research & Policy

This project, which has been in operation since 1990, consists of a continuous survey of research progress and policy options in relation to possible greenhouse effect-induced climate change and to other aspects of global environment change. Its scope is to keep the project's "customers"[1] permanently updated with the highlights of research and policy in these fields, as a guide for (or a reference to) their action. The continuing scientific assessment of these global change issues, of their potential impacts and of possible options for response strategies constitute the main product of the project.

The project is based on an extensive review of published scientific articles or reports and of communications to international conferences, which are analysed, compared and synthesised within periodic (normally bi-annual) reports. In 1992, more than 300 information items were reviewed, among which about 110 and 50 were analysed in detail, in the areas of climate change and ozone depletion respectively, within two reports[2].

[1]The Forward Studies Unit, the Directorate General for Environment (DG XI) and the Institute for Environment of the JRC.

[2]"Global Change Research and Policy: Updates. No. 3- June 1992"
"Climate Change Research and Policy: Updates. No.4- January 1993"

Excerpts of the conclusions of these reports are presented below.

2.2.1.1 Greenhouse-effect induced climate change

(i) The 1992 updating by the Intergovernmental Panel on Climate Change (IPCC) of its scientific assessment of the greenhouse effect has not essentially changed its conclusions of 1990. As a result of new greenhouse gas emission scenarios, the projection of global surface warming for the year 2100 lies in the range 1.8-4.2°C (best estimate: 2.8°C), instead of 2.1-4.8°C (best estimate: 3.3°C) predicted in 1990. When the climate forcing by sulphate aerosols and climate feedbacks due to CFC-induced ozone depletion and CO_2-induced fertilisation of vegetation are taken into account, the projected warming in 2100 is further lowered to 1.7-3.8°C (best estimate: 2.5°C), i.e. it stands nearly 1°C lower than the 1990 best estimate.

The uncertainties concern climate sensitivity rather than future emissions levels. The projected warming differs significantly only after 2050 according to the emission scenarios. Even at this reduced level, the projected warming still represents 4-5 times that which has been observed over the past century and is considered as a considerable challenge, should it actually occur.

(ii) It is increasingly felt that anthropogenic sulphate aerosols are currently cooling the climate and thus masking a significant part of the warming due to the GHGs (Green House Gases) so far accumulated in the atmosphere. It is claimed that this effect could explain the cooling of the Earth during the period 1940-1970, and other odd features of the Earth's temperature record, some of which are in contradiction to simulations of greenhouse effect-induced climate change. The first quantitative evaluations of this effect, although very uncertain, converge towards a figure of current aerosol-induced cooling of the same magnitude as the current GHG-induced warming; in other words, the actual greenhouse warming over the past century could be nearer 1°C than the 0.5 °C appearing in the global surface temperature record.

This evidence of a cooling effect from anthropogenic sulphate aerosols should be understood as contributing to confirmation of the significance of the greenhouse effect rather than as the discovery of a providential mitigation. In fact, it is expected that the aerosol-induced cooling effect, at a given fossil fuel consumption rate, will saturate long before the CO_2-induced GH effect. Moreover, a future reduction of sulphur emissions emanating from fossil fuels, as a result of other environmental requirements, would rapidly diminish or eliminate the cooling effect.

(iii) New results confirm that the detected global warming is related essentially to the increase of minimum (nightly) temperatures while maximum (daily) temperatures display little or no warming. This characteristic is generally explained by a correlated increase of cloud cover (possibly an aspect of greenhouse effect-induced climate change) but some experts also see here signs of the effects of aerosols, which are more efficient in decreasing the sunlight reaching the surface than in trapping long-wave radiation re-emitted by the surface.

(iv) On the basis of a striking correlation recently found between the observed surface temperature and the length of the "11-year" sunspot cycle over the past century, modelling studies in which this cycle length is hypothesised as a proxy of solar irradiance indicate that the variation of this parameter could have driven a good part of the surface warming observed over this period, reducing the contribution of greenhouse gases to about two thirds of the total (fig. 1). Such a result could necessitate an important downward revision of the significance of the greenhouse effect, although a definitive confirmation of the variation of solar irradiance to the degree implied in these studies will have to await decades of direct measurements of this parameter.

(v) To judge by the number of recent publications, research aimed at better understanding and modelling of the climate change feedback due to clouds - a key source of uncertainty in climate sensitivity and warming projections - remains very active. The results, however, are disappointing and do not, to date, afford any prospect of improvements to climate models. Also the role of naturally-occurring dimethylsulphide, as a potential moderator of climate warming, is still the subject of much debate.

(vi) The influence of climate change on polar ice sheets is the subject of continuing studies. Evidence of sea-ice boundary retreat is again notified, this time in the Antarctic. At the same time, new experimental evidence (in the Antarctic) and analysis of Northern polar paleoclimates have both been claimed to demonstrate yet again that greenhouse effect-induced climate change and enhanced precipitation in polar regions might lead to ice-sheet growth and concomitant sea-level fall. This view, however, is not unanimous.

(vii) It is increasingly recognised that the sink so far missing for balancing the anthropogenic carbon budget lies in the terrestrial biosphere, the enhanced carbon storage of which, as stimulated by climate warming, could well constitute an important negative feedback to CO_2-induced climate change. Until now, however, the various processes involved and their relative importance are not understood. Both vegetation and in-soil carbon storage should be considered. Although the role of forest area growth in the Northern Hemisphere seems uncontested, that of fertilisation of vegetation by the CO_2-enrichment of the atmosphere is the subject of contradictory research findings.

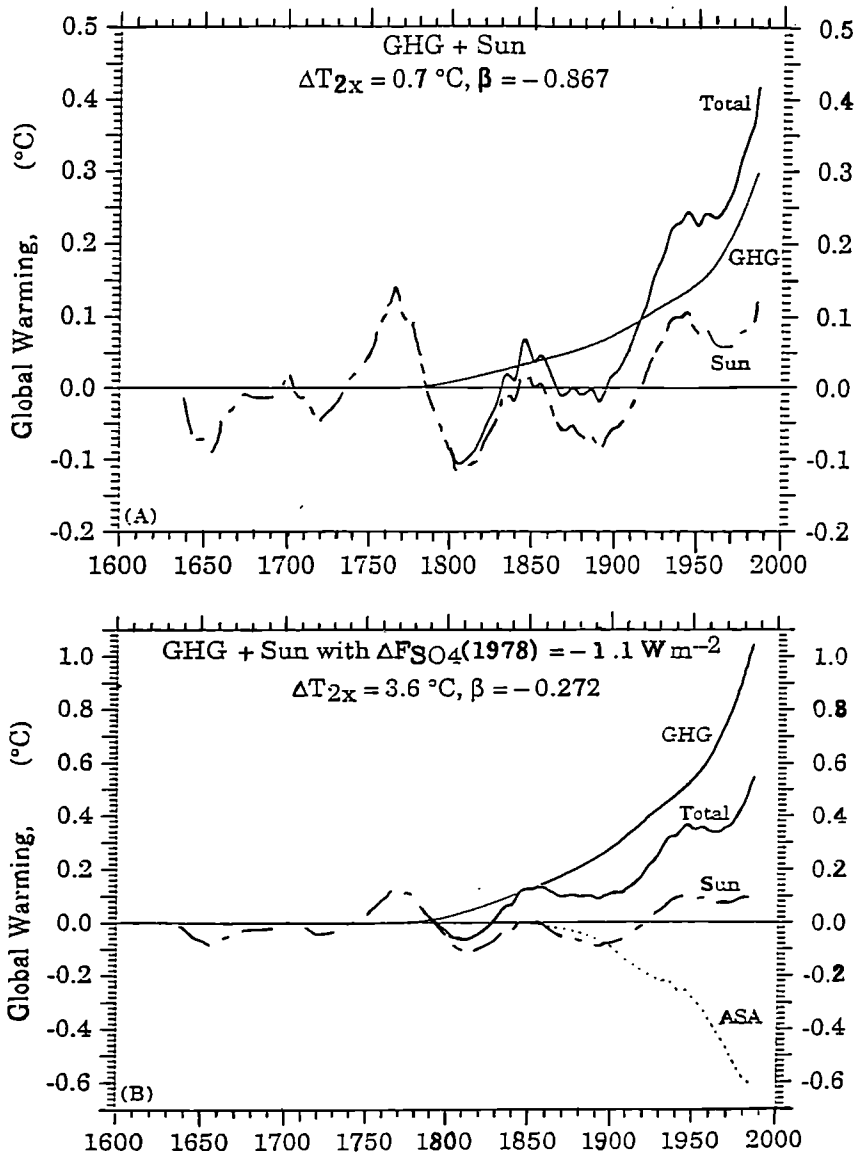


Fig. 1

Contribution of greenhouse gases ("GHG"), intercycle solar variations ("Sun") and (lower panel only) **atmospheric sulphur aerosols ("ASA") to global warming (ΔTm).**
These curves have been computed by the authors quoted hereafter using an upwelling-diffusion energy-balance climate model, and optimized values of model parameters and input data as indicated (climate sensitivity: ΔT_{2X}; coefficient characterizing the putative relation between solar irradiance and length of the solar cycle: ß; radiative forcing of sulphate aerosols in the year 1978: ΔF_{SO4} (1978).

Reprinted from Schlesinger & Ramankutty (1992), *Nature* , **360**, 330-333.

(viii) It has been calculated that the ban on CFCs (chloro fluoro carbons), as a result of the implementation of the Montreal Protocol for the protection of the ozone layer (together with its later amendments), will not bring any improvement with respect to the GH effect, although CFCs are powerful GHGs, because the corresponding decrease of CFC-induced GH forcing will be compensated, on a global scale, by an almost equally important increase of ozone-induced GH forcing. Moreover, the decrease of the direct GH effect due to halocarbons will depend very much on the substitutes adopted, as some of them are nearly as GH-effective as CFCs.

Nevertheless, in spite of their globally neutral greenhouse effect, as a result of their ozone depletion properties, CFCs are still considered as significant greenhouse contributors because of the latitude and altitude dependence of the resultant forcing This could stimulate dynamic climatic effects and unpredictable weather patterns.

(ix) Perhaps for the first time, the value of polar ice core measurements, which, in recent years, have formed the basis for synoptic monitoring of past temperatures and CO_2 (and other greenhouse gas) concentrations, showing strong correlation between their respective paleoclimatic variations, are under attack from different sources. It is still too early to assess the validity of these criticisms, which, if confirmed, would seriously undermine the greenhouse effect hypothesis.

(x) In spite of progress in some areas, research on the greenhouse effect seems to be characterised at present by a shortage of useful and convincing results. Some researchers advocate new approaches based on statistical analysis of ongoing atmospheric processes, with a view to identification of signatures or fingerprints of climate change. While this approach is seen as possibly more sensitive than the monitoring of surface global warming. a review of recently published results does not indicate that it is capable of producing significant and/or convincing new data.

(xi) Within a context characterised by uncertainty of research results, the confirmation by recent studies that delaying the implementation of aggressive cuts in greenhouse gas emissions by one or two decades (to allow time for current research efforts to materialise into useful results) would be acceptable in terms of any climatic and economic penalties thus incurred is particularly worthy of note by policy makers, even if still contested strongly in some quarters.

2.2.1.2 Ozone Depletion

(i) Recent modelling work confirms once again the ozone-depleting potential of chlorine, but also emphasises the role of the hydro-chloro-fluorocarbons (HCFCs) proposed as substitute products for CFCs. These new products deplete ozone less than the CFCs in the long term because of their shorter tropospheric lifetime, but probably have a worse effect in the short term since they are less stable in the face of photodecomposition and thus release chlorine atoms much earlier.

(ii) New concern about the integrity of the ozone layer centres on the Arctic area. Recently published results of the Airborne Arctic Stratospheric Experiment (1989) show ozone losses over this region, though much less marked and more variable than in the Antarctic. The main reason for these differences probably lies in the characteristics of the Arctic weather, which is less favourable to the formation of polar stratospheric clouds.

(iii) The most recent measuring campaign on Arctic ozone, the European Arctic Stratospheric Ozone Experiment (November 1991 to March 1992) confirmed that ozone was substantially depleted around 20-25 km altitude, total ozone dropping from the "normally" expected 350 Dobson units to about 250 Dobson units in certain places.

(iv) These important depletions are not necessarily due to halocarbons alone. Natural causes are still suspected, including the role of stratospheric aerosols coming from volcanic eruptions (e.g. Pinatubo); unfavourable synoptic conditions (blocked high pressure areas) have also been identified as an explanation. Much work will be necessary (and is, indeed, under way) to distinguish between these different causes.

2.3 Innovation indicators

Given the very close links between science and technology foresight and the innovation process, attempts have been made to develop our understanding of innovation and to assist in the creation of appropriate indicators. Following on the workshop held in 1991 (reported in the previous Annual Report) we have continued our collaboration with SEO - the Foundation of Economic Research of the University of Amsterdam - and encouraged new surveys of innovation, as documented in trade journals, in various European states.

As a result, surveys using this particular methodology have now been completed in Ireland, Austria and the Netherlands and are under way in the UK and Italy. We have contributed to editing a book[3] describing the methodology and the results of the various national surveys.

We have also been following progress on more traditional innovation survey techniques (through postal questionnaires) and have participated in the various working parties on this subject held under the auspices of EUROSTAT. An exploratory study on "International innovation comparisons with existing survey data" (Contract 4605-91-12 ED ISP GB) was undertaken for us by Keith Smith Associates early in the year and points to good prospects for harmonising existing survey data, possibly as a prelude to combining it with the results of other approaches.

[3]New Concepts in Innovation Output Measurement, A.Kleinknecht and D.Bain [eds,), Macmillan Press, forthcoming

3. PROSPECTIVE STUDIES

As noted above, prospective studies are performed at the specific request of clients. These are mainly Commission services but can also include so-called "third parties", under payment and providing that the work does not conflict with basic Community interests. In 1992, it so happened that work for "in-house" clients absorbed all available resources.

To provide continuity of both research manpower and funding, the Institute has sought to perform work for Commission services within the framework of multiannual agreements, formally drawn up at Director-General level. Such agreements have been signed with the Forward Studies Unit, Directorate-General III (Industry) and Directorate-General XI (Environment) and more are expected to be negotiated in the near future. In anticipation of this, work has already started on behalf of Directorate General XVII (Energy). A small contract also exists with the JRC's Environment Institute.

Ultimately the Institute expects to be able to conduct studies on a broad range of topics in science and technology. For the moment, however, a combination of existing competences and client requests have led to a focusing of interest on the three interrelated areas of energy, environment and transport. Some activity has also begun in a fourth area - industrial competitivity - and this is expected to grow rapidly in significance.

The following sections give some details of work undertaken in each of these areas.

3.1 Energy

Interest in energy futures research oscillates in response to such external events as OPEC price hikes, nuclear accidents, concern over acid rain, wars in oil-producing regions and - most recently - the debate on global warming. It is difficult to think of any other topic in which near-panic and complacency alternate with such frequency.

Paradoxically for a sector so subject to changing fashions at the policy level, the world's energy supply system is relatively inflexible, characterised by long lead times for new plant and distribution networks and slow market penetration rates for new technologies. Shift-changes, if they come, will take generations rather than months.

There is therefore a strong case for taking a long-term and systems-based view of evolution in the energy sector, drawing on past experience to identify potential flaws in the assumptions underlying short-term policy decisions.

Such ongoing system studies can have a number of different starting-points. For PROMPT the obvious point of departure, given the

background of researchers and the Institute's roots in the JRC, is with analysis of particular technologies. This will eventually be expanded into a more comprehensive analysis, blending "bottom-up" and "top-down" approaches.

3.1.1 Technologies worth watching

As a first step[4] towards analysis of long-term options for the energy system, we selected two technological areas - fuel cells and CO2 sequestration - which appear to have significant potential to make a major contribution to long-term energy policy objectives, particularly in respect of fears over global warming.

3.1.1.1 Fuel cells

Fuel cells convert the free energy in fuels into electricity through electrochemical reaction of hydrogen and oxygen. The conversion occurs with high efficiency and it is not limited by Carnot thermodynamics, as it is the case with conventional combustion processes. Most of the available fuels (such as natural gas, oil or gasified coal) need, however, to undergo a pre-processing step in order to deliver molecular hydrogen to the fuel cells. This conversion step lowers the maximum achievable efficiency of the fuel cell to around 60%, which is, nevertheless, considerably higher than the levels achievable by competing fuel combustion technologies. Process optimisation efforts aim to improve recovery of the available energy from exhaust gases, etc. (see fig. 2 for a typical energy balance diagram).

Our preliminary status report highlighted the following points:

a) The advantages of fuel cells (innovative technology, efficiency, modularity, partial load characteristics, flexibility, low pollution) are generally recognised and fuel cells are increasingly considered as a promising technology in the USA and Japan.

b) After three decades of discontinuous development efforts, commercialisation is proceeding more slowly than was previously anticipated. The number of operational fuel cell installations is expected to rise, over the next two years, to around 100, as against the present total of 30. The most promising of these plants have 200 kW capacity and are considered as pre-commercial market introduction units.

c) The key barrier to introduction of fuel cells has been relatively slow technological progress.

[4] Work for the Directorate General for Energy (DGXVII)

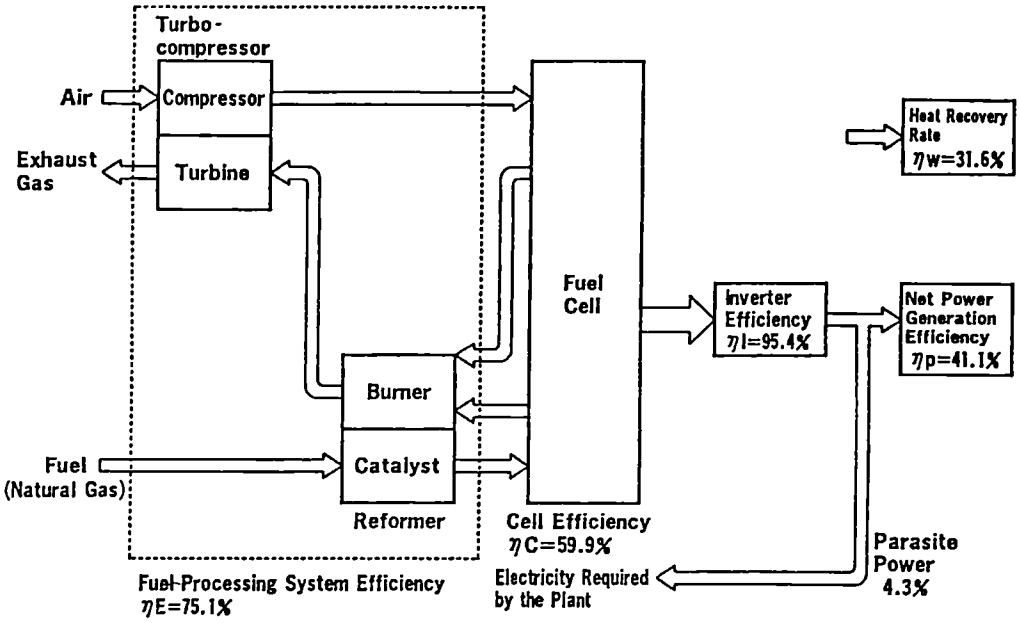


Fig. 2

Design values for the energy balance of a 11 MW fuel cell power plant

(from K. Shibata, Journal of Power Sources 37 (1992), 81-90)

d) Commercial market penetration will be feasible only after the completion of the first significant demonstration programmes (up to 1995). These demonstration programmes rely on phosphoric acid fuel cell technology (PAFC), which is the first generation of fuel cells and where overall fuel conversion efficiency potential is limited to about 47%. Therefore, it can be seriously challenged by combined power plant schemes in terms of achievable efficiency, prevention of pollution and power generation economics. System studies indicate that promising competitive advantages are expected for PAFC in the small capacities range (<50 MW), especially for dispersed/on-site power generation in remote and urban areas, where fuel cells offer unique operational characteristics in addition to the low pollution potential: high part load efficiency and modularity.

e) PAFC manufacturing techniques require further improvements in order to reduce their capital cost, which is presently in the range of 2500$/kW, a figure which implies little market penetration without legislative support.

f) The more advanced and more advantageous second and third generation fuel cell types - molten carbonate fuel cells (MCFC) and solid oxide fuel cells (SOFC) - offer the highest achievable overall fuel conversion efficiencies (above 60%, in relation to the system configuration). These fuel cell types are still at a pre commercial phase of development. Depending on current work aimed at resolving several technical and basic research problems, the first demonstration plants are scheduled to start operation towards the end of the century or shortly thereafter. Commercialisation is expected to become significant after 2010 for MCFC and after 2020 for SOFC. It is believed that these later generations of fuel cells will replace PAFC installations, which are considered to some extent as market openers.

g) Although fuel cell application to motor vehicles is generally recognised as attractive there is, however, broad agreement that the need for new concepts and substantial technological improvements (fuel processing, volume and weight) exclude market penetration before the turn of the century.

Such limited studies as have been published dealing with the long-term agree that the economics of fuel cell systems will depend on costs for hydrogen producing technologies, i.e. the internal/external or remote (centralised) fuel processors, with the fate of fuel cells related directly to the future availability and desirability of hydrogen as a fuel.

In the event of a hydrogen economy, fuel cell types other than the above first three generations, e.g. the polymer acid electrolyte fuel cell (PAEFC) or alkaline fuel cells (AFC) could come to the fore, particularly in automotive applications.

As far as short-term prospects are concerned, Japan and the USA are more strongly placed than Europe. Since, however, there are still major economic and institutional barriers to successful commercialisation of fuel cell technology it remains to be seen whether Europe's current relative disadvantage is significant. The next stage of the project, involving structured questioning of experts, may provide some answers.

3.1.1.2 CO_2 sequestration and storage

This project has been launched with a specific study, conducted with the support of an external contractor[5], examining possible technologies

[5]Nansen Environmental and Remote Sensing Center, Bergen, Norway.

for sequestration of CO_2 in the ocean. The study examines five technical options:

- dumping of CO_2 as dry ice
- dumping of CO_2 as hydrate
- injection of pressurised liquid CO_2 at high depths (>3000 m)
- injection of pressurised liquid CO_2 at intermediate depths (500-3000 m)
- shallow injection (<500 m) of pressurised liquid CO_2 or of CO_2-enriched sea water.

The first option was judged feasible from a purely technical point of view but was seen as probably very costly. Very little technical knowledge appears to exist regarding option two. Technologies for injection at high or intermediate depth do not seem attainable within the foreseeable future. The last option, however, was judged technically feasible and probably the cheapest, although further research is needed.

The increased carbon dioxide concentration in the ocean, as a result of large scale use of these technologies, would be negligible. The major environmental obstacle to implementation of ocean disposal may be the localised effects on marine life, in particular as a result of the lowered pH in the sinking plume (for shallow injection) or on the sea floor (for the first three options). Too little is known currently for a reliable evaluation of these technologies under that aspect. The same can be said as far as their economic evaluation is concerned.

This preliminary study concludes that sequestration of CO_2 in the ocean is probably feasible but costly, and that localised environmental effects and resulting public opposition might constitute other limiting factors for its implementation. It should be considered only in terms of a "last resort" option.

3.1.2 Sustainable energy

The study[6] of a sustainable energy future involves considering energy and environment. The scope is to provide elements for the evaluation of the impact of environmental constraints and technological development on the evolution of the energy system. This target has been approached by performing a sequence of studies, each time with a particular point of view.

The following directions have been pursued so far:

[6]Within the activities performed for the Forward Studies Unit

a) Information concerning energy conservation potential.
The conclusion was that the information gathered during our previous studies is probably sufficient for broad political decisions, which is what matters most in this context. The information has however to be improved for short-term sectoral decision making.

b) Role of nuclear energy.
As a follow-up of a study on the fuel cycle, the characteristics of advanced reactors are being considered, in view of their contribution to medium/long-term energy policies.

c) Quality and quantity of data available for the evaluation of airborne chemical pollution in Europe, at regional and interregional scale.
The two sides of the problem are being considered: emission inventories and transport/diffusion models.
The conclusion, at the present state of advancement, is that the main weakness lies with the emission inventories: they are numerous, but only for a few countries and are in any case not satisfactory. Definitions, spatial grids and other specifications are different, so that they cannot be collated to provide a consistent, basic set of data.

3.2 Environment

During 1992 the accentuated importance of environmental concerns noted in previous years was maintained, although there was somewhat less pressure to give such matters absolute priority. As has already been noted, with reference to the Observatory on Global Change, some of the urgency has gone out of the debate despite the high degree of publicity provided by the Rio Conference.

Nevertheless environmental worries are a recurrent theme in public policy and it would take very little to put them back in centre stage. As with energy (which is, of course, one of the areas most closely linked with many of the most pressing environmental issues) it is necessary to persist with research on a continuous rather than reactive basis.

In any event the economic situation has perhaps changed the tenor of the environmental debate decisively in favour of technological solutions as opposed to "anti-growth" arguments. New environmental technologies are welcomed not only for their ecological benefits but also for the new economic activity they bring, particularly in the creation of new employment.

The Institute's prospective studies in this area, apart from the ongoing work on global change reported above (section 2.2.1), are concentrated, therefore, on industrial opportunities and constraints. A more technically specialised study, evaluating prospects for linking pollutant emission data banks and models of airborne pollution, is also summarised below.

3.2.1 Business and the Environment [7]

3.2.1.1 Marked-based Instruments for Environmental Protection

The study focuses on cost-effective policies for environmental protection, with the aim of seeking to understand why the business sector is reluctant to support a market-based approach to environmental protection.

The main part of the study (prepared in collaboration with INSEAD business school) examines, through interviews and discussions with middle-level business managers, why the business community is not more sympathetic to market-based approaches to environmental protection.

As regards industry, the main least-cost approaches to curbing emissions of pollutants are through the application of pollution taxes and emissions trading. Both pollution taxes and emissions trading can achieve the least-cost solution, and the approaches are in many respects symmetrical.

Under the taxation approach, the unit tax rate is fixed and the quantity (of pollutants) is allowed to fluctuate, whereas under the trading approach, the quantity of emissions is fixed whilst the marginal costs are allowed to fluctuate. There are, however, important differences. Under a taxation approach, the desired fall in emissions may not occur because the initial unit tax rate may not be set at the optimal level, whereas, under the trading approach, the environmental quality standard is (in principle) guaranteed.

It appears that there are several barriers to business acceptance of market-based instruments, not least of which is a failure by business managers to accept that such approaches minimise the costs of meeting a given level of environmental stringency. Business managers generally express a preference for emissions trading over the taxation approach. The fear is that, if pollution taxes are applied, the total costs to industry may be higher than under the present command-and-control approach. This is because business would continue to pay taxes on those emissions with a higher marginal clean-up cost than the unit tax-rate.

Also, managers universally disbelieve government assurances that pollution taxes would be made revenue-neutral. For this reason, business people prefer emissions trading because all wealth transfers would be within the business community, rather than from business to government.

[7] Work performed for the Forward Studies Unit

3.2.1.2 Japanese and Californian firms' response to environmental constraints

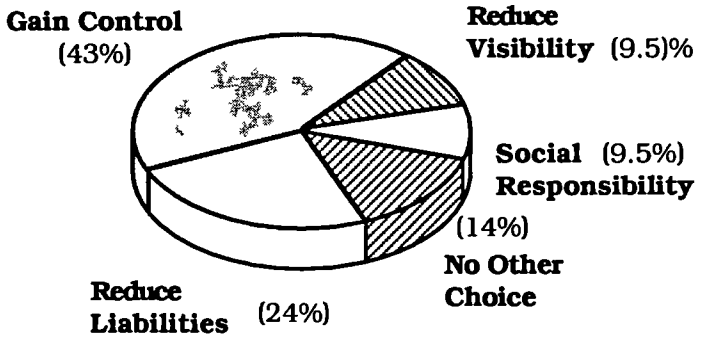
Short studies of the response of Japanese and Californian industry to environment pressures were carried out in 1991 (see 1991 Annual report). These were extended considerably in 1992 by an in-depth study of American industry which was carried out, on our behalf, by a US consultant[8]. Key findings were:

- Responses to environmental pressures are essentially either reactive or proactive ; little correlation is evident between proactiveness and industry size, industry type, or technology, but only between proactiveness and stage of development.

- Reactive companies focused 90% of their time on compliance; proactive companies focused only 50% of their time on compliance, with the remainder spent on beyond-compliance or voluntary activities.

- The most important incentives to becoming more proactive are a desire to gain control of the environmental pressures and reduce liabilities (see fig. 3), while the barriers to proactiveness are other business priorities and internal management resistance.

- Competitiveness is a key secondary incentive, achieved by reducing operational costs, offering new business opportunities, increasing market share, and raising barriers to competitors.



Source : SRI International, from interview responses.

Fig. 3

Initial Incentives to Proactiveness

[8] SRI International, California

3.2.2 Pollution Prevention : Exploiting the Technical Potential

Over the last twenty years the Community has implemented ever increasing levels of legislation focused on achieving reductions in specific emissions. From the outset of environmental legislation, regulatory controls based on technical standards were seen as a rapid and effective means for governments to abate pollution. Large improvements in environmental quality have taken place as a result of these early efforts. Not surprisingly, however, this command-and-control approach has resulted in pollution control - largely remedial and media-specific rather than preventive and multimedia in scope - becoming the predominant environmental strategy adopted by industry.

This study[9] catalogued some of the potential for pollution prevention and suggests that, as an environmental protection priority, governments need to harness the power of the marketplace to exploit this technical potential. Market-based approaches such as pollution charges and emissions trading, as well as market related instruments such as requirements for full-disclosure and legal liability for damage to the environment, also need to be considered.

There is no definitive means to predetermine the amount of waste reduction possible since opportunities to prevent pollution are embedded in every part of the industrial production system. In the industrial sector, pollution prevention is not a new concept and a wide variety of waste reduction techniques have traditionally been used to lower production costs and increase profitability.

At present, pollution prevention in industry is predominantly focused around good house-keeping efforts, and equipment and manufacturing process modifications. Industry has not, thus far, taken advantage of all effective pollution prevention opportunities.

Much of the potential for pollution prevention can be exploited using available technology. This existing potential, if supplemented with further research and development, offers the possibility of decoupling industrial waste generation and economic growth. Furthermore, while pollution prevention serves environmental protection goals, it also leads to an improvement in the efficiency of manufacturing processes and technology, with beneficial effects for the economy as a whole.

3.2.3 Regional impact of airborne pollution

A feasibility study[10] was carried out, concerning suggestions for R&D which may result from the evaluation of the state of the art with

9 Work for the General Directorate for the Environment (DGXI)
10 Work for the JRC Institute for Environment

mesoscale transport models and related emission inventories (Accidental releases and detailed short-distance transport models were, by definition, excluded from the study).

The tentative conclusion was that, although considerable improvements would be desirable as regards transport models, the main weakness lies with the emission inventories; a number of data bases exist, but they have been conceived by different organisations for different areas, not bearing in mind modelling requirements, let alone the use of a standard model.

Extensive studies are required to determine the desirable characteristics of a data base. The sensitivity of model calculations to uncertainties in the input data gives valuable indications on the quality required for a data base; this kind of work would be useful in establishing priorities for future modifications of the data bases.

Extensive work would also be required on the existing data bases to improve their compatibility; the next step would be to conceive an EC effort to set up a European Emission Inventory. Since this work should be carried out in a consistent way for every country in Europe, it is an example of an activity to be promoted by the Commission.

These tentative conclusions were discussed with external experts (Dr. Reiner Friedrich and collaborators, of the University of Stuttgart). The opinion expressed was that the reliability of models is worse than expected, with errors of the order of 100 to 200% occurring frequently when the pollutants concentration over particular areas (of typical size 50x50 km) is required.

A second point discussed was the danger of relying on oversimplified models: the importance of chemical reactions induced by solar radiation is such as to require considerable spatial and temporal detail in the emissions data as well as in the model calculations.

3.3 Transport

3.3.1 High speed rail transport [11]

While 1991 was devoted to improving our understanding of the railway system, also participating in professional meetings, organising some of them, and launching some external studies, 1992 was the year of harvesting results.

[11] Work for the Directorate General for Industry (DGIII)

We were able to collect the contributions of three main railways networks (Bundesbahn, Ferrovie dello Stato, SNCF) to our "joint simulation project". These results are currently being compared and synthesised by a specialised research organisation, INRETS, and will be available early in 1993. We also received the results of another study, subcontracted to INTRAPLAN (Munich) and INRETS (Paris), in collaboration with the International Union of Railways and DG VII (Transport), to analyse the technical-economic merits of different electrification scenarios, as a function of the projected traffic, region by region. In parallel, we also ran three expert-workshops, which are reported below.

We are now in a position to prepare a final report to DG III (Industry). This report will be submitted to a High Level Panel, consisting of representatives of the European rail companies (CCFE) and railway equipment manufacturers. Our study on techno-economic aspects of European networking of high speed trains will also provide the Commission with the material required to answer the request for such an evaluation by the Community Ministers of Transports.

3.3.1.1 Workshop on the strategic importance of High Power GTO's (Gate Turn Off) Silicon Controlled Rectifiers for the Development of the Future High Speed Rail Network

The workshop participants consisted of ten invited experts, with a PROMPT Chairman. The experts were mainly drawn from component manufacturers but two systems (i.e. locomotive) suppliers were also included. The main conclusions reached were as follows:

The "state of the art" for GTO's is broadly 4000 amperes (6 microfarad capacitance), 4500 volts and 400 Hz. The current development needs are for a similar voltage and current capability but with a lower capacitance and a much higher operational frequency.

The predicted performance plateaus of the GTO and CMOS devices is around 10 kV and 4.5 kA, which is more or less the predicted future requirement for these devices in the HST application. The development effort required to reach this performance is, however, considerable.

There is a clear need for an increase in the operating frequency of the devices, GTO's should be capable of operating at 1000 Hz after further development. However, the maximum frequency should increase more with the CMOS devices - perhaps to around 10 kHz.

The new devices and related new equipment (such as n-level inverters) will increase control of the adherence of wheel to rail, with a consequent reduction in engine weight. The new CMOS devices will result in cheaper control systems and simpler equipment for polycurrent trains. This is a field of technology in which many of the classic elements for failure exist: the market is small; there are only a few European component suppliers; Japanese suppliers are attacking the market with

vigour; system suppliers are happy to buy from anyone; the pool of expertise is small and vulnerable; the product is of strategic importance.

At the same time, however, the investment required for power electronics is much less than that for memory type semiconductors. The European technical situation in this field is quite advanced and, with a small precompetitive, collective effort, this technology could remain innovative and remain in Europe. The effort is required now in order to ensure that the right products are available for the next generation of locomotives towards the end of the century.

3.3.1.2 Workshop on the intercomparison of the three main European Rail Network electrical supply systems by simulation of the network requirement for three reference high speed lines

Following the preliminary work on this subject which was carried out for PROMPT in 1991 by Professor Sciutto of the University of Genoa , the full simulation exercise was executed by our partners in this exercise - DB (Germany), FS (Italy) and SNCF (France).

The supply systems chosen for this intercomparison were:

- 25 kV, 50 Hz
- 5 kV, 16 2/3 Hz
- 3 kV, DC plus higher DC voltages

The three lines were:

- Paris - Marseilles
- Berlin - Hanover
- Milan - Florence

The reference trains for the simulation exercise were ICE, ETR500 and TGV 2N respectively for the three partners (DB, FS & SNCF).

The objective of the intercomparison was to obtain a clear analysis of the advantages and disadvantages of the three supply systems; in practice, this proved to be a very difficult task. In the real world the supply systems are very complex and the difference in the electrical parameters is only part of the story. For example a crucial difference between the German system and the other two systems in this study is the fact that DB operates its own supply network and does not use the public supply network. This factor DB claims, is producing considerable economic benefits in operation.

Nevertheless, collaboration with the three railway companies was extremely useful. Although the conclusions from the exercise are still being refined, it is already clear that the low voltage DC supply system is significantly less efficient than the AC systems, even if it has

advantages over current AC systems. This result has contributed to the FS decision to use AC for the first Italian high speed line.

3.3.1.3 Workshop on the prospective for higher voltage systems for the future High Speed Rail Network in Europe

Current supply voltage levels for railway networks - i.e.25 kV AC (SNCF, etc.), 15 kV AC (DB, etc.) and 3 kV DC (FS, etc.) - represents a dramatic increase over previous systems. The voltage has increased mainly as a result of the need to provide much higher power for HSTs, with acceptable current densities for the catenary wire. In Australia and South Africa even higher voltages (50 kV) have been used (primarily for lines in remote areas).

In the light of the current variety of supply systems in Europe it is opportune to examine the prospective for higher voltages and to assess whether there might be a technological pull towards a convergence in power supply systems.

Consequently a "brain-storming" workshop was held by PROMPT under the chairmanship of the European Rail Research Institute and with the participation of experts from BR (United Kingdom), DB, SNCF, FS and NS (The Netherlands). As a result the following conclusions were reached:

- In the European situation no advantages are perceived in AC voltages higher than the current 15 kV (16 2/3 Hz) / 25 kV (50 Hz) systems. Either of the present systems is capable of supplying the power requirements for the foreseeable future, with train speeds up to 400 km/h and headway of a few minutes.
  Therefore there will be no convergence towards higher voltages and polycurrent trains are expected to continue to operate on the future European HST network.

- Although high voltage DC systems (say 30kV) could solve a number of problems and could produce significant economic advantages, considerable development effort would be required. Such effort should be preceded by an in-depth assessment of the anticipated economic benefits.

3.3.1.4 Study of future rolling stock requirements for the European High Speed Network

High speed traffic development in Europe has been studied by INTRAPLAN (Germany) and INRETS (France), on behalf of DGVII and UIC/IUR (International Union of Railways). Their model is based on confidential data supplied by individual national networks.

PROMPT agreed with DGVII and UIC to entrust INTRAPLAN and INRETS with a complementary study, based on the same input data

aimed at understanding to what extent and where international traffic will develop, depending on whether customers will cross borders without noticing them (on board compatible trains) or will have to take a connecting train (when high speed units are not compatible with power supply, control commands and signals).

This study is expected to give reliable figures, concerning high speed rolling stock requirements, in different regions and for different classes of electrification : monocurrent, bicurrent and tricurrent trains. These figures should help achieve an understanding of the economic merits of standardising locomotives as against standardising power supply.

3.4 Industrial competitivity

The theme of industrial competitivity, particularly as regards its relationship to science and technology research activity, now dominates the European research agenda. With its work on indicators, its studies on innovation and its participation in a wide range of international meetings, including those of the OECD Technology and Economics Programme (TEP) and the GISE (Groupe Interservice pour la Stratégie des Entreprises) series of meetings of the Forward Studies Unit, the Institute hopes to be prepared for what it anticipates will be a growing request for studies in this area.

Some initial efforts in this direction are reported below:

3.4.1 Space markets and European Competitiveness [12]

In 1991, PROMPT delivered to DG III a first study on the competitiveness of the European space industry. This drew the Commission's attention to the difficult situation facing the European industry and to a pending crisis at the European Space Agency (ESA). After the Munich ministerial conference had confirmed this crisis, DG III asked PROMPT to perform a more in-depth and longer-term study of space markets. This was completed during the current year. It consists of a market analysis (sector by sector), a comparison of American and Japanese strategies, a review of the prospects and limits of international cooperation and a series of interviews with leading European manufacturers.

During the first quarter of 1993 we plan to convene, with our customer, DG III, a High Level Panel of space manufacturers and users of space applications to discuss and validate our conclusions. Hopefully this

[12] Work for the Directorate General for Industry (DGIII)

panel's recommendations, together with our background material, will provide policy makers with enough material to take strong initiatives.

3.4.2 Technology policy and corporate strategies

PROMPT participated in several inter-service meetings, organised by the Forward Studies Unit of the Commission, on future R&D strategies for Europe. Its written or verbal contributions bore essentially on the following arguments:

a) the "linear paradigm" which presumes a direct correlation between R&D and economic growth may be misleading since science and technology are only one - and far from the most important - amongst many factors influencing corporate competitiveness.

b) the many constraints imposed on the EC S&T programmes for political and legal reasons need reviewing in order to promote the efficient use of Community research results by industry

c) overemphasising intracommunity alliances for R&D and technology might well delay or discourage more strategic international alliances and M&A, which are vital for competitiveness and market penetration.

d) In order to avoid misleading conclusions with regard to technology strategy, it is important to include defense issues.

e) It is essential to undertake an urgent global review of national and EC S&T policies in the light of the ever expanding area of R&D, combined with geometrically growing research costs. Otherwise there will be an increasing clash between research demand and public funding.

4. STUDIES UNDER THE RESEARCH FELLOWSHIP PROGRAMME

The Institute is able to host research fellows in receipt of grants under various schemes, notably the Commission's Human Capital and Mobility (HCM) Programme, which finally started up in 1992 and is expected to come into full operation in 1993/4. PROMPT hopes to welcome some 10-20 fellows under its auspices.

By December, 1992, three fellows were already in place. Two of these are registered for Ph.D. degrees (at the London School of Economics and the University of Manchester). In the future, however, most fellows will already be in possession of a doctorate, as envisaged in the HCM programme guidelines.

Since PROMPT has virtually no additional resources to allow Institute staff to participate in the projects, fellows will have to be largely self-reliant, although benefiting from the Institute's information systems and expertise. To encourage inter-disciplinary synergies, fellows will be assigned (wherever possible) to specific project teams, all members of which are engaged in exploring a common theme from different standpoints.

Themes are chosen on the basis of their perceived future importance, including areas where PROMPT has no current client to sponsor studies. Research teams will be around 3-4 strong, representing different disciplines and (of course) different nationalities. A particular strength of such an arrangement is that each team member has a unique range of contacts (or "personal network"), both disciplinary and national to contribute to the joint effort. Close contacts with "home" institutions and researchers will also be encouraged, particularly in the case of doctoral candidates.

4.1 Long-term environment/transport problems in European cities

Two post-graduate students - one a political scientist, the other an economist - started work on this project during 1992. They will be joined by others - post-graduate and post-doctoral - from a range of different disciplinary backgrounds in a project intended to last several years.

The focus of the studies is the future of transport, as constrained by environmental considerations, in major European cities. The provisional time horizon is 2030. Case studies of particular cities - Milan, Manchester and Seville, in the first instance - will supplement more general theoretical work.

In addition to contributing to a wide-ranging multi-disciplinary study on a theme of ever-growing importance, the research fellows will also be exploring the extent to which various different forecasting and planning methodologies can contribute, together and separately, to improving decision-making in this, and other similar techno-social problem areas.

4.2 Inter-regional cooperation in technological innovation

The role of technological innovation in economic growth and development has gained considerable attention, on national as well as subnational levels. Cooperative arrangements are considered as of particular interest. In the course of the previous year this study found that, on grounds of theoretical considerations, initiatives for regional cooperation in the field of technological innovation would have to deal with an intrinsic dilemma. The objective of the study is to identify, by way of case studies, those factors that enable this problem to be overcome.

Regarding regional cooperation, an attempt was undertaken to define a unified concept that would encompass the large variety of forms which this may take. The resulting high level of abstraction was found, however, to be impractical on the operational level with the obtainable data. Similar difficulties were encountered distinguishing regional cooperation from governmental and inter-firm cooperation at the regional level on the grounds of the unavailability or unsuitability of quantitative data. The study concept therefore relies on qualitative information.

Identifying cases of regional cooperation in innovation revealed the scarcity of such arrangements relative to other areas of collaborative activity. This contrasts with the theoretically claimed advantages and importance of cooperative efforts for regional development. On the other hand it may confirm the dominance of factors that effectively prohibit cooperation in technological innovation, factors that are largely ignored by scholars and practitioners promulgating such a strategy. These unsystematic incidences thus provide a preliminary hint that the theoretical result obtained in 1991 will be confirmed by real-life examples.

5. MEETINGS ORGANISED IN 1992

Presentation of the study on "The evolution and future of the ' trains à grande vitesse ' (TGV) in France and elsewhere".
Technical meeting with IIASA representatives
(Ispra, 13 February)

Seminar on "Pollution of time, space and mind: the effects of the European High Speed Train Programme"
Dr.J.Whitelegg, Department of Geography, Lancaster University, England
(Ispra, 15 May)

Workshop on "The strategic importance of high power GTOs (Gate Turn Off) (3000 Amperes plus and 3000 Volts plus) for the development of the future high speed rail network in Europe".
With representatives of the European semiconductor industry
(Ispra, 16-17 June)

Presentation of the study "Eco-business opportunities".
Technical meeting with CEST (Centre for Exploitation of Science & Technology) representatives.
(Brussels, 24 June)

Presentation of the study "The environment business - The view of industry" -
Technical meeting with SRI INTERNATIONAL representatives.
(Ispra, 26 June)

Seminar on "Environmental Input-Output Modelling and Applications",
Prof.J.W.McGilvray, Head of Economics Department, University of Strathclyde, Glasgow, Scotland
(Ispra, 13 July)

Workshop "Intercomparison meeting on simulations of high speed trains networks" -
With representatives of DB, FS and SNCF.
(Ispra, 8-9 September)

"Estimation de la demande et du parc ferroviaire nécessaire pour différentes hypothèses d'alimentation électrique des trains à grande vitesse en Europe, ainsi que pour l'évaluation de ces hypothèses"
Technical meeting with the Consortium INTRAPLAN-INRETS.
(Ispra, 13 October)

Seminar on "Sequestration of CO_2 in the Ocean: A State-of-the-Art Review"
Dr. Peter M. Haugan, Nansen Environmental and Remote Sensing Center (NERSC), Bergen, Norway
(Ispra, 16 November)

"Les marchés de l'espace, perspectives mondiales à l'aube du XXIème siècle"
Technical meeting with representatives from ARMINES-CREST.
(Ispra, 17 November)

Seminar on "Transport Technology and Environmental Assessment"
Dr. David Martin, Strategic Studies Department, ETSU - Harwell, England,
(Ispra, 23 November)

Workshop for Brainstorming on future railway electrification voltages"
With representants from national railway companies : BR, DB, FS, NS, SNCF.
(Brussels, 23-24 November)

6. LIST OF REPORTS

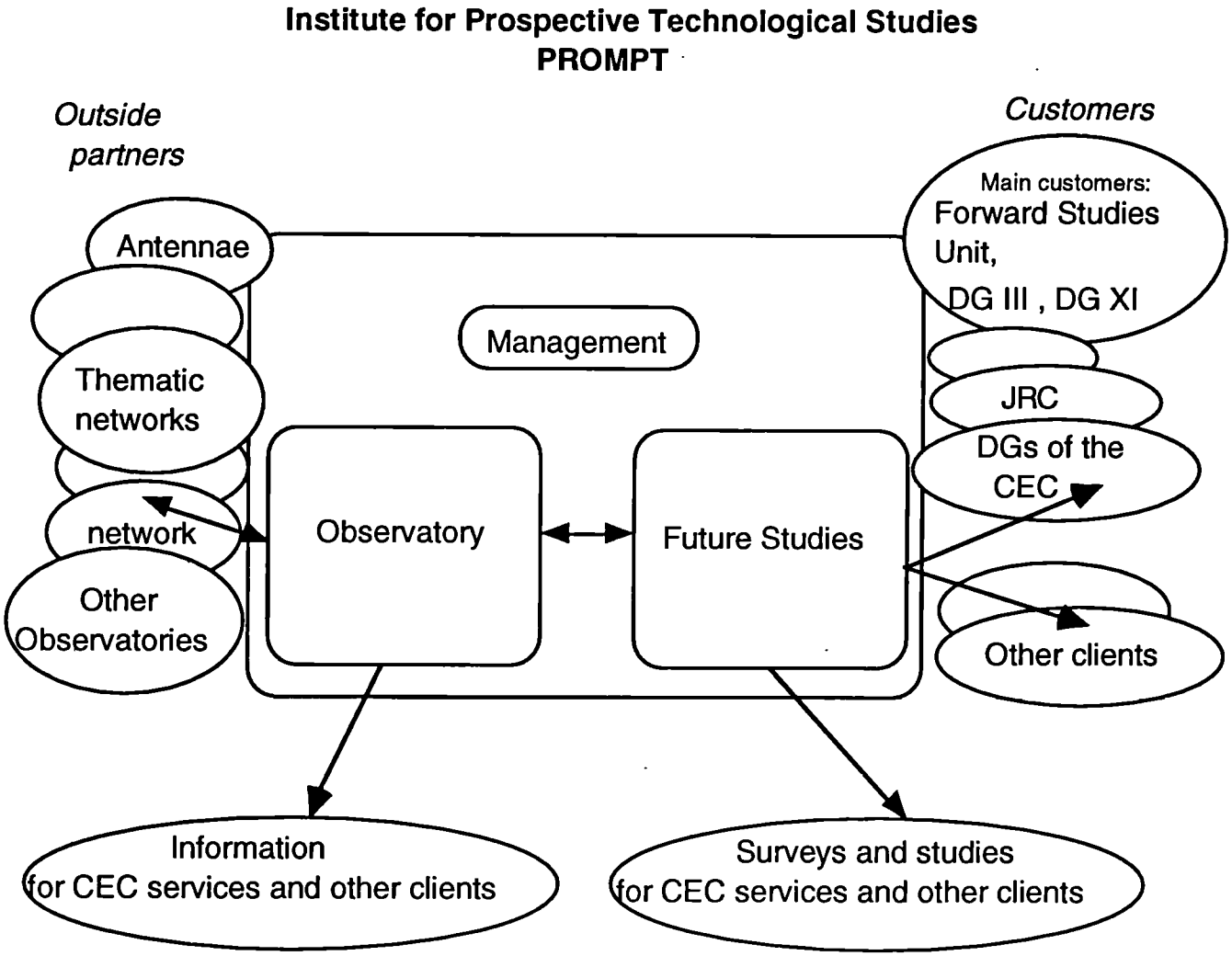
Client	Title	Date
Commission : Forward Studies Unit	. Science and the Greenhouse Effect	June 1990
	. Technological Response Options to the CO_2 Issue * Overview * CO_2 and Energy Consumption Setting Targets for Europe *Annex* : The role of electricity generation * The role of Renewable Energies *Annex* : Energy from biomass	September 1990
	. Climate Change Research and Policy: Updates (A periodic survey: N°1)	May 1991
	. The Japanese Technological Response to Global Environmental Problems	May 1991
	. Nuclear Energy-Reprocessing and Recycling are Key Issues	July 1991
	. The Technological Response to Global Environmental Problems - California	September 1991
	. Opportunities in Environmental Technology	October 1991
	. Climate Change Research and Policy: Updates (A periodic survey: N.2)	November 1991
	. A prospective Assessment on the Role of Renewable Energies in response to the CO_2 problem	January 1992
	. Global Change Research and Policy: Updates (A periodic survey: N.3)	June 1992
	. Market Based Instruments for Environmental Protection	September 1992
	. Climate Change Research and Policy: Updates (A periodic survey: N.4)	January 1993
Commission : DG III, DG VII, DG XII	Pre-Lotos Study : Air Transport and Aeronautic Industries	September 1990
	Lotos, update	March 1992
Commission : DG III	Compétitivité des industries spatiales européennes (Progress report) *Annexes* : * Rapport V.Panin (Consultant) * Microgravity: Future for the Space Industry ? (Status and Trends)	September 1991
	Rapport final de la phase 1	May 1992
	La politique spatiale au tournant du siècle	November 1992

Client	Title	Date
Commission : DG III	L'alimentation en énergie des réseaux européens de Trains à Haute Vitesse (THV) (Progress report) *Annexes* : * Technologie de la traction électrique roue/rail et aspects énergétiques * Evolution prévisible de la technologie ("Science et Technologie") * Alimentation en énergie électrique (Electricité de France) * Industries et marchés de la grande vitesse ferroviaire (JANE'S Inf. Group) * Introducing HST trains in Europe (IIASA)	September 1991
	Rapport final de la phase 1	May 1992
Commission : DG XI	Some Technology Options for dealing with Environmental Pollution	January 1992
	Pollution Prevention: Exploiting the Technical Potential	May 1992
Commission : DG XII	Concept des noeuds technologiques et de leur rôle dans la compétitivité	July 1990
Commission : JRC	Contribution to the Strategic Planning for the JRC : State of technology in ten years time * This World Around Us * Science and Technology Issues * S/T Assessments	March 1990
	Forecasting Technological Innovation (published by Kluwer Academic Publishers)	1991
	Prospectives on the Process of Innovation for Advanced Materials	September 1991
	Foci of interest and attention in global environmental change research; a literature-based assessment	December 1991
	Ruolo dei Materiali Innovativi nello Sviluppo delle Industrie ad Alta Tecnologia in Europa	December 1991
	European network for training in strategic prospective	June 1992
	Q^2 Information system - Progress Report	September 1992
	"R&D Projects" - Information systems	September 1992
Work for Third Parties		
BMFT - Germany	A Critical Literature Survey on the Prospects for Thermonuclear Fusion Energy	August 1990
Cork Experimental Station, Sardinia	Research and Technical Prospects for Cork.	January 1992

7. STRUCTURE AND STAFFING

As of 31st December 1992, the Institute's staff numbered 14, of whom 10 were scientific personnel. The Institute also hosted a national expert on secondment and 3 post-graduate fellows.

Organization Chart:



European Communities – Commission

EUR 15002 – Institute for Prospective Technological Studies - Annual Report 1992

C. Rinaldini, D. Bain

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1992 was a year of consolidation rather than rapid development, with the numbers of both permanent staff and research fellows remaining constant. Major expansion awaits approval of dedicated research funding.
ESTO, in particular, must await decisions on these matters before it can be developed to its full potential. For the moment it remains embryonic, with only the "Global Change Research and Policy" module operational. Development work on in-house information systems, particularly the European R&D projects data base QUI QUOD, continues and seems likely to attract sponsorship from potential clients elsewhere in the Commission. A small catalytic effort in the direction of producing new innovation indicators is also starting to show promising results.
Prospective studies are increasingly conducted within the framework of multiannual agreements with Commission clients. This considerably aids continuity and forward planning of resources. Such agreements were in force during 1992 with the Presidency's Forward Studies Unity and the Directorates General for Industrial Policy and Environment (DGs III and XI).
Studies undertaken during the year covered four main themes:
- energy (systems and technologies for the long term future)
- environment (industrial opportunities and constraints)
- transport (space markets, high speed trains)
- industrial competitivity (evaluation of EC strategies).