ISSN 1018-5593

INSTITUTE ANNUAL REPORT 95

PROSPECTIVE TECHNOLOGICAL STUDIES

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JOINT RESEARCH CENTRE

EUROPEAN COMMISSION

Report
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Cataloguing data can be found at the end of this publication

Luxembourg: Office for Official Publications of the European Communities, 1996

ISBN 92-827-7305-1

Printed in Spain

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EXECUTIVE SUMMARY AND INTRODUCTION

1995 has been a consolidating year for the Institute for Prospective Technological Studies (IPTS): the general production of reports and publications was nearly double that of the previous year; working networks have been strengthened; and the scope of clients contacting the IPTS is gradually enlarging.

All IPTS work is structured around the three specific mandates established by the work programme: the development of a Technology Watch function; research on Technology-Employment-Competitiveness; and work on request.

The **Technology Watch** activities are developed in order to accomplish the first mandate of the Institute: to detect scientific breakthroughs, trends and events that might lead to technological innovation and to alert EU decision-makers about their implications and consequences, specially when action at European level is needed. In this area, the IPTS works and shares its responsibility with the European Science and Technology Observatory (ESTO), a network of over fifty scientific members capable of providing timely access to information and a reliable quality control procedure.

In this first phase, the main activities have been developed in five different areas (Energy, Environment, Information Technologies, Industrial Technologies and Materials and Life-sciences). However, they will be progressively enlarged to cover most technological fields.

The Research, Education and Training Commissioner, Mrs. Edith Cresson, urged the IPTS to establish a tool capable of disseminating, among EU decision-makers the information collected through the Technology Watch activities. The **IPTS REPORT** , a monthly publication, is the result of Mrs. Cresson's initiative and the first public product of the Technology Watch activities.

The **Technology-employment-competitiveness** strand, or the second mandate of the IPTS, is based on two main objectives: the understanding of the factors which determine the ever increasing impact of technology on employment and on European industrial competitiveness; and the understanding of the role technology has in the creation of new needs, markets and services. Massive unemployment and wavering international competitiveness is very ominous, more so, given the requirements of consolidating the Internal Market, achieving EMU..., while constantly adapting to changing geo-political (Eastern Europe, Middle East) and market (GATT, WTO, NAFTA,...) situations. In this context, understanding and harnessing the forces governing technological innovation is a basic pre-requisite for sound decision making, given the pervasiveness and often decisive role technology has acquired in contemporary industrial society. Efforts to study and elucidate this broad issue from a number of different perspectives are consequently urgently required, especially with a view to enabling sound, progressive and pragmatic policy measures to be adopted at EU level.

In order to support decision-makers in coping with those challenges, the IPTS has reported on issues such as agro-food industry, transport telematics, pharmaceutical industry, Intellectual Property Rights...

The third mandate of the IPTS is the production of **work on request**. The aim of this kind of activity is to support the conception and/or the implementation of EU policies with sound S/T grounds and a common knowledge base. IPTS activities try also to build bridges between the several policies and activities carried out by the other Commission services. This means to provide the client with a broader view of side effects and bordering issues that are somehow linked to the concerned field of analyses. So far, projects have been carried out after a request coming mainly from the European Commission and for the first time, from the European Parliament (Scientific and Technological Options Assessment - STOA).

Even though this is not the first year the IPTS has conducted specific work on request , 1995 has been specially productive in this field providing analyses on matters such as plastic recycling, clean production technologies and best available technologies, business and environment, sustainable development, renewable energies or regional development.

In 1995, the Institute has also entered, for the first time, into the **competitive market of research contracts**. Several project proposals have been funded under different lines and programmes of the Fourth EU R&D Framework Programme in the fields of non-nuclear energy, environment and climate (work will be executed in 1996). This new branch of activity has not only provided the IPTS with additional financial resources but it has also strengthened the links with the scientific community.

1

Technology Watch: European Science and Technology Observatory (ESTO) The core of IPTS networking

The Institute for Prospective Technological Studies was created with a main task: the development of a European Science and Technology Observatory (ESTO) capable of alerting EU decision-makers on the implications of any scientific and technological developments.

The ESTO structure, a network of over 50 mainly European organisations was set up in October 1995 under the umbrella of the Fourth Framework Programme. The members of ESTO constitute a selected group of organisations and a source of potential partners for the Commission / IPTS to draw on for the purpose of occasional detailed projects and studies. This, coupled with the *networking added value* spin-off, and the opportunity to participate actively at a baseline level in alerting *The Commission* to selected scientific and techno-economic intelligence of relevance to its policy-making agenda, as well as its overall 'management of change' efforts, constitute considerable participation incentives. It should be borne in mind that ESTO membership is in principle open and will be periodically reviewed and revised with due regard to members' *level and quality* of participation.

ESTO will operate in thematic groupings, aligned to the main current areas of activity of the IPTS and will be animated by the corresponding IPTS members of staff. The function of these thematic sub-networks will be:

(1) To extend and improve the information data base,
(2) To ensure a *dialogue* with the main informed actors on any given topical issue,
(3) To discuss selection and processing of the available information and
(4) To ensure *quality control* and timeliness of the generated output.

The ESTO Network is intended to evolve into an instrument of support for all of IPTS' work, although in a first instance priority attention has been paid to getting the IPTS Technology Watch Monthly Report (the IPTS Report) off the ground.

The COM-Net.

At the *corporate level*, another network has been created.This Network is composed of colleagues drawn from services throughout the Commission, particularly in the start-up phase, from those that have an RTD portfolio and conduct technology/ society/economy-related strategic or prospective studies.

Four principles guide the operation of this network:

(1) It acts as a source of information
(2) It acts as an informed partner-cum-client, closely reflecting *The Commission's* thinking, in a dialogue to better understand its needs and priorities.
(3) It provides a vehicle for communicating to the IPTS requests for work and punctual studies.
(4) It offers a partnership with the IPTS in shaping the *content, timeliness and relevance* of information transmitted to *The Commission* at the highest level, through the monthly Technology Watch report (or otherwise).

The respective commitments include: for the IPTS to ask the COM-Net for its opinion on the content of its monthly report, and for the network members to reciprocate this collegiality by flagging any alerts, potential discords and warnings, as well as providing input of substance and conducting and communicating the results of in-service technology watch activities.
The IPTS is also collaborating with the S&T attachés of the Commission's third country delegations, encouraging them to provide timely scientific and techno-economic intelligence of events and developments abroad, initially concentrating in the US, Japan, China and SE Asia.

The scientific community

External experts and institutes represent a vast sea of S&T and other specialist knowledge, which the IPTS and ESTO may have call to tap into in a number of different ways. In all such cases, members of this community will net-

work around a given scientific or technical theme (e.g. micro-mechanics, rapid proto-typing, water resource management techniques, copyright in the information society, etc.), which may be put on the Technology Watch agenda from the top-down (i.e. identified as an issue by ESTO or COM-Net which calls for the incorporation from the scientific community of the required expertise into one of the appropriate thematic sub-networks), or from the bottom-up signalled directly by an expert.

The vehicle for such bottom-up alerts and spontaneous / virtual networking by the scientific community, or inter-expert electronic dialogue, is provided by the IPTS in the form of a structured IPTS www home-page.

The IPTS provides tools for communication, and oversees the animation and management of these various networks.

The IPTS Report

The Commissioner for Research, Education and Training, Mrs. Cresson, has engaged the IPTS to produce a monthly Technology Watch (TW) synthesis spanning across broad areas of S/T. The objective of such a publication is to alert the decision-maker to important implications of S/T developments.

A small group of ESTO members has been selected to formally assist the IPTS in the production of the Report during the first six-month trial period. During this initial phase, these core-members have entered into a contractual relationship with the IPTS under which they share editorial responsibility for the first six issues of the IPTS report, they identify important themes for topical articles, they monitor the development and balance of the running list of titles for forthcoming editions, they refine the editorial line, they provide expert comments

The collection, filtering and distribution of techno-economic intelligence to support the management of change

IPTS has made operational the notion of Technology Watch, together with the 'customer' (mainly, EU decision-makers, the Commission and the European Parliament) and the Network. No doubt this is a continuous process, demands are changing, knowledge is changing, but for the moment the working framework is the following:

The goal is:

- to collect, filter, and communicate Techno-Economic Intelligence (technology watch) for the management of change.

The specificity of the Techno-Economic Intelligence ("Technology Watch") necessary for the management of change is framed by :

- a policy relevance (but no policy interference, and no political controversies)
- timeliness (reporting configured around an 'event' (constructed or real))
- an interest and a relevance to all levels EU/National/Industry
- not just reporting but containing an analytical, prospective part
- a message

Reporting is done on the basis of a comprehensive and serious analysis and filtering by the ESTO-Network. The aim is not to study and report on technology impacts, but on the relationship between technology and society.

Work follows an integrated approach, i.e. close linkage among the main activities of the IPTS, which are structured around 1) Technology Watch (both product and guidance for other activities), 2) Research and Development on Technology-Employment-Competitiveness, 3) Communication and Dialogue. The IPTS does not see itself giving 'policy-advice' but it is positioning itself either up-stream or down-stream of the decision-making process.

(including modifications, factual corrections and updates, as appropriate) on drafted articles - either using their own expertise, or expertise accessed through each member's contact networks, and they take responsibility for one or more topics to be reported in the trial period.
The IPTS Report is published ten times per year, on the 15th of each month with the exception of January and August. It is presently available free of charge in four languages: English, French, German and Spanish. During the trial phase, its print-run will be of five thousand copies per issue.
The IPTS Report can be considered as being the first product of the Technology Watch.

1-1 Information Systems

The Technology Watch Information Systems

The IPTS work can only be understood under the cover of a fluent world-wide information system capable of giving access to all of its scientists to a whole range of updated information. The IPTS has had access to some 500 world-wide bibliographic, news and patent data bases ; it has been subscribed to 168 specialised periodicals; it has had nearly 2.000 inter-libraries loans; it has purchased 615 books; and it has paid off the development and use of specific software tools during 1995. All above mentioned networks (ESTO, COM-NET, ...) have also an important role to play to contribute to the enhancement of the IPTS information system.

As it was stated in the 1994 IPTS Annual Report, two software systems have been internally conceived. The first one, an information system named "Qui Quod" (Q2), enables access to current R&D projects in the Community and it has successfully proven its feasibility in this second phase of development. The second one, a technology watch information system (European Science and Technology Information Exchange System - ESTIES) for the collection, selection, indexing, retrieval and diffusion of information, with the scope to provide an early warning on scientific breakthroughs and technological innovations, is still under development.

R&D Projects Information System - "Qui Quod" (Q2)

The "Qui Quod" Intelligent Interface system (Q2IIS) is a tool that aims at providing a continuously updated picture of European R&D in selected fields, as well as the facilities, funding means and the teams driving such projects.
A survey, to identify R&D related data bases in the Member States (report *"EC Member States R&D Project Structured Information Sources"; Summary, June 93*), and a survey of the state-of-the-art in 'Intelligent Interface' related projects, and a set of user requirements of the Q2IIS as well as detailed functional specifications, in the form of a set of hierarchical functional decomposition diagrams have been presented, in the study *"Q2 Intelligent Interface Feasibility Study"*, Dec. 93. A call for tender was initiated and resulted in the undertaking of the implementation of the Q2IIS tool by the s/w development company INTRASOFT (Apr.94).
The architecture of the tool was defined in such a way so as to maximise flexibility in managing the sub-systems (local autonomy) as well as combining of new sub-systems in either a centralised or distributed model ("A tool providing Uniform Access to R&D project databases", CRIS95, Milan Italy, May 11-13, 1995)
The project was implemented in two phases, the first one of which (January 1995) included the devising of a prototype interface to be tested against a set of locally available data of the CERIF format and demonstrated to a group of selected R&D project Member State administrators in order to get users' comments as to the tool's functionality. The second phase (Jan. 96) resulted in a tool, which connected some of the existing R&D project data bases using the previously developed intelligent interface, and which was presented to the parti-

cipants of the ERGO (European Research Gateways Organisation) meeting, organised by DGXIII-D CORDIS in Luxembourg (Feb.96). Efforts to create a production system, including charging, security, access policy and web interface features as well as improve the quality of the data accessed will continue in collaboration with Member States and Commission services.

Technology Watch Information System (ESTIES)

As an aid to the Institute's Technology Watch Function, an information system (European Science and Technology Information Exchange System) has been conceived and is being developed to enable on one hand the monitoring and diffusion of information on science and technology and on the other hand, the more effective exchange of information among the various partners.

A working group was set up internally and the meticulous phase of understanding the problem, defining the user needs as well as trying to provide an initial solution was launched (Jul.94). As a second step, a study on the ESTIES requirements was commissioned (June 95). It encompassed the understanding of the business processes the system must support, the deducted system requirements as well as the technical approach and resulting resource implications from its deployment. The study consisted of a series of interviews within IPTS that brought in evidence the various levels of difficulty in automating the core business due mainly to the multi-disciplinarity of the approach and the width of the covered area (S&T).

As a result a HyperText 'active' document presenting the requirements identified as well as the resulting development phases plan and the required technical approach was compiled. The all pervasive World Wide Web (WWW) technology will be used as the foundation substrate for the development of this tool so as to maximise its diffusion, ease of use and ensure its hardware and software independence. It was also suggested that the system be preferably made up of 'components', which due to the maintainability requirement ought to be mostly directly purchased and not custom built. Taking account of the extended co-operation with existing units and organisations active in the field at national and local level in the Community, a deployment in phases was proposed that foresaw successively a base, a partner and an extended system to be developed incrementally allowing for continuous user feedback. The tool ought to be extensively tested internally at first and then among the IPTS Technology Watch partners.

Implementation progress is not straightforward as on one hand novel products enabling collaboration that exploit INTERNET capabilities, appear increasingly on the software market, and on the other the attributes of the Technology Watch process slowly become unveiled, through a series of consensus raising workshops, among the IPTS and its partners. Nevertheless the Institute's target is to develop a powerful Technology Watch computer-aided procedure, enabling it to combine optimally its own resources with those of selected external experts and policy-makers, in order to better perform its mission.

2

Technology, Employment, Competitiveness

2-1 Beyond competitiveness: from greening to sustainability

The IPTS has continued and expanded its activities within the area of sustainable development in 1995. Not only by providing the Forward Studies Unit (FSU) of the European Commission with a mainly reflexive report on mostly academic activities aimed at clarifying and operationalising the concept of sustainability (which is presently - on request of the FSU - being enlarged and deepened (see box)). The IPTS has also agreed to support the FSU on a much more down-to-earth subject, namely a study on the various forms of 'green accounting' and its use by industry, and finally, it plans to engage further into the analysis of the potentials for Europe to go a step forward into the realm of sustainability within 1996. The role of industry in sustainable development will obviously be the focus of such studies.

The IPTS' activities in the area of industry and green accounting is to be seen as support to the Forward Studies Unit in its co-ordinating and animating role vis-à-vis the follow-up on the important first step of the Commission's suggestion of a European System to allow for comparisons between Member States and the 'Greening' of national accounts.

The IPTS contributed to the drafting of the Commission's communication to the Council and the European Parliament on environmental indicators and green national accounting: "The integration of environmental and economic information systems". In February 1995, the chairman of the European Parliament's Committee on Environment, Public Health and Consumer Protection asked the IPTS to draft a support document on National 'Green' Accounting for the Conference on 'Green Accounting' organised by the Parliament, the Commission, World Wide Fund for Nature, and the Club of Rome. The IPTS additionally assisted the Committee's rapporteur in clarification of the subject.

The Institute has participated and chaired one of the sessions on Sustainable Development and Research, in the Spanish Presidency's conference on Innovation that took place at El Escorial in December 1995.

Industry and 'green accounting'.

The engagement of the institute in the technological, environmental and employment dimensions of sustainability leads to a specific interest in how to monitor these dimensions, particularly those embodied in the 'Life Cycle' approach and other environmental assessment frameworks applied by industry.

Of particular interest for the IPTS is to analyse what can be done to provide European industry with an improved basis for integrating environmental and other societal concerns into their strategies improving their competitive advantage on a global market.

The medium term objective is to identify and further develop significant achievements, theoretical as well as practical, in the creation of tools for the measurement of sustainable development in its environmental and societal dimensions at the macro, as well as at the micro level, with the aim of improving European competitiveness.

The various milestones in the work are to analyse concepts and methodologies used by industry for environmental assessment identifying means for harmonising - taking into account the Commission's 'Green Accounting' five years Work Programme - the concepts and methodologies, to analyse existing information systems linking technology innovation, employment creation and environmental performance with a view to identify means for further improvement; and to identify, on this background, major theoretical as well as practical developments.

For the time being, only a feasibility study on European industry has been started. However, it is intended that as far as possible a more global perspective can be given through contacts with international and other industrial organisations.

From greening to sustainable development

IPTS is presently engaged in developing a common framework of understanding, which will allow to 'see' some of its ongoing activities in a more strategic perspective as preparing the ground for a shift from 'greening' to 'sustainability'.

'Greening' of industry, which has been perceived as a burden to European industry for a long time, is now widely accepted not only as a positive stimulus, but also as an important innovative driver that keeps European industry at the edge of development and contributes substantively to improve European competitivity.

Even if the environmental component of the notion sustainability thus increased European competitiveness, the problem of lack of jobs forces the need for a broader analysis of the relations between the various components of a sustainable development, including jobs and the environment.

Reflections on Sustainable Development

An in-house report on sustainable development inspired by a Conference in Paris in 1994 resulted in a longer term project for the Forward Studies Unit of the Commission elaborating on some of the points raised in the report. The basic theses of the report can be summarised as follows:

1) *Substitutability will improve with technical progress.* The latter can be seen as a form of human capital in which society invests. In a **virtual cycle pattern**, *technical progress not only enhances substitutability across forms of capital, it also promotes economic growth, which in turn allows high investment in human capital formation.* The picture becomes less rosy when we are near **catastrophe thresholds**, or, perforce, when there is uncertainty about what such thresholds are. The inability of **price signals** to reflect the imminence of catastrophe threshold crossing is at the heart of the problem. It is due to limited (though improving) scientific knowledge but also to economic/legal issues (e.g. **property rights allocation, public good characteristics**). Uncertainty about the stability aspects of the biosphere renders problematic the application of standard rational agent rules (i.e. forming **rational expectations**, weighing **expected costs and benefits**, etc.). A useful rule-of-thumb seems to be to keep the option set as intact as possible for as long as possible while science improves our understanding of what is at stake.

2) The report presents a *distilled version of the salient topics* in Sustainable Development analysis, and suggests a **synthetic/eclectic approach** emerging from and drawing on all shades of the weak-strong spectrum. In brief, this synthesis consists in: **a)** assigning a **finite** *(possibly very high)* cost to resource depletion, when substitutability obtains; **b)** treating resource preservation as a rigid constraint whose violation carries an **infinite** cost, when faced with **irreversibility**; **c)** postponing critical decisions for as long as possible, when severely constrained by **information scarcity** (e.g. on the proximity of thresholds) - thus preserving the option set until scientific/technical progress reduces uncertainty; **d)** *promoting scientific and technical progress, not only as a means to resolve uncertainty and enhance substitutability but also as an engine of economic growth that will finance substitution across forms of capital, where technically feasible.*

3) The **dual role of technical progress**, both for enhancing substitutability and for sparking growth, can not be emphasised strongly enough. Preserving the natural capital restoration option for future generations may prove irrelevant if the technical and economic ability to afford restoration/recovery is not available. In this light, **growth and sustainability will either flourish in unison or stagnate in discord**.

The questions to be asked focus on the role of industry in a modern sustainable development. Not only the Forward Studies Unit of the Commission but also the European Parliament and other organisations are interested customers on this issue.

1995 has been a preparatory phase in this area. The IPTS has concentrated its efforts on the conceptual development that will be used in the projects to be undertaken in 1996.

2-2 Efficiency of European Industry

In response to a request from the European Commission's Industrial Research and Development Advisory Committee (IRDAC), the IPTS began preparatory work in mid-1995 for a literature review and synthesis on "industrial efficiency" as background to the setting up of an IRDAC Working Group on the same subject. The review focused primarily on efficiency in relation to the production process, taken to encompass not only manufacturing, but also R&D and technical innovation in the broad sense. The review was practically finished by the end 1995.

As well as serving as a background document, the review provides a list of possible themes and questions for further discussion by the working group. Some of the main points from the literature to which it draws attention include:

- Improved business performance can be achieved through: time based competitiveness, quality improvement, innovation and agility.
- Factors which significantly affect the level of efficiency within industries include:
  - The level of technology intensity as reflected in the levels of automation and/or the vintage of the machinery/equipment being used by the Industry.
  - The level of utilisation of capacity which reflects both market share and the capabilities of the personnel.
  - The organisation of logistics which again reflect the capability of management and operational personnel.
  - The propensity to improve which reflects customer and market orientation, learning organisations and integrated innovation processes.
- Management methodologies that are a critical component to the improvement of performance by individual firms include:
  - Total Cost Management
  - Total Productivity Management
  - Total Quality Management
  - Total Resource Management
  - Total Technology Management
- Four categories of R&D, that have been identified as being successful in contributing to increased efficiency include:
  - Strategically based basic scientific research.
  - New Market driven R&D seeking synergy between existing technologies.
  - Product & Process Development R&D which is incremental.
  - R&D based on Competition Analysis and the search for cost reductions.

The IPTS's work is set to continue into 1996 in support of the IRDAC working group, which should be set-up in early 1996.

2-3 Intellectual property rights: current trends in relevant areas of EU policy

With S&T at 'centre stage' as a key factor in most important areas of economic activity, the IPR system through which government gives incentives for investment in innovation and regulates diffusion of technology, also comes under increasing scrutiny. In this project, the first objective is to take stock of the activities and concerns of the EU institutions (primarily the Commission services) where IPR considerations are

directly or indirectly involved. This is to be done by means of an interview/ questionnaire survey and a compilation of existing EU legislation and published literature. The survey was launched at the end of 1995.
From this basis, the project purports to develop a selective and prioritised segmentation of the IPR field, which can evolve over time and usefully serve the IPTS's Technology Watch mission and its research activities in relation to the theme 'Technology Employment Competitiveness'. It is also intended to study a number of options for the establishment of an internal/ external network, or other such modality, as a flexible tool to discuss in detail punctual IPR related issues that may arise, either in relation to IPTS's work or the broader policy agenda.

The project should be finished in early 1996.

3

Regional Development and S/T

Several projects have been undertaken by the IPTS with the common idea behind them of studying the relevance of S/T for regional development. Even though empirical observation has proved that the `technology gap' within the EU regions is much larger than the `income gap', this is not an exclusive European characteristic. That is the reason why the IPTS has enlarged its study framework to other geographical areas such as the Magrheb or Japan.

3-1 RTD in the EU "Less Favoured Regions"

One of these projects analyses what the impact of RTD policies has been to overcome the `technology gap', in part as a consequence of the visible effort put on by regional, national and EU authorities. The project is mainly targeted on the less favoured regions (LFRs) of the EU, i.e. those defined as Objective 1 regions by the EU Structural Funds classification. It responds to an acknowledged policy concern stressed by European decision-makers, on the problematic faced by the LFRs on their paths of development and growth.

Performance of RTD policies will be measured, taking a broad perspective which should include not only the economic impact analysis of these policies, but the employment consequences of technological change for the regions and the sociological changes present in technology introduction. RTD measures can help LFRs develop their own competitive advantage, allowing then to attain a relative advantage in the production of some products, i.e. in order to be competitive in trade terms and to gain from these processes. It is not necessary that LFRs develop their competitive advantage in high technology industries, they have to develop their own strategies and detect some market niches. Policy makers have a defined role in this complex system of science, technology and innovation. They can foster the process creating the necessary environment for process/product innovation and diffusion, in particular favouring the creation of regional networks, providing information, supporting SMEs, giving knowledge support.

The next phase of this project will concentrate on the applied side, looking for the impacts of RTD policies and potentialities in the regions in different EU Member States. The project's final aim is to derive some policy conclusions combining theory and practice, which could prove useful to policy makers in the design and implementation of their day-to-day regional RTD policies.

3-2 Regional Technology Gaps and Comparative Advantages: an inter-regional investigation of industrial development potential in the agro-food sector

This pilot project investigates the possibility of rendering operational some concrete notions of *sustainability* in regional industrial development policy aimed at technologically-lagging sectors. Four regions have been chosen for the study (Ireland, Andalucia, Central Macedonia and South East Germany (new Lander), to coincide with Regional Technology Plan (RTP) or Regional Innovation and Technology Transfer Strategy (RITTS) projects already underway in these regions, and supported by DGs XII and XVI. The final output is expected to be an inventory of recommended action typologies aimed at reinforcing a technology-oriented drive to increased competitiveness in less favoured regions. These may focus on R&D, product development, networking, joint ventures, co-operation initiatives, training, or other areas identified by the study and will be based on an analysis and comparison of sector specific technology gaps and comparative advantages.

The project has been divided into four phases starting Autumn 1995 and to be concluded by Spring 1996.

These phases are:

1. Background

The purpose is to gather and review all available information on the chosen sector and sub-sectors of the regions concerned. A first inter-regional workshop was organised in October of 1995 and was held in Seville, at which regional experts and development agency representatives presented background information as a starting point for the study.

2. Inventory

The purpose of this phase is to identify the technology-related perceived problems and opportunities, and actions already undertaken or planned by authorities and other key players. A series of interviews will be conducted targeting both private firms and those involved in the evaluation of public schemes.

3. Criteria

This phase is devoted to the development of three complementary sets of criteria (factor suitability, regional development potential and sustainability potential). A workshop will be held to discuss and formulate the criteria set, which, with regard to the sustainability criteria, is a novel and challenging undertaking.

4. Analysis

Based on acquired background and inventory knowledge, and the constructed criteria set, an analysis will be conducted for each region in order to formulate some concrete recommendations and possible policy response typologies. A final workshop will take place following individual regional workshops to discuss and present the conclusions.

3-3 A comparative approach of European and Japanese experiences

IPTS is carrying out, on the behalf of DG XVI, a joint project with NISTEP (National Institute of Science and Technology Policy from the Science and Technology Agency) of Japan. The challenge is to see, on the European side, whether or not the Less Favored Regions (LFRs)of the EU, which cannot compete with Less Developed Countries (LDCs) in labour intensive activities or with the rich North in capital intensive activities, may acquire a comparative advantage with an innovation intensive environment.

Two studies dealing with the theoretical aspects of this question were completed in 1995. They showed, in particular, that the diffusion of new technologies in the production systems depend not only on the availability, quality and degree of integration of the supply with the local demand, but also on the business environment, including enterpreneurial culture and degree of co-operation among regional socio-economic actors. Several authors use the concept of technological infrastructure as a channel for the rapid diffusion of innovation throughout the local economy. These studies pave the way for on-going analysis of real situation at the local level which aims to provide data on regional S&T capacities (activities, human resources, infrastructures, etc.), analyse the local conditions for the diffusion of innovation (regulatory, administrative, financial, environment) and look at the demand side (firms and consumers) for new products and processes.

A paper was presented at the RESTPOR (Regional Science and Technology Policy Research) 95 Conference held in Kawanaga (Japan) in February and a workshop bringing together European and Japanese experts was organised in Seville in June 1995.

3-4 Technology transfer through co-operation between European and North African business

This pilot study analysed, from a limited series of test cases, the condition for successful technology transfer between Spanish and Moroccan firms. Technology transfer was defined in a wider sense, as movement/assimilation between one country (or market) and

another of the know-how which sparks innovation. A twin methodology was applied for the study : (i) a macroeconomics analysis of the Moroccan situation and (ii) more importantly, the production of a questionnaire addressed to businesses and the selection of a set of indicators. Analysis of the balance of payments shows that imported technology has provided the bulk of Morocco's technological capital. This is due to the weaknesses of the country's own system of innovation, which is unable to meet the needs of industrialisation. Foreign investors are attracted by the liberal reforms of Morocco, by the opportunities the country offers as a springboard for exports and by the cheap labour. However, the domestic market demand remains poor and still attracts little foreign investment. Nevertheless, detailed analysis of the development of a local company through co-operation has a positive effect on the surrounding environment and on the well-being of the population.

4

Energy

Energy and related services constitute one of the biggest markets in the world. A functioning energy supply has been an indispensable prerequisite for economic prosperity.

Whilst in the past dependence on sometimes considered dwindling resources or lack of national resources have lead to the initiation of powerful programmes, e.g. coal, hydro or nuclear energy, today the paradigm is a different one. The driving force for change now is a growing potential conflict between the advantages and the need for abundant energy consumption on one hand, and the real, or perceived, disadvantages of excessive energy use on the other hand, such as global warming.

The institute aims at contributing to the establishment of a common knowledge base to understand the problem of coping with the threat of global warming.

Particular objectives are the improved understanding of technology and its potential and the functioning of the main players-operators and industry. This should lead to direct input on environmental and energy legislative and R&D strategy as well as regional policy, including specifically the Mediterranean policy.

The different projects will not attempt to cover the complete range, but to make key contributions at the different levels, i.e. to understand the technology, to illustrate the science technology relationship and exploring policy options: CO2 tax, post-Rio, R&D, regional policy....

The approach comprises the questioning, the assumptions underlying the discussions on the topic (e.g. the extent of global warming to be expected). The validity of options will be scrutinised by illustrating and analysing a number of key technologies as well as their socio-economic surroundings, benefits and markets (e.g. coal, renewables). Based on the analyses of the individual technologies on a next level then the relationship between energy, environment and the economy can be analysed. Only after having understood these relationships, i.e. a through study of the market forces -demand and supply-, quantification of the problem and potential benefits of options, finally policy options can be explored. Particular emphasis will be put on the regional dimension and employment generation potential of the different options.

Under this framework, IPTS was defining its new strategy in Energy-related topics during 1995. New contacts with other European Commission services with fruitful collaborations, inclusion of IPTS in the competing arena with a successful result and the new focus of the energy projects have defined this year as a transition year. Projects concerning energy carried out in the institute during the year 1995 are summarised below.

4-1 Photovoltaics

Photovoltaics is considered as one of the most benign forms of electricity generation. The Institute for Prospective Technological Studies decided to start a study in order to analyse the future of the photovoltaic technology. During this year, that prospective study was concluded. The methodology selected to carry out this study was a bibliometric analysis, as a first approach and secondly, a questionnaire sent to more than one hundred experts around the world.

The study considers a time period of 50 years (from now up to 2050) and includes prospects on the PV production, percentage of electricity produced by PV, PV R&D status of the different countries (associated by region) as well as market and PV production in each region. It also includes market data and its trends. Special emphasis has been made on the constraints that this technology has to increase the annual production and the competitiveness with the other energy technologies. The prospects of the different PV technologies (cells and modules) as well as the main bottlenecks were also analysed.

The efficiency of the photovoltaic cells could reach 95% of the theoretical efficiency during the period 2020-2050, and silicon modules are expected to attain an efficiency of 23 % by the year 2050. The module cost in 2050 is expected to be half of the current cost and the global PV production is expected to increase from the actual 70 MW per year to 10 GW per year in the year 2050, an increment that represents double the production every 8 years. The main PV market is presently in the developed countries but the tendency is changing dramatically. By the year 2020, developing countries will represent the main market.

Experts believe the PV could be competitive in the period 2001-2020 and will be a common public utility in the period from 2021 to 2050. The main bottleneck for the development of the technology is economic (unsatisfactory return of investment) together with the lack of funding. The technical barriers in the non-module part of the photovoltaic system are mainly identified in the structure, inverters and energy storage systems.

4-2 Global change

Under the project of the "Observatory of Global Climate Change Research & Policy" a study is carried out in the form of reports covering relevant results of twice-yearly climate change research. The recent literature has been extensively reviewed and a communication with experts has been established, guaranteeing the flow of scientific information. Among the main results of the Year 1995, the following could be underlined:

The recent improvement of climate models and the reinforced effort of the scientific community in the field of global climate change has led to a real progress in understanding the complex nature of the climate system and the interactions of its driving factors. Thus, it can be said that distinguishing natural and anthropogenic evidence is becoming quite compelling. A major step for the scientific community was the declaration of the Intergovernmental Panel on Climate Change (IPCC) by the end of the year 1995 saying that recent evidence points to a discernible influence of human activities on global climate. This statement meant a real progressive step compared to its former more moderate assessment report on the issue of climate change. This was also revealed by the results of the Berlin Framework Convention in early April 1995. The IPTS followed the debate and summarised the results. Definite suggestions in terms of planning future strategies were postponed. Interestingly, the common concern focused on the extent of the change rather than on the doubts for a future climate change.

Following the scientific debate, the IPTS highlighted the revival of the discussion on the natural variability of the climate system. According to the models, it was understood that the external forcing might act as a trigger or amplifier of internal mechanisms like the ocean circulation, ice sheet dynamics or biosphere activity. Oceans, for example, form a reservoir of potential non-linear feedback during climate transitions since they have a delayed reaction in their response time to external forcing. This might explain quasi-irregular short and long-term climatic oscillations. Rapid switches of the ocean circulation observed in records of the past climate could be reconstructed by models and were assumed to be due to freshwater influxes into the ocean caused by dynamics of the ice sheet. The IPTS described in depth why the knowledge of these sudden changes is of importance for the European climate.

Furthermore, the increased occurrence of extreme weather events during the last decades was highlighted. The events do not show a cyclicity and are thought to be caused by global warming due to anthropogenic emissions. Yet, according to the critics, a statistically significant increase of extreme weather events could not be observed.

4-3 Separation, Storage and Sequestration Technologies for Carbon Dioxide from Power Generation Systems

A prospective study on the evolution of CO2 Separation (removal or capture), Storage (disposal) and Sequestration (biological fixation) technologies was initiated in 1993. The main goal of the activity is to provide appropriate technological options to DGXVII for CO2 constrained long-term energy scenario cases towards the year 2020 and beyond.

The studies on Separation and Storage technologies and their possible evolution were completed at the end of 1994. The third part on CO2 Sequestration (biological fixation) was concluded in the first half of 1995.

The report is based on a literature survey and summarises the current understanding of the options, their sequestration rates and storage potentials, their environmental impacts and their costs.

The results of the study highlight the following main trends:

Plants or trees can either be used to store sequestered carbon or harvested to provide a substitute for fossil fuels. Whereas storage has a time perspective of the order of 50 years, growing and harvesting biomass can have a life cycle of as low as 5 years for trees and even less than one year for non-forestry, marine and micro-algae options.

The realisation of biological sequestration entails the problem that whilst most fossil fuel plants with over 50 % of global CO2 emissions are situated in the wealthier industrialised countries with less available area for sequestration, the sequestration efficiency is highest in tropical regions which generally coincide with developing countries. Current purely industrial needs are the development of photo-bioreactors for microalgae which it is hoped will improve sequestration efficiency and help reduce surface areas, whereby the costs remain unclear. Also, gasification and gas clean-up, the least developed process steps in the conversion of biomass to electricity, methanol or hydrogen, require further development.

4-4 Elaboration of an action plan for the promotion of renewable energies for electricity supply, water supply and socio-economic development in southern Mediterranean countries (MEDENERGY)

This project was carried out under the DG XII APAS Programme.

Within this project, an action plan for the development of renewable energies in the above mentioned region was elaborated. The most promising renewable energy technologies were identified and a study about the energy situation of each country was made.

IPTS contributed to this project with the identification of the variables necessary to carry out a socio-economic impact analysis and with a pre-analysis of the socio-economical impact of the implementation of a certain renewable energy plan in a country. More precisely, the implications of the implementation of renewable energies in Tunisia were analysed.

4-5 Biomass

A study on biomass energy prospective in the European Union has been carried out with the support of an external contractor during 1995.

The aim of this study is to define the main opportunities and limitation of biomass exploitation for energy purpose in the next fifteen years. The study was originated by the need for a clear picture in this sector

to be able to perform robust policy (including agricultural, energy, regional, environmental, industrial) and commercial strategies. In order to get comprehensive inputs from real actors in biomass energy, a seminar was organised in Paris in July 1995, to coincide with the fulfilment of the first phase of the study.

The study estimates that the biomass contribution to the EC (Euro-15) primary energy demand is 3.5%, namely 6% of the primary energy produced in Europe. Although from 8 to 10 M hectares of EC land will be available for energy corps within the next 15 years, there are modest prospects for biomass contribution to the EC (Euro-15) total energy demand at the beginning of the next century: 4-7%. At the EU level, wood biomass will still remain the most important biomass resource for energy purposes, presenting the largest flexibility of conversion/end-use: industrial products, heat, power and alcohols. In the short term, unused urban and industrial wastes (4-5 Mtoe) and forest by-products (40-50 Mtoe in total) can be easily exploited for energy generation.

Presently, for heat and power generation, biomass combustion-based conversion technologies are the most valid, while biomass gasification, and co-combustion of coal and biomass have good medium term prospects for heat and power generation.

The economic aspect represents the principal obstacle to the development of biomass energy. Other obstacles are: a) of structural nature (competition with centralised energy supply networks), b) of management nature (it is needed because bioenergy it is not an homogeneous sector); c) lack in R&D effort (in 1994 less than 1% of the OECD energy R&D funds was dedicated to bioenergy). The possible benefits of bioenergy implementation are those related to the environment, rural spaces management, employment, energy supply & security.

4-6 Coal Technologies

In 1995, the IPTS looked at the status of modern coal-fired power plants. Throughout the discussions on global climate change often the future of coal as a source for power generation has been questioned. However, due to the importance of coal as a fuel within the EU and on a global scale, the possibilities regarding the technological development should be scrutinised. For this purpose, the IPTS asked leading experts in the field to give the state of development, current trends, as well as needs for further investigation. A series of reports dealing with the key technologies on coal based power generation strategies are now available. Particular attention has been paid to advanced combined cycles (Integrated Gasification Combined Cycles), as well as pressurised and atmospheric fluidized bed combustion techniques.

4-7 Technical-Juridical European Forum on renewable energy: European Enterprises facing technical & legal barriers of renewable energy

This project was developed under the Thermie-DGXVII-EC Programme.

The IPTS' main task was the organisation of a European seminar with the aim to identify and define the techno-juridical problems of introducing renewable energies in the energy market. The conclusions will provide the required support to policy-makers in the design of the instruments to facilitate the implementation of these technologies. The project was prompted within the European Forum for Renewable Energy Sources (EUFORES). A detailed examination of the main legal and juridical barriers for the penetration of renewable energies into the energy market was made and discussed during a conference organised in Seville in November 95.

4-8 Study on planning, rationalisation and modernisation of Las Palmas de Gran Canaria and Santa Cruz de Tenerife infrastructures

IPTS was subcontracted by OMICRON S.A., a Spanish Engineering company, to carry out an analysis of the current policies concerning urban transport that are being applied in different European cities. The study was made between January and May 1995, after which a report concerning the new policies and actions in the different cities was delivered.

4-9 Shared cost actions presented under the JOULE Programme of DG XII

Three projects presented by the IPTS to the JOULE Programme were selected in 1995. All of these projects were prepared and structured during that year. Their development will take place from the beginning of 1996 onwards. The titles of the projects are:

- Prefeasibility study for the integration of renewable energies for electricity production in the southern Mediterranean countries (INTERSUDMED).
- Climate Technology Strategy within Competitive Energy Markets: Towards New and Sustainable Growth (N-GICS).
- Externalities of Energy (EXTERN-E).

5

Environment

5-1 Cleaner Production Technologies and Integrated Pollution Prevention and Control (IPPC)

IPTS has been studying on behalf of DGXI technical solutions for the implementation of the IPPC directive (see Box). These solutions refer to the development of information collection/exchange procedures and to the preparation of Reference Documents on Best Available Techniques (BATs) for the industrial sector covered by the IPPC directive. To this end, a "multi step approach" was developed, tested and presented to the Commission and the Member States.

A new EC policy tool, the IPPC Directive (**Integrated Pollution Prevention and Control**), reached a common position in the June 1995 Council of Environment Ministers and its future implementation has a high potential to contribute to a strong European role in the development of clean technologies. The Directive will usher in a new era of environmental and industrial policy by regulating approval procedures for all kinds of industry according to integrated criteria which take into account the environment as a whole. Concepts for rigorously describing BATs (Best Available Techniques) will be applied throughout Europe, thus systematically ensuring harmonisation of technology use and compliance with achievable emission limits.

R&D and the demonstration of novel clean production routes can be stimulated by the rigorous BAT determination and updating procedures foreseen by the directive. In this way BAT-driven, integrated environmental policies for authorising industrial activity, which consider the environment as a whole, also offer potential for stimulating innovation for cleaner production. Europe, being the first to introduce the integrated approach world-wide could obtain a comparative first mover advantage. This advantage lies in the fact that legislators who are now split into separate single media services will be forced to rethink the permitted procedures, and industry in turn will have an opportunity to rethink its processes on integrated terms.

According to the multi-step approach developed by IPTS, the information collection is carried out through six standardised information exchange protocols while three additional steps are being designed to assist the BAT evaluation procedure and the preparation of BAT Reference Documents. This information exchange procedure on BATs at EU level is being tested by IPTS in two pilot projects (production of ammonia and nitric acid).

The overall information exchange system on BATs has been described in a progress report submitted to the Commission and distributed to the Member States in October 1995. The information exchange protocols, which are the building elements of the information system, have been conceived in a coherent way so that they can be applied to all the industrial sectors covered by the IPC annex 1. The standardised design of the protocols and of the information exchange procedure using these protocols as the main tools are expected to enable efficient use of advanced computing thus minimising the need to convene meetings. The information collected through electronic versions of the protocols (all versions including comments) will be accessible from a computerised archive. The easy access and interactive operation of such a system will contribute to the achievement of completeness of the information base as a result of the wide range of reactions expected from all the actors concerned.

Of particular importance is protocol 5 which requests industry to collaborate directly in the information exchange procedure. It has a central function to collect detailed information on recent BAT-relevant demons-

trations directly from the plant operators or the technology owners. Industries contributing to this exercise benefit from the fact that misinterpretation and misuse of BAT-related information is minimised. Thanks to the close industrial co-operation, protocol 5 has a serious potential not only to contribute to a better management of BAT related information but also to stimulate the development of unique data bases to be used as drivers for innovation towards clean technologies.

Advanced results are available for the ammonia case study. Prototype information exchange protocols were developed, presented and discussed at technical meetings of a BAT working group on ammonia production (Seville, 29-30th May and 30-31st October 1995). A first BAT Reference Document draft was also discussed in the October meeting.

IPTS has also been testing the first draft protocols for the nitric acid pilot project. The first version of these documents was distributed to Member States in October 1995.

5-2 Plastics recycling

Following a request from DG XI, IPTS has been carrying out a survey for identifying emerging technology options for plastics recycling in Europe.

The technology options considered by the IPTS study were:

- Feedstock recycling: Pyrolysis, hydrogenation, gasification and chemolysis processes.
- Mechanical recycling: separation, compatibilisation, remelting and extrusion technologies.
- Energy recovery: Mono and co-combustion technologies were investigated in full detail in various industrial sectors (waste incineration, cement production,...).

Survey reports on all the above-mentioned technologies (feedstock recycling, chemolysis, mechanical recycling and energy recovery) were prepared and distributed for comments to all industrial and R&D actors concerned. The information collected through the direct feedback from the actors provided IPTS with a fairly complete picture of all the current industrial activities in the field of plastics recycling in the world.

The technological studies were supplemented by a comprehensive survey of the European Legislation in plastic recycling with particular emphasis on the application of economic instruments which hold the promise to contribute to reducing the flow of wastes and to creating incentives for the application of recycling and management options.

The results of the study were presented to the Commission and to the scientific and industrial community at a dedicated conference on "Technology Options for Plastics Waste Recycling" organised on November 20 and 21, 1995 by IPTS in Seville. It brought together more than 30 experts from most EU countries to discuss how to integrate the technological, economical and policy aspects in the implementation of the European Packaging Directive. This conference provided a forum where policy-makers, industry and non-governmental organisations could exchange their views and improve their global understanding of the plastics recycling issue. In addition to the IPTS results, the most recent European studies on the experience gained in Germany and the Netherlands from existing recycling projects were presented along with the implementation plans for the European Packaging Directive in all southern European countries.

For most EU Member States going to build, nearly from scratch, a plastics recycling industry in the near future, several key issues were identified and discussed. First of all, the setting of collection and recycling targets should result from an integrated evaluation of logistics and performance capabilities of the final treatment technologies. Where high recovery levels are mandated, such as 64% in Germany, the technology mix needs

Although in most European countries plastics recycling is virtually non existent, the implementation of the EU packaging directive, adopted in December 1994, requests the achievement of significant recovery and recycling targets by the year 2000. The directive calls also for the review of the achievable targets every five years and opens a long-term frame for technology development.

World-wide, experiences on a national level on the entire prevention-collection-sorting-recycling cycle of post consumer plastics packaging waste exist, in particular in Germany. The major lesson learned tells us that traditional mechanical recycling based on the remelting and extrusion of waste plastics has limitations both in cost and efficiency. It can only achieve high recycling goals at extremely high cost. To solve these problems, new concepts including the feedstock recycling and the energy recovery options, are being developed and, if adapted efficiently in national waste collection schemes, could provide an optimum between cost and environmental benefits.

Under the pressure of the packaging directive Europe is already playing a leading role in developing innovative technologies. Japan has started only very recently to follow and the USA appears to have no large-scale action plans. In this context, better co-ordination between national and EU environmental and R&D policies is essential for guiding the adoption of fast developing technologies in the future and maintain the European leadership.

to include feedstock recycling and energy recovery in addition to traditional mechanical recycling. The optimum proportions of the various technology components of this mix can be established through eco-balance studies and depending on local conditions through interaction of market forces. Lower recycling targets, in line with the requirements from the EU packaging directive, can be achieved by either mechanical recycling or the novel technologies. In conclusion, it appears that nation-wide schemes able to achieve high recycling or energy recovery targets while minimising both collection/separation and recovery/recycling costs are feasible and could be developed in the near future. To move in this direction, countries without traditional mechanical recycling industry have now the opportunity to opt for the use of modern technologies.

5-3 Bussiness and the Environment: Micro-Economic Case Studies

As it was reported in 1994, the Institute is engaged in carrying out a series of micro-economic case studies to explore the nexus between business, the environment and technology with a primary focus on competitiveness and employment issues. These studies form part of the follow-up to the Commission's White Paper on "Growth, Competitiveness and Employment". They are carried out on behalf of the Commission's Forward Studies Unit.

Two case studies were reported in the 1994 Annual Report (Flue Gas Desulphurisation and Waste Minimisation) a third one was completed during 1995 and it is described below.

Case Study Three - Cleaner Technology

This third case study focused on the utilisation of cleaner technology by a small Dutch tannery. The study follows through the transformation of the technology employed by a small to medium enterprise (SME) in order to improve its environmental performance. The case study company had a 1993 turnover of HFL 40 million (about 17 MECU) and a staff of 100 full time personnel. The company produces high quality leather mainly for the furniture industry.

The main study conclusions are as follows:

- Competitiveness: There was a direct and positive impact on the company's competitive position from the

investment in cleaner technology. Profits were increased mainly through reductions in chemical, water treatment, waste disposal and labour costs. The internal rate of return on the investment was estimated at around 40%.

• First Mover Advantage: The company has pursued a proactive environmental strategy since 1985. It is not certain that this has resulted in a first mover advantage. However, it is clear that the tannery industry was facing major challenges from increasing environmental regulations in Europe coupled with strong competition from low-cost countries such as India. This pressure had resulted in one Dutch company being forced out of business and declaring bankruptcy during the period of this study. By contrast, the company under study has remained profitable.

• Public Support: The capital investment in the new (depilatory) process technology (see below) amounted to HFL 1.5 million of which HFL 310 thousand (approx. 21%) was subsidised. The programme through which the company was subsidised comes from the Ministry of Economic Affairs and it is intended to stimulate companies to carry out technological studies in biotechnology, materials technology and environmental technology (including innovative environmental technologies).

• Employment: Employment implications are negative. However, it must be stressed that the company has not reduced its staff complement. The new process technology requires more highly educated technical staff (engineers, chemists) while reducing the need for less qualified staff by 30%.

• Technology: The company has invested heavily (in spite of the adverse economic climate) in environmental technology (process, end-of-pipe and environmental management systems). The total investment over ten years has been HFL 5 million (about 2.2 MECU) of which HFL 1.5 million (about 652 kECU) was on the development of a new, advanced depilatory technique for animal hides which offered considerable economic, environmental and social benefits. This study focused on this new process. The process is not only cleaner but also enables previously waste materials (hair) to be recovered for possible use in other products.

• Company Image: The environmental programme has resulted in a substantial improvement in the company's image both amongst employees and local people. As far as the local community is concerned the dramatic reduction in odour missions is the main benefit. However, the improved morale inside the company has also had a direct impact on the company's fortunes, not least through a reduction in absenteeism from 12% to 2.5% over the period '86 to '94.

The three case studies completed thus far have featured a large (non-European) chemical engineering company, a large chemical production company and a small tannery. They were concerned with the manufacture of end-of-pipe environmental technology, waste minimisation (particularly water) and the introduction of clean(er) technology. They are all from the manufacturing sector. It is obviously a limited sample but it must be stressed that the selection of the companies was made with no prior knowledge of the results. The only selection criteria was that the case study should illustrate a particular facet of business and the environment and of course that the companies should be prepared to participate. Accepting these limitations, nevertheless the results show a general consistency which is quite interesting.

• The role of regulations in bringing about change in industry is fundamental.

• The economic advantages are significant and all the companies involved in the case studies now see an opportunity rather than a threat resulting from environmental pressures.

• Employment implications are relatively small (positive

or negative). However, there are indications that a less proactive approach by the companies concerned could have resulted in eventual job losses.

• The wider benefits (employee motivation, relations with suppliers and customers, local reputation) are considerable.

• The technological development costs can be high and a "project champion" in a senior position in the company is an important factor in achieving successful project completion.

Further case studies are in preparation.

5-4 Biotechnology Risk Assessment

As indicated in the 1994 annual report, the Commission has embarked on a review of its regulatory framework for genetically modified organisms (GMOs). As a small contribution to this review the Institute initiated a study theme on behalf of the Forward Studies Unit concerning the role of risk assessment (RA) in this field. The focus of this study was the deliberate release of GMOs (Directive 92/220) and environmental risk assessment. In 1994, a report on the Japanese approach to this problem was completed and in 1995 a more general critical review of risk assessment and the application of 92/220 to GMO plants was issued.

The main conclusions of this study were as follows:
Determining the hazards to the environment which should be included in the risk assessment for the deliberate release of GMO plants is essentially an exercise in plausibility (or scenario building). The hazards which are usually considered are:

- undesirable side effects of the plant itself
- increased tendency to persist or to invade natural habitats (weediness), genetic transfer to other plants
- genetic transfer to micro-organisms, and
- creation of new viruses

Risk assessments carried out under Directive 92/220 are qualitative in nature. They vary considerably between Member States and rely heavily on expert judgement. There is a suspicion that many are ex post facto in nature. Since the results are qualitative and the RA methods are not standardised, comparative risk assessments are not possible in general. The approach taken by the EU differs from that of the US and Japan. In both the US and Japan, the approach is to use voluntary guidelines at the research stage (these are compulsory for government funded research in both cases) and both the US and Japanese systems can change readily in the light of new scientific evidence (since 1993 simple notification has been possible in the US).

The report concludes with recommendations for more focused Directives which concentrate solely on real and significant risks to human health and the environment, for the involvement of the scientific community in this focusing exercise and for an improvement in RA procedures.

5-5 Modern molecular biotechnology and its role in the Greening of industry

IPTS initiated during 1994 preparations for the possible launching of a larger project to study the role of modern biotechnology in the 'greening of industry'. The project deals with the subject from various perspectives, and is thus being designed to look for areas in which modern biotechnology would be perceived to do 'good' things by public opinion, to analyse why the impact hasn't lived up to expectations despite a heavy supply side support from various sides and to use results in order to

suggest ways in which to improve the efficiency of European R&D Programmes.

The starting point is to examine how deeply modern (molecular) biotechnology has changed processes and products in European industry. 'Greening of industry', i.e. various attempts (e.g. the development and use of engineered catalysts) to bring industry better in line with environmental requirements, has been chosen as the object for the study because it is believed to be an area that public opinion would consider positive. The project would thus provide data which could be used to show that modern science and technology would not necessarily end up in what is easily seen as questionable by the anxious European public.

The project is well aware of recent valuable findings by the OECD and others within the same broad framework. This project, however, will concentrate fully on the integration of new knowledge in process and product design, and will thus not cover the various end-of-pipe applications of biotechnology which do not change processes or products, but starts where the environmental damage has already occurred. The OECD findings will obviously be of importance, and OECD has accepted an invitation to join the project-management group as regards a few feasibility studies which are actually preparing the ground for the fully fledged project to be developed in 1996.

To illustrate what is meant by 'greening' and what is meant by 'integrated' a look at two hypothetical cases will be taken:

- a pharmaceutical multistep process involving a number of very nasty chemical reactions (and thus potentially troublesome for the environment) is replaced by a one step process in aqueous medium using modified organic catalysts, produced by techniques of modern biotechnology, either through the use of genetically engineered micro-organisms or otherwise.
- a one step process in the area of bulk-chemicals which involves the use of some inorganic catalysts with known environmental problems (e.g. heavy metal based), cannot work if reaction conditions of 200 atmospheres and 1700 centigrade degrees are not established. This process is replaced by a one step process at room temperature and atmospheric pressure using a highly sophisticated engineered organic catalyst.

5-6 Water Resource Management

Water resource management is emerging as a priority area for action at the European level. In the north of Europe, water management issues primarily revolve around halting the decline in water quality; in the south, the quality issue is inter-linked with the supply constraints imposed by the generally dry climate. The spread of irrigated agriculture, rising standards of living and increased industrial demands combined with the deterioration in the quality of many water resources have led to local and regional shortages of water of adequate quality. IPTS aims to contribute to an informed debate on how this increasingly valuable and disputed resource can be properly managed to ensure the maximum good to society, in terms of overall socio-economic well-being for both present and future generations.

In all regions of Europe, the solution clearly lies in a combination of technological, economic, administrative, and educational tools, adapted to particular geographical conditions. IPTS activity is focusing particularly on the role of technology in providing society with sufficient water of adequate quality. In order to do this, however, IPTS is examining not only the technology per se, but also the various socio-economic, cultural, environmental and political factors which condition both the need for water and the appropriateness of particular water management tools.

In the context of the E.U.'s Euro-Mediterranean policy, our activities in the area of water resource management reach beyond the E.U. to include all of the Mediterranean basin countries.

5-6-1 Technology Watch & Assessment

As a part of the IPTS technology watch activities, a project has been launched to monitor and evaluate selected water management technologies. These technologies are assessed in terms of their availability, broad-based costs & benefits (economic, environmental, social, etc.), acceptability, and prospects for further development. This activity is designed to provide the Commission and other decision-makers with up-to-date information about present and anticipated water technologies. The IPTS is collecting and monitoring general information on a wide range of technologies. It is mainly focusing on water supply technologies, wastewater recycling and reuse technologies and groundwater monitoring technologies. In the near future, it is expected to initiate work on irrigation technologies.

The general methodology for this project starts with the identification of institutes, companies and administrations who are undertaking technological research and development in specific fields. From the identified experts, and the general scientific literature, we assemble technical and economic information about the present state of the art, and upcoming technologies; this information is then used as input to integrated prospective evaluations of the potential role of these technologies in meeting water resource management needs in specific contexts.

The impact of drought on the regional economy: a dried-out rice field in Andalucía

Water Supply Technologies

The focus of this activity is on non-conventional water supply techniques which include desalination, water recycling/recharging of aquifers, cloud seeding, long-distance transfer of water and transport of icebergs. Priority has been given to the desalination technology which, it is considered, may have the potential to be applied on a much greater scale in the European Community, specifically in the Mediterranean countries. Although the desalination technologies are relatively well developed, with total global desalination capacity at the end of 1993 exceeding 18,700,000 m3 of fresh water per day produced from over 9,800 facilities of unit capacities greater than 100 m3/day, they are not widely used in Europe and the Mediterranean region. (Over 60% of the global total are used in the arid Middle East and the U.S.A.). Major constraints to the wider exploitation of these sources are the cost of the technologies used, a lack of awareness of their potential and a lack of institutional incentives to exploit such a non-conventional water source.

There are two main types of technologies used in commercial desalination, thermal processes and membrane processes. Thermal processes involve distillation, where water is evaporated from a saline solution and condensed as fresh water. They are more suited to desalinating sea water, with its higher concentrations of dissolved salts, than other desalination processes. Membrane processes make use of semi-permeable membranes to differentiate and selectively separate salts and water.

Since start-up in August 1995, a literature review has been completed. The next step is to identify experts to participate in a panel meeting the aim of which is to obtain complementary information on the possible evolution of key parameters such as technical feasibility, capital/operating costs and environmental implications and on the prospects and timing for further diffusion of this technology over a specified time horizon (2020 and possibly beyond).

Waste-water Recycling and Reuse Technologies

In industrialised countries, while water supply treatment is becoming more and more expensive due to pervasive pollution, the quality of wastewater effluents is steadily improving, sometimes exceeding the quality of the receiving streams. In this context, as existing natural water resources reach their limits or are polluted in an ever larger number of regions, wastewater reuse is becoming one approach of choice to make ends meet. This raises the issue of the reliability, quality and public acceptance of water supplies. As a consequence, wastewater reuse is being developed, mainly for irrigation.

Wastewater reuse applications belong essentially to one of the following types:

* Agricultural and landscape irrigation,
* Other municipal uses,
* Groundwater recharge,
* Industrial water recycling,
* River flow augmentation, aquaculture and other ecological uses, and
* Reuse as potable water.

Wastewater reuse can be entirely controlled ("pipe to pipe") or occur after blending with non reclaimed water (e.g. after groundwater recharge). All applications require wastewater treatment prior to reuse and each may need to meet a variety of quality requirements.

Technological developments coupled with the increasing shortages of water in many areas of the world make the prospects for wastewater reuse very positive. In 1995, IPTS completed a review of the state of art with respect to the potential of using wastewater for irrigation. This work will be extended in 1996 to examining the full range of possibilities for wastewater reuse.

Ground Water Monitoring Technologies

The quality of European surface waters has generally remained stable or improved over the past decade as a result of more stringent control of point pollution sources. However, the quality of our groundwater has continued to decline due to both the delayed impact of old point-source pollution, and increasing levels of diffuse pollution. As groundwater provides the main source of drinking water in Europe, there is an urgent need to correct this problem. One component of the solution will require improved methods for quickly and accurately monitoring the condition of aquifers. This project is reviewing and assessing such technologies. We are focusing on technologies for monitoring groundwater **quality**. However, as aspects of quantity and flux are important for determination of spread of contamination, attention will also be paid to monitoring these characteristics.

IPTS is presently undertaking a survey of the institutions and companies involved in groundwater monitoring research and technical development. This survey is designed to give a picture of the present state of the art, and to identify the experts whose input will be necessary to conduct a complete prospective analysis.

5-6-2 Structural Analysis of the Role of Water in Regional Development

In many areas of the E.U., particularly in the southern countries where rainfall is not abundant, water supply is a limiting factor on regional development. Water managers must either reduce demands, increase supplies, and/or reallocate the existing water - using technological, economic, administrative, and/or educational tools. In order to promote the maximum level of sustainable development, the choice of water management option should be based on a sound understanding of the role which water has played, and could play, in a specific region. It is therefore essential to assess the end benefits which society derives from each competing use of water.

A pilot project to develop a methodology for this type of assessment is being carried out in the Lower Guadalquivir Basin. The project is assessing the use of water in this region over the past 25 years, and evaluating the benefits deriving from this water use (in terms of income generated, employment, quality of life, etc.), and their sustainability. It will also make a projection of the likely competing needs for water in the next 10 years and a critical assessment of the relative benefits of alternative water allocation strategies.

The present work is being undertaken in collaboration with the University of Sevilla. Data are being collected from existing archives, and complemented by interviews with representatives of the main sectorial water users. The results are expected to be of interest to regional planners and the water industry in Andalucía, as well as to DG XVI of the Commission. The methodology developed in this study will later be applied to other regions, particularly in the Mediterranean.

5-6-3 Water and Renewable Energy

High energy costs represent a major constraint for many water supply and wastewater treatment technologies. This is a particular problem in remote areas typical of the Mediterranean islands. However, the synergy of a possible integration between water technologies and renewable energy technologies has never been fully exploited in these areas. The typical technical problems to be solved include the high level of energy presently required by the technologies for water treatment and re-use; the reliability and efficiency of renewable energy sources; and the systems

issues related to technology integration and management. Furthermore, socio-economic evaluation, technology assessment and prospective studies need to be undertaken before the implementation of such integrated systems.

With the contribution of a visiting scientist, IPTS is developing an expertise in this field. Technical and economic information necessary to understand whether or not the integration of water technologies (particularly for water treatment and re-use) and renewable energy sources are likely to be implemented and widely diffused, is being collected.

On the basis of this expertise, IPTS is participating in a task force on the creation of an Agency for Renewable Energy and Water Management in Sicily. We are contributing towards the definition of the Agency's mission profile, and preliminary scientific work to identify technologies suitable for implementation in specific projects in the cities of Catania and Palermo.

6

Transport

The quality of the transport system is of essential importance for our modern society, from an economic as well as from a social point of view.
However, the continuous growth of the automobile sector has also negative impacts that are of increasing public concern such as environmental aspects (pollution and greenhouse-gas emission, land-use etc.) and congestion.

Therefore, the IPTS has considerably extended in 1995 its activities in the transport area, putting emphasis on individual mobility. Its goal is to contribute to managing the transformation of the present automobile into a future integral concept for sustainable individual mobility.

The work was focused toward two directions within multidisciplinary subgroups of the transport project:
- *Automobile technology*
This includes the assessment of present and future options. In co-operation with STOA (Scientific and Technological Options Assessment) of the EP (European Parliament) the IPTS has particularly investigated the fields of Power Sources Technologies, New Materials, Recycling and Telematics.
A final report on The Future of the Car will be ready in 1996.
-Socio-economic and political determinants
This exploratory work started late in the year 1995 and aims -in going beyond the mere technological view- at investigating the driving forces and impacts that will shape future individual mobility pathways. Studies which are carried out under this umbrella focus on individual life styles, the interrelationship between public transport and individual mobility and the potential role of life-cycle assessment for evaluating the overall costs of alternative car designs. In order to support a scenario development in this area different simulation methods (e. g. fuzzy modelling) have been explored and a delphi-study investigates the future of transport telematics in urban areas. In another study, technical, organisational and political barriers in intermodal freight transport are addressed in order to identify possibilities for supportive action.

6-1 Automobile Technology Power Sources Technologies

For the next 15 years, fossil resources will provide about 90% of the total energy (projections of the International Energy Agency). Transportation accounts for more than a quarter of the total energy consumption and will therefore attract most of the growth in demand. Alternative primary energy sources, and particularly renewable energies, which also offer a fast growth rate over the same period, are expected to provide only a small contribution to the total energy supply.
Nevertheless, there is a significant potential for energy savings by increasing the efficiency of transportation technologies. The open competition between different technologies will enhance these improvements.

Today, there is no ideal fuel in the market to power cars. The large majority of vehicles are powered by oil-based fuels, namely gasoline and diesel and it is these fuels that are responsible for vehicle emissions and for their global and local effects. The global effects concern the potential global warming by greenhouse gases, mainly carbon dioxide, and the damage to the stratospheric ozone layer. Local problems are induced by the main pollutants carbon monoxide, nitrogen oxides, hydrocarbons and particulates affecting mainly the human health in the surroundings of the emission source, in particular in urban centres.
In order to lessen emission problems, the use of many alternative fuels is being explored. Conventional fuels can be modified by additives or chemical reformulating. Oxygenated fuels such as methanol and ethanol are noted to be good fuel substitutes which can be produced from fossil fuels or biomass. Other fossil fuels

currently used include natural gas and liquid petroleum gas. Finally, carbon-free energy carriers, namely hydrogen and electricity, look very promising for future vehicles.

In any case, the full energy life-cycle analysis, covering fuel production, transportation, distribution and life-use is essential to determine the actual emissions impact and to be able to compare different technological options.

The hybrid concept appears today to be the best transitory option for obtaining an ultra low emission vehicle. The main idea is to combine an internal combustion engine and an electrical power source. Two basic hybrid configurations, namely serial and parallel, are under intensive development. Large scale introduction of hybrid vehicles may actually pave the way for pure electric vehicles, accelerating rather than delaying the day they will start diffusing substantially.

The market penetration of electric vehicles will be difficult to achieve in a mid-term time horizon, mainly because of the lack of effective on-board energy storage systems. Although, it is worth noting that electrical batteries are not the only possible way of storing electric energy. One alternative is the flywheel which today seems to give better performances than batteries and their development is likely to be promoted. Other energy storage systems such as ultracapacitors and supraconducting magnetic storage are also under study.

Technologies under discussion do make zero emission vehicles possible. Yet, it should be clearly understood that, a zero global emission vehicle could only be achieved through renewable or nuclear energy.

New Materials

The automotive industry is approaching an era that may revolutionise its use of materials. The major aim of the industry is to decrease the weight of the automobile in order to reduce fuel consumption, and consequently emissions. This also hopes to counter the trend of increasing vehicle weight, which has been caused by demands for increased comfort, safety and performance. For the moment, it appears that materials such as aluminium, magnesium and plastics that will be the preferred materials used in the future, at the cost of steel and iron.

The application of Life Cycle Analysis has permitted a re-evaluation of lightweight alternative materials' "cost" from the production of the raw material, through its useful life-time and then to its recycling and eventual re-use. This has tilted the balance back towards the lightweight materials as they have been shown to give the best overall value.

For the foreseeable future there will be no particular material that will dominate the overall structure of the car. It will therefore be composed of a complex mixture of various material types. Although this applies to all cars as they are at the present time, there is some scope for more radical changes with new electric cars, etc.. The true materials revolution may begin by car makers being able, and in some ways being forced, to design the vehicle from nothing in order to accommodate new propulsion systems and optimise the use of materials.

Recycling of End of Life Vehicles

Car recycling can be split into two main activities: The recycling of the current end of life vehicles (ELVs) and the introduction of design for recycling (DFR) into the development of new cars.

Developments in the ***recycling of ELVs*** emerge from the unsatisfying present situation, where 25 % of the current ELV mass are landfilled. Actual developments for the recycling of ELVs focus on reducing the mass flow of the shredder light fraction going to landfills. The main remedies are the drainage of vehicles and the dismantling of recyclable and reusable parts before

shredding. Recycling technologies for dismantled parts are more and more available; a number of valuable parts and aggregates are overhauled and remarketed. The remaining shredder light fraction is processed into a homogenous, standardised fuel and used for energy recovery in cement kilns (French way) or is processed into a homogeneous reduction agent for the steel works process, where it substitutes heavy oils (German way).

The second category of activities within car recycling, ***the design for recycling***, is driven by: the consumer demand for "greener" products and by the global development towards a total life cycle commitment for products, actually booming in the USA.

The IPTS' work in the field of ELV Recycling includes a survey of current activities in Europe, the US and Japan and an outlook on possible future concepts e.g. automised dismantling.

Advanced Transport Telematics - An Overview

In the future the gap between demand for road transportation capacity for people and goods and the provision of adequate infrastructure will widen and the service level of road transport, notably in urban areas, can be expected to deteriorate further. Since about the mid-eighties, various systems have been introduced locally in member countries of the EU which support better planning on the level of the individual traffic participant, traffic management authority and public transport operators, taking into account average traffic conditions and exceptional traffic conditions. These systems combining communications and information technology are increasingly known as **Advanced Transport Telematics** (ATT).

Traffic management systems, using sensors like inductive loops or video surveillance and road-based variable-message signs to inform drivers, have become a normal feature in many inner-cities and on motorway sections with high traffic density. The same goes for co-ordinated junction control and parking guidance systems. Generally these systems are technically proven and research goes towards the improvement and integration of systems and information resources. Traffic management systems are limited in so far as they cannot influence a traffic user's choice of transport mode, timing and routing. Only once a driver has entered traffic with his car the systems have an effect. The next step is thus a series of static and dynamic route guidance systems that help individual drivers to optimise their routes according to actual traffic conditions. Systems are piloted in several European regions. Dynamic route-guidance systems (i. e. those responding to changing traffic situations) are technically feasible but their implementation needs high investment. Apart from potential economic obstacles, the question of which system's architecture to choose and how to make systems from different providers compatible is not yet decided, although the awareness that this problem has to be overcome exists.

Static route-guidance systems (i. e. digital maps plus vehicle location through dead-reckoning and map matching) do not need an infrastructure based system and may thus be the first step to be exploited on a large commercial basis.

A further area is advanced driver support. It covers such things like automatic scanning of the vehicle surroundings and obstacle detection as well as the resulting possibility for automatic vehicle control and co-operative driving. Systems are basically still confined to laboratory testing.

Other applications with little relevance for individual passenger traffic can be found in freight and fleet management applications.

For similar applications different system architectures exist. Most striking is the issue whether computing

power for dynamic route guidance systems is best located distributed in each vehicle or centrally in a network of traffic control centres from which advice is electronically communicated to vehicles. In the interest of the user, systems will ultimately have to be compatible no matter who provides them and how they operate internally. First steps have been taken towards "dual-mode" systems.
Standards exist for RDS-TMC (radio data system - traffic message channel). Pre-standards exist for short-range communication. In order to create international standards, current specifications should be made ready for submission to the CEN and ISO organisations.

Another integration and co-ordination issue is the extent to which modes of transport other than the car are covered by ATT. Public transport, in particular, can become more attractive through the application of almost all areas of ATT, preferential traffic management treatment, customer information and guidance through incorporating public transport schedules and park and ride options into route-guidance information and fleet management applications. ATT research in the 4th framework program (205 MECU) will improve mobility across all modes of transport. Two thirds of the program will be follow-up work to existing road transport projects but targeted more towards intermodal. Economies of scale can be achieved if trans-European transport networks and the trans-European telecommunications network are used in a complementary way.

6-2 Socio-economic and Political Determinants

A first result of this exploratory work was the identification of the main areas which drive changes in mobility and transport systems. Apart from the technological realm, where both new car-based solutions and innovative systemic concept emerge, the main issues are the economic interests and constraints on the supply side of automotive industry, the changing orientations of individual mobility behaviour and lifestyles, the evolution of urban structures, and the processes and options which exist at the political level to trigger changes in the field of transport.
A conceptual framework has been developed which is intended to integrate the analysis of these rather disparate driving forces into a coherent perspective on the dynamics of mobility systems. In the next months and based on this approach, it is intended to explore the different issues further and to develop a methodology which should enable the formulation of scenarios of individual mobility.

An in-house study is forecasting which will be the likely level of use, in European cities by the year 2015, of some transport telematics technologies which have been selected from the pilot projects of the DRIVE/ATT Program of the European Commission (DG XIII). The forecasted technologies are related to management demand of transport in cities; travel and traffic information systems; public transport management, etc.
The focus is not only on the likely level of use of the technologies, but also taken into account is the direct effect of these technologies on congestion and traffic volume and which are the factors that could act as constraints for the widespread use of the selected technologies, such as social acceptance, economic viability and technological feasibility.

The final aim of this study is also a methodological analysis and comparison of the strengths and weaknesses of the two methods (Delphi and Cross Impact System and Matrices), in relation to the level of knowledge which they may produce and especially how far the information which stems from the assessment of the two methodologies is suitable for European policy decision-makers to update and review their political agenda on this specific field.

7

Information and telecommunication technologies

Work in the information technologies area during 1995 elaborated on the topics first suggested at the end of 1994, and it came under the rubrique of the Multimedia Information Society. In the context of this work interest was expressed by the European Parliament (STOA). Given this interest, IPTS' work led to the production of a report delivered to STOA in the Fall of 1995. The report is the basis on which an elaborated version is projected to be drafted during 1996. Some of the basic points of the report can be summarised as follows:

The Multimedia Information Society concept attempts to capture the transformation engendered by recent and promised (as well as promising) developments in the digital manipulation of content (in video, sound, text etc. forms), and its transmission over increasingly more capable networks, as well as the interaction of such networks with the social context from which they spring and which they shape. It is an all-encompassing term which includes as its integral parts the information highway and infrastructure concepts. The success of the MIS supernetwork of existing and future networks (terrestrial, mobile, Internet, commercial, etc.) will hinge largely on interoperability and interconnection, so that technical and regulatory obstacles do not lead to incompatibility problems and isolation of network parts.

The structure of the emerging market could be seen as a value chain composed of content originators, content packagers, network gatekeepers, distribution providers, access devices, and end users. There are four strong statements that can and have been made about this value chain/market structure. The first is that content providers (originators, packagers) will gain from the MIS. The second is that the future for distribution is not rosy. This is partly true: competitive pressures and technology facilitating entry are eating away at the comfortable profit margins of yesteryear. However, in the longer run, consolidation in the distribution industry will allow respectable profits for the remaining survivors. The third proposition suggests that gatekeepers (such as encryption technique specialists, navigational software producers, etc.) will benefit greatly from the MIS. This is true, although complacency and abuse of gatekeepers' positions will not only cause the regulators ire, but it will also instigate market entry and competition on their own turf. Fourth, the search for the killer application may be misguided, especially if the latter is some version of video on demand. There may have been too strong an emphasis on entertainment and not as much on business applications. In any case, for as long as the MIS's protean qualities confuse users, easily extensible packages and/or assistance to navigate through the sea of MIS information may be more attractive than entertainment packages, especially if they help turn information bombarding to knowledge build-up.

There seem to be at least four priority applications: teleworking, teletraining, telemedicine and teleadministation - i.e. links between the administrations (taxation, customs, statistics). Teleworking, in particular, is one of the most important applications impacting business as well as individuals. It may reduce commuting, traffic congestion and accidents, environmental pollution, office space requirements, and the rigidity of work and meeting schedules. It will also allow employees to spend more time with their families at home. On the other hand, the latter may prove a mixed blessing because it may blur the line between work and private life, limit social interaction substantially, and may create legal puzzles, regarding union practice and membership, insurance policies, etc. due to the blurry business/residence demarcation.

In order for these applications to reach the user, the last mile to his access device must be run. Telephone companies as well as cable companies (and increasingly others) may be competing in this race. Cable companies have better quality wiring already installed

but they do not have the coverage that telephone companies enjoy. Technology and wiring upgrading (especially in light of interactive services in the horizon) will be crucial. In terms of markets, whereas the telephony market is huge and for the cable companies even capturing a small part of it will imply large gains, the cable market is not nearly as large and hence telephone companies do not have as much to gain from reciprocating.

The TV vs. PC debate, related to the above 'last mile' issue, regarding the preferable access device is misguided. There will be many access devices in residences, with different forms and functionalities, depending on the need they satisfy (PC may be best for individual work/entertainment in study area, whereas the TV may be best at multi-viewing, living room gatherings). Telephone companies in any case, and besides the access device used, have an advantage in the sense that they 'own' the customer, through billing-a quasi-proprietary technology for telephone companies, and one that is not automatically picked up.

Billing brings us to pricing, a multifold and thorny issue for the MIS. First, the public good nature of certain network arrangements may lead to free-riding behaviour. Second, flat monthly fees encourage overuse. Flexible, per transaction bandwidth assignment and corresponding pricing, although efficient, runs into concerns about budgetary pre-allocations and the high cost of measuring information packets. Due to the different requirements of the various services, the time a user spends on the network is not an accurate indication of resource use.

The priority-tagging and costing solution that has been suggested (and for which switches are being designed) leads to other concerns and to one of the central insights of this report. Prioritisation of packages at a fee, will solve the traffic congestion, right of way problem only temporarily, if fees are fixed. The next and inexorably more efficient step is to let supply and demand decide the price of various priority levels at various points in time, possibly through an instant auction mechanism, which MIS speeds up and technology facilitates. The increased efficiency of such approaches may lead to higher priorities for packages benefiting private concerns (financial firms can probably afford high cost/high speed priority tags), and lower ones for packages such as telemedicine, whose speed may be more highly valued from a social perspective but for which the direct individual beneficiary may not be able to afford the high levels to which fees are being bid up to. The problem may be that the efficient solution may subject to the cash nexus increasingly larger parts of human activity, beyond a point society is willing to accept.

Pricing is one but not the only thing regulators need to think about. Interconnection and interoperability, the best way to promote universal service, cross-ownership and cross-service participation, the best way to promote competition and facilitating the acceptance of market-driven standards are some of the issues regulation is facing. The focus arguably should be on promoting competition in the 'bottlenecks'.

Security concerns and the need to balance freedom of speech with law enforcement needs are also a regulatory issue, especially given the tax-evasion incentives that the advent of digital cash will generate. Security is important not only due to the all-encompassing character of the MIS and the multi-type data the networks will carry, but also because of the illusion of internal links users may have, when, in fact, the virtual links they will be using will be actually using largely public lines. Encryption techniques seem to hold the key, as long as: i) the appropriate legal authorities can have access to a super-key (public-key-cryptography), and ii) use of this super-key will have to be legally and explicitly authorised, the possibility of filing for injunctions, and in general, timely and effective recourse to the courts can be guaranteed.

Security concerns, regulatory framework uncertainty, marketability/profitability of applications, and people's resistance to change are barriers to the quickening of the pace of the MIS transformation. Possibly the greatest concern however is employment. New technologies have always generated fears of job loss. In brief, though undoubtedly new technologies lead to skill obsolescence, the increase in efficiency and wealth generation they bring about leads to increased demand for goods and services (often quite different from the ones that it has displaced). This is the root of the problem: employment gains may be medium-long term, whereas losses are almost immediate, and learning new skills is not always easy or even feasible. Education and training are extremely important here, and the MIS technologies fortunately facilitate and enhance education and training (in a sense carrying with them some of the medicine for the damage they may cause).

There are and will be new jobs generated by the MIS transformation; they will be in the areas the earlier section on market structure suggested will benefit from the MIS. Clerical workers may be displaced but repairmen and maintenance will benefit. People who can help filter information will be in need. Crucially white collar workers may suffer more than blue collar ones. Repetitive tasks, and mechanisable, computerisable skills will not be in demand. The beneficiaries will be people who have a strong general education and the adaptability to be taught new skills and perform new functions upon demand; also people whose products are not vulnerable to 'reverse engineering', analysis and decomposition into elemental programmable steps (artists and/or strategic thinkers being typical examples). In general, creativity - including blue collar craftsmanship - will benefit.

Finally, the enabling aspects of the MIS should not go unnoticed. They stem largely from the disintermediation afforded by the MIS, allowing creators more direct access to their public, as well as allowing entrepreneurs quicker and cheaper means to access consumers and compete with incumbent goliaths. The MIS will also reduce communication costs for SMEs, possibly rendering true the statement that small is beautiful, if it is interconnected. The MIS will also facilitate the further 'hollowing out' of the enterprise, possibly facilitating industrial relocation and job creation in less favoured regions (a form of very long-distance teleworking). On the other hand, the spectre of further exclusion of those without access to the MIS offerings can not be ignored. It is crucial that steps are taken to guarantee that the potential benefits of the MIS reach also the ones who mostly need it, and not those who need it least, and who are best positioned to use it, explore it and exploit it.

A workshop planned in late 1995, and taking place in early 1996 largely confirmed the analysis of the MIS report.

8

Industrial Technologies and Materials

Relevant industrial technologies and materials have been selected for study on the basis of their industrial importance (critical, generic) and with particular emphasis on their socio-economic implication. Targeted issues include nanotechnologies, microsystems, diverse advanced materials (advanced composites, intelligent-smart, biomaterials), advanced techniques for the process industries (artificial intelligence and computer-based modelling, simulation and virtual reality) and environmental biotechnology. In addition, specific topics have been explored and are being implemented as pilot projects with interest for future extrapolation. The latter comprise a project dealing with integrated technologies for agri-products valorisation and another one about advanced additives to transform the solar spectrum through protective materials such as agri-foils.

So far, these activities are implemented as follows:

8-1 Nanotechnology

Nanotechnology is considered to be one of the most dominant technologies in the 21st century, producing a technological revolution that might be much larger than that of microelectronics. It is concerned with controlling, atom by atom, the structure of matter in order to produce materials and systems with dimensions ranging from the size of the atom up to some tens of nanometers. The applications of nanotechnology have an extraordinary coverage, breadth of going from material science and computers to biomedical engineering and they will eventually touch virtually every industrial activity. At present, although the path and rate of developments are difficult to predict, most scientists agree with the feasibility of nanotechnology and its large implication that is likely to pose one of the greatest challenges of the next century.

In a first approach of this subject, a review of different enabling technologies, application domains and likely implications has been carried out. First results indicate the need for co-ordination in this field. In fact there seem to be many, diverse disciplines involved and a lack of agreement in terminology and research direction. Yet, different techniques are becoming more interdependent and future major developments only appear achievable by synergy and integration of different disciplines . Regarding this issue, a study has been launched, with the collaboration of external experts.

8-2 Advanced materials

The Advanced Materials project has been running since mid-1994. Its aim is to gauge the impact of materials that have enhanced physical properties compared to traditional materials. As demand grows for them (metals and alloys; structural ceramics; advanced composites; engineering polymers; optical, electrical and magnetic materials; and medical materials), however, the assessing of their physical advantages in conjunction with their drawbacks becomes all the more important.

In an informal collaboration with the Institute of Advanced Materials (JRC Ispra) a sound foundation has been developed in this area. From this there is a current study on polymer composite materials, a completed study on the technology and markets of the titanium industry - carried out by an external expert, and initial investigations into nanomaterials, smart materials and biomedical materials. There has also been a contribution in the transport area, on The Car of the Future project, requested from the European Parliament (STOA).

8-2-1 Titanium Study

The use of titanium and its alloys has been mainly limited in the past to aerospace applications. Although lucrative, this has also been influenced by major fluctuations in demand, especially at the end of the cold

war. This has led to high costs, limited development outside of aerospace applications and a lack of interest and confidence from other markets such as the automotive industry.

The future does look more promising. Recent interest in titanium for bio-medical, sporting, industrial and, to a limited extent, automotive applications does allow for some optimism. It is thought that, for secured growth, there must be considerable investment in both marketing and development by the industry. There appears to be a need for a complete rethink towards a long-term strategy to ensure competitiveness in a tough materials market.

8-2-2 Polymer Composites Study

Polymer composites have the largest share of the advanced composites market. It appears at present that the industry is in a period of consolidation. Although development is continuing, there has been no major new material or manufacturing process found recently.

Growth is predicted up to the end of the century. There only appears to be a need for better production methods, to decrease cost and improve reliability, and increased marketing to find new applications. However, they are used in many sectors such as aerospace, transport, leisure and construction.

8-3 Various pilot projects

8-3-1 Additives for solar spectrum transformation

These additives, mainly based on a combination of Rare Earth elements, aim to counteract the negative (or inhibitory) effects of some parts of the solar radiation spectrum. They have a broad range of potential applications for solar protection materials such as polyethylene green-house films, bottles, windows, etc.

In the case of green-house films, the new material can be either added to the polymer base (before extrusion) or to the liquid monomer (to be polymerised and extruded) without significant additional costs. The specific additives transform the original spectrum of sunlight to one that favours plant growth so providing an earlier harvest or a higher yield.

So far, this latter application is being explored and its implementation assessed for the European regions where agri-foils are extensively used and where greater impact is expected. The study could set a case of successful technology transfer without side effects taking place.

8-3-2 Environmental biotechnology. Application of bioremediation to subsurface environments

The market for soil and water decontamination has grown rapidly over recent years. In Europe alone, it is estimated that more than one million sites will have to be treated in order to comply with tighter regulations. On the other hand, the use of biological methods, as complementary or alternative remediation measures, is becoming strongly competitive. Bioremediation appears more cost-effective, more suitable for degradation of recalcitrant compounds and in general it is claimed to provide better disposal or destruction of contaminants.

IPTS activities in this area intend to address the main issues involved in the development of this technology, identifying driving and limiting factors from both technical and regulatory viewpoints and assessing the relative position of the European industry. Up to now, the activity has consisted in gaining an insight into this subject and exploring specific topics of interest to be channelled firstly through the IPTS technology watch activity.

8-3-3 Biotechnology and advanced process technology for an integrated valorisation of agri-products and their wastes. Application to the exploitation of olive-oil by-products

During the last years, considerable efforts have been devoted to the search for alternative non-food exploitation of agri-products. The IPTS is involved in a project developing an ideal application in the area of olive-oil by-products exploitation. The objective is to construct a pilot plant to demonstrate the application of advanced technologies for the extraction of high value compounds from the olive by-products. The value of the project is that it responds to a general problem of the food industry, which simultaneously wastes valuable products and threatens the environment with its by-products.

This project will be fully developed from 1996 onwards.

9

Biotechnology

9-1 Pharmaceuticals and Medical Biotechnology

The health-care industry belongs to Europe's best-performing high-technology sectors. The fact that the pharmaceutical market does not only provide jobs in the drug industry but also generates many jobs upstream (chemicals, medical plants, packaging, biochemical and computer technology) makes it an important sector in the triangle technology- competitiveness-employment.

Consequently, one of the IPTS projects - R&D of European Pharmaceutical industry: assessment of the socio-economic impact of new drugs - deals directly with innovation, industrial competitiveness and socio-economic aspects in the important R&D sector of biotechnology application in diagnostics and therapy. The project examines the European R&D situation and the potentials for development of new pharmaceutics, and their impact on health care systems.

A medical biotechnology application not involving drug development is human genetics, one of the most rapidly moving medical technologies and at the same time one of the most controversial ones. European policies are concerned with the new ethical and socio-economic dimensions of DNA technologies. The IPTS Technology Watch Activity on "Human Genome Analysis, Genetic Screening and Gene Therapy" is focused on the commercial potential in order to provide basic information for the development of appropriate policies.

While DNA technologies have dominated the US, the emerging European therapeutic R&D companies have specialised more on small molecule synthesis. This strength might decrease the European dependency on natural products which up to now have been the main source of molecular diversity for new drugs. Consequently, Europe should define its own position in the discussion of the terms of access to genetic resources, currently negotiated in the framework of the implementation of the United Nations Biodiversity Convention. The project on "Concepts for the Use of Exotic Biological Resources" deals with this aspect.

9-2 A Prospective Analysis of European Pharmaceuticals: Research, development and innovation; Assessment of the socio-economic impact of new drugs

IPTS, in co-operation with the STOA (European Parliament) and with the support of 17 external high-level experts coming from 5 EU countries, is undertaking a project on the future of the European pharmaceutical sector. This study, to be finalised by October 1996, will report on the prospects of the competitiveness of the European Pharmaceutical industry in the light of intensifying international competition and will analyse the factors that will be affecting it. In addition, the study will identify the key competitive elements of each player in a dynamic structure and focus on the most relevant of them for the European pharmaceutical industry. The study will provide policy options that will aid policy makers and industrialists to devise a tool kit for the more competitive placement of the European pharmaceutical industry. More precisely, the following issues are being examined:

1- A prospective description of the potential for innovation in the European pharmaceutical sector (therapeutic substances, vaccines, diagnostics); Current status & future trends of European pharmaceutical R&D in the private & public sector; expectations for new medical therapies. The aims of this project will be: firstly, to appraise the limitations imposed on the selection of effective therapeutic interventions by the lack of or

imperfections in available diagnostic materials and techniques, and to suggest the most useful applications emerging from new technology. Secondly, to assess current approaches to drug and vaccine development, especially, for example, in biological and other synthetic technology, in order to identify the potentially most productive directions. Thirdly, to evaluate the implications of the above review for priorities in pharmaceutical research and development in Europe.

2- The future challenges for the European Pharmaceutical Industry in the global competition context. The research exercise will identify and quantify the essential factors that will allow effective comparisons between companies from the EU, the USA and Japan. Such indicators will include, for example: the output of innovative substances (NCEs) and the number of patents pending the number of truly new products launched; the age structure of product lines of selected drug manufacturers in each region and their R&D pipeline; the profitability of leading companies in each region; their level of vertical integration or horizontal diversification through strategic alliances; the degree of government regulation to which industries are subjected etc. regulatory environment on innovation; Competitiveness and employment aspects will also be examined.

3- The role of public authorities regarding innovation: recommendations. In this part the following two issues are analysed in depth: Interaction between academic institutions, industry and public authorities & comparison of the effectiveness of National and EU programmes of support with the situation in the US, Japan and other areas (analysis based e.g. in terms of the output in new chemical entities, patents etc.) and tools for encouraging R&D for socially useful new drugs (e.g. vaccines, orphan drugs).

4- The potential role for European SMEs in pharmaceutical innovation: (e.g. orphan drugs, biotechnology applications etc.). A case study of Spain will be presented, where a number of medium-size local companies have managed to stay as sales leaders of the industry in the local market and have made interesting progress in R&D exports and employment. The key question is to know -in the light of the new developments - the competitive advantages they had in the past and if it may survive and grow in the future or, on the contrary, if it will decline and leave these companies in stagnation.

5- Analysis of the socio-economic impact of 'new drugs'. The following aspects are analysed in detail: a) prospective analysis of the impact of innovation on public health expenditures in the context of European health care systems; b) new drugs & "ethical dilemmas"; c) impact of public acceptance on European and national policies on innovation.

9-3 Concepts for the Use of Exotic Biological Resources: New Resources for Pharmaceutical Industry in Europe and Sustainable Development in the Third World

Until now, extracts from living organisms have provided the principle source for the development of new drugs. 79% of all U.S. drugs have a natural product origin. More than 50% of all U.S. prescriptions contain natural products and it becomes 70% for the anti-cancer drugs. Natural products or derivatives are currently the basis for most antimicrobials, immunosuppressives, cholesterol lowering drugs, and many anti-cancer drugs.
Even though, only a small fraction of the vast global diversity of species (estimates between 60 million and 100 million) has yet been tested for containing potential

pharmaceuticals. Developing countries are the main repository for biodiversity whereas the main marketers are in Europe and America. The United Nations Convention on Biological Diversity introduces ownership in biological resources but is also meant to encourage global access to biodiversity and fair and equitable exploitation of the resources.

With new effective and cheap screening technologies the basic limiting factor for finding new drugs is the supply of chemical diversity. From 10.000 up to 1 million assays per year can be achieved by a medium-size biotechnological or pharmaceutical company. Through extremely efficient new screening techniques primary assays now amount to only US$ 0.10-1.00 per sample and therefore are the cheapest part of the whole drug discovery process.

However, only 0.01%-0.05% of extracts contain a new drug candidate, in the case of anti-cancer agents only one in 40,000 - 50,000 (0.0025 - 0.0020%, Cragg et al. 1995).

Natural products vs. synthetics

The relevance of natural products in drug development will depend on the efficiency and costs of access to chemically diverse extracts from living organisms, compared to new synthetic approaches like combinatorial chemistry. The particular strength of European industry in small molecules synthesis might diminish the need for natural products sooner than in the US industry. Recently, the supply of synthetic chemicals for screening has grown rapidly. This growth has come through the commercialisation of large chemical libraries and through the development of combinatorial synthesis techniques. Chemical diversity may no longer be in short supply. Changes in the supply of molecular diversity have always led to shifts in the pharmaceutical industry's interest in natural products.

However, it appears that, at least for the next few years, natural products will keep their importance because true innovative products are only expected to come from nature. The particular quality of natural products lies in their: uniqueness; unlimited structural diversity; patentibility (due to distinct chemical identity); and the complex mixtures of compounds.

While synthetics have an economic advantage because natural products:

- require higher efforts to collect and describe the samples. The costs of acquisition amount to $20-30 per gram, without any duties to source countries for commercialisation. A commercial company which also is concerned with sustainable development in source countries will have to charge more than US$150 per probe (BIOTICS, NCI charges $25 for 25 µg). These costs would increase if developing countries get tougher on the financial compensation for accessing natural resources.
- provide a more complex mixture and structure of natural compounds which makes it more difficult to identify and isolate a new lead, increasing the costs for pre-clinical testing.

Some of the disadvantages of natural products might be overcome through technical development (new structure determination, separation and assay techniques), focused search (traditional medicine) or improved infrastructure (databases of known compounds) but, in the long run, synthetics might increasingly drive biological extracts out of the drug development programmes.

An overall economical assessment of drug development based on natural products versus synthetic compounds must go beyond these technical aspects and include: incremental costs, return on investment, and opportunity costs.

Forecasting of such developments would provide important background for decision-makers in the European pharmaceutical and biotechnology industry

and the European negotiators involved in the implementation of the United Nations Biodiversity Convention. The IPTS will continue this study with an increasing focus on legal, political and economic aspects and technical developments in small molecule synthesis and combinatorial chemistry.

9-4 Human Genome Analysis, Genetic Screening and Gene Therapy: New Biomedical Services in the Light of Modern Techniques, Growing Insights and Ethical / Social Limits

Modern genetics, more than any other new technology, has an enormous potential to change human life within the next few years. Some scientists believe that by the end of the decade all the genes contributing to diseases are expected to be known, including the predisposition to complex diseases like high blood pressure and cancer, which are affecting more and more people in an ageing European population. These new insights open up vast avenues for commercial exploitation as existing clinical services in the public health care but will also lead to ethical, social and legal reservations in respect to their application.

The facts provided by this study should make it possible to estimate the dimension of the genetic health care market under different policy conditions. The IPTS Technology Watch activity in this sector intends to:
1- calculate the potential market and the employment potential;
2- assess the extent of genetic screening in the future, as a basic information on decisions in ethical and social questions related to genetic testing and screening and gene therapy.

In order to quantify the potential market the study examines:
1- the progress in genetic research, in particular on the detection and characterisation of disease genes;
2- the ethical and social limits for the application of genetic testing and screening, resulting from the different national and international bodies dealing with the subject.

At the present stage the study has produced mainly technical information on the basic principles and data in human genetics, on the state of the art in human genome analysis, on the recent developments for technical improvement of genetic testing, on the market for genetic screening, on the ethical and social aspects of genetic testing and screening and on the gene therapy.

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• RIBEIRO, J. F. - Carbon Dioxide Storage and Disposal Technologies. A Prospective Study towards the Year 2020 and Beyond. Power Technology International, Spring, 1995 - ART 42911

• ROJO, T. - What Projects for the Mediterranean? Alliage No. 2, Supplement, (1995) 19-20 - ART 42654

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• ALLGEIER, H.J.(Ed.) - The IPTS Report. Newsletter - SP/S.95.57

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European Commission

EUR 16405 - Institute for Prospective Technological Studies - Annual Report 1995

Editor: C. De La Torre, M. González

Luxembourg: Office for Official Publications of the European Communities

1996 - 56 pp. - 21.0 x 29.7 cm

Scientific and technical research series

ISBN 92-827-7305-1

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Energy, Environment, Information Technologies, Industrial Technologies and Materials and Life-sciences have been the main areas of work for the IPTS during this year.

Even though the IPTS' work is structured around: the development of a Technology Watch function; Technology-Employment-Competitiveness research; and work on request, in 1995 the Institute has also entered, for the first time, into the competitive of research contracts.

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