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THE IPTS REPORT

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9

NOVEMBER

1996

- **Developments in Wind Energy**
- **Integrated Gasification Combined Cycle: Environmentally Friendly Coal Power Plants for Tomorrow's Energy Supply**
- **What a Waste... of Water and Market Opportunities**
- **Technology and Employment: Against Pessimism**
- **Benchmarking of Best Practices: A Perspective for Policy**

EUROPEAN COMMISSION

he IPTS Report, launched in December 1995 on the request and under the auspices of the Commissioner for Science, Research and Development, Edith Cresson, has now completed its pilot phase What seemed like a daunting challenge in late 1995, appears now in retrospect as a crucial galvaniser of the IPTS energies and skills

The Report has published articles in a number of areas, keeping a rough balance among them and exploiting interdisciplinarity as much as possible Articles are deemed 'prospectively relevant' if they explore issues which are either not yet on the policymaker's agenda (but due to be there sooner or later), or aspects of issues which although on the agenda their importance has not been fully appreciated.

The thorough drafting and redrafting process, based on continuous interactive consultation with our collaborating network of institutes, which will progressively become even more involved in the process, guarantees quality control

The first, and possibly most significant, indicator of success is that the Report is being read Issue 00 (December 1995) - of which 2000 copies were printed in what seemed to be an optimistic projection at the time - has become a collector's item Since then circulation has risen to 6000 Requests for subscriptions have come not only from all over Europe but also from the US, Japan, Australia, Latin America, N Africa, etc

The positive comments our efforts have received have been highly gratifying and the constructive and engaging criticism of our readership has formed part of the ongoing process of improvement The comments we have received range from the informal, formal communications (in paper or electronic form), and take in as well as a Reader Survey commissioned by IPTS

Readers' direct engagement with the content of the report's articles has led us to include a Letters-to-the-Editor section, which started in the June issue

The rising esteem in which the publication is held is also making it increasingly attractive for authors from outside the Commission We have already published contributions by authors from such renowned institutions such as the TNO in Holland, the VDI in Germany, the ENEA in Italy, the Council of Strategic and International Studies in the US, etc

The Report is produced simultaneously in four languages (English, French, German and Spanish), by IPTS, to these one could add the Italian translation volunteered by ENEA (yet another sign of the Report's increasing visibility). The fact that it is not only available in several languages, but also largely prepared and produced on the Internet's World Wide Web, makes it quite an uncommon undertaking

We will continue to strive to meet the expectations of our very diverse readership, to avoid the traps of oversimplification, encyclopaedic reviews or the inaccessibility of academic journals The key is to remind both ourselves and our readers, that we cannot be all things to all people, that it is important to carve out our niche and keep on exploring and exploiting it, hoping to illuminate topics under a new, revealing light, for the benefit of the readers, to prepare them to manage the challenges ahead

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Research has always been centred on technical performance. Today, European society demands responses to a world that is ever more complex. In the future, the building blocks of the answers to the problems of growth, employment, economic globalisation, health, environment and mobility, among others, will be drawn from Science and Technology.

It is in this context that the Commission has drafted the document entitled 'Inventing Tomorrow: European Research at the Service of Citizens', the aim of which is to kick off the process which will lead to the definition of community research for the beginning of the 21st century and defining the terms of its tool, the 5th Framework Programme.

Thus, the first steps toward the 5th Framework Programme set out to reach a new balance, consolidating past results. Three main issues, which are complemented by three parallel activities, have been identified in order to put research at the service of the public:
- Uncovering natural potential and the resources of ecosystems.
- Developing an accessible information society.
- Promoting competitive and lasting growth.

The principle of added value, which guides European Community action, must also be present in the definition of the objectives of the forth-coming Framework Programme. Only activities that benefit from a common European approach should be undertaken at European level. Furthermore, European research should aim, more than ever, for a better ratio of cost to efficiency.
The objectives of the forthcoming Framework Programme, which have been defined by the Treaty and are intended to support the community's political objectives, must achieve the following:
- Respond to the aspirations of Europe's citizens and ensure a better quality of life, work and environment.
- Be based on the non-material investment of the Research and Development sector to ensure a positive impact on the employment and competitiveness equation.
- Further develop our understanding of a number of key questions.
- Create a favourable climate for Research and Development in Europe.

In order to achieve this a political will that is both strong and consensus-based is required. The Commission is open to the results of debate and to the reactions to these initial steps and a working paper presenting the detailed proposals will be published before the end of the year.

Edith Cresson

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Energy from the wind (aeolic energy), and the highly promising developments that have been made in the field, is the subject of the first article of this issue. Aeolic energy has given rise to a fast growing EU industry which has overtaken its US counterpart in terms of installed capacity, and is a renewable energy source which enjoys minimal environmental impacts (and it is technically possible to reduce these even further), and is quickly reducing its cost disadvantage vis-à-vis fossil fuels. Environmental pressures and declining costs may open large and as yet untapped potential export markets in fast developing countries. Including externalities (ie. the costs incurred by society as a whole, and which do not figure on the producer's balance sheet) could decrease the cost gap between fossil fuels and wind energy even further.

The Second article also looks at energy, more specifically at the integrated gasification combined cycle (IGCC) approach to the use of coal for electricity generation. Even though IGCC can not miraculously turn coal into a completely environmentally friendly energy source, it can at least reduce its environmental impact. Given the vastness of the earth's coal reserves, the inherent limitations of renewable sources and the likelihood that coal will be the first choice of rapidly developing economies to meet their fast growing needs, coal is likely to be with us for a long time to come. Thus, less damaging ways to use coal may not only ameliorate environmental impacts but also provide market opportunities for those developing and perfecting them.

The third article's starting point is also an issue of environmental concern; water and its, often wasteful, use. The article lists some of the simple low-tech solutions available to help limit waste, it also highlights the potential economic benefits of such measures in terms of both a reduction in the need for costly hydrological engineering projects (and the proportionally greater demand for waste-water disposal resulting from increasing supply) and the benefits to be derived from the commercial exploitation of water use reduction technologies. However, in order to exploit the market potential of these relatively simple low-tech solutions, consumers need education and accurate information and the unmasking and correction of certain factors that distort incentives in the supply and consumption of water needs to be addressed.

The fourth article takes a step back from the interaction of specific technologies and the market, and examines instead, or rather attempts to refute, certain pessimistic views of the interplay between technology and employment. It draws on both theoretical as well as empirical arsenals, underscoring the need to go beyond mere intrasectoral emphasis when analysing the impact of technology on employment.

Finally, the last article examines the growing use of benchmarking, one of the approaches adopted by firms trying to compete successfully in a rapidly changing technological and economic environment. Benchmarking exercises, and the resulting comparative studies of best performance practices by leading firms, have proven to be an invaluable tool for firms trying to learn what works (and possibly adapt it to their needs), and have gained increasing acceptance among policy-makers and their advisors, looking for frameworks which are conducive to successful adoption of best practices by domestic firms (especially smaller ones who may not be likely to undertake such studies/efforts on their own).

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Developments in Wind Energy

Miguel A. Aguado-Monsonet & Chris A. Hendriks

Issue: Wind energy is the fastest growing renewable energy industry in the EU and what is more, thanks to the efforts of several Member States, Europe has recently overtaken the USA in the amount of wind energy capacity installed.

Relevance: Within 10 years wind energy may well be able to compete economically with conventional electricity production technologies. World-wide large potential resources for wind energy exist, offering Europe a large potential export market, especially in countries in Central and South America, and to India and China. Therefore Europe will need a clear strategy for implementing wind energy at regional, national, and international level.

Wind is proving itself to be a cost-effective and reliable energy resource at installations located mainly in Europe, the United States and India. Technological advances over the last five years have placed wind energy technologies in a position to compete, in the near future, with conventional power generation technologies. The generation cost of wind electricity in Europe has decreased during the last 15 years by about 80%, from 0.5 ECU to less than 0.1 ECU per kWh. In some cases costs of 0.06 ECU per kWh are reported. At the same time the installed capacity has increased dramatically from less than 100 MW to 2,000 MW last year. By comparison, the current production cost from fossil fuel and nuclear plants in Europe varies from 0.04 to 0.08 ECU per kWh. In 1995, wind turbines generated 7 TWh of electricity, which is approximately 0.06% of the total electricity production world-wide.

These substantial cost reductions have been achieved through the development of cheaper, more reliable and efficient wind turbines, in combination with the production of larger turbines and an expansion of the market. During the last ten years **the price of wind turbines has decreased** by 5% each year, while at the same time **the yield has increased** by 30%. Ten percent of the wind turbines produced in 1993 had a specific yield (kWh generated per year per square meter of rotor area) of more than 1000 kWh.m-2.yr-1 which is more than twice the amount achieved by an early 55 kW model. Nevertheless, there seems still to be substantial room for improvement. R&D on wind turbines addresses a large part of its effort to basic aerodynamic, aerolastic and aero-acoustic research and at developing flexible blades, flexible mast and suspension, and the application of lighter materials. An important innovation is the implementation of variable speed systems and direct drive generators that decrease the number of components in the machine, eliminate the gear box (traditionally a vulnerable part of the turbine) and increase the output of the turbine. By application of these and other developments it is expected that, in the next ten years, the cost of the energy produced by wind turbines will reach the lower cost range obtained by conventional power plants.

Another trend is the **increase in machine capacity,** which amounts to a factor of 10 in the last ten years. As an illustration, the 500 MW installed wind energy capacity in Denmark represents 4,000 wind turbines, a figure that can

The cost of wind energy has decreased by 80% over the last 15 years, and capacity has risen dramatically

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now be achieved by just 800 turbines. Nevertheless, the optimum unit size depend on the type of application (e.g. offshore, coastal area, inland).

During the last few years the **European wind market**, which clearly dominates the global wind market, has risen by 250 MW in 1992, 330 MW in 1993, and 440 MW in 1994. In the same period growth stagnated in the United States. Thus, Europe has recently exceeded the total installed capacity in the USA. Stagnation in the US market can be attributed both to the pending restructuring of the electric utility industry and uncertain government backing, which has made utilities unwilling to plan any new capacity additions. The uncertainty in the long-term energy market is a handicap, especially for renewables, which typically require long-term contracts. The European development has been achieved thanks to the economic instruments that provide incentives for wind energy production, together with the social acceptance and environmental awareness. In Figure 1 the development of the capacity growth installed in Asia, Europe and the USA is depicted.

Uncertainty has led to the market in the US to stagnate, whilst incentives in Europe have brought about rapid growth. European capacity now exceeds that on the other side of the Atlantic

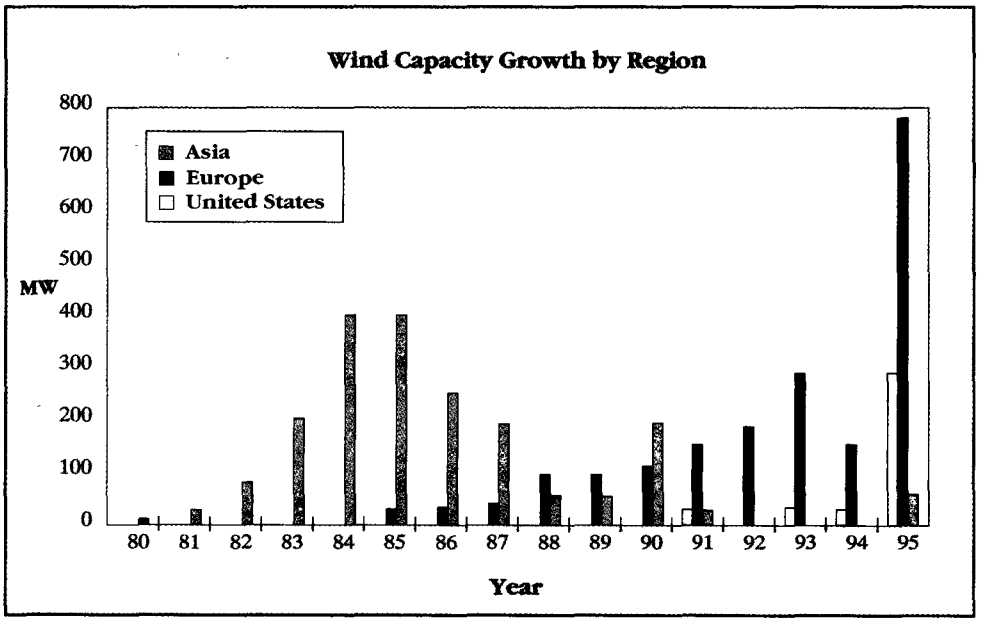
Although the energy supply conditions in the European countries differ substantially (for instance, Spain and Italy have small fossil fuel resources and the Netherlands and the UK have large fossil fuel resources), wind energy has been introduced in almost all European countries. During the last years, the wind market is growing rapidly, a process which began in Denmark and the Netherlands, and more recently has spread to Spain and the UK. The largest growth has been in Germany. Outside Europe, the wind market in India has grown more than 200%, from 180 MW installed in 1994 to 565 MW installed by the end of 1995. It is expected that in the near future substantial numbers of wind turbines will be installed in China. The American Wind Energy Association (AWEA) expects the global market to grow from the 5,000 MW installed now to 18,500 MW in 2005, with India and China accounting for about 30% of the total newly installed capacity. According to the European Wind Energy Association (EWEA), 10% of the European Union's electricity could realistically be generated by wind power by the year 2030. To reach this figure, 200,000 wind turbines of 500 kW each should be installed equivalent to 170 power plants. In the next 35 years this represents a total market of 70 to 100 billion ECU.

The world market is expected to grow from 5,000 MW to 18,500 MW over the coming decade, with India and China being the largest new markets

Economic instruments regulating the wind market

For fifteen years the development of the wind energy industry in Europe has been supported by national governments. Mainly economic instruments are used to support the penetration of wind

Figure 1: Wind Capacity Growth in Asia, Europe and the United States



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technology into the energy market. In Germany, Denmark and the Netherlands, subsidies from the government to install wind turbines were given, while at the same time research and development on wind technology was supported. Later on these investment incentives have been replaced by a combination of fiscal measures and the application of increased buy-back tariffs. For example, the implementation of an assured buy-back tariff of 0.09 ECU per kWh has put Germany in a leading market position. Fiscal instruments such as 'Green investment' and flexible depreciation possibilities for environmental investment have stimulated the implementation of wind turbines. 'Green investment' makes it possible to invest money under reasonable interest conditions. In the Netherlands, however, the application of this instrument has led to the situation that it is more difficult to find 'green projects' than to obtain the money for financing. Another instrument is initiated by the utilities, which give the consumer the possibility of supporting wind energy by buying 'green electricity' at higher prices. In this way the utilities oblige themselves to invest in renewables. The application of these instruments has created a very competitive wind turbine manufacturing industry.

Barriers to implementation

Wind energy faces a number of actual and potential problems which may hinder rapid penetration into the world energy market. The most important issues are the economics, integration into the grid, and the environmental issues: visual impact, production of acoustic noise, and impact on birds.

Wind energy can only penetrate the electric market if it is produced at competitive costs. The production costs of wind energy are still higher than the production costs of fossil fuelled power plants. Lowering these costs is therefore essential for its competitiveness. However, if the calculation of the price of electricity is based on the full costs of electricity, i.e. production costs accruing to the producing firm plus externality costs accruing to society as a whole, the competitiveness of wind energy would be improved.

The most important environmental issue is the **visual impact** on the landscape. Although a vast majority of the public supports the idea of using wind energy, many people are worried about its impact on the landscape. For this reason, construction of wind parks should be carefully included in the spatial planning at local, regional and national level. Currently the best practice is to avoid installing wind turbines in landscapes of high ecological value and to construct wind farms in close co-operation with the local community and with regard to existing land use; agricultural, commercial and recreational. Furthermore, the emergence of offshore wind power plants may reduce the visual impact. In fact, the estimated resource of offshore wind in Europe is reflected in Figure 2. Despite these benefits, offshore farms are currently not built because their cost is two to three times as much as onshore ones. However, for a (semi-)offshore wind farm in Denmark with a total capacity of almost 20 MW, which is operational since November 1995, a kWh production cost of 0.07 ECU has been calculated. Other pilot projects are undertaken in the Netherlands and Sweden.

As well as government financial backing, giving consumers the option to pay more for 'green electricity' is a way of providing incentives for developing and installing wind generation technology

Acoustic noise of wind turbines may create problems in rural areas which were previously noted for their quietness, and when the turbines are located close to houses. Noise is produced by blades and by the nacelle. The sound power level, a standardised measure, for a typical machine varies from 98 to 101 dB(A). The acceptable noise level set by local authorities in Europe and USA at the facade of a dwelling ranges from 35 to 65 dB(A). To limit the noise to 45 dB(A) in the neighbourhood, a distance of about 250 meters from the nearest house is necessary. The wind industry states that there is still room for improvement, and it believes that within 3 years a noise level of 96 dB(A) can be obtained. Improvement is to be expected from lowering the rotational speed, e.g. by introducing the variable speed concept, which reduces the speed of the blades at periods of low wind supply.

Despite their higher cost, offshore wind farms may be the solution to problems of visual impact

Impact on birds might be another problem. However, the number of casualties per kilometre of wind park is much less than the number of

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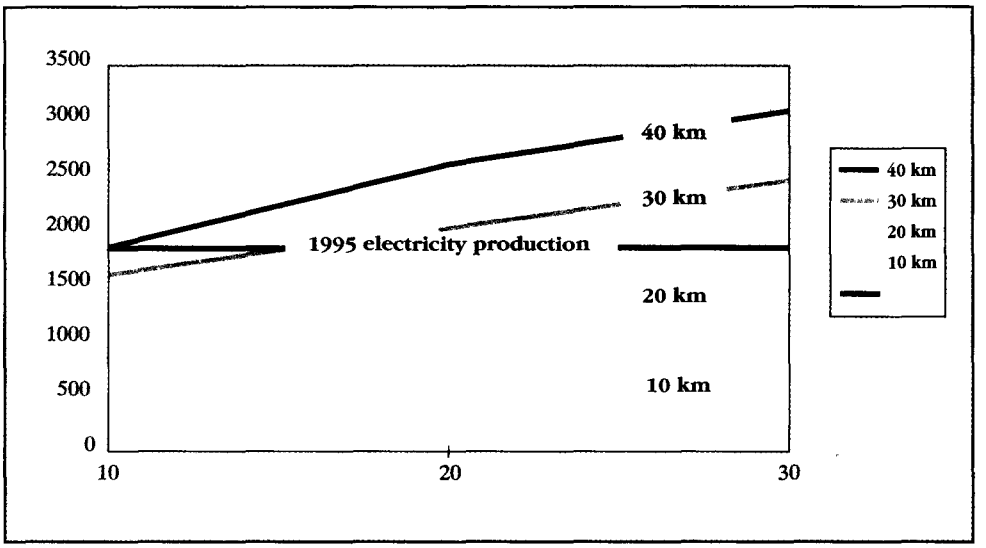
Figure 2: Technical offshore wind energy potential in the EU-12 as a function of the maximum water depth (in metres) and the maximum distance to land (in kilometres). Cost restriction are not taken into account. As a referenmcle the total electricity production of the EU-12 in 1995 is given.



New designs of turbine with slower rotational speeds are reducing the acoustic impact of wind generation on quiet rural areas

casualties per kilometre of highway. For that reason, the Royal Society for the Protection of Birds (UK) and the Dutch group 'Vogelbescherming Nederland', an affiliate of Birdlife International, do not consider wind farms a hazard to birds. Nevertheless, locations that interfere with migration routes should be avoided.

One problem is that wind farms are often located in isolated areas with poor grid capacity, making it difficult to deliver the electricity generated to the customer

The problems concerning **integration into the grid** may have to do with the local circumstances, the quality of the electricity (mainly in terms of the stability of the voltage and frequency) and the planning of the supply. Wind farms need to be connected to the local grid. A large development of wind energy supply in a given area may exceed the capacity of the local distribution lines. The question then arises, **who should pay for local reinforcement of the grid, and who would benefit from the various potential energy supply schemes?** This is a problem for large wind parks which require high voltage lines and transformers. Some interesting wind sites are located in isolated areas and with poor electrical infrastructures.

Utilities are wary of wind power because supply is intermittent and cannot easily be tuned to meet demand

The main reason why utilities hesitate to introduce large scale wind energy systems is the **intermittent nature of the source,** which may reduce the security of supply, and therefore decrease the economic value of wind. Utility studies have shown that wind energy does represent a certain capacity credit, though a factor 2 to 3 lower than the value for nuclear and fossil fuel fired plants. The capacity credit improves substantially when wind energy is combined with other types of renewable electric generators, or by application of energy storage systems.

Calculations show that the load/resource compatibility factor will not be reduced significantly by participation of up to 10% of wind energy in an open European electricity market, a percentage that, according to the EWEA, could be reached in the year 2030.

The future of wind energy

Wind energy may well become a large and important industry in Europe. In the short-term wind energy technology may also be an significant export product, once the right framework is created. The turn over of the German industry only has been 600 MECU in 1995. Due to several reasons, especially political ones, the German market for 1996 is expected to decrease by 10 to 20%. The main reason are the uncertainties concerning reimbursement of energy and the still ongoing debate on building and construction law. Analysis of the wind

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market in Europe shows that it is not an 'open' market. From the 1,200 MW installed in Europe up to the beginning of 1994, 75% of the wind turbines were installed in the same country as they were manufactured. Only Denmark succeeded in penetrating in the international market substantially, and its market volume is estimated at 425 million ECU in 1995 representing the country's top ten exporters. This analysis shows that there is a high correlation between a strong home-market and a strong manufacturing industry. In addition to Denmark, in the last two years Germany has strengthened its home-market by applying high buy-back tariffs, and at the same time stimulated its industry to export.

Whereas the supporters of conventional energy supply see the role of renewables vanishing in an open electricity market, because it will be priced out of the market, the supporters of renewables welcome fair competition on the basis of full costs. Open competition will provide electricity customers with the ability to choose from an expanded number of electricity suppliers offering alternative services including renewables. That this is not a chimera is shown by an experiment by the Dutch energy company PNEM and the Swedish company Vattenfall, which offer their customers the chance to buy 'green electricity'. The energy company found that, despite the higher price, the demand was far larger than the amount it could offer. Along the same lines, the AWEA proposes a "Renewable Portfolio" standard that relies on the free market to ensure that renewables are developed in the most economical way, rather than to rely on tax and subsidy schemes, and bureaucratic implementation. As a condition of doing business, every power supplier would be required to purchase a (tradable) percentage of its energy needs from renewable resources.

In the last five years, the USA has experienced a strong decline in the wind turbine market, because of pending restructuring of the electricity market and major change in the political climate. The resulting uncertainties slowed down the growth of the wind market to virtually zero. If Europe wants to keep its leading position in the wind market and profit from the huge potential markets in China, India, and Central and South America, it will need a clear and long-term policy. This would include development of location guidelines on regional, national and international level; agreement on the 'value' of renewables, considering their environmental benefits; and regulations to integrate wind power and other renewables into the grid. The ongoing decentralisation and liberalisation of the electricity market calls for a totally new approach, taking regional and national characteristics into consideration.

Up until now wind generation technology has mainly been directed at domestic markets, however, increasing importance is being given to exports

Experiments show that in Holland many consumers are willing to pay extra for 'green electricity'. The US is also studying the use of market forces to ensure the efficient development of renewable energy resources

Improved forest management could represent one type of active, but moderate, climate change policy

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About the author

Chris Hendriks, holds a PhD in "Carbon Dioxide Removal from Coal-fired Power Plants" from Utrecht University He has worked as an adviser for institutes, utilities, the Dutch government, and the European Commission on energy and environment related topics Within the IPTS his main areas of interest are 'Best Available Techniques' (BATs) in the framework of supporting activities for DGXI's Integrated Pollution Prevention and Control (IPPC) Directive, and an international study on the 'Assessment of Policy Instruments for Efficient Ozone Abatement Strategies in Europe'

Miguel A Aguado-Monsonet holds a doctorate in Chemical Engineering from the University of Barcelona, after working as a professor of Chemical and Environment Engineering he started work at IPTS on projects related with renewable energies. His main research interests are in the fields of Energy, and Chemical, Environment and Food Engineering, and is currently responsible for the "Implementation of Renewable Energy in the Southern Mediterranean Countries" Joule Project

Keywords

Electricity market, exports, renewable energies, wind energy

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Integrated Gasification Combined Cycle: Environmentally Friendly Coal Power Plants for Tomorrow's Energy Supply

Antonio Soria & Peter Russ

Issue: What is at present the largest Integrated Gasification Combined Cycle (IGCC) plant in the world is about to start operation in Puertollano (Spain). This plant is only one out of several IGCC projects under way in the USA, Europe and Japan.

Relevance: In order to contribute to the future electricity supply, power plants have to meet not only economic but also environmental requirements. Compared with their competitors, existing coal-fired power plants have significant disadvantages. New developments in coal technology like IGCC plants offer an opportunity to continue the use of coal for electricity generation in a less environmentally damaging way. The strategic value of these technologies may be particularly relevant in view of possible joint implementation plans with developing countries to achieve greenhouse gas emissions reduction.

Introduction

Traditionally, coal final use was found in virtually all sectors, for household consumption, industry, and, for electric power generation. The progressive electrification of society has restricted its potential within the household sector, but gave a significant weight to coal-fired power plants. However, in recent years increasing environmental concern has put pressure on coal use. Coal has serious disadvantages that a priori tend to penalize its use as a primary energy source: first of all, burning coal is harder than burning oil or natural gas, since the handling and storage of a solid fuel is difficult In addition, its combustion also produces a solid residue that has to be removed and post-treated. Coal combustion often produces chemical compounds such sulphur and nitrogen oxides that cause significant environmental damage via rain acidification. Last, but not least, it is well known that coal is the most carbon intensive fossil fuel: coal firing produces about 100 tCO2/TJ whereas natural gas combustion yields 54 tCO2/TJ.

Despite these disadvantages coal will be used in the future because it is relatively cheap and widely available. Current proven world coal reserves may exceed 1200x109 tec, but if known resources that might be exploitable in the future are considered, the estimate rises to 5000x109 tec ie., five times the present proven oil reserves in terms of energy contents. The proven level of reserves ensures today's level of consumption for more than two centuries.

New developments in coal technology could offer the possibility of continuing coal use for electricity generation in a more environmentally friendly way, overcoming its present drawbacks. One of the major options is the use of Integrated Gasification Combined Cycle (IGCC) power plants. The idea of coal gasification is not new, but the design of a combined plant where a substitute of natural gas is obtained from coal and then burned in a combined cycle scheme to obtain electricity is relatively new. Since the pioneering German power plant of Lünen (1969), IGCC, considered a

Coal was once a common fuel in all sectors, but now has largely been restricted to power generation. However, the problems associated with its handling and its environmental impact make it less attractive than other fuels

Known coal reserves could meet demand for the next two centuries. IGCC technology overcomes some of the disadvantages of coal as a fuel

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After initial successes the IGCC programme was frozen on account of its high costs, until environmental concern revived interest in it

valuable technological solution, is able to produce electricity from coal with high efficiency and low pollutant emissions. The high costs associated with this conversion scheme froze its development until environmental concern and in particular the pressure to reduce greenhouse gas emissions from power plants revived interest in it.

IGCC technology

Coal is gasified and then cleaned prior to combustion. This reduces emissions more cheaply than cleaning up the flue gases and makes poorer quality coal usable

The technology makes use of the thermodynamic/efficiency advantages offered by a combination of two cycles, a gas turbine cycle and a steam turbine cycle (see Figure 1). In order to apply this scheme, which nowadays is widely used in natural gas fired power plants, the coal has to be gasified prior to combustion in the gas turbine. The environmental improvements related to the scheme are based on the fact that the coal gas produced can be purified before combustion. This offers the advantage over the treatment of flue gases that significantly smaller quantities of gas have to be treated and, additionally, the composition of the coal gas is such that it allows easier purification. Moreover, low-quality fuel can be gasified and, after the fuel gas is cleaned up it can be used for electricity generation. The purification process may be extended and could also allow for the removal of exhaust carbon dioxide. Hence, the technology has been proposed as the basis for a low CO_2 emission coal power plant with CO_2 capture.

Althoug both the combination of gas and steam turbines and coal gasification are proven technologies, the integration of the gasifier in a power plant is a technical challenge

Both the combination of gas and steam turbines within the same power plant and coal gasification are proven technologies. The integration of the gasifier in a power plant, however, poses additional requirements. A minimum heating value is necessary for the coal gas to be efficiently burnt in the gas turbine. Adequate gasification processes have to be selected and the integration and optimization of all the processes are crucial for the overall efficiency. Coal gas clean-up is another critical issue.

The status of the technology

Today, we are witnessing IGCC take-off: around 87 IGCC projects are under construction, scheduled or under evaluation, and 10 power

Integrated Coal Gasification Combined Cycle (IGCC) power plants

The figure below shows the flow diagram of a IGCC power plant. The coal (or possibly a fuel mix) is gasified under pressure in the gasifier. The generated fuel gas is purified and fed into the gas turbine, powering the first generator. The hot combustion gases from the gas turbine are used to raise steam in a steam generator. The steam drives the steam turbine, which produces the remaining 30-40% of the total electricity output.

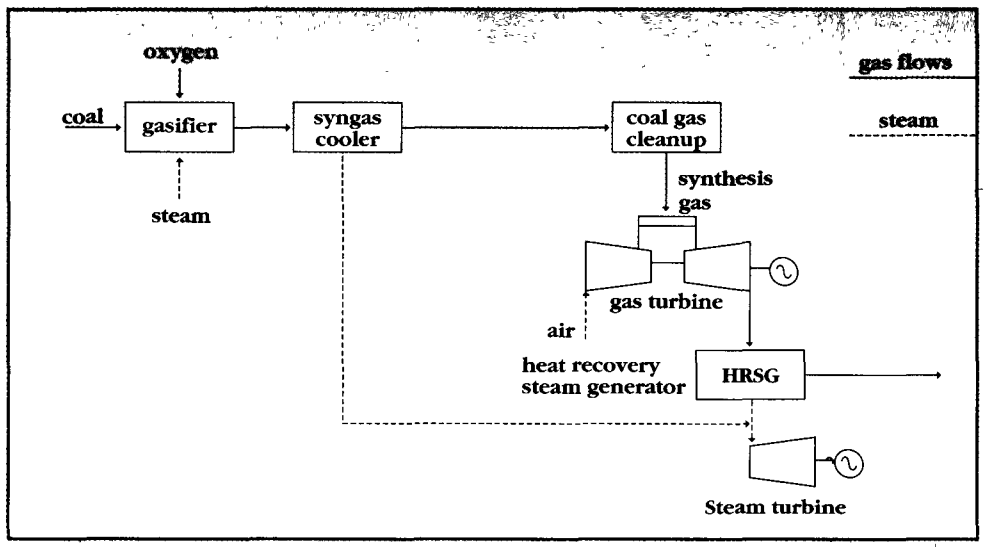

Figure 1: Flow diagram of an IGCC power plant.

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plants, with installed capacities ranging from 60 to 500 MW are expected to be operational between 1996 and 2000 Plant constructed to date has been intended to demonstrate the viability of the technology and to test the use of the gasifier and purification technologies. They do not represent fully optimized and integrated systems. The technology has been demonstrated and is now commercially available. The ELCOGAS plant in Puertollano is a joint venture by many European utilities and manufacturers, and is constructed on a fully commercial scale (330 MW el.). The plant, which will gasify a mixture of coke and local, low quality coal, will operate with a efficiency of approximately 45%. However, it will not include recent technological developments. An optimized scheme applying the latest technology is estimated to be likely to reach almost 50% efficiency, considerably higher than the coal technologies already in use.

Is the time ripe?

Considering the spate of IGCC plants around the world (reported in Pruschek, 1995), the immediate conclusion would be that this technology is experiencing a dramatic surge. Nevertheless, this phenomenon should be considered in the light of two factors. The first basic question is the fate of coal as a basic fuel for power plants. Here, not only the fuel and capital cost play a role, but also aspects belonging to environmental and strategic domains, such as the future need for CO_2 emission limitation, the potential of coal to improve security of supply, the political situation in fossil fuel provider countries, etc. The second issue is related to the role that IGCC may play with respect to other advanced clean coal technologies (CCT), disregarding the inter-fuel competition aspect.

Although the relative position of IGCC with respect to other clean coal technologies (CCT) may be considered promising, it seems that with the current price structure of fossil fuels and technology installation costs, IGCC (and, in general CCT) is condemned to be out of the market except for demonstration purposes.

The present cost of the technology is very high (around 2800 $/kW installed for the ELCOGAS project).

Nevertheless, since the plant is the first of its kind, the investment required for IGCC plants will decrease. It is, however, difficult to forecast the future direction capital costs will take. The increasingly competitive electricity market is increasing the pressure for ever cheaper electricity generation. Hence, unless dramatic improvements in the IGCC capital cost structure take place, significant increases in natural gas prices are a prerequisite for this technology to be fully competitive. It should also be noted that an average price increase in fossil fuels would also cause some of the recent renewable energy (RE) technologies cross the economic viability threshold, with fewer environmental problems; and reduced fuel and operation costs. This does not necessarily mean that IGCC would be placed in direct competition with RE under these circumstances as the space-time availability of RE is likely to still be the main bottleneck in the future. What is more likely therefore, is that a specialization process occur, with coal-fired power plants supplying baseload electricity, leaving the peak-load share to competitive RE (when available).

Conclusion

The necessary conditions for a definitive IGCC breakthrough are related primarily to the performance of competitors inside the clean coal industry, but also to the price of other fossil fuels (in particular natural gas), and also to the effect of RE technologies. The electricity demand path and its associated environmental costs are the underlying mechanisms that may help in the understanding of the overall picture. Under a slow electricity demand increase scenario, without dramatic gas price shocks, the electrical system may evolve progressively using gas, maintaining a significant coal share from the present installed capacity and eventually giving entrance to advanced, competitive RE. If a fast growing electricity demand scenario is considered, such as for instance in the Asian markets, the picture

The Puertollano power station will achieve 45% efficiency and efficiencies of up to 50% are envisaged using state-of-the-art technology

The future of coal as a fuel depends on environmental objectives, in particular greenhouse gas emission reductions, as well as the cost of fuel and plant

Given time the cost of IGCC should drop, but this may still not be sufficient for it to compete against natural gas and renewable sources. However, the fluctuating supply generated by RE mean that there will still be a place for fossil-fuel power-stations, possibly using IGCC technology

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changes completely: New generating capacity has to be installed rapidly, and this is most likely to be coal-based. The environmental constraints press for the adoption of clean coal technologies, and the technology to fulfil these requirements has to be ready. The question about the price of the technology may look different from this perspective: The incremental cost of upgrading standard coal fired power generation plants alone has to be compared with the cost of alternative CO_2 abatement measures to be taken in OECD countries in view of a possible joint implementation scheme. In this respect it should be pointed out that even if the variable and/or capital costs make IGCC expensive for the OECD demand patterns, gaining control over the technology may be worthwhile in view of efforts to lower the CO_2 emissions in developing countries. Indeed, the strategic value of controlling this technologies relies, at least in the short term, in the possibility of achieving cost-efficient greenhouse gas emission reduction in those countries experiencing fast-growing electricity demand via international technological collaboration and implementation agreements.

Keywords
IGCC, coal-fired power stations, greenhouse gases

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What a Waste... of Water and Market Opportunities

Anne Burrill

Issue: Per capita urban water use could be reduced significantly through widespread use in homes and public buildings of water saving fixtures and appliances. Their introduction could also provide a new market for goods and services. Nevertheless, such devices are not common in Europe.

Relevance: Increasing demand for water is one of the driving forces behind the present EU review of its water policies, and the selection of "environment-water" as the theme for a Task Force.

Meeting Urban Water Demand Without Increasing Total Supply

A quarter of all European water consumption is in urban areas: in households, public buildings and commercial establishments. While, particularly in drier countries, irrigation uses a greater total amount of water, meeting urban demand can be particularly expensive. This is due to the stringent quality requirements of urban demand and its high geographical concentration (which often implies high costs of transporting the water from distant sources).

More affluent residential lifestyles coupled with a growth in the water-thirsty tourist industry are leading to increasing water demand in most urban areas. The traditional approach to meeting such increased demand is to augment supply. As the cheapest sources of water are usually tapped first, however, mobilizing new sources involves ever higher costs. Beyond the expense, in a growing number of areas, there are no new economically viable traditional sources (such as water obtained from dams and water transport projects). Alternative sources such as desalination and recycling may make a considerable contribution to water supply in some places; however, these alternative sources are relatively expensive. Furthermore, meeting demand by increasingly supply implies parallel additional costs of collection and treatment of waste water.

Increasing water efficiency by reducing the amount of water required to accomplish a given task, is another means of balancing supply and demand. The water saved is, in fact, a new alternative source of water. There are many simple measures to increase water efficiency in existing buildings, without any reduction in lifestyle or comforts. These measures include 'fixture and appliance retrofitting', i.e. installation of flush controllers for urinals, low-flow taps, point-of-use water heaters in sinks and showers, flow-interrupters in toilets and showers, low-volume toilet tanks, etc. Installation of these devices can be undertaken quickly and incrementally, avoiding the long time periods and bulk capital outlays that are required to expand supply. As Table 1 illustrates, water use in single buildings can be reduced by between 20% and 40% by such technology.

Water-intensive domestic appliances can also be replaced with models which use less water. Some new washing-machines and dishwashers, in

Water consumption is increasing in many urban areas; meeting this demand is particulary expensive

Water efficiency can be increased relatively simply by between 20 and 40% without any negative impact on lifestyle or comfort

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Table 1: Water Savings from Retrofitting

Experience or Pilot Project	Results
Self-closing, spray taps (UK experience)	Consumption reduction of up to 50%.
Low volume shower heads (UK experience)	Consumption reduction of 10%.
Replacement of 350,000 toilets with smaller, 6-litre tank models (Mexico City)	Enough water saved to meet needs of 250,000 residents.
University dorm retrofit (Pennsylvania)	University water consumption reduced by 20%.
Hotel room retrofit (California)	Consumption reduction of 34%.
Medical centre retrofit - patient rooms only (California)	Overall water savings of 11%.
Installation of flow-interrumpers on showers and stop-buttons on toilets in 383 homes (Hamburg)	Consumption reduction of 15.8 - 28%.
Installation of low-flow shower-heads and ultra-low toilets (Tampa, Florida)	Total indoor water savings of 16%. 31% reduction in hot water use.
Retrofit of hotel rooms (Boston)	Consumption reduction of 40%.

Water saving devices normally pay for themselves in reduced bills in a period of 2 to 10 years Energy savings made by reducing hot water usage are even more significant

particular, consume only a fraction of the water required by older models. The "Eco-model" washing machines available in Germany, for instance, use only 49 litres per wash, as compared to an average of about 80 litres per wash for a traditional machine. The most efficient dishwashers use about 15 litres, as compared to about 37 litres for a normal dishwasher.

The Economics of Reducing Urban Demand

The cheapest sources of water are usually tapped first, thus new sources are generally more expensive than the existing ones. Moreover increased supply means increased waste water and additional treatment costs

At the most basic level, we can assess the costs and benefits of demand reduction technology by comparing the cost of its implementation with the consumer cost of the water saved over the lifetime of the new appliance or water-saving system. A World Bank estimate in 1995 put the cost of reducing end-user demand at between 5 and 50 US cents (.04 - .40 ECU) per cubic meter saved. This compares favourably with urban water prices, which generally range between 0.25 and 1.35 ECU per cubic meter in developed countries. Some specific examples derived from pilot projects are shown in Table 2.

In general, the pay-back time to the consumer in terms of reduced water bills, is generally less than two years for aerators on taps, and flow-reduction devices. More expensive measures such as replacing toilets or installing grey-water recycling systems have pay-back times on the order of 10 years.

Since the consumer will certainly also use less energy to heat (and in the case of large buildings, pump or distribute) the reduced volume of water, the energy expenditure savings should also be figured into the calculation of direct costs and benefits to the building owner. In the US, the use of water-efficient shower-heads and taps led to annual savings of between $26 and $170 per household, mostly due to reduced energy costs for

Table 2: Cost of saved water

Place	Technologies used	Cost per m3 saved
China	improved toilets in homes	.02 - .09 US$ (.02 - .07 ECU)
US	low-flow showe-heads and taps in homes	.03 - .10 US$ (.02 - .08 ECU)
US	toilet retrofit in homes	.16 - .20 US$ (.13 - .16 ECU)
Germany	Installation of flow-interrupters on showers and stop-buttons on toilets in 383 homes	.17 - .32 DM (.09 - .17 ECU)

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water heating. Where the cost to the customer of sewerage services is based on volume of water, these savings should also be considered. Although the value of installation of water saving devices is clearly dependent on the pre-existing technology and the local costs of water, energy and labour, the above examples suggest that it can save money for the consumer.

Additional benefits from the installation of such devices can accrue to the water suppliers and sewage companies. As the least expensive water sources are generally mobilized first, the costs — in monetary, social and environmental terms — of developing new water sources to meet increasing demand are almost always greater per volume of water than the historical average. This additional cost is borne either by water companies or by society as a whole (through government subsidy of engineering infrastructure). If the supply-demand gap is met by reducing the volume of water used, these costs can be avoided. The corollary savings resulting from the control of waste water volume may be even greater, as the full costs of increasing capacity to collect and treat waste water are increasing even more rapidly than the costs of supplying more water. Thus, in areas where demand is greater than the existing 'mobilized' supply, the 'production' of new water by reducing demand is normally the least-cost option for the water supply and sewage companies.

The introduction of demand-reduction systems presents additional potential benefits for the society as a whole: an entirely new market for goods and services is created. As many of the regions of Europe which are particularly prone to water deficits are also facing problems of economic stagnation and unemployment, the social benefits of these new possibilities should not be underestimated.

Proponents of supply expansion will sometimes claim that one of its advantages is the creation of jobs in the engineering and construction sectors — jobs which will not exist under a demand-reduction strategy. A Canadian study conducted in 1995, compared the strategies in the two regions of Ontario. It concluded that promotion of demand management ranked higher in terms of all the relevant economic indicators (gross output, value added, labour income, taxes generated and imports).

In the US, water service companies (WASCOs) are realizing profits from fixture and appliance retrofitting while saving money for their customers; one WASCO in Virginia charges a contingency fee based on a fraction of the measured water savings achieved. A grassroots retrofit program in Los Angeles also illustrates the potential for this market to promote sustainable development: funded by a utility rebate program, the organization hires and trains unemployed local people to distribute and install the toilets in low-income households. The households return the old toilets for remodelling, and save $30 to $120 (24 - 95 ECU) on their annual water bills. While WASCOs are not yet widespread, they are expected to take off in the US in the same way that contract energy management services developed in the 1980s following concern about energy supply levels.

A full cost analysis considering the factors mentioned above, clearly indicates a highly favourable benefit-cost ratio associated with introduction of demand management technologies, to both individuals and society as a whole.

Lack of Motivation by Customers and Water Supply Companies

Given that the technologies have been shown to be performant, cost-effective, and a potential source of new jobs and income, such systems should be widespread. However, with the exception of pilot projects in the UK, Germany and certain remote areas, these systems are not commonly used in Europe.

The problem can be partially attributed to **lack of information for consumers**. In many parts of Europe, water customers are unaware of the measures that they might take to reduce water use in their buildings. A German study found that, even when citizens are aware of the existence of water-saving devices, they consistently under-estimate their effectiveness and over-estimate the cost of

A Canadian study conducted comparing the demand management and supply increase strategies in the two regions of Ontario concluded that promotion of demand management ranked higher in terms of all the relevant economic indicators

In the US, water service companies (WASCOs) are realizing profits from fixture and appliance retrofitting while saving money for their customers

Consumers lack accurate information about the costs and benefits of water reduction measures Moreover, they tend to assume that such measures will reduce their level of cleanliness and comfort

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Across Europe society is effectively subsidizing the wasteful use of water; prices are generally below the total marginal cost of supplying water and collecting and treating sewage

There is no incentive for individual users to install water saving devices when bills are calculated on the basis of the total volume used in the building and not on the basis of individual meters

The legal mandate of water companies in some parts of Europe discourages them from providing demand management services

their installation. Many customers mistakenly believe that these devices will reduce their levels of comfort and cleanliness. Furthermore, most people do not have the skills to undertake full water audits for their buildings. The Institut National de la Consommation has recently started to fill this gap in France by providing information on technical options to reduce home water consumption.

Information deficit also conditions the opinion in some water companies that supply expansion is a 'safer' investment. The companies are worried that investments in demand reduction will not achieve the anticipated water savings return. In those companies which have decided that demand reduction technology is a good investment, **public image** is an important factor in their ability to convey this message to their consumers. In the UK following the recent privatization of the water companies, the public is generally wary of the companies who are in turn concerned about generating further conflict by promoting retrofitting and water use reduction.

The water supply and sewerage **pricing and billing system** in many areas also works against water demand management. To promote water efficiency, the resulting economic savings must be significant — both in absolute terms and relative to the cost of water-saving devices. Across Europe, however, society at large is effectively subsidizing the wasteful use of water and providing a disincentive to demand management the price charged to urban consumers for water and sewage services is generally well below the total marginal cost of supplying the water and collecting and treating the waste water; at the very best, prices are set to recover historical average costs.

Even where the tariffs are appropriately set, many consumers are not aware of the real costs of water. They are therefore not able to accurately evaluate the pay-backs from reducing water consumption. Experiments in the UK in redesigning water bills to make them more comprehensible have had encouraging results. In large companies, the problem may relate to the corporate structure of the owner company, bills need to be read by the building managers and not merely automatically paid by an accounts department.

Furthermore, where water bills are calculated on the basis of the total volume consumed in a building consisting of many units, the owners of the individual units do not have any incentive to install water-saving devices as the benefits will accrue over the entire building and not compensate the individual's investment. In many countries, there is a gradual move towards individual meters although this is commonly resisted by home-owners who are afraid that their water bills will rise. There is also of course a cost involved in installation of individual meters. (Interestingly, in Spain, the move to individual metering is being fuelled by a challenge to the constitutionality of common meters on the basis of consumer rights).

The **problem of 'who pays vs. who benefits'** can also be seen in **rental properties**. Typically, the landlord is responsible for installation of water saving technology, but the savings on the water bill will accrue to the tenant. Unless these savings can be articulated and built into the rental price, the landlord has no incentive to do the retrofitting.

Water companies would be a logical provider of goods and services for demand management. In some parts of the US, water companies have large divisions dedicated to (and making profit from) undertaking water audits and selling use-reduction technologies. However, the **legal mandate of water companies** in some parts of Europe discourages or even prohibits water companies from such activities.

In addition, many water companies have a **financial structure** whereby their income is related directly to the volume of water used by their customers; they thus actually benefit from increased consumer consumption. Although most companies also have the legal obligation to provide water to their customers, frequently there is little or no penalty when this obligation is not met in dry years so the company feels no urgency to find the best solution to meeting growing demand. Where the full cost (and particularly the environmental costs) of developing new traditional supplies is subsidized by governments, the water companies also have no incentive to find the cheapest way of making supply and

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demand balance. Additionally, where water and sewerage services are provided by different companies, the water companies do not benefit from cost avoidance related to waste water volume management The monopoly position of most water supply companies is a further disincentive to finding innovative solutions.

The Role of Policy Makers

Since society as a whole receives benefits from the reduction of per capita urban water demand, policy makers have a role to play in encouraging the adoption of appropriate water-saving technologies and demand management systems. Governments have several areas in which they could take action.

First, government could play a role in **ensuring information provision.** The EU has taken one step in this direction with the Ecolabelling scheme launched in 1993, whose full implementation will increase consumer's ability to choose more water-efficient options. Governments may also provide guidelines or regulations related to the consumption and price information provided on water bills, and is ensuring that consumers have full information about any public or private subsidies available for retrofitting.

Government also has an important role to play in **reviewing the financial and legal operating environment of the water companies.** If water companies are required to operate under a regime of full financial accountability, they would frequently find that encouraging consumers to use less water is to their clear advantage. A German study suggests that the benefit is of the order that the water companies should actually be in a position to profitably provide financial assistance to consumers for installing water-saving devices. (Of course, such an accountability system should also induce the water companies to tackle the problem of reducing the distribution network leaks, which in some old cities is in excess of 40%). Government policy could also encourage or mandate adoption of appropriate tariff systems for water and sewerage services (such as an increasing block structure), which discourage excess consumption, and the use of **least cost planning** as a tool in evaluating options for balancing supply and demand.

Experience from the US and Mexico has confirmed that **regulatory instruments** can be used effectively to promote water demand management in new buildings. While it is relatively costly and difficult to modify plumbing in existing buildings, plumbing solutions can be very economically designed into new or renovated buildings. Building code regulations could require use of specific water efficient fixtures and/or set flow-rate standards. Such legislation has been successfully introduced in several US states as well as at the federal level. Governments might also set maximum water consumption levels for domestic appliances. In order to ensure the effectiveness of such regulations, **standards for "best available technologies' and "best management practices"** need to be established and referred to in the regulations, preferably in such a manner that the standards are not frozen, but that there is an incentive for continued improvement.

Finally, governments may consider that some of the public money which is presently intended for water infrastructure projects, such as dams and large water transport projects, might be better spent **in subsidizing retrofitting programs for certain categories of water users.**

In order to ensure the full implementation of urban water demand management, the UK's Environment Agency is **developing a strategy** at the national level. It will identify measures necessary to provide both the individual consumer and the water companies with the information required and the incentives necessary to adopt the water-saving technologies and management systems which will benefit the society at large While other countries might undertake such national exercise, a similar operation at the level of the European Union could also prove fruitful.

Many water companies have a financial structure whereby their income is related directly to the volume of water used by their customers, they thus actually benefit from increased water consumption

As well as encouraging the adoption of appropriate water-saving technologies and demand management systems government has an important role to play in reviewing the financial and legal operating environment of the water companies

Building code regulations could require use of specific water efficient fixtures and/or set flow-rate standards

Governments may consider that some of the public money which is presently intended for water infrastructure projects might be better spent in subsidizing retrofitting programs

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Water, least-cost planning, retrofitting

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Technology and Employment: Against Pessimism

Dimitris Kyriakou

Issue: In recent years, technology pessimism has been on the rise, fed by persistent unemployment problems in Europe, which are sometimes misleadingly and simplistically attributed to technology.

Relevance: A better understanding of technology and employment linkages would first shield policy-making from destructive anti-technology rhetoric. Moreover it would help policy-making vis-à-vis not only technology, but also employment issues.

The perennial subject of Technology's impact on Employment (T-E) never fails to generate interest if not outright animosity; in terms of long-lasting fascination it ranks together with Malthusian limits to growth. At least since the beginning of the industrial revolution people have expressed fears that machines would abolish jobs. In the early 19th century Fulton's steam boat attracted the wrath of ferrymen, and Luddites treated jennies and looms as sworn enemies. In the 1940's computer pioneer Norbert Wiener forecast that computers would bring about a crisis worse than the Great Depression of the 1930s. Notwithstanding the evident inaccuracy of such prophecies, technology pessimists insist that the new worker-displacing technologies (IT) - informatics, telecoms, etc. - are of a new, employment-devouring variety - an argument similar to Wiener's in pessimism. It is argued that the all-encompassing character of the present revolution will have an impact that will be felt throughout the economy; ie. there will be no place left to hide, in the sense that the service sector 'hid' the workers displaced from manufacturing in earlier decades. This line of argument is oblivious to the fact that the all-encompassing term 'services' is equivalent to an 'all other' agglomeration, wherein jobs are created and destroyed without a priori quantitative limits.

Note that we are not examining jobs being taken by cheaper labour in developing countries- an issue that is dealt with in the trade literature.

Most importantly, however, pessimists suggest that for the first time even skilled white collar workers are at risk, and it is this fact which helps explain why the recent recession, although milder in several countries than that experienced in the early 80s has generated gloomier predictions, and a stronger sense of unease. This time around it was people with a voice who got hurt, or at least people close to the journalists, pundits and analysts with a voice, people who could more effectively fight being reduced to statistics - in earlier recessions star journalists would have been hard pressed to identify a friend who had lost his job.

Ever since the Industrial Revolution people have expressed fears that machines would abolish jobs

With this background, there are a few points that need to be kept in mind when thinking about technology and employment. These can be summarized as follows:

- Technological progress generates new wealth.
- Historical evidence does not show that technology reduces total employment.
- There are many other factors behind Europe's employment problems.

In the most recent people close to opinion formers were affected directly

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The implicit assumption that is being made by many pessimists is that there is a fixed amount of output to be produced

- Hiring people is akin to an investment, influenced by growth considerations just as all other investments are.
- In general, countries which have experienced the a slowdown in productivity growth have experienced a rise in unemployment.
- Comparison of Europe and the US refutes the argument that unemployment is being aggravated by the fact that IT is being introduced more rapidly than other technologies were in the past.
- Recent empirical evidence from the US shows that firms using advanced technologies pay higher wages, offer more secure jobs and increase employment more rapidly.

The aim here is not to present an exhaustive list, since, for instance, certain organisation theory aspects may deserve separate articles, nor simply to provide a source of interesting statistics; the emphasis is on the arguments themselves. Moreover, a very important aspect that is not looked at here, but which deserves more thorough treatment is the 'learning' process, through which agents deal with the new conditions brought about by technological change. Reaping the benefits of such change depends on the agents' 'learning capacity', an issue addressed partly by some of the points mentioned below, but which also deserves further treatment.

The transition from one level of technology to another will be less painful if part of the increased wealth is redistributed to the benefit of those displaced by technological change

Technological progress generates new wealth

Historical records show that the negative effects of technological progress on total employment are only transitory

First, the implicit assumption behind the pessimistic claims is that there is a fixed amount of output to be produced. **What is not taken into account is that technological progress generates new wealth;** and increased wealth leads to higher effective demand, causing increased investment and labour hiring in order to satisfy this increased demand (most typically through selling new products or services) [1]. In the short term technical progress may destroy jobs but the increase in productivity and in disposable income leads to increases in effective demand and eventually to the creation of new jobs. More accurately, given the various other factors that may complicate this process, what technical progress will do, is raise total income, and, with the exception of workaholics, it is income that people need and not jobs per se. 'Jobs' is often a shorthand name for 'income'. Now whether most people will effectively partake in enjoying parts of this higher total income - in terms of more/better jobs, or through redistribution schemes - depends on the economic framework, and not on technology. The transition and adjustment period will be rife with mismatches. It will be made less painful if a number of conditions are met:

a) Growth picks up quickly, leading to higher demand and faster job creation across the board.

b) Labour markets, but even more importantly product markets, become more flexible.

c) Education and training/retraining becomes more widely available and better focused - Europe has to base its strategies on innovation and quality, developing total competence and enhancing ability to adjust through a commitment on promoting lifetime learning.

d) A share of the benefits of technical progress and new wealth generation goes to those displaced by the market's implacable gale of creative destruction - favouring the creation of new more efficient arrangements at the cost of destroying less competitive ones - to cushion them through the transition period.

The historical evidence

Evidence through the decades does not justify pessimism. The last 200 years have seen strong technical progress, accompanied by increased income across the socio-economic ladder, net job-creation, and reduced working hours. Robert Solow (1987 Economics Nobel Prize-winner) aptly observed recently that technical progress and productivity growth do not have to be associated with high unemployment; in fact the high productivity growth post war years (what the French call 'les trente glorieuses') were accompanied by very low unemployment.

A multitude of factors

Technology in any case **cannot be singled out for blame for Europe's employment related ills in the last 15 years**, especially in light of the

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effects of the two oil price shocks, movements in the terms of trade, high taxes in labour-employment, increasing mismatch between patterns of labour supply and demand, high real **interest rates, etc.** There are many reasons for the emergence and (more crucially) the persistence, of unemployment The framework within which technology operates is usually much more important than technology itself.

Jobs represent an investment for employers

Importantly, since **hiring labour is akin to investing in people, low growth and low growth prospects, have not encouraged such investment since the seventies**. Firms impart training directly or indirectly to their employees, and wish their employees to stay long enough that they can reap the fruits of this investment, as in general an employee's performance/contribution curve rises with time. This is increasingly the case as Taylorist models of production become outdated in the organization of blue-collar work. In any case such assembly line models were never credible for white collar work, which is the type that new technological developments are supposed to threaten for the first time. Overall, to the extent that S/T and its adoption boosts growth, and growth prospects, it facilitates firms' investment in new people, ie. hiring.

A slowdown in productivity means slowdown in jobs

The fifth point is that, as the 1995 CEPR report "Unemployment: Choices for Europe" argues (p. 48-49), apart from Japan and Austria which are the two outliers, statistical, and not anecdotal, evidence from the OECD countries suggests that those countries experiencing the greatest slowdown in productivity growth (often technology-driven) also experience the strongest rise in unemployment.

The speed of change

It is also argued that information technology (IT) is being introduced much more rapidly than earlier technologies, not giving time for economies to adjust, especially in recent years when the cost of computing power has fallen sharply. The evidence does not justify panicky reactions against technology. Clearly, the US has been adopting IT faster than Europe, and the unemployment differential between the US and Europe has not reflected this speed difference. On the contrary, unemployment has behaved much worse in technology-tardy Europe than in the US. As suggested in point 3, above, there are many other factors, that determine job-creation/loss, aside from technology, and they are the key determinants. They have to do with the labour and product market regulatory framework, the ease of setting up a business, with interest rates, the agility of the banking system and of financial markets, and of course with training and education. Part of our employment problems now come from the fact that technical progress has been 'unskilled-labour saving' to an extent that was not matched by the progress of education.

Hiring people is a form of investment, so low growth prospects discourage it If S/T stimulates growth it will stimulate employment too

Education is undoubtedly the key for the achievement of a smooth transition, for staking out new job opportunities and exploiting them. The more controversial issue is the type of education best suited to the changes the information society will be ushering in. The standard apprentice schemes, teaching or retraining people in order to endow them with a particular skill, may make them more vulnerable if this particular skill is of a mechanizable, repetitive nature.

Statistics suggest that countries experiencing the greatest slowdown in productivity growth also experience the strongest rise in unemployment

Technology and quality of jobs

The seventh point concerns technology and the quality of jobs. This was raised by an illuminating recent publication (winter 1994/95) from the US department of Commerce ("Technology, Economic Growth and Employment: New Research from the Dept. of Commerce", Lewis Alexander, USDC Chief Economist) which spells out a number of points clearly. Using firm-level time-series data, collected since 1978, the study concludes that **firms using advanced technologies pay higher wages, offer more secure jobs, and increase employment more rapidly** than other plants. Technology is found to contribute to the creation of more good jobs. Advanced technology firms hire workers with more skills and pay them better wages (even when taking into account the skill level). Plants using

Part of our current employment problems arise from the fact that technical progress has made it possible to dispense with unskilled labour faster than workers have been trained for skilled jobs

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A recent authoritative US study suggests that firms using advanced technologies pay higher wages, offer more secure jobs, and increase employment more rapidly

A comparative study in the US suggests that regardless of whether adopting new technology is beneficial or not the effects the failure to invest in are generally more detrimental

advanced technologies have a higher probability of survival (failure rates - and the consequent employment losses- were found to be substantially smaller for such plants). Overall employment growth was observed in conjunction with the use of advanced technologies. The plants with increased productivity AND increased employment have an employment impact which outweighs that of those plants which have increased productivity and reduced employment (downsizers). Interestingly, and perhaps surprisingly, the smallest plants were over-represented among those with increased employment and reduced productivity, whereas large plants were over-represented among those with increased productivity AND increased employment. It is also shown that regardless of the size of the plant there is a strong positive correlation between the number of advanced technologies used and employment growth. Dynamic high growth plants were found to be crucial for industry performance. They provide well-paid and relatively secure jobs; the fact that they are often both high tech and active in export markets may indicate that both trade and technology contribute to their success. Finally, it is worth comparing the between results of investing in new technology and not doing so; the US Commerce Dept. report mentioned above found that regardless of the result of investing, **the outcome would have been much less attractive if the investment had not been not made.**

Conclusion

Analysing the technology-employment link actually can provide a view of the related role of competitiveness in all this. It can be seen that firms who fail to compete (eg. because they are slow in adopting new technology) will be deservedly punished - which indeed provides a 'competitiveness' rationale for the adoption of technology and the prevention of employment losses due to firm failures. Indeed it can be argued that unemployment in Europe is not due to technology, but rather to the slow adoption of technology (and of an appropriate accompanying framework) in Europe.

About the author

Dimitris Kyriakou holds a BSc in Electrical Engineering and Computer Science and a Ph D. in International Economics from Princeton University Before coming to the IPTS, where he is a scientific officer and is responsible for advising on economics issues and the editing of the IPTS Report, he worked as an economist at the World Bank His main research interests include information technologies, employment, regional development and sustainability

Keywords

Technology-employment, productivity, jobs, long-run impact, competitiveness

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Notes

- [1] Note here that we set aside Kaldorian interpretations of the effect of growth on productivity which may have a negative impact on employment in a quite peculiar fashion, through the impact of growth on the division of labour. We set it aside, not only because of its peculiarity but also because, since it operates through the division-of-labour mechanism it is best dealt with in the literature on international trade to which we referred earlier.

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Benchmarking of Best Practices: A Perspective for Policy

Cecilia Cabello

Issue: Benchmarking of best practices is becoming increasingly important not only as a strategy for improving business performance, but also as a fruitful analytical approach, providing new sources of input for formulating policy actions.

Relevance: Benchmarking of best practice has moved out of firms and is becoming a powerful tool for conducting comparative studies of business performance at various levels. These comparative studies provide analyses that can prove valuable for policy-makers not only in attempting to put in place frameworks conducive to the adoption of best practices but also for other policy instruments.

What is benchmarking?

Benchmarking can be defined as a formalised quality process that is used by business organisations to measure their products, processes, services and practices against competitors or best practice companies. The aim of benchmarking is to determine how their competitors or best practice firms reach high performance levels, so that this knowledge can be applied to their own operations to achieve a competitive advantage. Benchmarking aims at learning from best observable practices wherever they come from, even if they come from other sectors. Benchmarking is actually a diagnostic tool to quantify a firm's competitive gaps and involves an implementation stage which if adequately adopted can help firms improve their business operations and performance.

Benchmarking has reached increasing importance in the industrial world in the last ten years due to major successes that have been achieved by numerous international companies by using it. Costs, process flexibility and technological innovation are believed to be the key success factors for industrial competitiveness. Therefore, information on competition and benchmarking is indispensable in today's increasingly competitive markets. The US Council on Competitiveness, set up to comment on the state of US industry, reported that the most successful firms shared "an emphasis on competitive benchmarking" and that benchmarking has become a "routine matter".

Benchmarking also poses some problems however, because it is an information gathering process. It involves time, money and other resources, which may not be readily available to firms, especially SMEs. In addition, it requires an implementation phase which is critical for permitting the necessary changes to take place.

Benchmarking studies

The question may arise as to whether benchmarking should remain in the realm of private business. However, a significant development is that **benchmarking has moved out of firms** and, in the hands of analysts, is being used in comparative studies at more aggregate levels. As such, benchmarking is being

Benchmarking is a process by which firms compare their products and processes with competitors or best practice companies, with the aim of improving their own practices and so achieving greater competitiveness

Small companies may be at a disadvantage because they lack the resources to perform benchmarking studies

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Benchmarking is increasingly moving out of firms and into the hands of analysts and academics, who are using it to study whole industries, sectors and regions

developed by analysts and academics to study whole industries and sectors and compare competitiveness within a given region or between regions (see examples referenced below).

Such benchmarking studies examine the factors influencing performance which not only include the 'hard' elements of quantifiable performance but also the 'soft' elements which strongly influence firms' efficiency and competitiveness. The quantifiable factors include data such as returns on investment, unit costs, profit margins, and other financial or economic figures. The 'softer' or more difficult to quantify elements try to place values on factors that also influence performance such as strategic decisions on capability building, training and organisational culture, human capital resources, management styles, etc.

Factors such as training and organisational culture, human capital resources, management styles, etc. can also influence efficiency and competitiveness

Unlike other competitiveness studies that only usually take into account economic and financial data, and which have a number of limitations, benchmarking is an alternative means which includes the drivers of competitiveness, operational practices, managerial practices and firms' organizational behaviour. Its power lies in explicitly handling those factors, the significance of which is increasingly being stressed (organisation structures, technology management, training and education of personnel) and other such 'soft' measures which are not so easy to quantify.

Benchmarking is able to take into account competitiveness drivers such as organizational behaviour, and operational and managerial practices, which are hard to quantify

The overall aim of these studies is thus to give a more complete picture of the firm and its practices, as opposed to a more restricted one based on purely economic data, and consequently to draw useful, and otherwise less obvious conclusions regarding the important factors influencing competitiveness and comparative advantage, which decision makers - from both private industry and public authorities - should be aware of.

Policy implications

Benchmarking can provide a set of measures which can help policy makers identify trends

Why does benchmarking have relevance for the political debate? There is no simple formula or single way to help industry in the on-going process of change, but what has become evident for policy makers is that certain factors are becoming more and more important for industry, in addition to the traditional economic and financial issues. Benchmarking, though not an end in itself, can provide a set of simple measures which can help policy makers identify trends in competitive performance, and can provide a basis for setting targets backed by appropriate plans for reaching them.

A more complete picture of the drivers and factors influencing competitiveness has been presented by many recent studies. The OECD Competitiveness Indicators, 1996, and Enhancing European Competitiveness, 1995 are examples of these kinds of reports, and they highlight how traditional measurements by themselves do not give a clear picture, and that other criteria need to be taken into account. The European Competitiveness Advisory Group (Enhancing European Competitiveness, 1995) stated that "the drive to competitiveness should... encourage benchmarking strategies to develop new technological opportunities". In addition, competitiveness is known to crucially depend on the ability to invest in intangibles - knowledge, skills, creativity - which form the basis for better quality jobs.

There are many examples of interesting findings which have policy implications. A study on benchmarking technology management in high spending R&D firms in Europe, USA and Japan (Roberts, 1995) indicated that firms are currently looking for external resource support, and are experiencing major shifts towards acquiring technology from outside sources. In particular, it was noted that firms are relying increasingly on universities for **research** activities, while depending on joint ventures and alliances for **development.** In addition, attention was drawn to the divergent tendencies in how these firms manage corporate R&D, in Japan the trend is to centralise more (corporate control) while in the US and Europe the opposite is the case. Emphasis could therefore be placed on helping firms achieve **co-operation** in such a competitive environment.

Another interesting point made in this same study, contrary to what has been reported in much of the literature is that within these firms the highest

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priority in their technology strategy is placed on **matching R&D to market needs** (demand), and not to the management of R&D with constrained resources. It is not a matter of resources, it is rather a matter of determining what the consumers want. It was noted, however, that European firms involve their consumers less in the product development process than do US and Japanese firms. This is relevant to the recent innovation policy debate and The Green Paper on Innovation. It was highlighted that innovation is not linearly related to R&D, it involves the development of human resources, making firms sensitive to economic intelligence, better **adapting products to demand**, etc.

This last point ties in closely to what was found in a series of studies, Made in Europe, (Voss, et al., 1995) which examined manufacturing firms in Northern Europe. The lowest scoring firms often experience unwillingly, what may be termed a 'supply chain failure'. These firms need to better understand and develop strategies which are geared towards the consumers. It is not enough just to implement business practices to improve productivity, reduce costs, etc. It was concluded that the **largest source of best practice is customers**, where the strongest source of diffusion of best practice is through the supply chain. This implies that only when there is an intimate and continuous learning relationship between designer, manufacturer, supplier, and consumer can a firm reach high performance levels and thus be more competitive.

The nature of today's business environment has transformed the basis of industrial competitiveness: a requirement for heightened customer focus is a clear competitive mandate which involves a systematic way to incorporate the 'voice of the customer'. Research shows that world class manufacturing organisations are better able than their competitors to align their products to customer wants and needs. Achieving this goal requires an ongoing interchange between the customer and the manufacturer, designer and supplier organisations.

Another study, *World Class Manufacturing* (Andersen Consulting, 1994) investigated manufacturing performance and management practices of automotive components plants in nine countries worldwide - Japan, the US, Canada, Mexico, France, Germany, Italy, Spain and the UK. This study made some interesting findings, noting that, contrary to the widely accepted notion that world class performance in the automotive industry depends on the full use of the Japanese type production system, this was not the case for some European world class firms. Although global manufacturers have the opportunity to combine knowledge and learning from different countries they need to achieve a balance between the 'corporate way' and the local situation in which they operate. This was evident from the fact that Japanese plants generally are not doing well outside Japan and some European plants perform well with local methods. The study draws attention to the fact that local factors can play an important role in achieving performance. These finding may have implications on regional, local or other polices and highlights the importance that within Europe, the regions have unique cultural, social and other endogenous factors which may need closer attention.

Conclusions

Benchmarking from the perspective of private firms can help businesses achieve their goals of improving competitiveness, increasing benefits and profits by improving practices, operational procedures, etc. For public authorities, however, more aggregate benchmarking studies from the perspective of the analyst/academic, help provide a wider picture of the present situation of industry, giving hints as to what may be the drivers of competition in the future, and provide some valid background information on which policy may be formulated.

Competitiveness is known to crucially depend on the ability to invest in intangibles such as knowledge, skills and creativity

Surprisingly, studies have shown that R&D is not constrained by limited resources but by knowledge of consumers' needs. European companies involve consumers less in product development than their competitors

Customers are a more important source of 'best practice' within the supply chain This makes an intimate and continuous learning relationship between all parties essential

Regions have unique cultural, social and other endogenous factors which may need closer attention, a balance needs to be struck between the 'corporate way' and the local situation

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Keywords

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Bridge Building at the IPTS: Outlining Priorities for Future European Research

Paola Di Pietrogiacomo

Following a request from the European Parliament Research Committee the Institute recently organised two expert workshops focused on priorities for European research.

Representatives of research, industry and the trade unions met to discuss the main trends and challenges of the European socio-economic system and the catalytic role of research and innovation policies in managing the transition towards the future. **"European Research towards the XXIst Century"** was the title of the first workshop, dealing with the emerging trends within European society and the role of research in the management of change. During the discussions a remarkable consensus emerged concerning the importance of the European Social Model and the fact that, although it needs to evolve, it is not incompatible with competitiveness.

Shifting the emphasis of the research programme towards critical social problems at Member State level could prove to be beneficial on a number of counts. A number of distinguished participants argued that coping with Europe's poor performance in translating scientific results into successful products and services required that more emphasis should be given to social demand and to the organisational dimension of the innovation process. It appeared that, in order to tackle the variety of problems relating to unemployment and to develop a new European economic model, the concretization of concepts like "quality value" combined with massive investment in education are basic requirements without which the necessary transition cannot be made.

Another major challenge to which S&T is expected to make important contributions is the transition to a more sustainable society, and **"Sustainable development and research policy"** was the theme of the second workshop organized by the Institute. During the discussion between experts and the members of the European Parliament's Research Committee, it appeared that one of the main tasks of research programmes dealing with this issue is collaboration in providing an adequate common vision of the form of sustainable society that is being sought. Research has an important specific role in building a scenario of sustainability; a scenario which is adequate in the sense that it is based on scientific foundations and acceptable in the sense that it results from an socially articulated process. Moreover, research can contribute ideas, alternative solutions and operative tools able to promote and favour wider social dynamics, as well as technical solutions to specific environmental problems.

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New meso-regional activities of the IPTS

Matteo Bonazzi & Sergio Gómez y Paloma

The IPTS has recently signed a framework agreement with the "Consejería de Medio Ambiente de la Junta de Andalucía", with the objective of sharing information and undertaking joint research projects on environmentally related technological issues.

This will make a pool of technological information available for exploration anddissemination. Both Institutions aim to observe, detect and analyse the most significant technological issues for the protection of the environmental resources, in particular in order to be able to alert and inform decision-makers of the opportunities and challenges presented by technological innovation.

As well as offering a richer understanding of the issues, the complementary perspectives of a European institute and a regional one offers the possibility to promote dialogue with social sectors implicated at various levels in the decision-making process.

The IPTS already benefits from the backing of the European S&T Observatory network as an essential knowledge and quality control resource. Additionally, the locally-focused input from an "Objective 1" region will make it possible to explore technology, environment and employment issues from a different perspective: this highlights the need to view technological innovation and market dynamics as important tools when addressing the complex social and environmental challenges of sustainable development.

Sustainable development can only take on meaning as a global concept, embracing and integrating environmental, socio-economic and cultural dimensions of society on a world scale, but in a world where academic thought is placing increasing emphasis on the importance of regions. The synthesis between the local approach and the European perspective on technology and policy will broaden discussion on the theory and practice of sustainable development in both peripheral EU regions and in the broader context of the Mediterranean.

Furthermore, taking the Mediterranean as an example of a Meso-Region, the agreement is the first of a series of steps IPTS is undertaking to deepen the attention to meso-regional matters, such as socio-economic integrated systems.

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ABOUT THE IPTS

The **IPTS** is one of the seven institutes of the Joint Research Centre of the EU Commission. Its remit is the observation and follow-up of technological change in its broadest sense, in order to understand better its links with economic and social change. The Institute carries out and co-ordinates rsearch to imporve our understanding of the impact of new technologies, and their relationship to their socio-economic context.

The purpose of this work is to support the decision-maker in the management of change, pivotally anchored on S/T developments. In this endeavour IPTS enjoys a dual advantage: being a part of the Commission, IPTS shares EU goals and priorities; on the other hand it cherishes its research institute neutrality and distance from the intricacies of actual policy-making. This combination allows the IPTS to build bridges across EU undertakings, contributing to and co-ordinating the creation of common knowledge bases at the disposal of all stake-holders. Though the work of the IPTS is mainly addressed to the Commission, it also works with decision-makers in the European parliament, and agencies and institutions in the Member States.

The Institute's main activities, defined in close cooperation with the decision-maker are:

1. Technology Watch. This activity aims to alert European decision-makers to the social, economic and political consequences of major technological issues and trends. This is achieved through the European Science and Technology Observatory (ESTO), a European-wide network of nationally based organisations. The IPTS is the central node of ESTO, co-ordinating technology watch joint ventures with the aim of better understanding technological change.

2. Technology, employment & competitiveness. Given the significance of these issues for Europe and the EU institutions, the technology-employment-competitiveness relationship is the driving force behind all IPTS activities, focusing analysis on the potential of promising technologies for job creation, economic growth and social welfare. Such analyses may be linked to specific technologies, technological sectors, or cross-sectorial issues and themes.

3. Support for policy-making. The IPTS also undertakes work to supports both Commission services and other EU institutions in response to specific requests, usually as a direct contribution to decision-making and/or policy implementation. These tasks are fully integrated with, and take full advantage of, on-going Technology Watch activities.

As well as collaborating directly with policy-makers in order to obtain first-hand understanding of their concerns, the IPTS draws upon sector actors knowledge and promotes dialogue between them, whilst working in close co-operation with the scientific community so as to ensure technical accuracy. In addition to its flagship IPTS Report , the work of the IPTS is also presented in occasional prospective notes, a series of dossiers, synthesis reports and working papers.

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