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THE IPTS REPORT

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02

MARCH 1996

- **Are Microbes Still a Threat?**
- **Combined Heat and Power: Technological opportunities and regulatory frameworks**
- **Decisions in a Climate of Uncertainty: Addressing the CO_2 issue**
- **Toward the Zero Emission Vehicle: The role of the hybrid car**
- **Wastewater Reuse: Ever more a resource for the future**
- **Manufacturing Employment in Europe: high-tech growth versus low-tech decline?**
- **What Future For Middle Managers?: Information technologies and white-collar jobs**

EUROPEAN COMMISSION
Joint Research Centre

This Report is addressed to the decision-makers involved in 'managing change', seeking distilled, selective presentation of technoeconomic intelligence and prospective alert on underdiscussed facets of a topic, rather than a deluge of data and encyclopaedic reviews.

This Report stands as the most visible indication of the commitment of the IPTS to Technology Watch, its main priority and mandate. In this context, the Report aims to focus on issues of projected pertinence for the decision-makers, exploring *prospectively* the socioeconomic impact of S/T developments. On the one hand, such exploration implies signalling on issues which are not yet clearly on the policy-makers' agenda, but can be projected to draw attention sooner or later. On the other hand it implies alerting actors about underexplored aspects of an issue on the agenda, aspects which, though under-appreciated today may have substantial consequences tomorrow.

The Report benefits from a validation process, underwritten by networks of renowned experts and Commission services, making this Report a product of not only the IPTS, but also of its collaborating networks of Commission and external experts. The process of interactive consultation guarantees the validity of the points highlighted, the relevance of the topics chosen, and the timeliness of their examination.

There are many publications excelling within their discipline. The Report takes the extra step, prospectively exploring interdisciplinary repercussions, often drawing surprising connections. Moreover, sharing the Commission's priorities, the Report is still the product of a research institute, and can be a neutral platform for dialogue on issues of relevance and a nexus for facilitating debate.

The present issue is the third installment in a seven-issue introductory series that will last until September 1996. Throughout this period, and with the feedback and comments of its readers, the Report will be shaped and fine-tuned. Both the *brief notes*, which aim to inform and not analyse, and the longer analytical pieces, attempt to cover issues spanning a vast spectrum, in a balanced way. Instead of lamenting having inexorably to deal with disparate topics, we make a virtue out of necessity, and cherish escaping restrictive tags. Nevertheless, we attempt here to help orient the reader and ease navigation through the articles.

The alarming reappearance of infectious diseases that were once believed to be eradicated offers the backdrop for the first article. Unwise prescription practices has fed microbes' incredible ability to develop resistance to antibiotics. On the one hand this gives rise to health preoccupations; on the other it presents a market underexplored by pharmaceutical companies, and underdiscussed in policy terms. Policies and energy market liberalisation in particular, play a crucial role in the second article. In it the promising combined-heat-and-power (cogeneration) technology is presented. It is argued that the impact of liberalisation on cogeneration technologies is not clear, and would largely depend on local institutional factors in each country. Similarly unclear is the evidence of anthropogenic emissions as the cause of climate change (as opposed to natural climatic variation accounting for observed changes). Nevertheless the third article reminds us of other reasons to deal with anthropogenic emissions, such as fossil fuel depletion, the spectre of potentially catastrophic events (regardless of the cause) etc. The fourth article examines the hybrid car (combining advantages of both combustion engines and electric vehicles) as a useful development, paving the way towards an eventual zero-emission vehicle.

The fifth article also includes an environmental dimension, though it has a multidisciplinary approach typical of IPTS work. Pressure on water resources in many areas of the world promotes wastewater reuse. However, the debate on microbiological minimum standards is intense and reflects the different priorities and economic impacts of water treatment in wealthier and poorer countries. Significant economic effects can also be seen in the reduction in European manufacturing employment over the past 20 years, accompanied by a concentration in low-middle technological sectors, as explored in the penultimate article. However, niches within these sectors could form strong economic growth nuclei. Finally, the last article discusses the way information technologies recast jobs under a new light: low-middle level white-collar tasks may be more easily computerisable than some blue-collar tasks. In any case, creativity and flexibility will be key elements for income and job security, and successful education and training programmes would take this into account.

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Community Policy for Research & Technological Development

Sound, forward-looking policy is essential for the future of Europe's research and technological development effort. RTD policy over the last ten years has seen the establishment of the framework programme as the main vehicle for Community research. This has enabled better coordination of research activities, facilitated the planning of all concerned, and produced many significant results. Community research programmes have yielded the first ever sequencing of a chromosome, the first production of significant fusion power, and many other notable results. Research into the impact of the framework programmes shows that the participants derive real benefits from their collaboration, not least the continuation of this collaboration after the end of the projects reported by 91% of those questioned in one member state. In many countries, too, the development of new products or new processes results from over 50% of projects. But we can do better! There is still no innovation culture in the European Union; the barriers to innovation - financial and administrative - are still too high. Scientists receive their kudos from publication not patenting or production. Much of this must change if Europe's goals are to be attained.

The innovation problem is addressed through a Green Paper, issued last December, outlining weaknesses and obstacles to innovation in the EU, and specific approaches to deal with them. Another priority on the research agenda is improved focus. Mme Cresson, Commissioner for Research, Education and Training, together with Industry Commissioner Martin Bangemann, and Transport Commissioner Neil Kinnock, has established task forces in a few, clearly-defined areas - transport, information technology, and biotechnology - whose remit is to determine how research can help European industry lead in these fields. Although research in other areas is also important, we can expect increased concentration of effort on a reduced number of targets in the future. Improving coordination between the research activities of the Community and the Member States, and between the civil and military sectors, has also been identified as a key goal. Indeed, the JRC (the Joint Research Centre of the EU Commission) includes coordination as a major part of its remit. The Treaty on the European Union gives the Commission the politically-sensitive mandate to ensure better coordination. CREST (the Scientific & Technical Research Committe comprising two government-appointed representatives from each member state) is exploring appropriate mechanisms, towards the achievement of this goal.

What of the future? Towards the turn of the millenium, the Community's Fifth Framework programme for RTD, currently in the early stages of preparation will take over from the Fourth. It will address the concerns being raised today, and the policy it enshrines will be the driving force behind the technology of tomorrow.

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Are Microbes Still a Threat?

Georgios Mezelas, Patrice Laget

Issue: Many 'successful' antibiotics commonly used in healthcare have become ineffective as many different microbes are now resistant to them. This resistance could facilitate the spread of microbial diseases considered until recently as being eradicated. As a result, it may only be a matter of time before there are serious outbreaks of untreatable diseases unless new antibiotics are discovered.

Relevance: The increasing resistance of microbes to antibiotics points to the necessity of developing new drugs and of taking precautions to limit resistance-buildup by microbes. With the US leading the way in developing 'new' antibiotics, the European pharmaceutical industry faces a new challenge and, through coordinating the efforts of the private and public sectors, another chance to capture a larger share of a world market for antibiotics estimated to be worth US$18 billion.

The increasing ineffectiveness of antibiotics

A large number of antibiotics, formerly active against bacterial pathogens, are now ineffective. Although this is not a new phenomenon, what is new is the rapidity with which resistant bacteria can spread through patient populations throughout the world. An antibiotic that takes a decade to bring to market can induce resistance within months of its introduction into clinical practice. According to the 1994 report of the US Office of Technology Assessment (OTA), in the USA alone 19,000 hospital patients die each year due to hospital-acquired bacterial infections, treatable until recently with antibiotics.

Over recent years there has been a general resurgence of infectious diseases worldwide, including outbreaks of cholera, malaria, yellow fever, and diphtheria. The difficulty in controlling the latest tuberculosis (TB) outbreak in HIV-positive patients, as there is no cure for some multidrug-resistant TB, is an alarming example.

It seems that microbes "mutate" faster than scientists can produce new substances. Infectious microbes, have a remarkable ability to evolve, adapt and develop drug-resistance in an unpredictable and dynamic way. The reasons for the increase in incidence of many infectious diseases are very complex and not fully understood. Among them are population shifts and population growth; changes in human behaviour; urbanisation; poverty; changes in ecology and climate; and inadequate public health infrastructure. Resistance is fuelled by the dramatic increase in the use of antibiotics in both human healthcare and veterinary medicine; the emergence of new pathogens; the increase in the number of immunodeficient patients (HIV infection, cancer); and the mass migration of people worldwide carrying infectious microbes across borders with their human or animal hosts.

An antibiotic that takes a decade to bring to market can induce resistance within months of its introduction into clinical practice

Microbes quickly develop drug-resistance, due to their remarkable ability to evolve, adapt and mutate

Table 1: Consumption Pattern Of Antibiotics In Four European Countries, 1992

Defined Daily Dose per 1000 inhabitants per day				
ANTIBIOTIC TYPE	**GERMANY**	**FRANCE**	**ITALY**	**U.K**
Tetracyclines & combinations	3,66	3,34	0,47	3,51
Chloramphenicol & combinations	0,00	0,04	0,01	0,00
Penicillins broad spectrum & combinations (except for Tetracyclines chloramphenicol, aminoglucosides and sulphonamides) includes amoxycillin, ampicillin and derived products	1,71	11,35	6,10	4,50
Cephalosporins	0,46	3,41	1,38	0,80
Trimethoprims & similar formulas	0,97	0,66	1,18	1,35
Macrolides & similar products	1,23	3,99	2,88	1,54
Fluoroquinolones	0,60	1,76	1,38	0,36
Penicillins (non -broad spectrum)	1,91	1,07	0,07	1,21
Aminoglycosides & combinations	0,01	0,15	0,11	0,01
Carbenicillins	0,00	0,00	0,02	0,00
Rifampicins, rifamycin	0,00	0,00	0,17	0,00
Others	0,00	0,47	0,20	0,01
TOTAL	10,56	26,24	13,97	13,29

Source · ECO-Santé, OECD Credes, OECD 1995

Antibiotics have been the victims of their own success

Antibiotics have been the victims of their own success. About 40% of the *Streptococcus* responsible for pneumonia are resistant to penicillin. Of particular worry is *Staphylococcus aureus* which is now resistant to all current antibiotics except one, vancomycin, a drug with serious side effects. In the past vancomycin was usually used as the 'last chance' drug. In 1989 a strain of *Enterococcus faecium* also acquired resistance to vancomycin and has now spread around the world. Some scientists are worried that if this antibiotic resistance spreads in the near future to other organisms, it may facilitate the reappearance of diseases that until now were

considered to be eradicated, creating a major public health problem. Still, the frequent, irrational use of antibiotics is one of the main factors in the development of microbes' resistance.

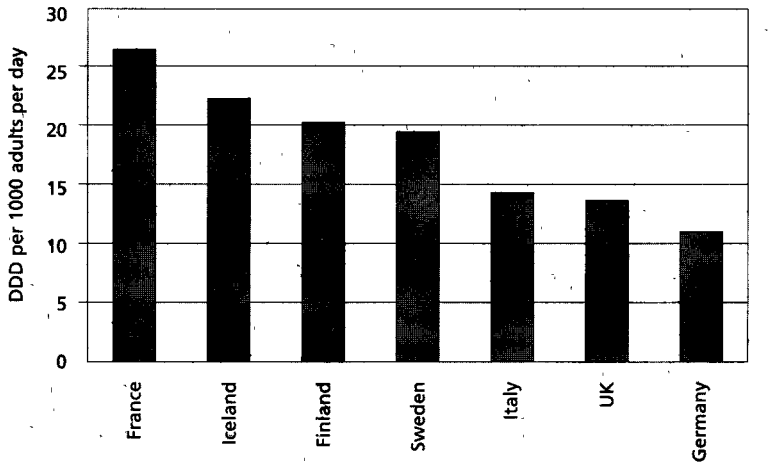
European comparisons

The current world market for antibiotics is estimated to be worth US$18 billion. So-called beta-lactams (eg. penicillins, cephalosporins) have the largest share of the multi-billion dollar international antibiotic market.

The world market for antibiotics is currently estimated to be worth US$18 billion

Italy and France have the highest shares of the European antibiotics market, where antibiotics take up about 10% of the national drugs market (Figure 1). Italy has the most antibiotics products on the market (289) but each is commercialised only in 2 distinct forms. By contrast, in the UK and Germany, for each antibiotic there may be up to 6 different commercial forms of the same product.

Figure 1: Total Antibiotics Consumption in Selected European Countries 1992



Note: Data for other European countries is not collected and even for the countries listed is not available as a comprehensive time series

France seems to be the largest antibiotics consumer in Europe

Source : ECO-Santé OECD Credes, OECD 1995

Table 2: Consumption costs of antibiotics in four European countries, 1992

MEASURE	Germany	France	Italy	UK
Units (per 1000 inhabitants per day)	55,8	**116,4**	79,4	110,8
DDD (per 1000 inhabitants per day)	10,6	**26,2**	14,0	13,3
Dispensing costs (FF per 1000 inhabitants per day)	78,8	**280,4**	241,2	88,4
Average price (FF/DDD)	7,4	10,7	**17,3**	6,7

Source : ECO-Santé, OECD Credes, OECD 1995

In terms of "Defined Daily Dose" (DDD) per 1000 habitants consumption, France seems to be Europe's largest consumer, with a consumption about twice as high as in Italy and the UK, and two and a half times that of Germany. Although consumption in Italy is only half that in France, the overall expense, calculated in DDD, is similar due to greater use of more recent, and more costly, antibiotics (see Table 2).

In some EU countries data is not collected systematically, but is often the result of specific surveys by interested parties

When considering the high prescription rate in France, an explanatory factor could be the average duration of antibiotic therapy in hospitals, which varies between countries, ranging from 6 days in the UK to 11 days in Italy. Even for serious infections such as meningitis, patients in the UK receive an average of 6 days of treatment while in France the average duration of therapy is 24 days. A deeper analysis of these differences in medical approaches, for the same diseases, would be very interesting.

The problem of antibiotics' resistance will probably remain confined to hospitals for the immediate future

In France it was also demonstrated that consumption of antibiotics is much higher for children, compared to other countries. This then decreases in adulthood and again picks up slightly towards old-age. Doctors tend to prescribe antibiotics in order to treat their young patients more quickly. Apparently this "antibiomania" corresponds more to parents' demands, especially when both parents are working. For sure this is not exclusively a French phenomenon. Also, sending children at an early age to nurseries, when their immune system is still not completely developed, favours the diffusion and repetition of infections to them. Added to parents' desires for quick recovery, it seems that social phenomena may, at least indirectly, influence this important health issue.

Although there are many antibiotics under development, these are mainly variations of the 160 existing drugs

Thus, according to available data and the studies of antibiotic consumption over a long period, it has been shown that age, epidemics, important infectious diseases, economic differences and differences in medical approach, all influence the prescription and consumption of antibiotics in different countries.

This analysis is based only on available data: in several EU countries there is no data available partly because there is no official body mandated to collect this kind of information at an EU level. Data is not systematically collected, and when collected it is often the result of a specific survey, requested by an interested party at a certain point in time, and follow-ups are rare. The absence of such information does not facilitate policy-makers' work which needs scientific evidence for the definition of future strategies.

Future perspectives

For the immediate future the problem of antibiotics' resistance will probably remain confined to hospitals, at least in developed countries where it can be kept largely under control by rigorous infectious disease control. Nevertheless, in the growing cities of the developing world, and in those parts of the population in the developed countries faced with infrequent access to health services (i.e. poverty, immigrants), it can only be a matter of time before there are serious outbreaks of untreatable diseases.

Although the answer to maintaining effective long-term use of therapeutic agents at present lies in a more prudent and rational use of antibiotics in human and animal healthcare, new antibiotics need to be discovered. There are more than 160 antibiotics on the market today with many more in development, although many of the new drugs are variations of existing ones. Some pharmaceutical companies, mainly in the US, are looking for entirely new classes of antibiotics with encouraging results. It has been reported that nearly a dozen new antibiotics show promise in controlling drug-resistant organisms (Table 3).

According to researchers at Upjohn, for example, among the most promising new substances are the *oxazolidones* which have a new chemical structure that is different from current antibiotics and which stop the growth of drug-resistant organ-

Table 3: New Antibiotics

Company	Compound	Target
Upjohn (US)	Oxazolidones	Protein synthesis
Rhône-Poulenc Rorer(FR/US)	Streptogramins	Protein synthesis
Parke-Davis (US)	Boxazomycin	Protein synthesis
Roussel-Uclaf (FR)	Ketolideas	Protein synthesis
Eli Lilly (US)	LY 333328	Cell wall formation
Bristol-Myers Squibb (US)	New ß-lactams	Cell wall formation
Abbot Laboratories (US)	2-Pyridone	DNA replication
Pfizer (US)	New fluoroquinolones	DNA replication
Wyeth-Ayerst (US)	Glycyclines	Protein synthesis
Cubist Pharm.(US)	Inter.-based inhibitors	Protein synthesis

Source: Science, Vol. 270

isms. A series of novel peptide and steroid antimicrobial agents discovered in sharks and frogs have attracted attention at the US biotechnology company Magainin Inc.. Schering has reported that another new anti-microbial agent, *eerninomicin,* isolated from soil bacteria, is active against *Gram+, Saphylococcus, Enterococcus,* and strains resistant to multiple antibiotics seem promising. Other researchers are screening and retooling old compounds, by slightly changing the chemical structure of existing antibiotics, in order to inhibit microbes resistance mechanisms. (e.g. Eli Lilly:'new' vancomycin and Rhone-Poulenc: streptogramins). Research is also under way to develop a drug to block isoniazid-resistance in *Mycobacterium tuberculosis*, the microbial agent responsible for tuberculosis. At least six more compounds are under development. Several companies have preferred to shift their focus from the crowded antibiotic 'arena' to the anti-viral and anti-fungal arenas where competition is limited: the incidence of serious viral and fungal infections has increased dramatically in recent decades mainly because of the increase in immuno-supressed patients. The increased use of anti-fungals and antivirals, as with the increased use of antibiotics, has also induced resistance in a number of species.

Public health officials and researchers consider that, in order to improve the efficacy of future products, pharmaceutical companies should target research to a "narrower" spectrum of antibiotics, limited to certain diseases. This suggestion could limit pharmaceutical companies' profit margins and may reduce their incentives to develop new drugs. Bacterial diseases were not a concern for many companies for several years, due to a small market for new drugs. According to an OTA report, a drug effective, for example, only against MRSA (*methicillin-resistant Staphylococcus aureus*), would currently have a market of 'only' about US$60 million a year, well below the US$100 million benchmark used by the industry to decide whether or not to invest in research in a particular area.

Although international efforts must be coordinated to prevent pandemics, disease surveillance is still a national responsibility

"The saga of microbial resistance to antibiotics demonstrates how little scientists understand of the forces of change and adaptation in the natural world What is clear is that microbes have been around for 3500 million years and will probably still be around before, if ever, the book on infectious diseases is closed". *(Financial Times, Oct.95)*

It will, however, be a long time before the industry brings the new antibiotics to the market. It takes 5 to 15 years for these drugs to find their way through the clinical trials necessary to demonstrate their safety and efficacy, and there is no guarantee any of them will make it that far. The long term consequences for public health need to be considered and a strong research and training effort must be sustained and strengthened in order to avoid the undesirable phenomenon of a reappearance of 'forgotten' diseases. The current level of support for research and training in laboratory and field work on infectious diseases, other than AIDS and TB, is very limited in both Europe and the US.

As the US seems to be the current leader, for the moment, in the development of "new" antibiotics (especially biotechnology-derived products), the EU should support pharmaceutical innovation by establishing priorities and co-ordinating European research efforts in antibiotics. Meanwhile effort should be made to educate professionals and consumers alike about their rational use, according to accepted medical practice.

Efforts at an EU level for collection of comparable data by an appropriate body could become systematic. Information technology is revolutionising communications worldwide and such technology can be applied to disease control programs. Member States, in co-operation with the World Health Organisation (WHO) could develop their surveillance network through health ministries, hospitals, national laboratories and practitioners. Although international efforts must be co-ordinated to prevent global pandemics, disease surveillance is above all the responsibility of each sovereign nation. To ensure that an unusual outbreak is reported when it occurs, efforts in national disease surveillance must be supported and encouraged. The development of a sense of shared responsibility and mutual confidence needs to be developed in the global effort to combat infectious diseases.

Keywords:

Antibiotics, drug resistance, drugs, drug consumption, pharmaceuticals

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Combined Heat and Power Technology:

Technological opportunities and regulatory frameworks

Matthias Weber

Issue: In order to improve the efficiency of the transformation processes along the energy supply chain, new and better technologies need to be introduced. At the same time, our energy supply systems are confronted with far-reaching liberalisation plans. The impacts of these plans on the prospects for new and more sustainable technological options are unclear, leading to the question of whether or not liberalisation is compatible with a switch to a sustainable energy supply trajectory.

Relevance: Combined heat and power technology (cogeneration, CHP) promises considerable increases in energy efficiency on the production side, and is already bordering on economic viability. Diffusion of the technology has been significant over recent years, and further innovative improvements are expected, especially for small-scale cogeneration units. Whereas some experts expect liberalisation to further boost the wider diffusion of cogeneration, others are pessimistic. Identification of the underlying reasons for this disagreement is of crucial importance for a realistic assessment of the merits and dangers of liberalisation, and hence for the definition of an efficient regulatory framework.

The disputed advantages of cogeneration

Cogeneration technology can be defined as the simultaneous generation of power and useful forms of heat, in the same process. In principle, cogeneration can transform the chemically-bound internal energy of the fuel into electricity and useful heat at **up to 90% efficiency.** This is an obvious advantage compared to traditional power-only plants which allow efficiencies of typically up to 40% (large coal-fired power stations), and in best cases (combined cycle gas turbines) up to 55%. CO_2 emissions can be reduced by a similar order of magnitude, or - depending on the input fuel - even higher. However, a couple of additional considerations should be kept in mind when looking at these data. The comparative advantage of CHP depends on the specific conditions used in the analysis. For example, CHP can typically only be used to cover the base-load of an individual site, so, where heat and power loads vary significantly from the base-load, cogeneration needs to be supplemented by conventional technologies. This represents a significant constraint for the use of CHP. Other factors relevant for the environmental comparison of CHP with other supply options are the level of optimisation of system operation, heat and power transmission losses and the fuel transportation chain. A comparative reduction of CO_2 emissions in the order of 10-20% should be regarded as a realistic value.

Cogeneration technology (CHP) allows simultaneous generation of power and useful forms of heat, with high efficiency and reduced emissions compared to traditional power-only plants

Notwithstanding these considerations, experts are agreed that CHP allows substantial increases in the fuel efficiency of our energy supply systems, and a comparable reduction in CO_2 emissions. Its wider diffusion therefore represents a desirable goal for our medium-term energy future.

Recent and future technological developments

A great variety of technological solutions apply the principle of cogeneration, each adequate for particular types of applications and heat requirements (e.g. steam or hot water). Systems based on engines (gas and diesel), on gas turbines, on steam turbines or on combinations of the latter have been realised on a wider scale. Steam turbines and combined cycles are typical for large district heating and industrial schemes. The small-scale systems have a power range of up to a few megawatts per unit, corresponding mainly to engine-based solutions or small gas turbines. They can be used in large individual buildings, group heating networks, and on industrial sites.

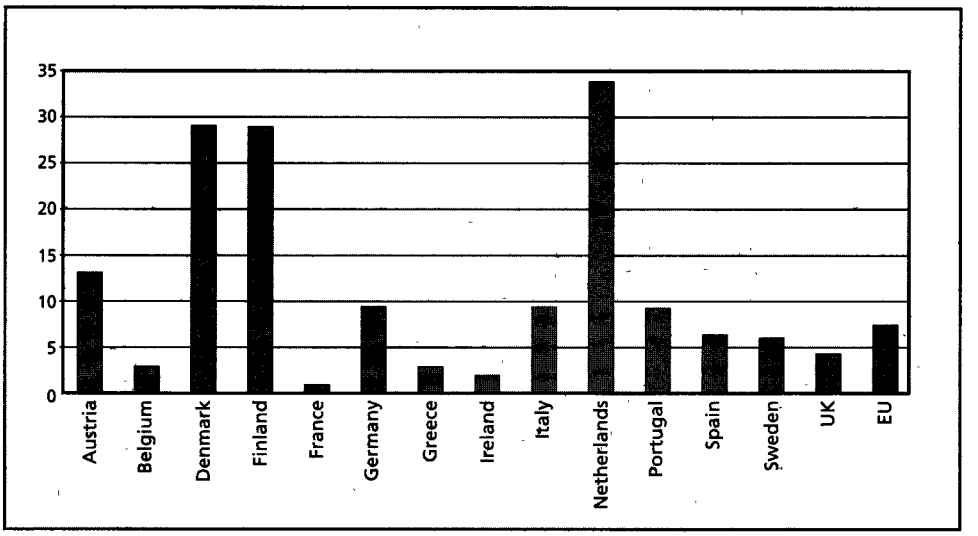
Small-scale CHP has advanced enormously in recent years

Small-scale cogeneration technology has made enormous advances in recent years (see Box 1). **These developments are expected to continue over the next few years**, complemented by a substantial price drop due to standardisation and series production. Furthermore, whereas in the past CHP has mainly benefited from spin-offs from other industries, the growing size of the CHP-market has led to more **targeted development efforts**. One of the most promising medium-term hopes for CHP-technology is, nevertheless, a rather general power technology, namely fuel cells. However, at present prices these are still prohibitive, and reliability needs to be further improved.

Box 1: Main improvements of small-scale cogeneration technology

- Development of small gas and diesel engines down to a size of about 5 kW per unit, although the limit of economical viability is still around 50 kW.
- Gas-turbines are now available at much smaller sizes than a couple of years ago (down to 50-100 kW per unit) with good economic performance of units in the range above 500 kW. In addition, the average electrical efficiencies have been improved considerably.
- Considerable reductions of the comparatively high investment costs due to the onset of series production, especially in the range of 0.2 to 1 MW engine-based systems.
- Higher reliability and lower maintenance costs, achieved through the development of sophisticated on-line control systems to monitor and optimise system operation.
- Ancillary equipment to optimise system operation, e.g. by combining CHP with absorption chilling systems for higher load factors in summer, or heat storage systems to buffer daily variations of heat load.
- Improvement of the combustion process and the development of catalytic systems in order to achieve higher environmental standards.
- Considerable learning effects in the area of system integration, providing well designed and fitted components and "packaged" solutions.

Figure 1: Share of cogeneration in European electricity production in the early 90s



Source: COGEN 1995

Diffusion patterns in Europe are diverse

Barriers to diffusion in Europe

Diffusion patterns of cogeneration technology are rather diverse in Europe, ranging from a negligible contribution to power supply in France and Ireland, to about 30% or more in Denmark and the Netherlands where market saturation appears to have been reached (COGEN, 1995). Overall, CHP supplies about 7% of European electricity production. Whereas large-scale district heating is stagnating, industrial applications are growing moderately in most countries. All countries with a non-prohibitive regulatory framework have witnessed a fast growth of small-scale CHP applications since the mid-80's, although starting from a very low level. The most dynamic markets for small-scale and industrial CHP can be found at present in the UK, Italy, Spain and Germany.

The technical and cost developments, as well as the recent diffusion patterns, seem to promise a bright future for CHP. However, the opportunities of CHP at the lower end of the power range should be regarded with caution. One of the main difficulties of CHP is its complexity: it is much more complicated than a heat-only boiler plant and a connection to the electric grid, hence **requiring specialised skills and knowledge** for plant design and operation. In addition, CHP needs to be adapted to the specific conditions of the site. Consequently, although in principle the technical problems at the low end have been overcome, and economically viable solutions been realised, the successful implementation of CHP still depends to a large extent on the competencies of local operators and planners. New arrangements like **contracting** could alleviate these difficulties but have not yet fully entered the small-scale market. In addition, a higher level of **standardisation** of equipment would be very helpful - both with regard to economies of scale and to simplified operation.

Regulatory environments differ across countries, and are often not compatible with the requirements of CHP

Another obstacle for CHP has been gradually overcome in recent years, but is still relevant in many Member States: the **regulatory and organisational framework**. Differing considerably among the Member States, these frameworks are often just not compatible with the requirements of CHP and have been set up to suit a power infrastructure based on large-scale power-only plants. Due to the constraints on heat transmission, CHP inevitably implies a decentralisation of power supply, and the combined produc-

Various electricity tariffs, fuel costs, and equipment cost determine economic viability of CHP

tion requires horizontal coordination of supply chains. In several countries **decentralisation of organisational responsibilities and horizontal coordination of supply chains** would therefore be required in the energy supply industries in order to match the technological characteristics of CHP.

Whether liberalisation will help CHP depends on local institutions and ability to coordinate

The interface between users and the electric utilities is of crucial importance for the feasibility of CHP-plants, i.e. the different electricity tariffs applied (for supply, back-up, stand-by and surplus power) and the technical conditions for grid connection. Together with the fuel prices and the additional investment costs for CHP-equipment, they determine the economic viability of a project. The prevailing type of electric utility has **a double-edged interest with regard to CHP**. Whereas utilities do not usually have any incentive to support independent power plant projects, they are often quite interested in operating CHP-plants of their own, or at least in participating in projects, especially if they are horizontally integrated suppliers of electricity, gas and heat.

Reforms of the electricity supply systems have led to a significant increase in CHP-capacity in some countries, backed in some cases by financial incentives (e.g. in the Netherlands). In others, the situation has been helped by the removal of administrative and institutional barriers (Germany, Italy), or the existence of a reliable long-term energy policy conducive to CHP (Denmark) (OECD/IEA). Liberalisation of energy markets is often seen as helpful for cogeneration because it removes the barriers put up by the utilities to protect their monopolistic positions against independent power generators. Furthermore, a variety of **specialised services can emerge** which facilitate the planning and operation of independent power projects. On the other hand, **liberalisation undermines the long-term coordination and system integration function** fulfilled by monopolistic utilities.

Investors' short term criteria may undermine CHP prospects

For potential CHP-investors the situation is equally ambiguous. Large electricity users, expecting a drop in power prices due to competition, perceive CHP as unpromising. Others, like small companies and commercial users, who usually do not count on price reductions, identify CHP as an opportunity to become more independent from the utilities. However, these two groups of investors will apply very strict payback criteria for non-core investment - typically two to four years. The third main group of investors, power generating utilities, who usually apply longer time horizons for their investment (up to 20 years), are also forced, in a competitive framework, to apply much stricter investment criteria. Although from an environmental point of view, CHP may be the superior solution, they lose the flexibility to take these aspects implicitly into account - as has happened frequently in the past. Hence, **unless environmental externalities are integrated in the cost-benefit calculations for energy supply projects (e.g. by taxes), the commercial logic will dominate investment decisions at the cost of the environment**.

In the UK and Spain, the enabling effects of liberalisation seem to have prevailed, and the markets for CHP have grown rapidly over recent years. Before liberalisation the potential was almost completely blocked by fierce resistance from the utilities. The release of natural gas as a fuel for power generation has also triggered the growth of gas-fired plants. The examples of Denmark with its cooperative though monopolistic energy policy framework, of Germany with its strong local utilities, and of the Netherlands where a combination of liberalisation and financial incentives has been applied, show that **the diffusion of CHP is not just a question of whether the overall framework is "monopolistic" or "liberalised". Rather it depends on the organisation of incentives inside each of the frameworks, and how**

far coordination and system optimisation can be achieved. There is little evidence that liberalisation by itself would improve the conditions for CHP. The national histories, institutions and structures determine whether a liberalised framework would be helpful or not.

CHP and liberalised energy markets in Europe

Based on the preceding analysis, the effects of a liberalised Internal Energy Market in Europe on CHP can be expected to differ considerably among the Member States, and could be both positive and negative. In particular, where countries already have a conducive framework for CHP, liberalisation could have a damaging effect. Until now the proposals to liberalise the grid-bound supply systems for gas and electricity have had two major consequences. Firstly, they have created a lot of **uncertainty among potential investors and the utility companies regarding CHP**. This has led to a delay in the diffusion of environmentally-beneficial investment in CHP, at least until more stable and reliable planning conditions prevail. Secondly, they have **stimulated preparatory adjustments of the national frameworks** in those countries with unfavourable institutional settings (e.g. Italy and France), thereby opening up new opportunities for CHP. However, given that long-term investment in energy supply requires a **stable and reliable framework**, a decision on the future European energy supply framework is required as soon as possible. If no decision is taken, the present window of opportunity to switch to a more decentralised and efficient energy supply trajectory - based on a larger share of CHP - could be missed simply because of the uncertainties of the regulatory framework.

Conclusions

CHP is widely recognised as an attractive option for improving energy efficiency in the short- to medium-term. Although small-scale CHP has progressed considerably in some Member States in recent years, future prospects remain uncertain. Further technical improvements can be expected over the next few years, increasing both the technical and the economic potential. However, the successful application of CHP is still confronted with obstacles at the user level. These could be overcome by the development of more "user-friendly" technology and the dissemination of further information to potential users. Stable and reliable regulatory frameworks are also necessary to provide a solid planning base for long-term investment in energy supply systems like CHP. The question of whether a liberalised framework is conducive to the use of CHP cannot be answered in general. In fact, it is likely to have a double-edged impact on CHP, depending on the specific organisation and history of energy supply in each Member State. In countries where utilities are still in a position to prevent investment in CHP, liberalisation appears to be a helpful solution. However, introducing strong competitive elements in countries with cooperative organisational patterns in the energy supply sector could endanger the further diffusion of CHP.

There is a window of opportunity for a more decentralised and efficient energy supply trajectory

Keywords

cogeneration, combined heat and power, liberalisation, energy markets, environment, energy policy, regulation

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Decisions in a Climate of Uncertainty:

Addressing the CO_2 issue

Astrid Zwick

Issue: Decision-making under scientific uncertainties is difficult. Although the latest assessment report of the Intergovernmental Panel on Climate Change (IPCC) emphasises the anthropogenic influence on climate and proposes a rapid reduction in CO_2 emissions, many critics still doubt the scientific evidence to support this view. Given this uncertainty, the issue of CO_2 emissions needs to be addressed in an integrated way in order to realise appropriate response strategies.

Relevance: The issue of CO_2 is not only a matter of concern for climatologists. Increasing energy consumption and the depletion of our fossil energy sources demand an awareness by policy makers of the limitations of our energy supply. Both possible threats, the impact of CO_2 emissions and the depletion of our fossil energy, justify the consideration of controlled energy consumption via a stronger introduction of modern technologies. The following article analyses the points of concern about CO_2 emissions and explains why it is time to react.

Decision-making is prompted by a perceived need for action. This perception results from a change in our natural environment which, if sufficiently intense, will have a significant impact on the world's ecosystem and on human welfare. The perceived change in the global climate is one of the issues that needs to be addressed.

There is **a striking correlation between the increase in *anthropogenic CO_2 emissions* (about 7Gte carbon/year), the increase in *atmospheric CO_2 concentration* (about 30% from pre-industrial to industrial times) and an *observed increase of temperature* of about 0.3°C to 0.6°C during the last 150 years**. However, uncertainties arise when comparing this to the natural climatic oscillation pattern, since this observed temperature increase still lies within the range of natural variability. In the scientific community, there is a growing awareness of natural climate changes due to *external factors* such as *long-term solar activity cycles*, predominantly the 80 year solar sunspot cycle, that might have an impact as large as the changes in CO_2 concentrations (Cubasch, 1995). Usually this external forcing leads to internal oscillation modes, like oceanic circulation changes that, in turn, result in further *feedback mechanisms* forcing climate to change apparently irregularly. In addition, the natural warming may be reinforced by the effect of anthropogenic greenhouse gas emissions.

The observed temperature increase still lies within the range of natural variability

Given the scientific uncertainties, why should we react? While we have to wait for scientific answers about the extent of climate change and its possible causes and impacts, decisions based on these results may arrive too late. The argument in favour of prompt action is supported by our understanding of the causes of past climate

Anthropogenic influence can drastically reinforce small-scale natural oscillation leading to disproportional climate impacts

changes, revealing that only small environmental perturbations can easily change the whole pattern of the atmospheric circulation. Over the last 10,000 years the climate has been unusually stable suggesting that, in the longer term, a more prominent change is likely. Indeed, scientists have detected natural climatic oscillation patterns of timescales shorter than those originating from astronomical forcing. These *small scale oscillations* could be reinforced by anthropogenic influence and, thus, may have substantial effects on the world's ecosystem and human welfare. Against this background precautionary measures are justified.

Regardless of cause, action may be justified due to the potential effects and impacts

Possible impacts of climate change

Apart from an increased *desertification* in certain areas and recurrent *flooding* in others, scenarios of the future greenhouse world foresee a *rise of the global sea level* of between 0.3m and 1.0m by the year 2100, if the greenhouse gases alone are considered (IPCC, 1995). This, of course, affects small island states worried about their existence. Even though the extent of the anthropogenic contribution to global warming remains uncertain, sea level is expected to rise due to natural climatic fluctuations. **Whatever the cause, action is required.**

Depletion of fossil fuels by itself justifies efforts towards energy efficiency and alternative sources of energy

Other possible, and important, impacts of climate change include precipitation changes and a shortage of water resources. This would affect agricultural productivity and thus the food supply, and possibly threaten the economy of those countries relying on the export of agricultural goods. Another burning topic is the increase in *catastrophic weather events* resulting from global warming (IPCC, 1992). However, weather extremes due to global warming are statistically not yet significant, again revealing the lack of confidence in probabilistic assessments of climate extremes (Hasselmann, 1995).

There is an opportunity to avoid developing countries being locked into fossil fuel technology from the start

Climate change uncertainty and energy supply - looking for a compatible approach

The scientific uncertainties lead to different interpretations of the issue of climate change. From a *fatalist's* point of view, the issue is considered to be completely out of human control. Certain industrialists believe that there is no real problem, unless proven otherwise, while some environmentalists believe that the earth is on the verge of disaster. The hierarchist's view is that there is a limit to the extent that the environment can tolerate human activities and we are (usually) comfortably within this limit (Paoli, 1994). This latter view comes closest to that of today's Western governments, cost-benefit analysts and many scientists.

There remains another possible approach to this problem. While environmentalists are primarily concerned with minimizing greenhouse gas emissions, this can be linked to addressing the problem of the *depletion of fossil energy resources*, as the combustion of fossil fuels is a major source of CO_2 emissions. It is expected that most of our fossil energy resources will be depleted within the next century, demanding a re-consideration of our conventional energy sources and a switch to *energy efficient and alternative technologies* (Peet, 1992). In addition, the start-up time for a new technology needs to be considered, given that it could take several decades before a new technology becomes fully commercialized and competitive.

Thus, it is time to work out *strategies that address both the problems related to the threats of climate change and meeting future energy demand*. The latter is important since it is doubtful whether social behaviour can be drastically changed in terms of energy consumption habits. Moreover, the largest share of greenhouse gas emissions will soon come from the developing countries. These countries have a growing de-

mand for energy and it could be wise to introduce modern energy efficient or alternative technologies at an early stage, to *save money on energy consumption* in the long term (Hess, 1994). However, high investment costs would require some financial assistance from the developed world. Given the global relevance of greenhouse gas emissions, developed countries also stand to benefit from this investment.

Options and costs

There are several categories of potential strategies which would enable us to deal with the approaching limits of the natural environment and the depletion of our fossil resources (GAO, 1990). Apart from being *inactive*, **adaptation** may be a solution. This would involve adjusting to the environment, or our ways of using it, to reduce the consequences of a changing climate. The range of responses include avoiding the development of unprotected coastal areas, developing more heat-resistant strains of crops and using water more efficiently.

A second option, moving beyond the passive approach, would be the implementation of **limitation** strategies to control or stop the growth of greenhouse gas concentrations in the atmosphere, thereby reducing the anthropogenic influence on climate change. Limitation strategies would also slow the rate of fossil fuel exploitation. Significantly, slowing the rate of the anthropogenically-enhanced global warming would make it easier for society to adapt to changes. However, while limitation strategies require worldwide cooperation, adapting to the consequences of global warming do not.

There are a range of actions that could be implemented within a limitation strategy. On the one hand, 'no regret policies' (encouraging low key changes in lifestyle and energy consumption patterns) could be beneficial in terms of energy saving and reduced social costs; on the other hand, draconian measures, such as ecotaxes and traffic regulations, may have a more immediate impact but prove more costly. Another possible strategy involves reducing our reliance on fossil fuels, which currently provide over 75% of the world's energy, by increasing energy efficiency, or by replacing fossil fuels with alternative energy sources. A more controversial solution would be to reduce atmospheric CO_2 concentrations through the storage, disposal or sequestration of CO_2. However, the economic viability of such technologies is in question.

Strategies include adaptation of, for example, water resources and coastal zones.. .

The latest IPCC report proposes an immediate reduction of CO_2 emissions by 50-70% in order to stabilise atmospheric concentrations at their present levels (IPCC, 1995). However, the scientific justification for such drastic and costly action is questionnable as research has shown that natural carbon sinks are able to increase their uptake capacity as they absorb CO_2 This also demonstrates the importance of reliable predictions and detailed observations of climate change for the development of effective controls on greenhouse gas emissions and adaptive measures.

..and limitation of greenhouse gases emissions

Previously proposed international policy instruments, such as country-by-country targets, carbon taxes, and tradable permits, face major difficulties as stand alone proposals. The use of *tradable emission permits*, for example, could lead to a control of CO_2 emissions via the world market (Klusmann, 1995). They would be distributed according to each country's economic situation and using the principle of burden-sharing. Over time, the number of permits could be reduced and the tax rate increased if improved scientific knowledge so dictates (Harvey, 1995).

Tradeable permits could help reduce CO_2 emissions, but their initial distribution is a source of discord

Recent negotiations for voluntary *CO_2/energy taxes* in an EU framework have broken down and will not be revived in the short term. However,

Although our approach needs to be informed by scientific evidence, there are other dimensions to the issue which call for action, and do not depend on a definitive scientific answer

they were considered to be a viable option for the control of CO_2 emissions (Europe, 1995). The debate centres around the use of harmonised CO_2/energy taxes after a four-year voluntary period, or a 'pure' CO_2 tax. The EU Member States have not yet come to an agreement. The carbon tax would encourage the use of less carbon-intensive fossil fuels, a switch to renewable energy sources, and more efficient use of energy more efficiently. Notably, recent calculations suggest that tax implementation would only result in a 5% reduction of global CO_2 concentrations, and thus lead to a 0.8% reduction of the increase in temperature (Böttiger 1995).

Estimating the costs of global climate change is controversial. In the latest assessment report of the IPCC, estimates showed that the costs of repairing damages caused by climate change, such as catastrophic weather events, are less than the costs of implementing strategies to reduce greenhouse gas emissions (Masood, 1995). These estimates were made on the assumption that the value of a life in a developing country was about one-fifteenth the value of a life in the developed world.

The development of environmental policy needs, therefore, to assimilate massive conflicts between different assumptions, values and, last but not least, costs. The need to control CO_2 emissions and safeguard our energy supply appear to be two different problems, but they are in fact compatible. Since both issues may be a threat at the same time, it could be wise to react in thinking about economically suitable measures for all possible events. Any international agreement made in response to the possible and serious environmental threat is now based upon the precautionary principle. However, ***it must be flexible and capable of adjustment as new scientific results become available***, since the scientific facts do not yet provide the right grounds for implementation strategies. While scientific uncertainties concerning the climate system and its behaviour create a nice "shopping list" for future research, there are compelling reasons for decision-makers to address the CO_2 issue now. Technical solutions are not able to stop climate change but they can delay an anthropogenic contribution to global warming and reduce the pressure on our fossil fuel resources.

Keywords:

CO_2, climate change, fossil fuels, sustainable development, energy policy, energy taxes, emission permits

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Toward the Zero Emission Vehicle:

The role of the hybrid car

Hector Hernández, Patrick Canarelli

Issue: Automotive technologies need to adapt to meet the contradictory demands of, on the one hand, market expectations of higher performance and, on the other hand, public concern for more environmentally-friendly vehicles.

Relevance: Fierce competition between existing technologies and alternative ones that should meet tighter requirements is likely to reshape the automobile industry over the medium to long term. In this context, hybrid vehicles may have an important role to play in paving the way towards the cleaner car.

The hybrid concept

The automobile has to adapt to contradictory demands resulting, in particular, from public requirements for more environmentally-friendly transport and ever higher vehicle performance. In this context, a large range of options are being explored, yet dogmatic positions hinder the debate.

Contradictory demands for vehicles that are environment-friendly AND offer high-performance

On the one hand, the currently dominant vehicle, powered by internal combustion engines (ICE), seems to offer some room to decrease fuel consumption and emission of local pollutants, but does not appear to be the required solution for the long term. On the other hand, the zero emission vehicle (ZEV), such as the electric vehicle (EV), is strongly limited by the low, present and foreseeable, capacity of on-board electrical energy storage systems.

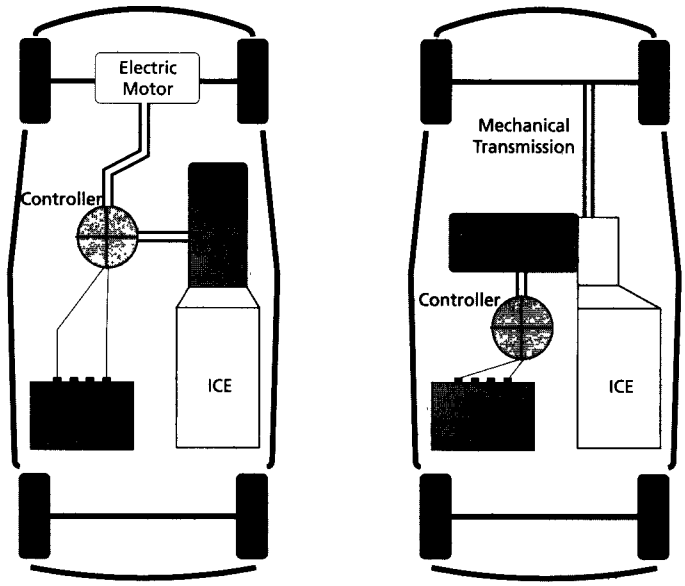
could be met by hybrid vehicles combining characteristics of both internal combustion engines and electric vehicles

A third option is the hybrid vehicle (HV) which attempts to combine the advantages from both the ICE vehicle and the EV. Hybrid vehicles have been studied extensively over the last decades but recent progress in energy storage systems, electrical devices and control electronics seem to make them more practical today. **Besides offering a large potential for providing an ultra-low emission vehicle (ULEV or below), the hybrid vehicle may actually help the eventual introduction of EVs.**

The main idea behind the hybrid concept is to combine the internal combustion engine with another power source so that it operates as close as possible to the optimal conditions. For reasons of versatility, efficiency and compactness, the most suitable associated power source is an electrical system comprising an energy storage system, typically batteries or flywheels (see *IPTS Report N°00, December 1995*).

Depending on the configuration of the two power sources, two main types of HVs have been developed, namely serial and parallel, as depicted in Figure 1.

Figure 1: Description of hybrid vehicles



Serial Hybrid Parallel Hybrid

Serial hybrid vehicle

In the serial version, the ICE only drives an alternator which charges an electric storage system (e.g. a battery pack), which in turn powers the wheels through one or more electrical motors. Because the engine runs at a fixed regime, it can be operated close to its minimal emission and highest efficiency levels. Results reported so far indicate that the serial HV may achieve emission levels well below the ULEV limits.

An important drawback of serial HV concerns a lower electrical transmission efficiency (including the storage system), which may, however, be compensated by the higher efficiency of the optimised engine. In addition, the HV has a narrow range of optimal operating conditions and a high performance sensitivity to the respective importance of the ICE and electrical system. Thus, multi-purpose usage HV appears to be difficult to achieve. For instance, in order to cope with high power demands, an oversized electrical transmission is necessary, thus affecting vehicle efficiency.

Parallel hybrid vehicle

The parallel hybrid vehicle is configured in such a way that the ICE and the electrical motor work simultaneously in parallel. The combination of the power sources can be arranged in several ways. A possible configuration is to place the electrical motor on the mechanical transmission line, before or after the gearbox. Then, a strategy to use the power sources is devised according to the desired characteristics (e.g. to provide average and peak power demands).

In principle, the parallel configuration offers a higher overall efficiency of the transmission chain and the possibility of mechanically transmitting a higher power to the wheels, yet, at the price of potentially higher emissions (ETH, 1995).

Design must aim to benefit from the advantages of ICE and electric vehicles while avoiding their drawbacks

Comparative characteristics of hybrid vehicles

There are many common features to both types of HVs. Their arrangement covers in principle the range from pure ICE vehicle to pure EV. It allows, as in the case of pure electric vehicles, the recovery of braking energy which can, particularly in urban driving conditions, substantially reduce fuel consumption. Furthermore, **HVs have the potential to gain from the respective advantages of both power sources.** Yet vehicle optimisation is critical, and badly designed HVs can, on the contrary, lead to the drawbacks of both ICE vehicle and EV.

From past experience, it is known that this important issue of optimisation has no single solution: it is, to a large extent, dependent on vehicle requirements. Optimisation can be carried out at conceptual and operating levels. The type of vehicle usage (e.g. trip pattern) determines, in particular, engine and electrical motor sizes, and the electric energy storage capacity. This has important consequences for refuelling time and for vehicle performance such as range and acceleration capabilities. Concerning vehicle optimisation during operation, there is a need for greater use of "intelligent" controllers and for electronic management systems generally.

Production costs are a concern, but not significantly higher than EVs

A common drawback of HVs is obviously their production cost which would be substantially higher than today's ICE cars. However, compared with EVs the cost is not significantly higher, due to the need for a smaller (cheaper) electrical system which compensates partially the ICE cost (SAE 2, 1994). In addition, costs could be partially offset by lower running costs and particularly by a higher durability of the engine.

The main differences between serial and parallel HVs are in the extent of optimisation of fuel consumption and emissions. The serial HV offers a higher potential for engine efficiency and emission optimisation, yet at the price of a lower electrical transmission efficiency which may have negative impacts on fuel consumption. On the other hand, the parallel HV enables a potentially lower fuel consumption, but with higher emission levels.

In comparing the respective benefits of hybrid vehicles, ICE vehicles and EVs, a large set of criteria have to be considered. A qualitative comparison of these technologies, with regards to technical performance, is summarised in table 1 for a typical case.

Table 1: Qualitative comparison of hybrid, ICE and EVs
Assessment relates to a four passenger car under urban driving conditions

	Energy consumption	Local emissions	Range	Acceleration
ICE vehicle	- -	- -	+ +	+ +
HV serial	-	+	+ +	+
HV parallel	0	0	+ +	+ +
EV	- / 0	+ +	- -	-

Note: scale in progressive order of performance: - -, -, 0, +, + +

The broader perspective

Besides technical considerations, there are broader aspects that need to be examined. Diffusion of technology is both dependent on and influenced by several factors outside the purely technical area. Thus, diffusion of hybrid vehicles would, on the one hand, only be possible if certain criteria are met and may, on the other hand, result in some important changes in the area of individual transportation technology.

Non-technical aspects are important for technology diffusion

It goes without saying that any significant diffusion of hybrid vehicles will require widespread user acceptance. Such acceptance would eventually induce interest from the car industry and then result in mass production. **Although the acceptability of new car technology is determined by a large number of criteria, some need to be absolutely fulfilled: low cost, high performance and convenience**.

The **cost** of hybrid vehicles is strongly dependent on the volume of production - which underscores the importance of the regulatory framework, especially in the early introductory stages.

Performance concerns, above all, range and acceleration. The very principle of hybrid vehicles allows for a range comparable to that of ICE vehicles. Because HVs can cover the full range from ICE vehicles to EVs, the acceleration capabilities are largely variable. Thus, other drawbacks apart, the HVs' performance should not be too far from that of conventional vehicles.

The **convenience** of vehicles relates especially to their "freedom" (range) and ease of refuelling. Since HVs can, in principle, be refuelled either with gasoline or by recharging their electrical energy storage system, convenience will be boosted by the possibility of using the existing high density network of petrol stations.

The hybrid nature facilitates refuelling, thanks to the existing network of petrol stations

Thus, it appears clear that **their greater acceptance gives HVs a chance of substantially higher diffusion than EVs.** Important consequences would then be induced with significant impact on the EV itself, relating particularly to the issues of fuel infrastructure and technological investment.

With the growing diffusion of HVs, electric utilities would have large incentives to initiate adaptation of the electricity network to fulfil their developing recharging needs. This adaptation would especially concern the setting up of home and public overnight recharging facilities. This is, indeed, an example of how a hybrid concept can be used to overcome technology lock-in, and enable the eventual transition to a different technology.

but also increases incentives for the creation of a network of recharging stations, and thus improves prospects for pure EV

Car makers too would have incentives to invest in hybrid vehicle technology as the niche develops, and with it competition within the car industry. Although requiring some specific R&D effort, related in particular to combining both power sources (e.g. with controllers), HVs are largely a mix between traditional (ICE vehicle) technology and EV technology. Investment in HV development would thus probably be of benefit to both. In addition, investing in a dual technology transport means might, as an important consequence, offer reduced risks associated with technological development.

Hence, the dual fuel and dual technology system that is inherent in hybrid vehicles may be an efficient way of solving the "chicken and egg" problem related to technological development and fuel infrastructure. HVs may help ease the acceptance and the subsequent introduction of pure EVs, in particular with the help of private investment.

The dual technology of HV reduces the investment risks related to technology development

Toward cleaner cars

It seems that the automobile will evolve inevitably toward a zero emission vehicle. The most representative option to date, the EV, appears far from being ready for wide diffusion. Thus, a transitory solution can be envisaged for shortening the delay by which more environmentally-friendly automobiles will become available.

This is the role that may be devoted to hybrid vehicles. Besides being an elegant and smart technological option, HVs offer important advantages. Firstly, even if they are not actual ZEVs, they significantly reduce two drawbacks of present cars related to energy consumption and emissions. Secondly, they have the potential for easing and shortening the eventual introduction of pure EVs thanks to the resulting build-up of fuel infrastructure and the general speeding up of EV technology. A third positive aspect arising from investing in HV technology would be the reduction of development risks inherent in any dual technology product.

Thus, the hybrid vehicle and the electric vehicle should no longer be considered as mutually exclusive options. Instead, the HV could actually pave the way to the cleaner car of tomorrow.

Keywords:

Transport technology, electric vehicles, hybrid vehicles, zero-emission vehicles, energy consumption, energy storage, dual technologies

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Wastewater Reuse:

Ever more a resource for the future

Laurent Bontoux

Issue: Due to the increasing pressure on water resources in many areas of the world, issues of reliability of water supplies are becoming acute. As a consequence wastewater reuse is being developed, mainly for irrigation.

Relevance: In spite of the fact that technology exists to make wastewater reuse safe, the development of wastewater reuse is raising public health concerns and generating hot debates about microbiological quality standards, Many developing countries do not have the know-how nor the financial means to apply this technology systematically. Differences in standards and in the practice of wastewater reuse in different countries create distortions in its acceptance. This raises a number of issues ranging from the public health of local populations, to international competition for tourism or exports of fruit and vegetables.

In spite of being sufficient on a global scale to satisfy human needs, freshwater resources are unequally distributed in time and space, creating local difficulties in water supply. Additionally, in the last few years, and besides the occurrence of local droughts, a combination of increasing irrigation to satisfy the food needs of a growing population, economic growth and industrial demands have created acute water shortages in many regions of the world. In industrialized countries, while drinking water treatment is becoming more and more expensive due to pervasive pollution, the quality of wastewater effluents is steadily improving, sometimes exceeding the quality of the receiving streams. In this context, as existing natural water resources reach their limits or are polluted in an ever-larger number of regions, wastewater reuse is becoming one option to make ends meet. This raises the issue of the reliability, quality and public acceptance of water supplies.

Population, economic growth and industrial demands are creating acute water shortages in many areas of the world

Wastewater reuse applications

Wastewater reuse applications are essentially of five types:

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

Wastewater reuse can also be entirely controlled ("pipe to pipe") or occur after blending with non-reclaimed water (e.g. after groundwater re-

Europe faces local water shortages, environmental constraints and pervasive pollution

Treatment technologies exist to reach any desired water quality

Process reliability, public acceptance and trace pollutant issues have so far limited potable reuse to extreme cases

charge). All applications require wastewater treatment prior to reuse and each may need to meet a variety of quality requirements.

In industrialized countries, the increasing cost of water and wastewater treatment due to pervasive pollution, coupled to ever higher quality requirements for wastewater treatment, make the treated effluents increasingly attractive for reuse. In developing countries, wastewater reuse presents the triple advantage of preserving water resources, avoiding pollution and avoiding adverse public health impacts. Thanks to this, and to its high reliability as a water supply, wastewater reuse is now joining the mainstream within water supply strategies.

Irrigation: the main form of wastewater reuse

Serious research on wastewater reuse is being carried out in places as diverse as the USA, Australia, the Middle East (especially Jordan and Israel), the Maghreb and Southern Africa, to cite only a few. Due to its generally abundant water resources, Europe has so far not invested heavily in this issue. However, this general situation hides very diverse realities as the recent acute drought in Spain is reminding us. Besides local water shortages, increasing environmental constraints and pervasive pollution everywhere in Europe are generating renewed interest in this practice. Because irrigation accounts for by far the largest use of water in the world, and the quality requirements are among the easiest to achieve along with a few industrial uses, it is the largest reuse application in terms of volume. In the future, because of an increasingly urban world population, its proximity to wastewater, the existence of suitable technologies and the general increase in the quality of wastewater effluents, potable reuse could become increasingly popular. However, this raises issues such as its now apparently high cost, process reliability and public acceptance. Other reuses now appearing in cities are non-potable household uses through secondary water distribution piping networks (e.g. toilet flushing, car washing, garden irrigation,...). Examples exist in Tokyo, St Petersburg and Florida (USA).. This type of application is limited by the costs of installation of a double piping network and the dangers of cross-connection to the drinking water supply.

Secondary non-potable water distribution networks are being tried for the domestic reuse of treated wastewater but the installation costs are high

Quality requirements

Since wastewater reuse is usually practiced as a water supply strategy, the reuse application dictates the required water quality, which in turn will determine the treatment technology needed (and the associated cost). Treatment technologies exist to reach any desired water quality. Wastewater reuse is exceptionally carried out for sanitation purposes, mainly in Europe.

Therefore, every type of wastewater reuse calls for its own quality standards. Industrial reuse specifications are non-controversial since the necessary water quality is determined by the industrial process requirements. The economics of the operation are industry specific. Potable water standards are not very controversial but process reliability, public acceptance and trace pollutant issues have so far limited potable reuse to extreme cases. Because groundwater recharge also provides a form of water treatment that has been shown to be efficient, discussions around recharged water quality remain usually limited to nutrient levels (phosphates and nitrates) and pesticide residues requirements in the case of percolation. Direct injection recharge has higher quality requirements because of potential clogging of the installations.

Microbiological quality standards

While wastewater is an attractive source of water for irrigation thanks to its fertilizing capacity, the microbiological quality standards applicable according to the type of irrigation practiced and the type of crop irrigated are currently hotly disputed. The issues are essentially confined to "unrestricted" irrigation (vegetables that can be consumed raw, sports fields,...). Many industrialized countries, especially the USA (led by California), and providers of technology usually promote a stringent stance (comparable to drinking water), confident that the most expensive technology provides safe enough water (i.e. free of enteric viruses and parasites) for those who can afford it. However, developing countries with severe water shortages call for epidemiological studies to defend existing, less stringent WHO quality guidelines. Viruses are difficult (and expensive) to monitor. Therefore, the WHO guidelines, prepared with the needs of developing countries in mind, only prescribe a limit for faecal *coliforms* (<1000FC/100ml) and eggs of intestinal nematodes (<1/litre). Faecal coliforms are used as indicators of the potential presence of viruses. As a consequence, the whole argument revolves around the validity of such limits as a sufficient guarantee of safety for the water used in irrigation. One must also realise that in the cases where raw wastewater is directly reused, the WHO guidelines are already a major step forward. For example, while not covering viruses nor faecal *streptococci*, they are more stringent than the European standard for bathing water on faecal *coliforms* (<2000FC/100ml).

Epidemiological studies are notoriously difficult to carry out and their results difficult to interpret. Besides the strictly statistical questions they raise, it is always extremely difficult to single out a parameter to determine a clear cause/effect relationship. Additionally, immunity build up and variability of sensitivity between human populations render results difficult to extrapolate or transpose.

Debates on microbiological quality standards reflect the priorities of wealthier countries rather than poorer ones

Economic and social aspects

These questions are very relevant and the stakes are high for four main reasons:

1. In many developing countries with water shortages, the direct reuse of raw or poorly treated wastewater for irrigation is common (e.g. Morocco). This is causing serious public health problems weighing on the well-being of local populations and on the local economy. A high rate of morbidity decreases productivity (e.g. diverts resources to take care of the sick) and generates healthcare costs.
2. The tourism sector is increasing worldwide and becoming more international. Developing countries are attractive destinations and international tour operators take advantage of favorable local conditions to establish hotels and vacation villages which can often be a significant source of income for the host countries. In their large majority, tourists come from industrialized countries where water quality is good. If diseases spread in their holiday destinations due to low water quality and contaminated fruit and vegetables, they will not return and will generate bad publicity. Thus, the economic stakes can be high both for the tour operators and the host countries.

In sunny areas of industrialized countries, which are often short of water in the summer, the problem is rather different. Water demand is highest during the dry months of the year. Wastewater reuse can therefore be called on to bridge the gap. It is becoming an increasingly attractive alternative as the quality of wastewater treatment is on the rise, at least in Europe. This practice may have the added benefit of decreasing

In some countries direct reuse of raw or poorly treated wastewater for irrigation is common

In dry areas, the increasing demand and higher standards imposed by tourism puts pressure on water supply

Standard setting influences, and is influenced by, the relative position of fresh produce exporters

wastewater discharges to surface waters at a time when the dilution of pollutants in rivers is at its yearly minimum and the risk of acute impact is high. This is particularly relevant for Spain with its large tourism industry concentrated in areas with insufficient water supplies.

3. The microbiological quality of irrigation water from reuse may also have other economic aspects. Southern Mediterranean countries have sizeable raw fruit and vegetables export markets towards Europe. This requires a good sanitary quality of the produce being exported. Since these productions are usually irrigated, the issue of microbiological quality of the irrigation water is relevant [1]). Israel, with relatively high financial and technological capabilities in comparison to the Maghreb countries, is favorable to stringent irrigation water standards, hoping to gain a commercial advantage over Algeria or Morocco, which are as yet unable to match systematically these standards in the race towards the export of fresh vegetables to Europe. Tunisia has a clear water use policy forbidding wastewater reuse for the irrigation of produce to be consumed raw. The same question could be raised within Europe if irrigation with reused wastewater increases in countries such as Spain and the applicable water quality standards do not have a pan-European acceptance.

4. All these issues are creating a potentially large global water and wastewater treatment technology market, where American and European suppliers are the main competitors. Thanks to the involvement of many European experts in projects for developing countries, in particular in the Southern Mediterranean region, wastewater reuse can be a way to increase cooperation between Europe and these countries.

Need for appropriate technologies and further research

As a consequence, there is a need to increase our epidemiological knowledge on the health impact of reused wastewater both for agricultural workers and for consumer markets. This could lead to the determination of a widely-accepted minimum standard for wastewater reuse in irrigation and clarify the controversy around the existing WHO guidelines.

While substantial effort has been invested in the development of wastewater treatment technologies, more effort is needed to develop inexpensive, safe and reliable technologies adapted to the developing world. This could go hand in hand with the training of competent personnel. In the case of wastewater reuse, the issue of reliability is also applicable to industrialized countries and may modify the relative preferences for wastewater treatment technologies. However, this work must be carried out in coordination with the development of the standards in order to determine the best cost/benefit balance for every geography. More research is needed to study the public health relevance of water quality standards for irrigation. All these developments would benefit from a framework policy on wastewater reuse developed at European level, helping wastewater reuse to prosper in the Mediterranean basin, a densely populated region with serious water resource limitations.

1 not so much for citrus because they are under "restricted" irrigation, more for strawberries, tomatoes etc

Keywords:

Wastewater reuse, public health, epidemiological studies, developing countries, irrigation, water standards, Mediterranean region

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Manufacturing Employment in Europe -

High-tech growth versus low-tech decline?

James Gavigan

Issue: Over the past 20 years or so, there has been a serious decline in manufacturing employment (> 20%) in Europe, while its main competitors, the US and Japan, have experienced net manufacturing employment increases of 1.5% and 4% respectively. The counterpart to this is the fact that most manufacturing jobs have been created in the high-technology industries serving high-growth markets, areas where the US and Japan are shown to have particular trade specialisation and comparative advantage. Europe's trade specialisation, on the other hand, is thinly spread over primarily low to medium tech industrial sectors.

Relevance: For Europe, leap-frogging into a stronger position in those high-tech areas could be accompanied by trying to capitalise more, in terms of growth and employment, on its strength in several other sectors. One way may be to identify, and direct policy selectively at, the 'high-technology' tips and sub-sector niches within low to medium tech industries which constitute actual or potential high growth nuclei.

Manufacturing is undergoing a drastic transformation

In spite of the emergence of an increasingly dominant 'services' sector in modern industrial economies, we still live in a material world, where 'manufacturing' and directly related productive activities continue to constitute a vital economic backbone. However, the *way* in which manufacturing is conducted is presently undergoing something of a revolution (IEEE Spectrum Sept. 1993), fuelled by a growing technological 'iceberg', the size of which can only be inferred from the 'tip' visible to society at large, and which increasingly penetrates into the daily lives of all citizens, transforming the world in which we live.

Related to this emerging new manufacturing paradigm is a whole series of sub-issues and trends such as *manufacturing agility, benchmarking of best-practice, integrated technology management*, etc., each with various different short and long-term policy connotations which merit, and will receive, individual consideration in future issues of this Report in relation to the broad triangular relationship between Technology-Employment-Competitiveness. In this first note, however, attention focuses on *the employment trends in manufacturing* and how they relate to the on-going technological revolution.

n the past 25 years employment in manufacturing has dropped...

...and in Europe the losses have not been offset by gains in services

Throughout the OECD, the relative importance of manufacturing in terms of output has held its own over the past 25 years or so. However, in employment terms, its contribution has declined from 40% to under 30% between 1970 and 1992, with a parallel rise in the importance of employment in the service sector.

Europe fails to absorb manufacturing sector job losses

However, one can appreciate that the productivity improvements necessary to maintain the stable proportion of manufacturing output have been substantial, freeing up profits and capital to fuel further investment and job-creating growth, not only within the services sector but via new, demand-driven manufacturing activities as well. It is thus that one can find a 4% increase in the absolute number of manufacturing jobs in Japan through the 70s-80s, and a similar 1.5% increase in the US. However, the corresponding figure for the EU over the same period has been a dramatic 20% decline (OECD Jobs Study 1994). Moreover, it is well known from the attention given to Europe's overall unemployment problem, that the European service sector has been far from capable of offsetting the manufacturing sector's losses. (A detailed breakdown of these data by region, time and sector, is discussed, with due regard to short-term cyclical variations, in the recent OECD study on Technology, Productivity and Job Creation, 1996, Chapter 4).

The reasons for the EU's predicament are manifold and complex. With due regard to the overall picture therefore, our analysis proceeds to take a primarily technology slant, starting from the observation by the OECD, that countries that have best adapted to new technologies and have shifted production and exports to rapidly growing high-technology markets, have tended to create more jobs.

Recent EU-level aggregate analysis of sectoral trade statistics paint a dreary picture in this regard (Panorama of EU Industry 1995: DRI). Firstly, in current commercial as well as technology capability building (i.e. investment in innovation and research activities) terms, Europe's position is weak in the fast growing area of IT and electronics, which is the primary mover in the current technological revolution, underpinning the generation of many new products, services and jobs throughout the economy. Secondly, the EU trade patterns reveal a thinly spread and relatively weak sectoral specialisation in primarily low to medium tech industries such as textiles, footwear, household appliances, etc., and in just one high-tech sector - pharmaceuticals. This compares with a more focused, and high-tech export specialisation in for example, aerospace by the US and the electrical- and electronics-related sectors by both the US and Japan. Thirdly, even in sectors such as mechanical engineering and chemicals, the EU's leading position may be threatened in the future by the higher R&D investments being made by competitors, in particular by Japan which, according to some patent indicators, are beginning to yield fruits.

Countries focusing on rapidly growing high-tech markets have tended to create more jobs

While this overall situation of EU manufacturing is determined mainly by statistics from the large Member States, the aggregate data hide the fact that smaller Member States such as Finland and, notably, Ireland, have developed keen specialisation in high-technology manufacturing and are currently reaping the benefits with growth rates in GDP of 5% and 6.5% respectively for 1995 (the two highest in the OECD and more than twice the European average). Paradoxically however, both Ireland and Finland are plagued with high unemployment rates of 14.5% and 18% respectively. For Ireland which, at > 5 %, has averaged the highest OECD growth rate over the past 10 years, it is presently conjectured that unemployment may have begun a hesitant decline, with its high-tech, export-oriented manufacturing sector being one of the prime net creators of new employment and jobs.

Trade data show European strength in low-mid tech industries and in one high tech industry: pharmaceuticals

Referring to the OECD's observation above, the link therefore between high-technology manufacturing and net job creation exists in so far as it refers to high-growth, expanding markets. This is borne out in another recent study (Panorama of EU Industry 1995: PIMS/ IMI) which analyses firm-level data for 3,000 US and European businesses. It demonstrates that the highest levels of employment generation within firms strongly correlate to both market share growth and market growth itself, as well as growth in profits. The same work shows that many more North American firms operate in high-growth markets than European ones.

Intra-firm employment growth correlates with growth in overall market, in market share held by the firm, and in firm profits

It may not be easy for the US and Japan to maintain leadership

Private enterprise will play a key role in reviving European manufacturing

The transition from industrial to information society needs to be monitored and managed

Can Europe catch up?

So the question is what can be done in Europe to take better advantage of the new manufacturing employment opportunities and potential? Again, the answers to this are manifold and complex, but there is still room for more simplistic reasoning.

Some commentators advocate that public industrial policy measures should emphasise, and concentrate on maintaining and reinforcing, those industries where the EU has a strong comparative advantage. This would appear to be essential in the near to medium term. But given that we are talking about primarily low to medium tech sectors this would ultimately prove to be grossly inadequate, since on the face of the above evidence these sectors offer poor *new* employment generating prospects, and are increasingly exposed to price competition as the associated goods move down the value-added chain or as the newly industrialised world catches up.

The previous view is obviously much more simplistic than reality - where added-value margins for certain high-tech goods can be seriously squeezed and other goods normally associated with low to medium tech sectors can carry very high added-value. It should be seen in the light of the following question: whether or not the EU is destined to become a medium-tech economy relegated to follow the high-tech lead of Japan and the US, picking up the left-overs in the newly developing high-growth markets, with a permanent lag in the development of cutting-edge technologies? The answer is not necessarily, for the following reasons. Firstly, **the comparative advantages resulting from the technological nature of business and/or regional specialisation are much more fragile than the more traditional forms of comparative advantage resulting from reliance on factor endowments of labour and capital**. A lasting competitive advantage and leadership can only be maintained through a continual process of renewal. Secondly, drawing on micro-economic analysis, **'challenger' or lower-share businesses coming from behind with respect to the market leaders, are more likely to turn innovation into economic value, and ultimately displace the leaders from their position** (Panorama of EU Industry 1995: PIMS/ IMI).

If European manufacturing is to bounce back in force, it would therefore seem clear that the determinant will be policy's ability to coax out from the grassroots, and let flourish, the private enterprise initiatives and business ideas with the potential to leap-frog from a lagging to a challenging position, and eventually to pre-eminence on the international stage.

Regarding employment, however, the question still hangs over us as to whether, high-growth markets or not, the new manufacturing paradigm will eventually usher in an era where technology and automation will have rendered almost obsolete the use of manpower in the 'manufacturing' function of production. History gives us the example of agriculture where precisely this happened because of mechanisation. The yielding of agricultural society to industrial society brought with it turmoil but, on the whole, tremendous benefit to mankind. If industrial society is about to yield to something called the information society, or the like, the effects of the ensuing changes on society, and particularly employment, need to be monitored and managed correctly.

But if history eventually *appears* to be repeating itself with manufacturing, perhaps it does not matter, as the cause for concern may be due to problems of definition. Already commentators, and firms themselves, speak of, or purposely blur, the distinction between services and manufacturing, with suggestions that the service content or service-generated added-value portion of manufactured goods can often exceed the intrinsic value of the actual product (e.g. processed foods), etc. - a topic which may merit a separate article.

Keywords:

unemployment, trade specialisation, exports, manufacturing, high-technology, competitiveness

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What Future for Middle Managers? :

Information technologies and white-collar jobs

Dimitris Kyriakou

Issue: Information technologies bring a restructuring of work. Jobs that involve tasks and skills learnt easily by other workers or machines will be particularly affected: this includes those white-collar tasks traditionally better shielded vis-a-vis technological progress.

Relevance: In light of the projected trends, training and retraining programmes (and employment policies in general) may need to update their model of operation so as to strengthen the skill base and smooth the transition towards a restructured work environment.

Emphasis in analyses of employment impact should move from formal education to the type of task executed

White-collar workers and restructuring

The improvement in the lot of blue-collar workers after WWII and until the '70s, has been followed by a ~20 year period during which the wage gap between white-collar and blue-collar has widened in the US. In Europe, where prices/wages have not been allowed to fluctuate as much, quantities (i.e. number of jobs) have borne the brunt of adjustment. Past recessions used to hit blue-collar workers the hardest, whereas white-collar were relatively more secure.

The emerging technological developments associated with information technology (IT) may be raising the vulnerability of 'skilled' and 'white-collar' rather than blue-collar workers. The clearest message one should underline involves a reformulation of the skilled-unskilled dichotomy. For a long time science and technology have been viewed as threatening mostly unskilled labour, a term usually used to denote labour with a low formal educational background. We argue that this categorisation is misleading though still highly popular (witness the otherwise excellent April 1995 CEPR authoritative report on *Unemployment: Choices for Europe*, as well as the *OECD Jobs* report of 1994).

The critical dichotomy is not between skilled and unskilled but rather between repetitive, computer-reducible tasks and creative, 'irreducible' activities. In other words, a worker's strongest advantage is based on tacit knowledge and skills, not explicit ones (a lesson that is corroborated in artificial intelligence research on expert systems). An important source of skill-obsolescence in recent years is IT, threatening not only blue-collar but also, if not mostly, white-collar, 'educated' workers. In this light, the work of many middle managers is in danger because of its often repetitive character. However, the work of strategists is not threatened (which is not a surprise), but neither is the work of gardeners (which may be). Craftsmanship is not computer-reducible. Computers are ideal for easily-programmable, logical steps that do not require in-

tricate motor skills or dexterity. It is a little known fact that we have almost as much difficulty in teaching a computer to adapt to non-preprogrammed situations, as we do in teaching them to walk like a human being. Tasks that require high motor skills and/or imagination are much safer than repetitive white-collar ones.

To put it differently, uncomputerisable, irreducible craftsmanship - even of the blue-collar kind (e.g. gardening) - may not be adversely affected by IT, whereas white-collar workers performing computerisable tasks (e.g. accountants, bank-tellers) may be, at least indirectly. We should also note that crafts involving little creativity are far from immune (e.g. baking or timber cutting). As artificial intelligence pioneers have pointed out, it has been easier for computers to solve complex mathematical problems than perform 'common sense' functions, such as putting together toys etc. The catch of course is that although the **least educated may not be the principal victims of the coming technological breakthroughs, they will be the ones who would have the hardest time getting a new job, if and when they lose theirs.**

Overall, new technology leads to income redistribution. Innovation that reduces the unit cost of production may render certain skills obsolete, and will require a different set of skills. Although the overall change has beneficial effects for society as a whole (aside of, albeit crucial, distribution issues) by increasing wealth-creating opportunities, if labourers can not easily change their skills new technology will bid up wages for one type of worker and depress them for another (for whom it may also lead to unemployment). For instance, in the 'multimedia information society' (MIS) teleworking may reduce jobs in the transport sector while increasing job openings in the equipment installation and repair sector. If the skills on demand in the early 20th century were car repair, in the early 21st century it may well be repair and maintenance for information/communication devices and 'smart' home appliances. White-collar clerical personnel (which are not necessarily highly skilled but are often treated as such because of formal educational attainment, e.g. high school degree) may be gradually driven out of the market whereas craft-based repair and maintenance personnel may flourish.

In the long run technology will give rise to more jobs than it destroys (as stated in the OECD and CEPR studies referred to earlier, and demonstrated in the history of technological and economic growth over the last 200 years). Nevertheless, in the short run not every displaced telephone operator will be available to work as a computer repairman. The transition and adjustment period will be rife with mismatches. It will be made less painful if:

a) growth picks up quickly, leading to higher demand and faster job creation across the board;
b) labour markets, and even more importantly product markets, become more flexible;
c) education and training/retraining becomes more 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) part of the gain reaped due to technical progress and new wealth generation goes to the displaced victims of capitalism's implacable gale of creative destruction, to cushion them through the transition period.

Education: a key to success

Education is undoubtedly key to a smooth transition, for staking out and exploiting the new job opportunities. The more controversial issue is the type of education best suited to the changes the MIS will be ushering in. 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 mechanisable, repetitive nature. Blue-collar **crafts, that incorporate a certain creative**

The vulnerability of a job depends on how easily it can be learned by other workers or by machines

Evidence of this incipient trend has begun to appear for low level white-collar employees ...

component, may be less mechanisable and hence more resilient with respect to automation and MIS advances. Furthermore, predicting skills that **will** be in demand is not something that ministerial bureaucracies setting up retraining programs are renowned for. Indeed, a 1993 US Labour Department study found that less than 20% of those retrained under federal programmes found new jobs paying at least 80% of their previous salaries: this is not to say that such programs are not useful - think of what the numbers might have been without them (M. Rogers, 1995).

Since this is a prospective analysis about **future trends,** data is not available to persuasively support or disprove such claims. There is, however, an incipient trend that can be discerned in the 'delayering' attributes of recent and on-going restructuring and 're-engineering' exercises in large firms. Such delayering has attempted to increase efficiency by reducing intermediate layers in the firm hierarchy, directly hitting white-collar middle managers. It has thus reached beyond the most vulnerable low-sophistication white-collar professions (e.g. bank-tellers), into the hitherto untouchable middle level and even high level white-collar positions associated with higher education, income etc. It has recently been reported that AT&T, the US telecommunications giant, will be reducing its personnel by about 1 in 8 over the next three years as part of a restructuring exercise. As ABC news reported on 16th January 1996, most of these jobs will be white-collar jobs, many at middle management level. Another piece of evidence is the increasingly precarious position of functions such as bank-tellers and telephone operators etc. described above. Even if IT did not directly cause this tendency towards flattening of the hierarchy, it is playing an important enabling, catalysing role in such delayering.

but also in the 'delayering' of middle management seen in the restructuring of large firms

More evidence of the incipient trend identified in this article, comes from a recent report on the future of work by the OECD (November 1995). Here it is noted that OECD economies are seen to "be in the midst of dramatic technological and organisational changes" and that new managerial approaches entail " significant reductions in the number of managerial layers and spinning-off activities using task-based contracting out.". Moreover, "firms are expected to put even more emphasis in the future on new, flexible ways of employing knowledge workers"; "work in the future will demand more adaptable skills and a greater capacity to continuously learn". Finally, it is claimed that IT may "undermine.. technical drafting, typesetting and even teaching", which are not necessarily typical blue-collar jobs.

Low-level and mid-level white-collar tasks have suffered over recent years, largely because many of these skills were found to be mechanisable or redundant. **The key to avoiding exposure to the arrows of such fortune is to provide value-added in a creative, non-mechanisable way**. This is, presumably, the case as we move towards the high end of white-collar tasks, where strategic thinking and creative, intellectually-driven endeavours dominate. It is still human thinking that comes up with a breakthrough, or a creative solution to a vexing problem, and not laptops or wireless modems - the latter have simply increased the working day by allowing the worker to be on-line almost all the time. In praising creativity we should not forget that public-sector jobs will suffer during cutbacks regardless of their creative component (cf. R&D and cultural funds cuts). Note however that, as mentioned in the beginning, we are focusing not on general threats to jobs, but rather on the particular effects of IT on employment (if one speaks more generally, the effects of the business-cycle on industries such as construction, and competition from other humans can not be ignored).

Education and training is key but needs to focus on adaptability and 'learning how to learn', rather than specialisation in specific tasks

As long as artificial intelligence does not solve the creativity riddle (and we are a long way from such solutions) the most resilient shield from technology-driven skill obsolescence is creativity and flexibility. And the best way to provide such creativity and flexibility is to guarantee a strong primary and secondary education. Workers need to be literate and numerate enough to be able to be constantly trained and retrained on the job, and to have the basic skills that will permit them to learn new skills even at a later age. What most firms need is not the specialist low- or mid-level white-collar worker but rather intelligent, creative, educated people who can be easily trained to perform various demanding tasks. **Flexibility and adaptability (which are not necessarily proportional to years in school or number of degrees held) will be the key**: the good news is that these are attributes that can be instilled through training. They involve not simply flexibility within a task (e.g. being able to program in many languages), but flexibility in learning new tasks, related or unrelated to current ones.

In summary, providing value-added in a way that is hard to imitate (by machine or human), is key in preserving jobs and reaping attractive rewards. This article has focused explicitly on information technologies; this does not mean that jobs can not be lost to skillful human competitors, domestically or internationally. The key in all cases remains the provision of value-added in a way that cannot be easily reverse-engineered and matched, a principle that increasingly applies to white-collar as well as blue-collar tasks.

Education and training is key but needs to focus on adaptability and 'learning how to learn', rather than specialisation in specific tasks

Keywords:

unemployment, skills, blue-collar, white-collar, training, education, creativity, information technologies, computerisable

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Foresight Studies: Basic principles for an EU approach

A recent panel discussion on foresight, which took place at the Research, Technology and Employment seminar organised by the EU Spanish presidency in El Escorial, Dec. 6-8 1995 (see *IPTS Report,* Issue 01), focused on some of the lessons learned in recent foresight exercises. It concluded that maximum use of feedback mechanisms (especially in the context of group-based foresight exercises) is crucial, as is an emphasis on continuity and persistent application of methods so that skills are developed and the process becomes a more useful tool for managing change and contributing to shaping the future. The challenge for foresight studies is to look beyond competitiveness towards sustainability in terms of competition, environment, regional development etc.. There is a need to focus not so much on forecasting developments but rather on understanding and exploring evolutionary trends. The new objective is, therefore, to provide a common knowledge, background and understanding - including early warning - on the basis of which different actors can make mutually reinforcing decisions to support the management of change. Such foresight studies will be less likely to identify single winning technologies but rather emerging markets - usually based on a mix of technologies.

Moreover, knowing about and understanding technological change and mastering advanced technologies is not only vital for assuring competitiveness - it is also one of the main levers we have to solve present and future problems facing our societies. It is here where technology shows the most promise for opening **new** markets for new products and services, and for generating new employment. In order to achieve these goals it will be necessary to develop methods which are reproducible, decentralized to allow for cultural and regional differences, and mutually enriching through networking. The information must also be usable within the available institutional and chronological framework. In terms of research, foresight currently relies heavily on qualitative methods but in the future more quantitative solutions may be found (e.g. using 'fuzzy logic' models), not to substitute but to complement existing qualitative methods.

The boundaries between technologies will become increasingly blurred and the key organising element will not be the "discipline" or the "substance" used, but customer needs and the custom-made technological response to it. Foresight exercises are then a process more than a single effort which, to be functional, should be participatory, cumulative, continuous, multi-disciplinary - and should become an integral part of the decision-making system.

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Agile Manufacturing - a new paradigm for the next millennium?

During this century the basis of manufacturing has progressed from *craftsmanship* through *mass production* to *lean manufacturing*, and presently continues to evolve in a direction where the only certainty is change, at an ever-increasing rate. The newly-emerging paradigm may well turn out to be so-called *'agile manufacturing'*. This conjures up notions of virtual companies, a total re-invention of manufacturing organisation, business processes, contractual arrangements, etc.. Social and personal issues will also be fundamentally affected, such as continuity of employment, maintenance of skills, motivation and reward, and family lifetime financial planning.

This month (5-7 March 1996), over 750 senior managers from across all sectors of US industry have gathered in Boston for the 'Fifth National Agility Conference'. This event is indicative of the serious consideration being given in North America to the revolutionary changes which the emerging market and technology are beginning to impose on the way manufacturing is conducted (mass customisation; further compressed product cycles; full lifecycle service; instant communication and data availability, etc.). In fact a continuous high level of activity, in the form of industrial fora and collaborative projects relating to *'agility'*, has been supported by the US government and industry for a number of years, at a cost of over US$210M per year. This activity was sparked off by a report, *"21st Century Manufacturing Enterprise"*, commissioned in 1991 by the DoD and written by Goldman & Preiss of Lehigh University.

European activity in this area appears to be sparse and fragmented, consisting mainly of work conducted in academic institutes and under publicly-funded programmes such as the UK "Innovative Manufacturing Initiative" (IMI), and some others. In a forthcoming article, this and the general 'agility' trend in manufacturing will be explored in more depth as well as its possible implications and significance for EU policy.

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COMPETITION: Win a trip to Seville!

IPTS are looking for an alternative name for the *IPTS Report*. The name should evoke the journal's European scope, and its prospective and policy focus. Please send any suggestions to Dimitris Kyriakou, Editor-in-Chief at the adsress shown. The prize will be an all-expenses paid trip to Seville to see IPTS at work!

My suggestion for a name for the IPTS Report is:

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The IPTS is one of the eight institutes of the Joint Research Centre of the Commission of the EU. 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 coordinates research to improve our understanding of the impact of new technologies, and their relationship to their socioeconomic 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 policymaking. This combination allows the IPTS to build bridges across EU undertakings, contributing to and coordinating the creation of common knowledge bases at the disposal of all stakeholders. Though the work of 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 similar organisations operating at the national level. IPTS is the central node of ESTO, coordinating 'joint ventures' in technology watch towards 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 a driving force for all IPTS activities, entailing analysis of the potential of promising technologies in terms of job creation, economic growth and social welfare. Such analyses may relate to specific technologies, technological sectors, or cross-sectoral issues and themes.

3. Support **for policymaking**. IPTS works in support of the Commission services and other EU institutions in response to specific requests, usually as a direct input to their decision-making and/or implemenation processes. Such activities are fully integrated with, and take full advantage of Technology Watch activities.

IPTS works with the policymakers to understand their concerns, benefits from the knowledge of actors, and promotes dialogue that involves them, and collaborates with scientific community to assure accuracy. In addition to its flagship IPTS Report, the work of IPTS is also presented in occasional prospective notes, a series of dossiers, synthesis reports and working papers.

The IPTS Report is published 10 times per year, on the 15th of each month with the exception of January and August. It is edited in English and is available free of charge in four languages: English, French, German and Spanish.

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