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THE IPTS REPORT

Produced by IPTS and issued in Cooperation with the European S & T Observatories Network

- **Radical Innovations in Automotive Technology: Opportunity or risk in a globalised economy?**
- **Incentives for Innovation in Electric Power Utilities**
- **Olive Oil on the Increase, Oil Blends on the Attack: Technology and market displacement**
- **Producing High Value-Added Molecules in Crops: A sustainable alternative for agriculture?**
- **Dual Use and Technology Transfer in the Titanium Industry**

MAY 1996

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 under-discussed 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 decision-makers, exploring *prospectively* the socio-economic impact of scientific and technological 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 inside and outside of the Commission. The process of interactive consultation used 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.

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Transport

Innovative urban transport concepts, which represent a radical departure from established trajectories, may provide an effective response by European automotive manufacturers to the dual challenges of globalisation and sustainability.

Energy

The liberalisation seen in the electricity industry over recent years has provided little incentive for technical innovation, in what is a largely conservative and capital-intensive industry. Rather, the evidence suggests the nature of the regulatory regime is a key influence on technology development.

Environment

While the current rapid growth in demand for olive oils bodes well for producer countries in the Mediterranean, new developments in vegetable oil blends pose a potential threat both to the economies of these countries and the health of their populations.

Biotechnology

The manufacture of drugs and other chemicals from transgenic plants, so-called molecular farming, represents a major commercial opportunity for the European pharmaceutical industry, and has implications for standards-setting and for the Common Agricultural Policy

Technology and Competitiveness

Originally oriented towards the aerospace and defence industries, titanium has many other potential uses. Successful exploitation calls for targeted diversification and technology transfer actions between the military and civilian sectors.

Brief Notes

The first article in this issue provides a profound analysis of the two apparently opposing forces in car manufacturing. On the one hand, the globalisation trend leads to sharpening competition, and makes car manufacturers increasingly risk-averse, converging towards models/practices appealing to the notorious average client. On the other hand, the congestion/pollution pressures make imperative the search for alternative, sustainable models, beyond mere expansion along the present trajectory. The article indicates, however, that there is room for innovative policies that will explore the synergy between the two trends, and alleviate the apparent tension between them.

Innovation and innovative practices are what is at stake in the second article as well, only in this case the focus is on the electricity utilities. Drawing upon recent experience in the UK and elsewhere, the article argues that liberalisation of the type often practised or envisaged may not enhance innovation in this industry, which will certainly need it, at least from a social perspective, given the mounting need for clean, affordable energy. Regulated firms were not known to be aggressive seekers of radical innovation in the past; at most they indulged in incremental innovation or defensive patent purchases. As long as the cost structure of the industry allows dominant players to be quasi-monopolists; as long as liberalisation pertains to access of providers to the grid, but leaves out price-setting; as long as regulation is on an internal rate of return or a myopic price cap basis that does not allow some profit reward for the innovating firm; as long as capital markets fail to efficiently back innovation efforts with long payback horizons, the innovation potential of a more liberal environment will not be realised. Incidental opportunistic entrants will have no incentive for radical innovation, and defensively-oriented incumbents will pursue innovation more or less along the pre-liberalisation lines.

The third article concerns both liberalisation and innovation. Due to advances in medicine and the concomitant desirability of olive oil, and to innovations in the olive oil industry, the prospects for the southern EU countries which overwhelmingly dominate world production would look excellent. However, thanks to recent breakthroughs, vegetable oil blends can imitate the taste - though importantly not the health profile - of olive oil at a much lower cost, threatening not only the prospects for olive oil but also the livelihood of millions of families in Southern Europe. This may also lead to foregoing an improvement in the health profile of the users of oil, leading to changes in healthcare costs which are not internalisable (i.e. whereas the profits accrue to a few agents, the hidden costs in terms of higher health bills are shouldered by society as a whole, instead of being reflected in the price of the product). Standards-setting and innovative labelling, clearly warning consumers of the qualities (or lack thereof) of 'blends', and differentiating them from olive oil, may help avoid some of the aforementioned problems.

The need for standards-setting is one of the points raised by the next article on transgenic plants, where it is also indicated that the so-called molecular farming may provide relief for the strains the common agricultural policy has been under, as well as a potentially large source of income, given the projected size of the market. The last article on titanium begins precisely by observing that the market size for titanium and its fluctuations in the past have been due to its dependence on the defence industry. The projected uses of titanium for civilian applications call for a decoupling of titanium from defence, and indeed suggest an opportunity for exploring dual use characteristics, and promoting defence-to-civilian industrial conversion.

The Forward Studies Unit

The Forward Studies Unit (Cellule de Prospective or CdP in French) was established by the European Commission in January 1989 as a small think tank reporting directly to the President. The CdP's primary task was to monitor and to anticipate European integration by studying long-term prospects and structural tendencies. Its work programme, set out in a Commission decision, provided both broad directions and methods:

- *The Unit's task is to monitor and evaluate European integration on the basis of research, involving a network of institutes or centres in member and non-member countries specializing in long-term forecasting and planning.*
- *In addition to this permanent monitoring, the Unit must be able to perform specific tasks at the request of the Commission.*
- *As a general rule, the Unit will work in close conjuntion with the appropriate Directorates-General and ad hoc groups will be set up as required.*

Since that time the CdP has evolved considerably and detailed work programmes are now agreed each year with the President and his Cabinet. Currently this work is grouped under four main lines of research reflecting the major challenges for European integration.

(I) the significance and future of the European project; (II) managing the transition towards a more balanced development, European construction in a changing world, competitiveness and welfare; (III) the adaptation of the European model of society and the restoration of social cohesion; (IV) renewing the art of government (governance).

Within each of these broad themes a wide range of in-depth projects have been executed many of which have resulted in a major publication. Two such examples are: "Promoting Sustainable Economic and Social Development - The Future of North-South Relations" and "The European Challenge Post - 1992 - Shaping Factors shaping Actors"

The CdP has developed a certain "house style" for such prospective studies with the use of the "Shaping Factors - Shaping Actors" methodology based on expert consultation. It is much less formal than, say, the full Delphi method, which is both a strength and a weakness. In engineering parlance it is to a certain extent "quick and dirty" i.e. it can produce results rather quickly but these results may lack the apparent precision of more formal methods. For policy makers this is clearly a strength. There is little point in producing studies months, if not years, after the policy requirement became apparent. Furthermore, the formal Delphi Method encourages convergence which may hide divergent views. The Shaping Factors-Shaping Actors Method should include such views. Its weakness lies mainly in the fact that each study draws on a restricted number of experts and is therefore, to an extent, a partial view. Thus, the selection of experts is crucial to the success of the method.

While the main thrust of the CdP's work is socio-economic and legal in nature, there is a need for considerable technological input, largely provided by IPTS. So far, the IPTS has made a significant contribution to work in the fields of climate change and business and the environment.

The interaction between CdP and IPTS has been mutually enriching and since 1992 IPTS has seconded a senior member of staff to the CdP. (In the future this permanent position may be replaced by IPTS visiting researchers.)

There is a world-wide resurgence of interest in the contribution of think tanks to the resolution of societal problems and the pragmatic exploration of alternative futures. The CdP expects to continue to play a small but significant part in this activity.

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Radical Innovations in Automotive Technology -

Opportunity or risk in a globalised economy?

Matthias Weber

ISSUE: Globalisation trends and the need to stay globally competitive are key determinants in the industrial strategies of automotive manufacturers. In addition, their products also need to contribute to solving the main problems in our present mobility systems, namely congestion and pollution.

RELEVANCE: Although the need for different mobility concepts has been increasingly recognised, product development in automotive manufacturing is mainly driven by the short- to medium term pressures of global competition in vehicle technology. This favours the extension of the established trajectory of car-based mobility systems, rather than more radical responses to the longer-term, but nevertheless pressing, environmental and congestion problems. A number of recent developments show that there is increasing scope for, and industrial interest in, substantially different approaches. The traditional arguments against the feasibility of a reorientation in mobility provision appear to be questioned. In the present unstable situation, setting the right framework and indicating the desired direction for our transport future will be of crucial importance.

In recent years, the automotive industry has been challenged by three major developments. It has become apparent that transport in general, and the pervasive use of cars in particular, have severe negative externalities. Impacts which have dominated the public discussion are, firstly, the environmental question (pollution, CO_2 emissions, resource depletion), and secondly, increasing difficulties in maintaining high quality transport systems (congestion and safety problems). As a third issue, industry has gone through a period of global restructuring and reorganisation which has challenged the competitiveness of European automotive manufacturers, requiring them to rethink their products, production processes, supply chains and marketing strategies.

Options and opportunities to address transport-related problems

The development of a new generation of mobility systems and vehicles offers a promising alternative to address these challenges. Recent technological advances in propulsion systems, materials and recycling seem to offer opportunities to address the pollution and resources problems, e.g. reductions of fuel consumptions, new types of propulsion systems like batteries, fuel cells or hybrids, use of new materials, design for recycling or long-life cars. (see IPTS Report 00).

Forecasts of transport-demand growth underline that we are reaching the capacity limits of our

The automotive industry faces far-reaching environmental and competitive challenges

Demand-side approaches to solving the transport problem have been underexploited

Sustainable mobility offers a stark contrast to traditional, 'expansion-oriented' systems

transport infrastructures, and that further capacity increases will involve very high costs - both in economic and environmental terms. However, the options for addressing the congestion problem are not limited to improving vehicles and shifting traffic modes, but also encompass the integration and reduction of transport (see Table 1).

TABLE 1: APPROACHES TO TRANSPORT PROBLEMS

Levels of Action	Examples
Improvements in transport technologies	Provision of better infrastructure Improvements in components and vehicles
Modal shifts	Improvement and promotion of public transport Extension of combined transport
Integration & coordination of transport	Car pooling Provision of city cars for public use Application of telematics Reorientation towards mobility services
Reduction of transport needs	Virtual mobility (e.g. teleworking) Application of telematics Car sharing

Until now, R&D efforts have mainly been aimed at improving existing types of vehicles by innovating at the "component level" of transport technology. Comparatively few initiatives have sought to address the demand side, through shifting, integrating and reducing transport demand. Most of these recent proposals and concepts go beyond purely technical solutions. Car pooling, car sharing and city cars for public use challenge the concept of individually-owned automobiles, and represent a step towards the provision of transport services instead of vehicles. The architecture of transport systems, their configuration and the coordination between different modes are the focus of a range of approaches (e.g. the TULIP-concept by PSA, STORM and Munich Comfort, see Box 1) which make extensive use of telematics technology. A further step towards reducing transport demand can be seen in the replacement of physical mobility by "virtual mobility", e.g. by means of sophisticated forms of teleworking and teleconferencing.

These innovative types of systems could be labelled "sustainability-oriented mobility systems" (SOMs) as contrasted to the traditional "expansion-oriented mobility systems" (EOMs), which are at present incrementally improved and modified. SOMs are represented by concepts which :

a) take the possibilities of all four levels into account (as shown in Table 1), i.e. which aim ideally at providing the necessary physical transport services in the most efficient way;
b) facilitate the integration and interconnection of different modes in order to use the transport mode is best able to fulfill the requested service;
c) aim at the fulfillment of a combination of economic, environmental and service performance criteria, both for the individual and society.

In contrast to this, EOMs can be characterised by :

a) the provision of individually-owned vehicles which enable mobility and are targeted towards the expansion rather than the containment of physical transport;
b) high barriers for integrating, coordinating and operating jointly the different modes, thus building on the principle of competition rather than complementarity;
c) mobility choices implied according to short-term individual benefit criteria only.

Box 1: Innovative Projects for Urban Transport

A variety of projects have been set-up by European car manufacturers which go beyond the concept of the traditional car. Four interesting examples are TULIP, PROMETHEUS, STORM and Munich Comfort.

TULIP is an initiative by PSA which aims to introduce a small electric city car, together with the necessary infrastructure for recharging, payment and coordination. It is a public vehicle which can be hired at easily accessible stations in the vicinity of a city, thus enabling interconnection with other transport modes. TULIP has entered the phase of extensive field trials in a number of European cities.

STORM, a project in the area of Stuttgart, involves Daimler-Benz as well as a variety of supply companies and public authorities. It aims to improve the coordination of different public and private transport systems at the regional level. Munich Comfort follows a similar approach under the leadership of BMW.

PROMETHEUS is a wider European programme involving a number of car manufacturers, supply companies and research institutions. It aims to explore the possibilities for an integrated traffic management system which will improve the environmental performance, economics, safety and flow of traffic.

All approaches make extensive use of information and telematics technologies, information being key to optimising and integrating mobility systems.

Obviously, an additional condition which both SOMs and EOMs need to fulfill is that of industrial and economic feasibility: they need to be economically sustainable to the extent that a wealth- and employment-generating industry can support the corresponding technology.

Globalisation, competitiveness and SOMs

Notwithstanding the attempts to address the environmental and congestion issues, the development of new vehicles seems to be dominated by the third challenge mentioned: globalisation.

Globalised markets imply the provision of vehicles which can be supplied worldwide. With expectations concerning future car types being rather similar across the industry, the difference between the products is becoming minor. Competition tends to be based on a combination of price and the "emotional" characteristics assigned to vehicles to justify price differentials; in other words on the features and 'gadgets' which help hide vehicles' increasing similarity in terms of performance. These differences are complemented by certain minimum environmental, safety and comfort characteristics which were distinctive features initially, but have since become standards.

This market globalisation is complemented by globalisation in production, supply, sourcing and partnerships (see Box 2). In such an environment, companies' decisions are influenced more by the short- to medium-term pressure of global competition than by the longer-term social and environmental needs.

Globalisation inhibits risk-taking by vehicle manufacturers

Product development also needs to be seen in this light: the fear of being shaken out of business for having made a deviating product decision, forces manufacturers to follow the established technological trajectory. Innovation is regarded as only being feasible within this framework, and rarely goes beyond it. Any departure from the established pathway is perceived as a high risk, due to fundamental uncertainties about future transport needs.

Consequently, any claim for a substantial reorientation of transport technology supply in Europe is rejected for fear of loosing market share, leading in turn to job losses and industrial decline. An alternative approach for Europe might provide competitive advantages for home

Box 2: Globalisation of Automotive Manufacturing: The Main Elements

Growing trade flows of finished vehicles
Global sourcing and component supply
Construction of production and assembly plants worldwide
Product development for global markets ('world cars')
Growing density of collaborative and other links between the main manufacturers and emergence of a few 'strategic blocks'.

There are barriers to sustainable mobility for both producers and users

The introduction of new transport concepts could be a major stimulus to global competition

manufacturers but might also decouple them from world markets.

While the above analysis refers mainly to the macro-economic level, further micro-level obstacles can also be identified. Apart from a kind of psychological reluctance to depart from a concept developed over one hundred years, companies' competences, knowledge and skills are often not matched to the requirements for developing SOMs. Most of the European car manufacturers are product-focused companies: exploitation of SOMs would require building up new activities in infrastructure services, information and telecommunications technologies and other transport modes. Consequently, SOMs are not perceived as attractive commercial opportunities.

Another assumption which questions the feasibility of SOMs is that consumers would not accept a departure from the traditional car. The field trials with the new concepts like TULIP or STORM will certainly provide valuable information about the acceptance of these systems. Although the car's environmental characteristics may already be a relevant factor in users' choices between different options, the behavioural changes needed for an SOM are seen as problematic.

Reasons and possibilities for a sustainable change

From this point of view, it appears as if a substantial switch to SOMs and the requirements of global competition are incompatible with each other, hence implying an inevitable extension of the existing EOM-trajectory. This may be true within a static framework where technical change is an external force, and where medium-term competitive performance is indeed the main determinant of product decisions. But this provides too limited a picture of the complex world of technological change. If the longer-term effects of radical innovations on firms' competitive positions are taken into account, then the conclusions are different. In fact, the introduction and diffusion of a new concept in one of the main regional markets would have feedbacks on global competition not only in terms of costs and other characteristics of single vehicles, but also in terms of the basic types of vehicles - or better transport systems - supplied. From such a perspective, four main arguments can be advanced to support the feasibility of a reorientation towards SOMs.

Firstly, environmental and congestion concerns are becoming increasingly pressing, global problems. This is already evident in Europe, Japan and the US, where a paradigm shift in urban transport seems inevitable. Often the argument is raised that the new future markets will initially need "cheap and simple" cars rather than sophisticated integrated systems in order to fulfill their emerging mobility needs. But the urban areas of major Asian cities have already reached their capacity limits and show alarming signs of congestion and pollution: the only question is, **when** these problems will be addressed by the rather autocratic political regimes in many of these countries. In addition, individuality as one of the main attributes of the traditional car has had a less important value in Asia than in Europe or the US.

Secondly, globalisation reinforces the repercussions of changing technological patterns in the main regional markets. Europe is still the biggest car market in the world: it is the essential market for the European manufacturers, and also a major export market for non-European manufacturers. If a switch was made in Europe it would affect the global trends in product development and define new standards. Apart from this demand side effect, there would also be a supply side effect in that European car-makers are intertwined with foreign companies and play significant roles in shaping foreign markets and establishing new visions. The fear that European manufacturers would become less competitive globally if they had to switch to different products and philosophies in Europe can therefore be questioned. Furthermore, the apparent inevitability of SOMs in the longer term would give those manufacturers that make a timely shift in this direction an early competitive advantage.

Thirdly, at the company level one can already identify some forward-looking European manufacturers who are well prepared to deal with SOMs. This growing interest of manufacturers in integrated concepts is evidence of the recognition of business opportunities in these fields, suggesting that there must be some economic rationale in these approaches. For example, FIAT and Daimler-Benz, being already involved in diverse activities, are in a very good starting position. But the examples of PSA with its TULIP-concept and of BMW (Munich Comfort) show that even car-only companies are starting to look for innovative solutions for mobility provision, joining forces with other companies with complementary expertise. It can also be expected that new integrated and service-oriented transport concepts will attract the interest of companies which have traditionally been involved in the provision of infrastructure and utility services.

Fourthly, although transport users are said to oppose any change of transport philosophy, the increasing level of congestion problems can be expected to favour a reorientation not only in Europe, but worldwide. Changing value systems and lifestyles, as well as raising claims for an environmentally-compatible car, support these expectations (SFZ 1996). However, such a reorientation does not mean the end of the individual car, but rather a limitation of its use where necessary.

Consequently, rather than waiting for others to make the running, it would seem promising for European companies to take the lead in an apparently inevitable direction towards sustainable mobility systems. The present phase of instability due to globalisation should be seen by manufacturers as an opportunity to actively establish a new trajectory, rather than as a threat to competitiveness.

The contribution of European policy

It is generally argued that globalisation substantially reduces the influence government action can exert on the decisions of multinational companies. However, if the argument holds that the weight of the European transport market is still big enough to induce feedbacks globally, then an active strategy by the EU could be of crucial importance in framing and coordinating emerging developments in industry, especially in a period of turbulent transition such as the present one. Whereas the traditional policy approach was either to support very specific technological options or to improve competitiveness at a general level (e.g. by improving macroeconomic conditions -such as labour costs or infrastructure), the arguments mentioned above favour a different strategy. A stronger coordinating function for government and especially for the EU would be recommended, providing reliable orientations for transport technology manufacturers - at least for the European market. This does not imply an interventionist approach of prescribing industry and users what they should do, but aims at reducing the high level of uncertainty on the future trajectory in transport technology by clarifying the priorities, visions and goals for the European transport systems and for related policies. Where this coordinating and orientating function is missing, market signals alone would perpetuate car manufacturers' reluctance to switch to what have been called SOMs. Providing reliable regulatory signals is important in terms of giving the industry the time to develop technological solutions in line with social goals and visions.

Present trends provide an opportunity for Europe to establish an early competitive advantage in SOMs

A first sign that globalisation and competitiveness have been recognised as complementary to the supply of more environmentally-compatible transport technology can be seen in the recent Japanese and American government efforts to establish new technology standards (CSSTS 1995).

By playing a coordinating role, government can reduce the risk and uncertainty within the European market

The steps made recently by the EC follow this example. They aim at coordinating industrial activities to reconcile the environmental and competitiveness dimensions (e.g. in the Task Force "Car of Tomorrow"), and the inclusion of the notion of an "intelligent car" points to the recognition of con-

The Task Forces may help provide a coherent approach

gestion problems too. The Task Force "Combined Transport" deals with the issue of congestion at a higher systemic level, as a first step towards the reduction and integration of transport, thus going beyond the vehicle level. However, the increasing interest in SOM-like concepts by industry seems to be reflected insufficiently by the European Task Forces. There is a need to provide support not only for the improvement of cars, on the one hand, and the coordination of modes on the other, but also for approaches which follow an integrated philosophy from the outset, to match the increasing interest of industry in SOM-like concepts. This has also been acknowledged in the recent Green Paper "The Citizen's Network" which still needs to be translated into specific action. Of crucial importance in this area will be the definition of adequate interfaces and standards, not only in order to limit duplication costs in Europe, but also to develop a convincing alternative for world markets. Overall, it will be interesting to see whether the results of the different task forces will provide a coherent picture of the needs of the mobility systems of tomorrow, or whether their results will be rather contradictory due to the very different levels at which the transport problem is addressed.

Obviously, an integrated approach also requires changes from the users of transport systems. It will be crucial to set the right incentives for enabling transport users to accept and make a switch to SOMs, by providing information about new approaches and by reinforcing awareness about transport-related problems, thus paving the way for a more purpose- and service-oriented attitude towards transport. This, as well as several other issues mentioned, could only be touched upon briefly in this article, because the relationships between new mobility systems, globalisation, environmental concerns and performance constraints are highly complex. More detailed reviews of these critical developments may be presented in future issues of the *IPTS Report*.

Keywords

transport, competitiveness, globalisation, sustainability, technological change, congestion, pollution, automotive industry, transport policy, industrial policy

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Incentives For Innovation In Electric Power Utilities

P. Moncada Paternò Castello

Issue: Despite market liberalisation, regulated electric-power utilities may continue to operate like monopolies, especially where fixed costs cannot be reduced. The incentive for utilities to innovate in the regulated market has traditionally been low, and the situation could be similar in a liberalised electricity market.

Relevance: Over the next few years, the electric-power sector is expected to face a broad number of challenges: increasing environmental constraints, socio-economic development, energy supply security, as well as the de-regulation and privatisation of the market. The role of technology renewal within this framework is crucial. In this respect, key themes are the weak incentives for electric power utilities to innovate, the framework in which competition between these utilities and new power producers will take place, and the agent that will play a major innovative role in the electricity market.

The changing nature of electric-power utilities

The electricity industry has been driven by significant economies of scale causing declining long-term marginal costs. The traditional, regulated electric-power utility has normally been restricted in its operations to a defined geographic area so that these savings cannot be fully realised. Although recent developments have removed some of these economies of scale (for example, improvements in information technologies have removed the economies of scale in management of the communication network), the burden of costs in physical assets for this industry remains strong in most cases. Clearly, duplication of the physical transmission and distribution networks is simply too expensive. Nevertheless, there is a worldwide trend towards less regulated electricity generation. Privatisation in the UK electricity industry requires British power generators to compete to sell power to a regulated transmission grid. In the USA, independent power producers are now selling power across state boundaries on regulated transmission networks. Thus there are moves to liberalise sales of electricity in each area, but maintaining the regulation on the distribution network, where sophisticated information technology applications allow individual power suppliers to "rent" capacity.

The electricity utility cost structure and exit and entry barriers

The cost structure of a typical power utility is heavily weighted towards high fixed costs. Typically, between 30% to 50% of its costs are fixed in the form of debt repayments on assets such as power stations, transmission lines

Long debt-repayment periods linked to the lifetime of assets represents a significant exit barrier for utilities...

..while newcomers are deterred by the market dominance and cost advantages of the utilities

Utilities favour incremental innovation rather than more risky and costly path-breaking innovation

and distribution lines. Most utilities use large amounts of debt-financing, with a maturity time similar to the economic life of the assets concerned. Therefore, most of the older power stations are almost paid-off, while the newer power stations are just the opposite. As electricity utility assets have almost no alternative use, this debt is a serious exit barrier for the utility. Furthermore, as the existing utilities have already paid off a portion of their productive equipment, they have a significant cost-advantage over new entrants to the electricity market. A new entrant would have to fund all of the assets and this will be reflected in the cost-structure. Therefore, unless there is a major technological breakthrough which can give a competitive edge to newcomers, they will be deterred from entering the market. Operating utilities are well placed to cut prices so as to starve out the new entrant, and to raise prices again when the challenge has disappeared.

These two forces (exit and entry barriers) and concomitant regulation have kept the industry stable for many decades. The emergence of a power-generation technology significantly cheaper than the present one is unlikely to appear in the short term. Nevertheless, something is changing in many countries: market liberalisation has taken place not only by transferring the property of the utilities to the private sector, but also by allowing access of third-party producers to the grid. The consequences of these novelties in an industry with slow-moving cost curves have to be analysed.

Innovation policy for utilities and other actors within the electricity sector

Utilities

The main motivation behind carrying out path-breaking, *risky* R&D would be to control the "killer technology", i.e. the *radical* innovation that will put other utilities out of business. Such innovative research is too costly for most utilities to conduct individually, so joint research has often been implemented. The possibility of gaining a monopolistic position is therefore removed and, as a result, these collaborative efforts have not, to date, been very effective. Utilities have been known to purchase 'sleeping' patents so that they would have the means to slow down the diffusion of a new technology until they can fight back against a challenger. In fact, the adoption of a new technology by a utility would accelerate its penetration and might result in a situation where the industry would not be able to control the diffusion, being forced to modernise equipment before the end of its useful life.

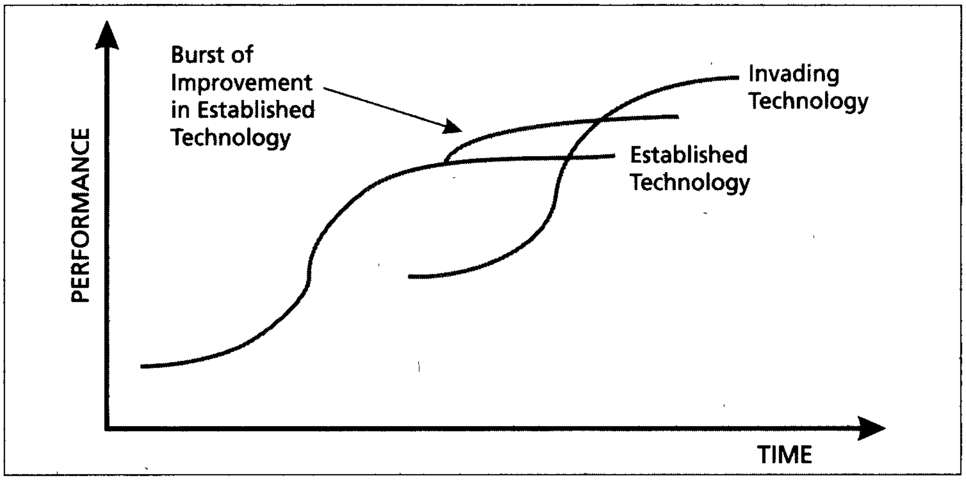
On an individual basis, utilities can carry out *incremental,* innovatory R&D, i.e. improving the efficiency of a well-established technology. However, regulatory schemes which focus on fixing the utilities' internal rate of return do not typically provide sufficient incentives for utilities to innovate. On the other hand, price cap regulation can allow the utility a healthy profit and enable to utility to cover some R&D effort. However, usually regulators look very carefully at all cost structures and tend only to accept engineering as a legitimate cost under their R&D expenditure. The utilities' ability to innovate in a regulated market will therefore depend on there being price-cap revisions which allow profit incentives for R&D spending.

Power utilities have a *defensive* innovation incentive, however. An established, unchallenged technology may be capable of reaching tremendous improvements when seriously threatened and when more predatory price cutting is not sufficient to deter new entrants. Newcomers with radical innovations should assume that power utilities with financial resources will respond vigorously with innovation of their own (see Figure 1).

Traditional equipment suppliers

Innovation in the electricity supply industry has traditionally been undertaken by the large suppliers of capital equipment. The industry, being old, has built up competencies over a long period, accumulated as an enormous amount of tacit knowledge. These well-established technologies have a sound state-of-the-art position

Figure 1. Patterns in the emergence of radical innovations



originated from a past innovation effort which is later improved by minor modifications, taking full advantage of the sunk cost investment made. Companies have been able to earn rents on intellectual property and they have traditionally devoted a significant amount of their revenues to incremental R&D. Unless these companies can benefit from a new dominant position in the market, they are likely to be opposed to the introduction of any radically new technology as it will undermine their basic knowledge base. Hence, equipment suppliers will, in general, be oriented towards incremental type technologies.

Government

Governments are concerned with the social costs and benefits of new technologies, so they will sponsor research into cheap technologies which have low negative (or possibly positive) externalities. These may be both *radical* or *incremental*. The former would be the case for a new technology which is so efficient that it is able to provide cheaper power even with respect to competitors with a more favourable fixed-cost structure. Needless to say, returns on these investments are highly uncertain. Spending money on incremental technologies would probably get support from the utilities, but this may not be the case for the radical technologies.

New Entrants

As suggested above, aspiring entrants into the electricity supply industry may focus their research on technologies that are likely to displace the established utilities, so they will try to develop radical innovations.

Figure 2. Possible types of technology innovation facing the electric power utility

RADICAL		INCREMENTAL
Very-Radical	**Semi-Radical**	**Incremental**
New technology that replaces all a utility's current assets (e.g. fuel cells).	New technology that replaces some of the existing assets and relies only in part on the assets of the utility (e.g.: wind generators, which still require substantial back-up)	Improvement of existing technology

Even after privatisation, if utilities do not have a sufficient profit margin, capital market imperfections may hold back investment in innovation

Suppliers of other energy sources will have similar motivations. Many of the new technologies may use a competing energy source as a feedstock. For example, fuel cells require a supply of hydrogen - something the oil companies are possibly able to supply. Thus competing energy suppliers will also pursue radical technologies, but will concentrate on those technologies that will use their fuel as feedstock. Where the energy source uses new fuels, or even no fuels (i.e. solar energy), the R&D push will probably be external to the power market, coming primarily from the electricity-production equipment sector, unless combined forms of exploitation are devised.

Innovation in deregulated markets

In a deregulated market, it can be projected (and has been witnessed in some countries) that the traditional utility would hold on to most consumers, while small incidental suppliers (i.e. whose core business is not electricity production) will operate on the fringes. The latter do not have much incentive to innovate because of their opportunistic presence in the market, as is the case of those independent power producers which consume most of the electricity they generate, and sell their excess.

Although the large utilities are likely to retain their position in the electricity market after privatisation (or deregulation), their investment in innovation may still be small if revenues are reduced and capital markets fail to provide financing. In the UK, for example, R&D investments declined in the utility industry following privatisation (1989): in 1988/89, the overall R&D expenditure in the UK electricity industry was £236 million, whereas in 1993/94 it was about £130 million (note, however, that this drop may be partly attributed to the business cycle). In the case of the United States, only a small fraction of the utilities' revenues is eventually allocated to industry research funds. This applies not only to the capital-intensive, radical innovation efforts, but even (and with particular force) to incremental innovations that exhibit in many cases positive environmental externalities. This scenario is likely to predominate when the liberalisation of the access to the grid by independent producers is not accompanied by a parallel price deregulation: even when a firm is willing to indulge in R&D financing, it may lose the incentive to innovate if the authorities reduce the price-cap by too much, thereby reducing any benefit that could be gained from innovation.

Consequently, when the above conditions apply, it can be expected that the electric-power utilities will focus their efforts less on technology innovation (which has a long payback-horizon) and more on securing low input (e.g. fuel) prices, as well as on diversifying end services. When power-generating companies are forced to compete, they will at first try to strengthen their competitive position by lowering their operating costs, so they can reduce their prices, maximising the use of their most cost-effective power plants. In addition, utilities will try to improve the electricity service quality, due to the limited investment needed to improve performance.

Under this scenario, R&D activities in power-generating technology will probably be carried out by equipment suppliers that can invest the available capital more efficiently in a range of precise innovation objectives. If they succeed, power utilities operating in a deregulated market may be willing to buy the new technology, thus allowing them to achieve high profits.

During the period of transition to a competitive market, there will be some evident possibilities of market distortion, simply reflecting the underlying cost-structure of the industry. Collusion schemes among companies can occur in a deregulated market with considerable barriers to entry and in which only a small number of electric utilities operate; such collusion does not offer a favourable environment for innovation.

Bearing this in mind, it seems that privatisation and deregulation of the electricity market should be achieved through a carefully evaluated and well balanced framework in which utilities and other industry actors can efficiently compete and find incentives to innovate. Fiscal incentives could be used to stimulate investment in innovation or to assist innovation (e.g. in environmentally beneficial technologies), but they should be carefully monitored to avoid distortion. This strategy would be in line with the objective of achieving a low-cost, low-pollutant, and high-quality electricity supply.

Conclusion

To summarise, innovation in a regulated power utility is driven more by defensive reasoning rather than a need to increase profits or improve market sales volume. With current technologies, the ability to switch to competing energy sources is limited. Profits are regulated and/or there is a need to provide the shareholders with a reasonable return on investment. As there is little profit-driven incentive for innovation, the focus of R&D is for survival. Regulated utilities have been inclined to under-invest in path-breaking R&D, and when they have invested, it has been to purchase sleeping patents for use in controlling the diffusion of a new technology. On the other hand, the electric-power utilities in a deregulated market will be inclined to buy innovative technology in order to achieve a competitive advantage, but are unlikely to self-finance effective innovation efforts if profits remain small and capital markets fail to provide financing. The restructuring of the electricity market should allow the costs of the system to be more accurately placed. The chosen scheme of deregulation will play a key role towards technology development in the market and therefore towards enhancing the benefit that customers and the society can receive from innovation.

Keywords

Technology innovation, competition, electric power utilities, regulated & deregulated markets.

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Olive Oil on the Increase, Oil Blends on the Attack:

Technology and market displacement

Matteo Bonazzi

Issue: World demand for olive oil is expanding rapidly, with fastest growth in developed countries where consumers are switching to more healthy diets. The market prospects, strengthened by expected GATT and Euro-Mediterranean trade dynamics and technological advances in the industry, could be crucial for the Mediterranean basin, where the majority of world olive oil is produced and consumed. However, new and extremely cheap vegetable-olive oil blends can imitate the taste of olive oil perfectly, and although they do not have the same health qualities, threaten both its existing and future markets.

Relevance: Olive oil provides the basic income for about two million families in the southern EU, and almost three million in all the Mediterranean countries. Furthermore, it is fundamental to their dietary and cultural patterns. Many of them are investing heavily in the olive oil sector, driven by the multiple benefits of technological change, employment restructuring and expanding export markets. In this context, cheaper imitations based on oil blends could threaten both the cultural identity and economy of many regions in Spain, Italy, Greece, Portugal and the Maghreb, generating up to a 15% increase in unemployment. This situation calls for very cautious policies, as the conflicting interests currently threaten to undermine the opportunities for development of the Mediterranean.

The king of vegetable oils

Olive oil, fundamental to the health, culture and economy of the Mediterranean....

World demand for vegetable oils is growing faster than for any other food and oilmeal produce, driven by demographic growth, increased purchase power in lower-income countries, and increasing health and taste concerns in high-income countries. Therefore the market for palm and sunflower oils could grow fastest in Asia and South America, while market growth for olive oil will be concentrated in developed countries. Olive oil is fundamental to the Mediterranean diet, which was recently recognised as being even better than the low-fat and high-fibre diet patterns: olive oil is the healthiest of all the vegetable oils, offering a safeguard against cardio-vascular diseases, neoplasia and ageing dynamics.

Olive oil is also the king of vegetable oils from an economic standpoint: it accounts for only 3% of their world volume, but between 10% to 20% of their market value (although a significant share of this is due to EU subsidies). It is the most typical product of the Mediterranean basin, where 96% of world production and 91% of world consumption is concentrated. Of this, Spain, Italy and Greece alone account for around 75%. Furthermore, olive oil constitutes the basic income source for around 2.7 million families, of which around two million live in the southern EU, predominantly in the less-favoured regions. It is a fundamental part of the dietary and cultural patterns of this region, and environmentally, olive crops play an important role in preventing serious desertification.

On the other hand, the olive oil market is taking on a global dimension and expanding into new markets. Driven by health and taste concerns, demand is mounting, mostly in high purchase power countries. So far the USA has been the fastest growing market, witnessing an impressive increase of +460% over the last 15 years. Australia, Japan and Canada have experienced similar trends, and Argentina and Brazil are expected to follow over the next few years. This market growth can largely be attributed to the healthy and natural image portrayed in the constant and flexible promotional campaigns. Under the same conditions, non-producer EU countries could witness the same demand explosion, estimated to be around +350% in 5 years.

To date, the EU Common Agricultural Policy (CAP) has heavily subsidized European olive oil production, consumption and trade, resulting in prices which are higher than could be expected in an open market. However, following the GATT agreement, the EU will have to gradually lower this protection from July 1996 to the year 2000. Pressure on prices will mount, pushing producer countries to set up aggressive export strategies to penetrate into new and expanding markets. Furthermore, the future Euro-Mediterranean Free Trade Area, foreseen for the year 2010, will push the Member countries to specialise their production patterns in order to promote new and market-based cohesive dynamics within the EU and the Mediterranean basin.

All these market prospects present olive oil as a promising sector for sustainable development in the Mediterranean. Moreover, radical technological change looks set to rationalise the whole production chain, especially in European producer countries, transforming this traditionally backward sector into a more competitive industry. Innovation, both in primary production and extraction technologies, will have a significant impact on employment, environment and cultural patterns. Genetic programming, mechanized harvesting, ecological management of pests, water and soil, as well as new extraction technologies, will dramatically cut both economic costs and environmental degradation, simultaneously allowing a better product quality. To achieve this new level of competitiveness, the olive oil sector will become much more capital intensive, especially in southern Europe, where technology availability and market pressures are greater.

Ultimately, this will promote a shift from low to higher skilled jobs as the sector becomes more technology- and market-oriented. Policy makers should support this change in the employment structure by promoting the creation of these new job profiles. In addition, these changes can be exploited for maximum benefit by integrating the olive sector with other activities so as to become more niche oriented. These niches should respect the fragile environmental equilibrium and cultural identity of the Mediterranean regions; factors which could offer competitive advantages. For example, the identification of agricultural products with a specific territory and its attributes - landscape, scenery, culture - could enhance their competitiveness, and can catalyse business opportunities if well linked to service sectors, such as rural tourism.

Tomorrow's olive oil producers and marketers

In the short term, world olive oil demand will grow and rationalization of the sector will enable all producer countries to increase both olive oil production and quality, which will play an increasingly significant role in the market. The EU will maintain its world production share, while its share of consumption will be lower; thus a growing share of its production will be targeted at non-EU export markets.

Within the EU, Italy now imports seven times more olive oil than Spain, but controls, through

. .is now spreading into richer markets USA, Canada, Japan, Australia and northern Europe

Future world trade dynamics, new market and technological prospects...

..are pushing many Mediterranean countries to invest heavily in the olive oil sector..

.. as well as pushing companies to market vegetable-olive oil blends, "imitating" olive oil

.. and promoting the positive health impact of olive oil in northern EU to internalize healthcare costs

The low price of blends threatens olive oil: a lost opportunity for sustainable growth..

brand-oriented market policies, the largest share of the export markets. This trend will continue over the next few years: **Italy** will strengthen its position as the world's largest consumer and marketing country, being the better equipped in vertical integration within the whole production chain; **Spain** will become the biggest olive oil producing country, while **Greece** will take a half-way position between the two. Spain and Greece have already reached a high quality production level, but will probably pay the price for their current marketing backwardness.

The opportunities presented by market growth and technological change are also alluring many non-EU Mediterranean countries to embark on important strategies for expanding and modernising their olive oil sector. The Moroccan government has prioritized the olive sector, which already generates 11 million working days and 11% of the food export value. Significant technological modernisation will enable production increases of up to 50%, in order to meet a 2-3 fold demand growth. Although at first glance they will provide competition for EU producers, the benefits in terms of economic development and reduced demographic/migratory pressures should not be underestimated.

Casting oils on the flames: olive oil or blends?

The same favourable prospects which are encouraging many Mediterranean countries to invest in the olive oil sector are embittering the competition from blends of olive oil with other vegetable oils. The performance of oil blends has recently become more competitive thanks to technological change. In fact recent achievements in genetic research allow the production of vegetable oils with a smooth taste and healthier performances due to the higher content of oleic acid. With only a 10% share of olive oil, these blends can "imitate" its taste and flavour perfectly, though less well its health profile, but at a fifth of the price.

Both production and trade of these vegetable-olive oil blends have been banned so far in Spain, Italy, Greece and Portugal and olive oil producing countries unanimously agree that these regulations should be extended throughout the EU and Mediterranean. The argument has so far focused on the inability to detect the exact olive oil share contained in the blends, thus making it impossible to detect frauds. In any case, it is necessary to explore prospectively other under-discussed but very important facets of the problems presented by vegetable-olive oil blends.

In the expanding olive oil markets consumers are primarily being led by health concerns, while the traditional olive oil consumers in Spain, Italy, Greece and Portugal are concerned primarily with taste. As vegetable-olive oil blends are able to combine both a low price and the taste of olive oil, they could snatch a huge share of the olive oil market in the latter countries, severely impacting on their dietary habits, cultural patterns and health.

Large companies are already successfully testing the introduction of the blends at international level. They could partially penetrate into virgin sections of the world market, while in other sections they would compete heavily with olive oil, seriously jeopardizing the latter's image and market expansion. These market losses at both EU and world level could cost the EU dearly in terms of intervention prices and subsidies for olive oil production, consumption and trade, clearly in conflict with the current trend in trade deregulation.

The introduction *tout court* of vegetable-olive oil blends into the world markets risks the loss of an opportunity for both economic and social welfare growth in many Mediterranean countries, not to mention its significant impact on their dietary patterns and cultural identity. Moreover, it could threaten the very survival of many rural economies all around the basin: Spain, Italy, Greece, Portugal and the Maghreb could witness a related rise in unemployment rate of up to 12%, while at the regional level, it could in some cases increase by 15%. The conflicting interests of the producers, industry and trade sectors prevent a clear definition of the future market for vegetable-olive oil blends.

Even the EU Seed Crushers and Oil Processors national associations have not taken a unanimous position on this controversy: each of them has been left free to defend its own vision and strategy. A recent questionnaire pointed out that only those of Spain, Italy and Portugal are promoting a ban on both the production and trade of oil blends. Those from Germany, Denmark, The Netherlands, France and United Kingdom would allow both, although so far only a few companies are involved in this business (less than 100 000 marketed tons all together). Some companies from The Netherlands have assumed a very interesting and original position on this matter: to permit both production and trade of these blends provided that no reference in name or illustration is made to olive oil.

Over the next few months, the European Commission will have to develop very cautious policies about both the production and trade of vegetable-olive oil blends. With this in mind, attention should be given not only to the importance of growth in the olive oil sector to development of the Mediterranean, but also to the possibility of negative health impacts if olive oil becomes substituted by oil blends in these countries.

In this light, vegetable-olive oil blends should not compete directly with olive oil. Instead, a product and market differentiation could be established through the introduction of a special labelling system for olive oil and its blends following on from, and incorporating the aforementioned proposal from Dutch firms. Such a labelling system could enable consumers to clearly distinguish the different characteristics, origin, performances and quality of each product, in a clear, concise, jargon-free, large-print form.

. . as well as a danger for the healthier profile of Mediterranean consumers?

Similarly, as northern EU countries are characterised by a high purchase power, consumer sensitivity to health concerns, and high incidence of cardio-vascular diseases, an effective labelling system and promotional campaign could help inform consumers of the health benefits of olive oil and contribute to the internalisation of significant healthcare costs.

An honourable solution: a special labelling system to protect the "olive oil culture" in southern EU

Overall, the importance of olive oil in the Mediterranean, and its health benefits, should be taken into account in formulating cautious policies, aimed at defining a tailor-made labelling system to fit in the peculiar physiognomy of the olive oil sector and its blends.

Keywords

olive oil, vegetable-olive oil blends, market, free trade, Mediterranean, sustainable development, competition, unemployment, cultural patterns, EU policy

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Producing High Value-added Molecules in Crops:

A sustainable alternative for agriculture?

Mario Demicheli

Issue: Molecular farming, aimed at engineering and producing high value-added molecules in plants, may be a valuable alternative to classical techniques and bring new benefits to agriculture. Until now crops have been grown mainly for production of raw materials in various sectors such as food, paper, energy, building, etc. Important natural pharmaceutical molecules have also been extracted from plants. Modern genetic engineering techniques are now opening up new avenues for the use of plants as chemical factories.

Relevance: The policy implications of using plants for the production of high value-added molecules are manifold. Among them is the obvious market opportunity for cheaper production of drugs or other chemical compounds, as indicated by the scale of recent investments by the US pharmaceutical industry. Secondly, this new process calls for careful risk-assessment and standard setting. And thirdly, this approach can contribute to alleviating the strains under which the Common Agricultural Policy is operating.

Biomedical applications

Not so long ago, most pharmaceutical preparations came from plants. However, from the middle of this century, most drugs have been totally or partially synthesised in factories, often through a number of complex and costly steps. Genetic manipulation, which started with animal cells, has now been widely extended to plants. Transgenic plants with improved characteristics have already reached the market. Scientists are also turning their attention to the production of high value-added molecules in plants, ranging from biopharmaceuticals (antibodies, antigenes, drugs) to enzymes or 'nutraceuticals', administration to humans. Once synthesised within the plant tissues, molecules are usually extracted and purified through rather complex processes. However, if they are targeted to edible parts of the plant, the production of raw foodstuffs for oral delivery could also be envisaged.

Plants offer many advantages for antibody production....

Antibody engineering in transgenic plants

After the finding that a complex mammalian protein such as immunoglobulin could be assembled within a plant cell [1], plant antibody production has proceeded at a slow pace. Meanwhile, the recombinant antibody industry was building on other expression systems and traditional cellular fermentation technology, rather than an agricultural base. However, plants offer key advantages, especially in their ability to match the protein assembly capabilities of mammalian cells. This applies to single chain fragments as well as to the full-length antibody [2].

Plants are generally inexpensive to grow on a large scale, and their production is not limited by fermentor capacities. Preliminary results have shown that plant organs, such as tobacco seeds or potato tubers, are better suited for expression of antibody fragments than are bacterial or other systems [3]. Once a stable integration of the foreign DNA into the plant genome is achieved, the appropriate cross-fertilisation of these single transgenic plants leads to a variety which can produce the desired antibody with yields between 1 and 5% of total plant protein [2,3].

The choice of plant material is crucial for the successful production of antibodies in large quantities. Research groups are currently screening plants in order to select the part that is best suited to antibody production, i.e. that leads to better yields and simpler extraction. Unfortunately, recombinant proteins expressed in green tissues generally cannot be stored after harvesting without cooling or immediate isolation. By contrast, seeds look promising for holding proteins for long periods of time without degradation.

An additional advantage of plant-derived antibodies over those derived from other recombinant systems (bacterial, yeast) or hybridomas, is that they are not exposed to, or generated in, the presence of animal agents, products or adventitious organisms. However, sensitisation to plant antigens and secondary plant metabolites with recognised biological functions may be a matter of concern for future applications [2].

Because the protein backbones, processing and assembly are known to be preserved in tact in plants, plant antibody evaluation is likely to be focused on comparing their function with the parental mammalian antibody source.

Potential for therapy

The potential of recombinant antibodies for human and veterinary medicine, be it passive immunotherapy or cell targeting, has been appreciated for many years and yet, to date, only three antibodies have been approved for clinical use. Clearly, there are problems in developing therapeutic monoclonal antibodies, irrespective of the expression system used for their production. Transgenic plants may help to overcome some of these problems, especially with regard to the requirement of large quantities of antibodies at low cost [2].

In September 1994, Agracetus Inc. (Middleton, Wisconsin) announced a multi-annual research, development and manufacturing agreement with Bristol-Myers Squibb Pharmaceutical Group (Princeton NJ) to produce BR96, Bristol-Myers Squibb's leading therapeutic monoclonal antibody, in transgenic plants. This antibody has shown some promise in pre-clinical trials as a vehicle for targeting the chemotherapeutic drug, doxorubicin, to breast, colon, ovarian and lung tumours, and is now following clinical trials to determine its safety in humans [5]. This is a typical example of direct neutralising effect, in which the antibody need not be designed to bind antigen.

Large amounts of monoclonal antibodies are required for *in vivo* passive immunisation. A good, topical example is immunotherapy for dental decay, where infection by *Streptococcus mutans* can be prevented and the level of disease reduced through regular application of monoclonal antibodies. However, secretory immunoglobulin antibodies are the predominant form of antibody at mucosal sites in humans, and hence would be more effective than monoclonal antibodies at these sites. Large-scale production of secretory antibodies in transgenic plants can now increase the feasibility of this treatment.

The expression of antibodies in plants also offers an alternative to "antisense", a gene-blocking technology which was hastily tested for treating AIDS or cancer, and whose mechanism is far from being fully understood [6].

Another approach is to use transgenic plants for active immunisation. Several independent re-

...including low cost of production and lack of exposure to animal agents, products or adventitious organisms

There are problems in development of recombinant antibodies irrespective of the expression system

Commercial production of non-food products using bioengineered plants has begun, including lauric acid for soaps, eruric acid for nylon, and isomers of oleic acid for margarine

search results indeed support the possibility of using genetically engineered plants to produce vaccines against human diseases, ranging from tooth decay to serious infections such as bacterial diarrhoea, cholera and AIDS. These studies are in an early stage of development. So far it has been demonstrated that proteins can evoke immune responses in mice for two different systems (hepatitis B virus in tobacco and enterotoxin in potato tubers). Still, several issues have to be resolved before production of vaccines in plants can advantageously displace current methods.

Beyond antibodies: non-food products in general

Biotechnology is changing the concept of plant-based raw materials. Initially concentrated on improving the quality of food plants, geneticists are now focusing their attention on creating plants that can supply other different materials.

The first non-food products of plant bioengineering likely to be commercialised on a large-scale are tailor-made industrial oils and speciality polymers. Calgene is involved in the commercial production of lauric acid, a 12-carbon fatty acid used to make soaps and detergents, using a genetically-engineered rapeseed plant. By introducing a foreign gene that stops fatty acid synthesis after 12 carbons, the plant was induced to make lauric acid with a fairly high productivity. Other far-reaching developments include the production of erucic acid, a lubricant and feedstock for making nylon 13-13, and isomers of the oleic acid used to make margarine. Commercial plastic-producing plants remain several years away, although researchers have been making progress. Also worthy of note is the introduction into plants of bacterial genes carrying the information required for producing enzymes that catalyse the synthesis of biodegradable plastic.

Again, one of the main research challenges is how to target production in specific plant regions which can accumulate profitable quantities of product without significant impact on plant growth or seed yield. Unfortunately, the benefits of using bioengineered plants fall steeply with the complexity of the synthetic pathway.

Commercial aspects

It has been estimated that by expressing antibody in soybean at a level of 1% of total protein, 1kg of antibody could be produced for about $100 [9]. Costs will certainly be further reduced as improved vectors and purification procedures are being developed.

Presently, Agracetus (US) is engaged in collaborative agreements with over half a dozen pharmaceutical companies for the purpose of evaluating the commercial availability of antibody production in plants. Agracetus has termed this technology 'Plant Bioreactor Production' (PBP). The **claimed** advantages of PBP over conventional antibody manufacturing technologies are shown in the table below.

The University of Leicester, in collaboration with industrial partners Unilever and Plant Breeding International (PBI), is now undertaking a research project aimed at developing technologies that would make plant-production of antibodies commercially feasible. This partnership brings together three complementary sets of expertise: the university's skills in plant science, Unilever's expertise in immunology and antibody functions, and PBI's experience in crop agronomy and genetic modification [4].

Calgene and Limagrain have recently completed an agreement covering seed-specific expression and molecular farming patents for the production of pharmaceutical proteins from genetically-engineered canola varieties. Limagrain also forged an agreement with Jouveinal for the development of new drugs against cystic fibrosis by means of plant gene therapy [10].

More generally, experts from the Consulting Resources Corporation in Lexington, Massachusetts have predicted that the sales of non-food products from transgenic plants will grow from $15 million per year today to \$320 million or more by 2005 [8].

Policy implications

Like conventional techniques, the release of transgenic plants for growing specific molecules may entail some risk for human health or the environment. Risk assessment is now being undertaken in some countries on a case-by-case basis, leading to tailor-made procedures for each crop which are disseminated. These rules tend to stress measures of biological confinement [11]. However, the definition of risk assessment procedures dealing with large-scale dissemination and marketing of transgenic plants need to be improved. A report by the EC's Forward Studies Unit concludes that European legislation should be focused on plants and molecules, where the risk to human health or the environment is real or significant. Specific standards can be developed with the help of the scientific community. Moreover, considerable efforts should be made to improve risk assessment techniques and to make the process more uniform across the EU [12].

Technological innovations promise significant environmental improvements. The use of bioengineered plants now offers an economical way of making antibodies on an industrial scale, outside the pharmaceutical industries. The growth of these crops could also add to crop diversity and help re-direct European agriculture away from heavily subsidised, and/or surplus crops. The use of indigenous crops for the production of cheap antibody vaccines offers enormous potential for improving healthcare in the Third World, whilst also introducing new commercial crops into the existing agricultural infrastructure in these areas.

Sales of non-food products from transgenic plants have been forecast to grow from \$15m in 1996 to \$320m or more by 2005

	Existing technologies	Plant bioreactors
DIRECT PRODUCTION COSTS	Crude: $\$10^4$ to $\$10^6$ per kg Purified: $\$10^5$ to $\$10^7$ per kg (Bio/Technology 11 (1993) 349)	Two to three orders of magnitude less $\$10^3$ per kg (Agracetus estimate)
PRODUCT QUALITY & SAFETY	Bacterial fermentation produces biologically inactive products Poor post-translational modifications Contamination with pyrogens, toxins, animal pathogens and adventitious agents Extensive purification required	Biologically active Post-translational modifications present Food crops with a long history of safe use must be used at hosts Allows orally-active formulation or industrial applications with minimal processing
SCALE-UP	Many parameters, difficult to optimize Limited in scale Require \$30 to \$70 million capital investment and FDA* validation of facilities	Just plant more seeds on increased acreage Can produce virtually unlimited quantities Contract grower network well established, no capital investment for production facilities required

Source. Food and Drug Administration

The Union is starting to work in this exciting research field and some actions have already been taken in the context of the Fourth Framework Programme (cf. FAIR Programme). The Task Force on vaccines and viral diseases is addressing the issue of molecular farming and sees it as a very promising field for further development. Further action could be directed toward building expertise within Europe and networking. Europe's broad tradition in molecular biology and in agricultural science is to play a major role in matching the need for health and environmental protection and the need for European industry to be competitive.

Keywords

antibodies, transgenic plants, therapeutics, non-food agriculture, pharmaceutical industry

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Dual Use and Technology Transfer in the Titanium Industry

Tonino Amorelli

Issue: Titanium and its alloys offer physical advantages over their material competitors. However, fluctuating demand, mainly from aerospace and defence, has led to high costs. As demand grows from other areas, the European industry will need to evolve to meet it, mostly through exploiting opportunities for dual-use and technology transfer.

Relevance: As demand grows for advanced materials with specific physical and mechanical properties, there is a chance to stimulate diversification within the titanium industry. Given the high-tech history of both the aerospace and defence industries, an opportunity exists for technology transfer between the military and civilian sectors, defence industry conversion, and for securing a more competitive position in the world titanium market.

Introduction

The area of advanced materials is currently very competitive. Industrial demands for lighter weight, energy-saving components and parts with enhanced chemical and physical resistance are increasing. These, however, must be supplied with some guarantee and at a reasonable cost; criteria which titanium has been unable to meet in recent years. However, there are some promising prospects for the industry. Possible applications range from biomedical uses, such as prostheses, to minor automotive applications, and interest is growing throughout the different industrial sectors including the construction industry. This diversification provides an opportunity for the transfer of advanced technologies, and extensive knowledge and experience, from the defence and aerospace sectors into low-technology areas. Furthermore, there is an opportunity for the conversion of defence-oriented titanium production into an industry focused on civilian production, by exploiting its dual use aspects.

For many years there has been consensus throughout the titanium industry that action is needed to improve the competitiveness of the metal in civilian industry. However, to date end-user considerations of cost and reliability of supply have prevented its widespread, high-volume use. Titanium also faces tough competition from aluminium alloys, composites and newly-developed steels. However, its physical properties give it an edge in some applications, and it is these that are now being exploited.

Worldwide trends

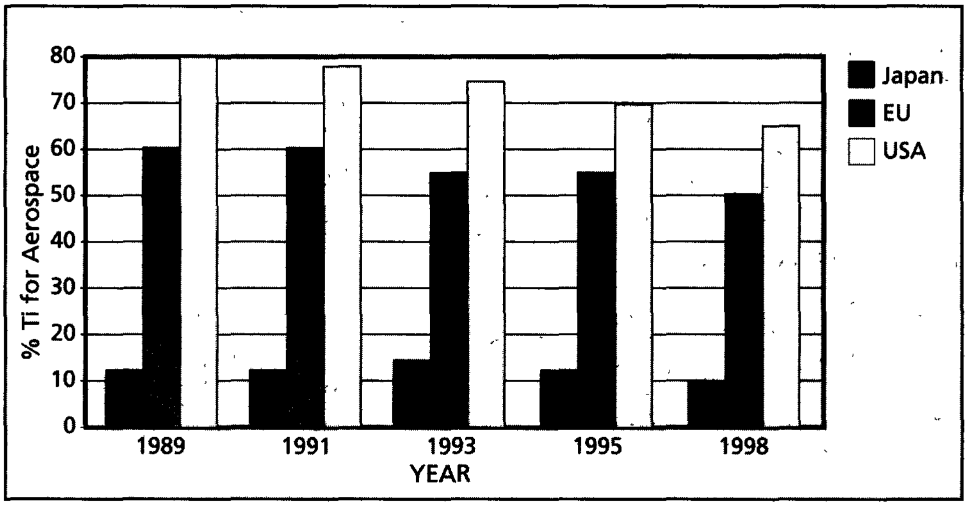
In both Europe and the USA, the titanium industry faces not only technical problems, but economic ones as well. This is due to the industry's close connection with aerospace and defence, which in recent years has accounted for more than half the titanium produced (currently 55-60%) although this figure is now declining (see figure 1). The industry has therefore been sus-

Aerospace and defence account for over half the titanium market in the US and Europe..

Technology and Competitiveness

..in Japan the market is more diverse

Figure 1: Titanium used for aerospace applications: trends and forecast to 1998



ceptible to the demand cycles of the aerospace and defence sectors; a situation not conducive to industrial development or innovation. The dominance of these sectors has also meant that production processes have been developed which are either not suitable or too stringent for higher volume industrial applications.

This is not the case in Japan, as it does not have a strong domestic aircraft industry and its titanium industry has successfully sought other industrial opportunities. Furthermore, the development of industrial markets requires commitment to a long-term and consistent effort, more likely to be found in Japanese firms than in European ones.

It is estimated that the world market for titanium is well in excess of US$2 billion and growing. However, the industry is fairly inflexible to demand fluctuations, with companies making considerable losses during the periods of low demand which have to be compensated by price increases during 'boom' periods. Despite price increases of 35% over the past year, US, UK and Japanese companies are still experiencing losses.

Diversification of the titanium industry is the only solution for long-term growth

A considerable amount of expertise has been built up over the years at the high-tech, high-cost end of the market, through collaboration between the titanium producers and the aerospace/defence industries. The opportunity to transfer this knowledge to more low-tech sectors may now have arrived.

Competition and need for action

The US share of the titanium market, and its strong alliance with the aerospace industry, impact heavily on the industry worldwide and so cannot be examined in isolation. US companies, for example, have an aggressive acquisition policy in Europe and currently control 42% of world titanium production. The most recent merger took place between Timet (USA) and IMI (UK), a deal which followed an earlier approach to the French company Cezus, a subsidiary of Pechiney. It is difficult to forecast the success of this merger, as industry experts have commented that the newly-formed company may make greater losses than the two companies operating separately.

Over the past three years there has also been an influx of titanium from the former Soviet Union (FSU), which has also strongly affected the international market. The fall in demand from the domestic defence industry has forced FSU manufacturers to look for other markets, and large amounts of titanium have been exported in search of hard currency. One company, VSMPO, has made significant efforts to move to more commercial, civilian sectors.

The Japanese market is not defence-dependent and has therefore been more varied. It has shown both consistent growth, and also considerable innovation in the application of titanium for both industrial and non-industrial applications. As a result, the Japanese titanium industry has a clear advantage over its international competitors, as there is no need for technology transfer into civilian applications or conversion of military installations.

US manufacturers are aiming to diversify their production into different end-markets, with some companies (RMI in particular) aiming for 50% aerospace, 50% other by the end of 1997. The US government has also invested heavily in technology transfer programmes, e.g. Small Business Innovation Research (SBIR) and Co-operative Research and Development Agreement (CRADA) programmes, to help the diversification of those companies previously heavily dependent on defence contracts (however, recent political changes in the US Congress look set to reduce the size of these programmes). In the EU there is little comparable support for the diversification of the titanium industry. Only in the UK has there been some funding available from the 'Konver' programme, aimed at encouraging the creation of new businesses and helping to create innovation and training programmes.

Similar strategies may be useful on a pan-European scale. The importance of preserving the knowledge-base and expertise built up in the titanium industry, and industries like it, may be vital for their future survival in Europe. The stimulation of innovation within the industry through dedicated technology transfer programmes may be one method, but of equal importance is the subsequent diffusion of information to the awaiting marketplace. The re-education of both the supplier and the buyer may be the key to guaranteed success.

Why titanium could be of future importance

The aerospace industry favours titanium because of its combined high fatigue strength, fracture toughness and lower density as compared with other materials. It is these same properties, along with non-toxicity and its chemical resistance to environments which cannot be tolerated by other materials, that have now enabled its re-entry into the market in new industrial sectors. Applications which are now beginning to evolve include:

- *medical*: dental implants, bone joints and recently an artificial heart
- *pollution control*: flue gas desulphurisation, nuclear waste storage
- *off-shore & marine*: platforms, pipelines, desalination plants
- *automotive*: springs, valves
- *construction*: roofs, cladding
- *industrial*: reactors, pipes, etc.
- *leisure & recreation*: bicycles, golf clubs, etc.

The physical properties of titanium has advantages outside the aerospace and defence industries

In lifecycle terms, the main disadvantage of titanium is the high energy input required for its manufacture, which is similar to that required in aluminium manufacture. However, a number of benefits can be balanced against this. Titanium offers potential reductions in operating costs by reducing energy consumption in engines and other equipment, where weight-saving translates into better fuel economy; improved heat transfer; corrosion resistance, and environmental protection from the reduced risk of leakage through corrosion.

The titanium industry is also supported by a well established recycling infrastructure, due to the history of large amounts of waste during the production of aerospace parts. The recycled content of new material can be between 45-65%, but as with all advanced materials, the variation of alloy composition and lack of standards can be a problem. With respect to this, it is interesting to note that the Versailles project on Advanced Materials and Standards (VAMAS - concerned with promoting a consistent measurement base for advanced materials in the international market, including EU, USA, Japan and Canada) signed a memorandum in 1992 which did not include titanium. However, in 1990, the USA did include titanium in a list of *strategic materials*.

Dual use and technology transfer offer solutions to the problem of diversification

Conclusions

The problem with the titanium industry is the "boom or bust" situation which has been a factor of the industry for 40 years, due to its dependence on the fortunes of the defence budgetary priorities. As with all materials, there are technical considerations for the industry and further research on a replacement for the production (Kroll) process would be beneficial. However, this is by no means the limiting factor to the growth of the industry, and by far the greatest priority should be given to expanding the market for titanium outside the traditional aerospace and defence industries.

In order to realise the opportunities for diversification, attention needs to be given to technology transfer mechanisms and exploitation of titanium's dual-use characteristics for military-civilian industrial conversion. These objectives could apply equally to other industries which have traditionally been dependent on defence and aerospace contracts and should contribute to the overall competitiveness of European industry and protection of a well-established knowledge-base. In order to support this process in the titanium industry, it may be necessary to set up a European trade association, already well established in both the USA and Japan. A body with a European focus, and which may also include the FSU, may allow greater industry-wide co-operation and the chance to develop clear industrial strategies for the future.

Keywords:

materials, titanium, dual use, industrial competitivity; market diversification

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Novel Environmental Technology Should Not Discourage Small Enterprises

Novel technology for olive oil extraction that uses no water is expected to diffuse through the olive oil producing countries of the Mediterranean. However, this technology calls for new ways of upgrading the large amounts of residue generated (a plastic, sticky olive cake with 50-60% humidity). One of the more radical approaches being adopted is its combustion for generation of heat and/or power (e.g., Vetejar - Spain, Ansaldo - Italy, CRES and others - Greece). However, for this approach to be viable a minimum amount of power generation has be achieved, requiring an investment that small, isolated producers are not ready to assume. Moreover, there is a risk of fuel shortage -demonstrated during the last and present season's droughts, requiring plants to have an available biomass/fossil substitute for emergency situations.

A more cautious alternative has been found by medium-sized olive oil co-operative companies in Spain. They have concentrated efforts on improving the storage, transportation, and drying technologies to deal with the residue, as well as seeking out novel markets for its derivatives. In the Andalusia region of Spain, for example, the increase in local demand for dried olive cake (45% of the raw cake mass) used as fuel, caused the price to double last year (which, however, was an unusual one because of the small olive harvest).

This approach appears to suit new manufacturers and small-medium producers better, allowing them to benefit from the good market prospects for olive oil and its by-products, while avoiding the high costs of the power plant and reducing risky ventures.

Nevertheless, it should be pointed out that in this second approach additional capital and operation and maintenance costs must be incurred for fuel conditioning (i.e. drying) purposes. Furthermore, standard dryers use fossil derived fuel. Therefore, an economic, environmental, and energy analysis of the overall system (e.g. from olive production to olive-oil and power attainment) seems to be appropriate before promoting the widespread application of such small-sized schemes.

By using dry olive cake for heating and/or electricity generation, a small integrated firm in this sector will be able to save energy and may also sell the surplus energy. However, it is supposed to be economically and environmentally more efficient if small/medium co-operative companies, being grouped for the purpose, take on power generation at a larger scale. Considering, for example, a generic biomass combustion system, the scale-up of a power plant from 5 to 50 MW can improve its efficiency (% low heating value) from 18 to over 30. Similarly, the only power plant capital costs decrease from US$ 6000 to 2000/kWe, while the electricity production cost falls from 17 to 9 US cent/kWh.

Of course, the conditions for achieving such joint ventures depends on local economies, farm/co-operative position and structure, *and* entrepreneurial culture.

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Information Technology: Development Myths and Realities

The recent report *"Telecommunications Indicators for the Least Developed Countries"* by the International Telecommunication Union (ITU), presented in Geneva in October 1995, says that "The experience of many of the middle-income developing countries is that the gap is now narrowing," but in the LDCs "there is strong evidence of 'market failure' in that potential investors are deterred by small market size, regulatory restrictions, lack of information and, in some cases, civil instability."

Twenty-nine LDCs are in sub-Saharan Africa, one is in the Americas, 13 are in the Asia-Pacific region and five are in the Arab States. Among the worst phone networks: Cambodia has a teledensity of 0.06; Chad 0.07; Zaire 0.09; and Niger 0.12. Among the LDCs with more developed networks, Nepal and Bhutan have teledensities of 0.35 and 0.25 respectively. Problems in this context are unavailability of service for long periods; noisy lines; high tariffs; long waiting lists; and unavailability of new services in rural areas.

Apart from the problem of civil conflict, primary causes are poor management, insufficient training, poor planning and low level of penetration in rural areas.

Furthermore the report says that LDCs invested only $289 million in telecoms infrastructure in 1993. At that rate, teledensity would rise from 0.28 lines per 100 people to only 0.42 by the year 2000. One of the main reasons LDCs invest so little in telecoms networks, in contrast to the demand for services, is because of hard currency shortages.

The ITU's report concludes with a series of recommendations:

- greater financial and management autonomy for telecommunications entities;
- independent regulators, with training for regulators;
- close cooperation among LDCs to pool resources and strengthen their bargaining positions;
- more funding from multilateral banks, some of it intended to spur a high degree of private participation.

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The Myth of Electronic Car Safety

Road accidents cost about 50,000 lives in Europe each year, a figure similar to the number of US casualties during the entire Vietnam war. As an important part of the solutions proposed to cope with this tragedy, the help of technology has been sought. Today, this relies on safety belts, airbags and ABS (anti-lock braking system), and tomorrow, on road-side beacons and on-board radar and cameras. Technologically-oriented solutions today provide great hopes for a future significant reduction in road accidents.

Yet, recent statistical studies from insurance companies have shown that, contrary to these expectations, drivers using a car equipped with airbags or ABS had a higher accident rate than those using a vehicle not using these technologies. The likely explanation for this effect lies in the fact that individuals accept a given risk level. When objective safety conditions change, road users' behaviour adapts to the accepted risk threshold.

At a societal level, these results can be related to those found at IIASA regarding an oscillation, from the 30s to the 70s, of the road fatality rate of around a value of 25 deaths per 100,000. Intrigingly, this figure appears to be similar for other developed countries. Naturally, a large reduction of this rate has been observed over the last two decades, particularly in Europe, implying that this fate is avoidable. Yet, this effect seems to be generic and may find roots in a social risk perception. Indeed, above a given threshold (which may change with time) of both perceived and accepted risk, society reacts through more severe legislation, stronger enforcement and more careful user behaviour, while below this level, the decrease of public awareness leads to a less significant social reaction.

Naturally, nothing is doomed to be invariant over a long time period. Yet, it may be argued that technology alone, whatever its level of development, will not solve the road safety issue. Only a deep integration of advanced technologies and changes in public attitude and behaviour will allow a substantial and long-lasting improvement in road safety.

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