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ABOUT THE IPTS REPORT

The IPTS Report was launched in December 1995, on the request and under the auspices of Commissioner Cresson. What seemed like a daunting challenge in late 1995, now appears in retrospect as a crucial galvaniser of the IPTS' energies and skills.

The Report has published articles in numerous areas, maintaining a rough balance between them, and exploiting interdisciplinarity as far as possible. Articles are deemed prospectively relevant if they attempt to explore issues not yet on the policymaker agenda (but projected to be there sooner or later), or underappreciated aspects of issues already on the policymaker's agenda. The long drafting and redrafting process, based on a series of interactive consultations with outside experts guarantees, quality control.

The first, and possibly most significant indicator, of success is that the Report is being read. The issue 00 (December 1995) had a print run of 2000 copies, in what seemed an optimistic projection at the time. Since then, its circulation has been boosted to 7000 copies. Requests for subscriptions have come not only from various parts of Europe but also from the US, Japan, Australia, Latin America, N. Africa, etc.

The laurels the publication is reaping are rendering it attractive for authors from outside the Commission. We have already published contributions by authors from such renowned institutions as the Dutch TNO, the German VDI, the Italian ENEAand the US Council of Strategic and International Studies.

Moreover, the IPTS formally collaborates on the production of the IPTS Report with a group of prestigious European institutions, with whom the IPTS has formed the European Science and Technology Observatory (ESTO), an important part of the remit of the IPTS. The IPTS Report is the most visible manifestation of this collaboration.

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

We shall continue to endeavour to find the best way of fulfilling the expectations of our quite diverse readership, avoiding oversimplification, as well as encyclopaedic reviews and the inaccessibility of academic journals. The key is to remind ourselves, as well as the readers, that we cannot be all things to all people, that it is important to carve our niche and continue optimally exploring and exploiting it, hoping to illuminate topics under a new, revealing light for the benefit of the readers, in order to prepare them for managing the challenges ahead.

Preface

As the century draws to a close Europe still holds a strong position in scientific research, indeed is leader in many domains. Nevertheless, it does not derive all the benefit it should in industry and commerce, and is unable to transform its intellectual wealth into products and services which meet the needs of our society. Europe suffers from real difficulty in innovating and it is too often forgotten in the debate on employment that innovation has an impact on both the level and quality of employment.

It is enough to look at recent developments in this domain in the United States to be convinced. Over ten million new jobs have been created in the US in the last four years, of which two thirds are in the high-technology sector. It is also noteworthy that highly-innovative SMEs have played a very important role in this process. Moreover, contrary to what is widely believed, they are mostly highly qualified jobs.

This is just to start with the most eloquent figures. Similarly the development of new products represents less than half of research spending in France and Germany, whereas it represents over 60% in the United States and Japan.

In their fight to create employment European countries have tried a wide range of methods but few policies have had a significant impact on the motor of innovation.

This would require the main obstacles discouraging innovation to be lifted. For example, it would be worthwhile to clarify and simplify the patent application system. The decline in the European situation in this domain is

particularly conspicuous. Of the 220,000 patents filed throughout the world in 1960, half were European. In 1995 only 85,000 of the world's 645,000 patents were from Europe.

We should, at the same time, rethink the whole system of financing our innovating companies. If a significant number of innovating SMEs have been created in the United States it is because it has been possible to redirect large amounts of capital towards them. Europe could also make similar means available with a more appropriate form of organization. Venture-capital funds are just as abundant here as on the other side of the Atlantic, but here they are less directed towards the high-technology sector. Thus, although biotechnology was born in Europe it is in the United States that the jobs have been created. Finally, we need to promote a true innovation culture across the board in education and business, and including public administrations. Without this our efforts in scientific research cannot have their full effect.

It is in this spirit that the Commission has adopted its Action Plan for innovation. With eighteen million people registered as unemployed in the Community it is clear that every effort must be made to obtain growth that stimulates employment. Our society, and our ability to face the challenges of the twenty-first century, depend upon it.

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EDITORIAL

The article that opens this issue deals with the issue of nitrates in foodstuffs and regulations regarding their intake. Two seemingly contradictory strands of experiments have created some misunderstandings among policymakers. On the one hand fruits and vegetables have well known and well documented effects on health - including the reduction of the risk of certain forms of cancer. On the other hand, nitrates (contained bywhich fruits and vegetables contain) have been linked to the formation inside the body (intragastrically to be precise) of a class of chemical carcinogens (N-Nitrosos compounds to be exact). The apparent contradiction is resolved when one notes that in the second class of experiments, fruits and vegetables were not used as 'inputs'; rather, very large doses of nitrates were fed to animals. It turns out, both from epidemiological research as well as other experiments, that when fruits and vegetables are consumed, the carcinogenic compoundscompounda are not formed due to the activity of other active agents to be found in fruits and vegetables such as vitamin C. This is why the World Health Organisation experts who studied the issue recently, came up with upper limits of daily intake of nitrates, but, knowing the positive effects of fruits and vegetables on health, and the absence of evidence linking them to the formation of carcinogenic compoundscopounds in the body, they did not derive limits for the intake of nitrates from fruits and vegetables. Recent regulations by some member states and the EU, soon to face revision, may need to take these considerations into account.

The second article argues that renewable energy technologies, and particularly photovoltaic technologies can offer a cost-effectiveeffecive alternative for rural electrification, especially when compared with extending the electricity grid to remote and lightly populated areas. Socio-economicSocioeconomic and environmental benefits of photovoltaic technologies may justify intervention in the important areas of standards, access to credit, adequate training provision, etc. Though electrification will raise standards of living therether is no proof of significant direct impact on income generating activities - electricity may at some point be a necessaryneceessary though not a sufficient condition for development. Growth has benefitedbenefitted by rural electrification when it has been promoted by a dynamic agricultural sector.

The third article suggests that the advent of the information society hashane profound implications for enterprises, and may, given the right framework, provide an opportunity for less favoured regions. The basic argument is that these technological developments may make mass-production and scale less important and distance less overwhelming an obstacle. The two areas in which policy-makingpolicymaking could move to guaranteegurantee a conduciveconducxive framework, would include the provision of high quality infrastructure locally, and not just between large centrescenters of international economic activityacrtivity, and the support of 'bridging' institutions stimulating networking among SMEs and spurring them into what has come to be known as the "cybereconomy".

The fourth article argues that European firms are very strong in the design and production of high cost, engineering intensive complexcomnplex products and systems. An example of such systems is that of mobile communications, in which Europe has been very successful in promoting GSM technology. The article argues thattaht a lot can be learned from the GSM example regarding the importance of coordinated collective action in setting common standards, and creating large markets.

The last article suggests that environmental policies based on increasinglyincresaingly stringent environmental standards have tended tohas been met by the adoption of curative (end-of-pipe) approaches. The paperpapaer argues that a well-managed technology development strategystartegy can help guide SMEs towards more environmentally- benign operation, if embedded from the beginning in the design and executionexecutiopn process, and not added as an afterthought. Moreover such a recasting of environmental considerationsconsideratuions will be a driving force for innovation, given an appropriate use of economic instruments.

Nitrates in Foodstuffs: A Food-Safety Issue

Miguel Vega and Laurent Bontoux, the IPTS

Health

Issue: Some *in vitro* and *in vivo* experiments have shown that a major fraction of the total body load of N-nitroso compounds (a class of chemical carcinogens) could be attributed to an intragastric formation related to the uptake of nitrates. However, other experiments have demonstrated consistent epidemiological findings that a diet rich in fruit and vegetables (generally the most important source of nitrates in the diet) reduces the risk of gastric cancer.

Relevance: Recent studies show that the Acceptable Daily Intake (ADI) for nitrates, allocated by the Joint FAO/WHO experts committee back in 1995, can be exceeded by just eating one meal rich in vegetables. Though the FAO/WHO experts did not derive limits for vegetables, several Member States, and later the European Commission, adopted maximum levels for nitrates in certain vegetables. These levels, and the vegetables to be included in the Commission's regulation, will be reviewed in the very near future; it is important that this review take into account the more recent experiments showing that putting the blame on vegetables and on nitrates naturally occurring in them, may not be advisable.

Introduction

The natural occurrence of nitrates in plants is a consequence of the nitrogen cycle whereby mineral nitrogen is assimilated by the plant as nitrates to use them in the synthesis of plant proteins. Nitrates are thus naturally found in vegetables as mineral nitrogen in cell fluids and sap as a precursor to protein formation.

Nitrates are also found in drinking-water due both to natural occurrence and to contamination of water supplies, mostly from agricultural sources (fertilisers and livestock manure) and municipal wastewater. They are also used as additives in cured meats due to their bacteriostatic properties (which prevent botulism) and for their red colour fixing properties. Therefore the three main sources of nitrates intake in the European diet are vegetables, water and cured meat. Vegetables constitute the major dietary source of nitrates, generally providing more than 80% of the daily dietary intake.

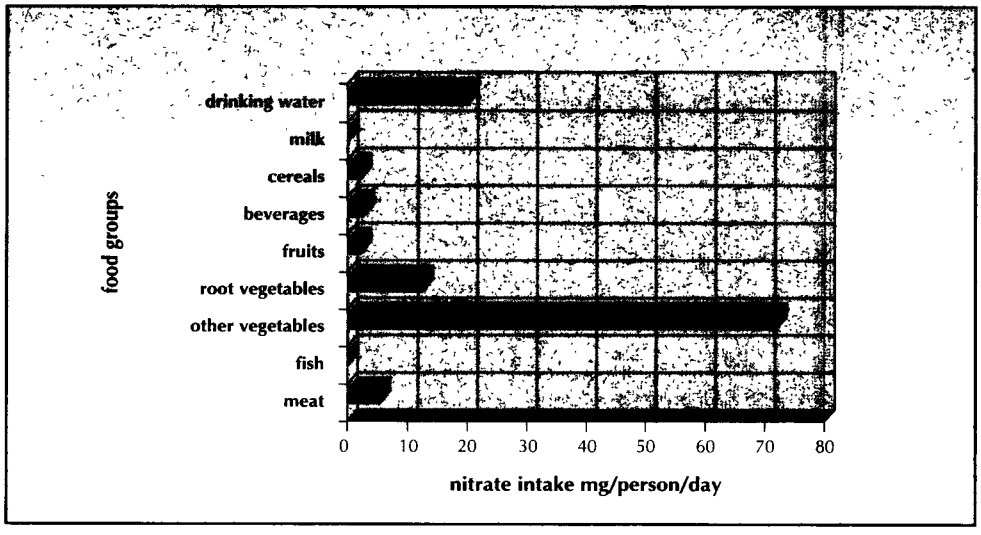
The public and political concern over nitrates in foodstuffs is two-fold: on the one hand, they may create an excess of methaemoglobin possibly leading to toxic effects such as cyanosis; and on the other hand they may cause the endogenous (internal body) formation of N-nitroso compounds (carcinogenic agents) such as nitrosamines. This article only addresses nitrate-derived carcinogenicity.

Certain food processes and specific circumstances in the stomach have been found to provide suitable conditions to form N-nitroso compounds. However, the most practical studies show the importance of having a diet rich in

Nitrates enter the diet via vegetables, water and cured meat. Vegetables account for 80% of dietary intake

There is no evidence of a link between vegetable consumption and endogenous N-nitroso compound formation except in the case of a few high-risk groups

Chart 1. Estimated total dietary intake of nitrates from foods prepared for consumption



Source Health aspects of nitrates and its metabolites International workshop Bilthoven, Netherlands Nov 1994. Council of Europe Average of available data from UK, Switzerland and The Netherlands

vegetables to prevent several types of cancer. They also show no evidence of a link between vegetable consumption and endogenous formation of N-nitroso compounds. At the same time these studies point to the risk of ingesting preformed N-nitroso compounds in foodstuffs, which are formed during certain biological, chemical or physical processes in crops, industry transformation or even at the time of consumption.

With respect to the occurrence of nitrates in foodstuffs a distinction can be made between nitrates present as additives and nitrates as naturally occurring substances

Occurrence of Nitrates in foodstuffs and their importance

It is generally accepted that nitrates in foodstuff are rapidly absorbed as soon as they reach the intestine. Once they are absorbed, nitrates undergo a metabolic process and rapid urinary evacuation. The issue of nitrates in foodstuff is this absorption and its subsequent reaction in the organism, which may have potential adverse health effects: it may create an excess of methaemoglobin leading to toxic effects and also it may cause the endogenous formation of carcinogenic agents.

With respect to the occurrence of nitrates in foodstuffs a distinction can be made between nitrates present as additives and nitrates as naturally occurring substances.

Nitrates as additives are widely used in the production of cured meat products, and to a lesser extent in the preservation of fish and in cheese production. Nitrates, and also nitrites, are listed as officially accepted preservatives in the Council Directive 95/2/EC on food additives other than colours and sweeteners. The concentration limits for nitrates, calculated as potassium nitrate, range from 50 mg/kg for cheese to 250 mg/kg for meat products.

Nitrates as naturally occurring substances may be found in fresh meat products, milk and milk products, grains, fruit, alcoholic drinks and vegetables including potatoes. For most of these foodstuffs only low concentrations are found, with the exception of some types of vegetables. Intake surveys given in chart 1 make clear that the exposure to nitrates is mainly a question of vegetables consumption and more specifically of the type of vegetables consumed.

It is difficult to estimate an average dietary intake of nitrates because it depends on each individual's diet and on the nitrate content of drinking water, which also varies according to regions and even seasons. The estimated total dietary intake of nitrates from foodstuff ranges from 50 to 150 mg/person/day. Vegetarians have a rather higher nitrate intake of about 200 mg/person/day, however this estimation may vary depending on the vegetables consumed.

Acceptable Daily Intake (ADI)

The Acceptable Daily Intake is a maximum recommended quantity of a substance to be ingested per day. It is allocated on the basis of a No Observed Adverse Effect Level derived from toxicological tests for additives, or other substances, that may pose a health risk.

An ADI of 0-3.7 mg per kg of body weight, expressed in nitrate ions, has been recommended by the joint FAO/WHO experts committee. However, "In deriving an ADI for nitrate the Committee took a cautious position. It was aware that vegetables are an important potential source of intake of nitrates. However in view of the well-known benefits of vegetables and the lack of data on the possible effects of vegetable matrices on the bio-availability of nitrate, the Committee considered it to be inappropriate to compare exposure to nitrate from vegetables directly with the ADI and hence to derive limits for nitrate in vegetables directly from it." (Page 349. Evaluation of certain food additives and contaminants 1995. Joint FAO/WHO Experts Committee)

Since the toxicity of nitrates results from its conversion to nitrites and the possible endogenous formation of N-nitroso compounds, nitrite ADI should also be taken into account. Therefore, for nitrites, the joint FAO/WHO experts committee recommends an ADI of 0-0.06 mg per kg of body weight, expressed in terms of nitrite ions. This ADI applies to all sources of intake, however nitrites should not be used as an additive in food for infants below the age of three months. The ADI does not apply to such infants.

Carcinogenicity studies of nitrates and nitrites have shown negative, with the exception of those in which extremely high doses of both nitrates and nitrosable precursors were administered. There was no quantitative evidence of the endogenous formation of N-nitroso compounds at intake levels of nitrates, or nitrites, and nitrosable precursors achievable in the diet. As a result, a quantitative risk assessment on the basis of endogenously formed N-nitroso compounds was not considered to be appropriate by the joint FAO/WHO experts committee.

Box 1. Acceptable Daily Intake (ADI) allocated by the joint FAO/WHO experts committee

Nitrates

ADI: 0-3.7 mg/kg body weight, expressed as nitrate ion.

It is allocated on the basis of the NOAEL (No Observed Adverse Effect Level) of 370 mg of nitrate ion/kg body weight/day in the long-term study in rats and a safety factor of 100.

Nitrites

ADI: 0-0.06 mg/kg body weight, expressed as nitrite ion

It is allocated on the basis of the NOEL (No Observed Adverse Effect Level) of 5.4 mg of nitrite ion/kg bw/day in 90-day toxicity studies in rats in which hypertrophy of the adrenal zona glomerulosa was observed, and 6.7 mg of nitrite ion/kg bw/day in a 2 year toxicity study in rats in which toxic effects in the heart and lungs were observed and a safety factor of 100. This ADI does not apply to infants below 3 months.

Source Evaluation of certain food additives and contaminants Forty-fourth report of the joint FAO/WHO Experts Committee on Food Additives WHO 1995

When defining the acceptable daily intake the committee took a cautious view, balancing the value of vegetables in the diet against the possible risks

Carcinogenicity studies of nitrates and nitrites have been negative, with the exception of those in which extremely high doses of both nitrates and nitrosable precursors were administered

Health

Given the valuable contribution of vegetables in the diet and the lack of evidence linking them to carcinogenic compounds, the FAO/WHO did not define limits for nitrates in vegetables

Studies have found that far from being dangerous to health, dietary nitrates are actually an essential part of our mechanism for neutralising toxic bacteria in the stomach

Occurrence of N-nitroso compounds and their importance

N-nitroso compounds are generally considered to be carcinogens in humans because of the evidence obtained from the extrapolations of results from animal tests to humans, which show that no animal species is known to be resistant to the induction of N-nitroso compounds, to date. There is also a wide body of evidence supporting the direct induction of human cancer by N-nitroso compound intake.

N-nitroso compounds may be of two different origins: endogenous formation, which is a natural formation of N-nitroso compounds in the stomach; and preformed N-nitroso compounds present in food and drugs due to manufacturing or processing techniques.

The **endogenous formation** of N-nitroso compounds begins when nitrates are reduced to nitrites by micro-organisms in the oral cavity, which later are transformed into nitric oxide in the stomach due to the acidic conditions therein. Under specific circumstances, such as chronic gastritis, nitrites may be oxidised to nitrosating agents (N_2O_3, N_2O_4) in the stomach and react to form N-nitroso compounds. This reaction occurs with nitrosable precursors, which include a large variety of dietary components such as secondary amines, amides, proteins and urea derivatives.

Several studies[1] have apparently shown that endogenous nitrosation yields large enough quantities of N-nitroso compounds to pose a relevant risk at intake levels for certain dietary nitrates. However these scientific studies use chemical compounds to recreate real conditions instead of using real vegetables. These studies either use in vitro tests or extrapolate results from surrogates to humans or use the N-nitrosoproline test to range the nitrosation rate, assuming that nitrosamines play the same role. Some studies needed to use even extremely large doses (10 times ADI) of nitrates and nitrosable precursors to prove the production of N-nitroso compounds.

On the other hand other studies2 such as epidemiological studies on populations having a rich diet in vegetables have revealed a negative correlation between nitrate intake and gastric cancer. Also in vivo studies of the endogenous formation of N-nitroso compounds caused by consuming vegetables have failed on demonstrating nitrosation in the stomach. This is almost certainly due to the amount of protection offered by natural dietary inhibitors of gastric nitrosation, such as vitamin C which is an important component of fruits and vegetables. These studies show that there is no health risk linked to dietary nitrates intake, with the exception of certain disease states, such as chronic atrophic gastritis or chronic urinary bladder infections, that have been implicated as mediators of nitrosation.

Other studies have found that far from being dangerous to health, dietary nitrates are actually an essential part of our mechanism for neutralising toxic bacteria in the stomach. Pathologists working at the University of Aberdeen and at St Bartholomew's Hospital in London, have discovered that the combination of nitric oxide and stomach acid is highly effective in destroying harmful bacteria such as Salmonella and Shigella. The nitrates found in saliva, which come mostly from the diet, may therefore be part of the body's defence against infectious diseases.

Apart from this particular health benefit, there are continuous findings showing that vegetables contain valuable anticarcinogenic substances. For example, Capsaicin, the principal component of capsicum fruits (peppers), has a chemopreventive action against the tobacco-

specific nitrosamine NNK; and Sulforaphane and Brassinin, both found in the cruciferous vegetables, can also be regarded as cancer chemopreventive agents.

The other form of occurrence of N-nitroso compounds is the preformed N-nitroso compounds, which appear in clinical research studies as a reliable cause of tumours. The main sources of preformed N-nitroso compounds (e.g. nitrosamines) are tobacco smoke, cosmetics and food products. The joint FAO/WHO Expert Committee on Food Additives noted several studies which showed that food preparation techniques for meat and fish products, as well as vegetables that have been damaged or stored poorly, can, under certain conditions, promote the formation of N-nitroso compounds. In the last report, the joint FAO/WHO experts committee emphasised the need for good manufacturing practices in the preparation of meat and fish products so as to reduce exposure to these compounds.

These preparation techniques include malting, smoking, drying and broiling of fish and meat products, as well as frying of cured meats including bacon. An example of this is given by a latest study of nitrosamines in foodstuff concerning the common ham. This study shows that boneless hams processed in elastic rubber nettings contain high levels of nitrosamines in the outermost layer, probably originating from the netting.

Policy aspects of nitrates in foodstuffs

Nitrate content in foodstuff is regulated at the European Union level by two laws:

1. European Parliament and Council Directive No 95/2/EC of 20 February 1995 concerning food additives other than colours and sweeteners. This establishes a maximum residual amount of 50 mg of Nitrates/kg on cheese and 250 mg of Nitrates/kg on cured meat products. In general this directive overestimates the amount of nitrates needed for foodstuff preservation, therefore will be probably reviewed in the future. As an example recent data indicate that mean levels in cured meats is generally between 10-30 mg/kg. At this point it is important to point out the significant effort made by food industries towards the decrease of nitrates used as an additive.
2. Commission Regulation No 194/97 of 31 January 1997 setting maximum levels for certain contaminants in foodstuffs. This regulation sets a maximum nitrates level in spinach and lettuce depending on the season harvested. For spinach ranges from 2.500 to 3.000 mg/kg fresh product and for lettuce ranges from 2.500 to 4.500 mg/kg fresh product. It also establishes a maximum level of 2.000 mg/kg product for preserved, deep-frozen or frozen spinach. These levels will need to be reviewed based on the results of controls carried out by the Member States.

Within the regulation which sets maximum levels for certain contaminants in foodstuffs there is no reference of any safety evaluation carried out to justify this measure. The main reason seems to be the necessity to ensure market unity in view of the fact that some Member States have adopted maximum levels for nitrates in certain vegetables. These Member States are Belgium, Germany, The Netherlands and Austria and the vegetables regulated include lettuce, spinach, beetroot, celery and radishes among others. The adoption of maximum level of nitrates in vegetables is still controversial, not only in terms of public health, but also because these limits may distort competition between Member States.

The nitrates in foodstuff issue also links with the European Community's Nitrates Directive (91/676/EEC). The implementation of this Directive implies the definition and the application of a Code of Good Agricultural Practices in each Member State. This Code may be

Health

The main sources of preformed N-nitroso compounds, which have been shown to be tumour-inducing, are tobacco smoke, cosmetics and food products

Current EU regulations placing limits on nitrates seem to be based more on a political need for uniformity between Member States than on safety evaluations

This Code envisaged under EC directive 91/676/EEC may be expected to reduce nitrate application to cultivated soils

expected to reduce nitrate application to cultivated soils and also will make a significant contribution to the protection of freshwater resources from nitrate pollution.

Conclusions

It is clear from the evidence presented above that it is not possible to justify the setting of a maximum tolerable nitrates level in vegetables. The results of a few studies on the endogenous formation of N-nitroso compounds (chemical carcinogens) are insufficient. These studies barely demonstrate the formation of these compounds after intake of extremely high doses of nitrates and nitrosable compounds, far above common dietary nitrates level intake; most of them also do not take into account the role of natural dietary inhibitors of gastric nitrosation such as vitamin C, which are present in large vegetables, but absent from most laboratory experiments). This determination is even less justified in view of new clinical studies which conclude that nitrates found in saliva, which come mostly from the diet, may be part of the body's defence against infectious diseases.

It would seem then reasonable to focus our concern less on the natural occurrence of nitrates in foodstuff, and more on the occurrence of preformed N-nitroso compounds in foodstuff. On the one hand nitrate intake through vegetables has not been proven to pose health risk because of endogenous formation of N-Nitroso compounds. On the other hand the existence and pernicious effects of preformed N-nitroso compounds in foodstuff are well-known (e.g. nitrosamines which are potent agents in inducing tumours).

Keywords

additives, carcinogenic, chemical carcinogen, food-safety, N-nitroso compounds, nitrates, NOC, nitrosamines, vegetables

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Contacts

Miguel Vega García. IPTS
Tel: +34 5 4488211. Fax: +34 5 4488339. e-mail: miguel.vega@jrc.es
Laurent Bontoux. IPTS
Tel: +34 5 4488299. Fax: +34 5 4488279. e-mail: laurent.bontoux@jrc.es

Health

About the authors

Miguel Vega holds a Masters Degree in the Agro-food Industry and graduated as an Agricultural Engineer from the Polytechnic University in Madrid He is currently working as an Auxiliary Agent at the IPTS in issues concerning Life-sciences and was formerly a consultant for the Spanish Federation of Food and Beverages Industries. His research interests include the agro-food technologies under a safety and environmental context.

Laurent Bontoux holds a diploma of food engineering from ENSIA (France) and a PhD in environmental engineering from the University of California at Berkeley (USA). He has worked as Environmental Safety Scientist at Procter & Gamble before joining IPTS as a Scientific Officer. His expertise ranges from wastewater treatment to ecotoxicology and chemical safety, including environmental technologies and waste management. His current activities cover mainly waste management, recycling and wastewater re-use.

Energy

Photovoltaic Technology and Rural Electrification in Developing Countries: The Socio-economic Dimension

Juan Carlos Ciscar, the IPTS

Issue: Renewable energy technologies may be able to play a key role in improving the living standards of rural people and in stimulating productive activities when certain conditions are fulfilled.

Relevance: Rural electrification is a large potential market segment for photovoltaic (PV) technology in developing countries. The socio-economic and the environmental benefits of such applications, as well as the existence of market failures, may justify a public intervention in the diffusion of photovoltaic technology in developing countries. The European Union intends to play a leading role in such a process in several areas, for instance in the countries to the south of the Mediterranean.

Analysis:

1. Introduction

At present there are two billion people without access to electricity, most of them in rural areas of developing countries. Indeed, as the World Bank points out, the lack of access to energy in rural areas is above all a manifestation of poverty (World Bank, 1996). This situation is closely related to major problems in poor countries such as under-development and the depletion of natural resources. Within this context, rural electrification programmes are implemented in developing countries in order to stimulate development. According to the World Bank's estimates, in the last twenty-five years developing countries have provided access to electricity to 800 million people in rural areas.

There are three options for electrifying rural areas: centralized electrification, decentralized local grids and stand-alone systems such as Solar Home Systems

There are three options for electrifying rural areas. The first one is centralized electrification which consists of the extension of the domestic electricity network. Another option is decentralized local grids powered, for instance, by diesel or small hydro plants. The third option is electrification without grids which includes stand alone systems such as Solar Home Systems (SHSs).

An SHS can be defined as a system that provides power for a single household. Each SHS has a solar PV panel, a rechargeable battery for energy storage, a battery charge controller, one or more lights and other low-power-consuming appliances. A key characteristic of SHS is that it has a rather limited power supply since it is normally sized in the range 10-100 Wp. As a consequence, it can only provide power for basic household uses, such as lighting and audio-visual services (radio/TV)[1].

So far most rural electrification projects have been implemented either through centralized systems or decentralized local grids. However, for

the case of small-scale electricity uses, and thanks to large past investment efforts in RD&D, PV technology is becoming commercially competitive in terms of costs vis-à-vis the other options for rural electrification. Moreover, the fact that it is an environmentally sound technology produces major benefits for the global environment because SHSs do not contribute to the greenhouse gas emissions. Nevertheless, nowadays SHSs have a very low market penetration rate. This can be explained by certain barriers, in particular lack of credit and weak delivery mechanisms. This article focuses on SHSs and contains five sections including the introduction. The second section analyses the prospects of the market niche for SHSs. In the third section, the main market failures for the implementation of rural electrification projects are discussed. In the fourth section, recent empirical evidence concerning the socio-economic effects of rural electrification projects is reviewed. The fifth section points out the main conclusions of the previous analysis.

2. The market niche of Solar Home Systems

At present, the diffusion of PV technology is growing and, in particular, the potential market niche for SHSs for the next few decades looks promising. During the period 1990-1994 SHSs accounted for 15% of world PV module shipments and in 2010 this market segment is forecast to be the most important application of PV modules, absorbing around a fourth of overall shipments (see European Commission, 1996). Furthermore, the stock of SHSs installed is currently over 500,000 and around 80,000 systems are being set up annually, most of them in developing countries. Consequently, the World Bank recently approved a loan and a Global Environmental Facility (GEF) grant payment for a rural electrification project in Indonesia consisting of the instalment, on a commercial basis, of 200,000 Solar PV systems (see Box 1).

To date most rural electrification projects have been implemented through centralized systems or decentralized local grids, however, PV technology is becoming attractive for small-scale uses

The current stock of installed SHSs stands at over 500,000 and around 80,000 systems are being set up annually, most of them in developing countries

Box 1: The Indonesian Solar Home System project

In January 1997 the World Bank approved a loan of US$20 million and a Global Environmental Facility (GEF) grant of US$24.3 million for a Solar Home Systems (SHS) project in Indonesia. This is the first large World Bank project with photovoltaic decentralized rural electrification up to date. The project has the following characteristics:

- *Cost of the project.* The estimated total cost of the project is US$ 118.1 million. 72% of the total costs are imports, mainly the solar PV panels.
- *Private Sector participation.* The private sector wholly implement and commercialize the project. The only subsidy is that of the GEF grant.
- *Financing Scheme.* The SHS are to be paid completely by rural customers. The payment system is based on a US$75 to 100 down payment and a US$ 10 monthly payment.
- *SHS characteristics.* The project consists of the installation and sales of 200.000 SHS over a period of five years. About one million Indonesian will benefit directly from the project. The size of the whole project is 10 MWp. Each SHS has 50 Wp and will provide 15 kWh/month per household.
- *Abatement cost per ton CO_2.* It is estimated that the SHS project will lead to an abatement of about 2.2 million tons of CO_2. This means a GEF abatement cost of about US$ 11 to 18/ton CO_2.
- *Internal rate of return.* The internal rate of return is 39%. It drops to 12% without the GEF grant.
- *Technical specifications.* All SHS units must meet strict technical specifications.

Table 1. Costs of Solar versus Traditional energy sources in Indonesia

Daily Service Provided	Solar Home System (monthly cost in US$ 1993)	Kerosene and car Batteries (monthly cost in US$ 1993)
6 hrs. task lighting 60 Wh for other loads	8.25	9.25
12 hrs. area lighting 14 hrs. task lighting 500Wh for other loads	13.25	19.25

Note Employment values relate to different years (1990, 1992, 1993), and are based on widely differing national definitions, usually covering only part of the industry

Souce Cabraal et al , 1996

SHSs can be the least-cost option when household electricity demand is low and when households are located in remote areas

The driving force of the increasing competitiveness of SHSs in rural areas, when compared to other electrification options, rests on their economic costs. Photovoltaic SHSs can be the least-cost option if two conditions are met: dispersed population and low energy demand[2]. In fact, both the population density and the level of electricity consumption in rural areas are usually quite low. This makes often the SHS choice for rural electrification an economically-viable choice.

Another interesting point is the fact that a SHS can be even cheaper than the traditional energy sources of the rural world, which are kerosene and car batteries. Table 1 shows the economics of PV versus traditional energy sources with Indonesia cost data (Cabraal et al., 1996). Two kinds of energy use are considered. The first one is equivalent to about 15 kWh/month per household for grid services, while the second one corresponds to twice the previous amount of energy. For both energy uses the SHS alternative is cheaper than the traditional one.

Therefore, we can conclude that SHSs can be the least-cost option when household electricity demand is low and when households are located in remote areas. This, together with the environmental advantages of such renewable energy technology, improves the prospects for, and desirability of, market penetration of SHSs in developing countries in the next few decades.

3. Market failures and the scope for public intervention

In spite of the advantages of SHSs as a means of electrifying rural areas, several major barriers exist preventing such systems from spreading further across developing countries. Some of those obstacles, which may be called market failures, may justify public intervention in order to foster the commercial diffusion of SHS.

Of the 300-400 million households without electricity in developing countries only 10% can afford SHS. This could rise to 25-50% if appropriate credit and delivery mechanisms were made available

The first key barrier concerns the affordability of electricity to rural consumers. Nowadays it is estimated that there are 300-400 million households without electricity in developing countries, of which 10% can afford SHS, that is, 30-40 million households. This percentage could rise to an estimated 25-50%, if appropriate credit mechanisms and delivery arrangements were established. This is closely related to whether the SHS is paid for mainly by the government (through subsidies) or by the consumers on a commercial basis. The World Bank has commented that household electrification programmes with PV should be completely paid for by rural consumers, that is, their payments should guarantee the full recovery of capital and maintenance costs. Grants and subsidies should be only used for market-conditioning activities that include training, promotion, project design, feasibility studies, setting and enforcing quality standards, monitoring

and establishing of infrastructure (Cabraal et al., 1996). This view is similar to that of the recommendations of the Séminaire de Marrakech in 1995 where teams from twenty countries discussed the prospects for a change in scale in decentralized rùral electrification with funding organizations and operators[3].

Furthermore, it is useful to note that in most communities where PV kits have been installed on a commercial base, the target population of the PV project is usually the better-off, for example in the case of the World Bank's Indonesian SHS project.

A second barrier is the access to credit, since installing an SHS implies an investment decision that absorbs in advance the amount of money to pay for energy consumption corresponding to a period of around 15-20 years. This is in fact a huge allocation of resources for rural communities. Moreover, if we take into account the fact that usually only short-term credit is available for rural customers, it is likely that most customers do not have access to SHSs. There may be scope for public intervention here because if international organizations give financial credit, this can catalyse the participation of private banks of the concerned country.

One way to ease the funding problem could be via the Joint Implementation scheme, a cooperative mechanism that intends to facilitate procedures reducing greenhouse gas emissions. Under such scheme, countries invest in abatement in another country, when it is less costly than doing so at home, and thereby receive credit for the resulting reduction (see Hendriks et al., The IPTS Report, October 1997). In fact, at present there is an ongoing Joint Implementation pilot project of rural solar electrification in Honduras.

Although the credit barrier has usually been pointed out as the main obstacle to the implementation of large PV electrification programmes, the lack of adequate delivery mechanisms (i.e., the instalment of the equipment and its maintenance along the lifetime of the system) also explains to a large extent the poor commercial diffusion of SHSs in rural areas. When there is a lack of established high-volume supplier-dealer chains it is very difficult to successfully install and maintain the SHS in very dispersed villages in the long lifetime of the system. Again public sector intervention could be justified here in order to overcome such delivery problems. In this sense, there has been a recent proposal to set up the Solar Development Corporation (SDC) with the main goal of stimulating the PV market in developing countries through private sector channels (see Box 2).

Installing an SHS implies an investment equivalent to paying 15-20 years energy use in advance

The difficulty of maintaining SHS systems in remote areas throughout their lifetime is a barrier to their up-take. Training and standards would seem to be essential

Box 2. The Solar Development Corporation

The World Bank and some American private foundations have recently proposed the creation of a Solar Development Corporation (SDC), whose main aim will be to raise to a large extent the commercial market penetration of solar rural electrification in developing countries. In particular, the SDC will contribute to the development and financing of a commercial market for entrepreneurs, firms, financial institutions and other private agents that are involved in the whole process of the implementation of a SHS project. This process includes the distribution, sale, lease-hire and financing of the systems.

The SDC's initial capitalization is to be around US$50 million. After a start-up period the SDC is supposed to become financially self-sustaining and it could provide US$100 million/year of financing for PV electrification projects.

At first, the SDC will set up operations in three regions: Southeast Asia, Africa and Latin America; in these regions there is a strong commercial potential market for electricity generation using PV.

In June 1997 a multinational consortium of business advisors, led by Coopers & Lybrand and IT Power, was appointed. In November 1997 it will have its findings concerning the current potential of the SDC and, in the case of its being viable, the business plan for the initial three year period.

Finally, the lack of adequate maintenance and incorrect use of SHSs seem to explain the failure of many SHS projects in the past. Therefore, it is essential to train users and to guarantee a certain level of technical standards. Moreover, the setting and enforcement of minimum technical standards is indeed a requirement of banks to provide credit. Government agencies set performance standards for the different components of the SHS.

4. Socio-economic effects of rural electrification

One of the primary aims of rural electrification programmes in developing countries is to stimulate rural development[4], which is certainly a formidable goal. The theoretical foundation for that positive relationship between electrification and development is the following: since energy is an input for essential human needs, as happens in developed countries, providing electricity to rural areas could be a motor for rural growth.

From a theoretical point of view a rural electrification project can have two major kinds of effects. Firstly, there may be positive effects on the living conditions of the local population. Electricity, or more broadly speaking energy, is a basic input for many basic living conditions both at household and community level in rural areas. These living standards may include illumination (for reading, cooking, etc.), education (for reading), health (for food storage, refrigerators for vaccine storage), recreation (for audio-visual services) and other community services (e.g., for illumination of religious centres). The lack of electricity may prevent people from using or having access to these essential goods and services.

Whilst the impact of electrification on living standards is clear, its effect on economic development is less directly obvious

Secondly, the electrification project can affect the income of the local community when it stimulates productive activities. In rural areas such activities mainly include agriculture (e.g. a PV powered water irrigation system), livestock and small industries (i.e., handicrafts). More energy can increase level of incomes, raising then the productivity of labour.

Yet the empirical evidence concerning the relationship between rural electrification and development is a rather controversial issue. There are two kinds of empirical evidence with rural electrification, a first one with decentralized systems and a second one with centralized systems.

With regard to decentralized systems, the Asia Alternative Energy Unit (ASTAE) of the World Bank has recently done a series of ex-post evaluations of household electrification with photovoltaic technology in four countries (Sri Lanka, Indonesia, the Dominican Republic and the Philippines). The main conclusions concerning the impact on development are the following. Firstly, rural electrification projects have had a positive impact on living conditions. Better lighting and audio-visual services are the most common uses of PV electricity. Before the PV project, those services were provided by kerosene lamps (posing fire and health hazards) and car batteries (time-consuming and costly).

Secondly, the groups most favoured by these improvements are women and children. Women enjoy more flexibility in their leisure-work choice: they have more available time to do their domestic tasks and, thus, for instance, they can sew and cook during the evenings, instead of either getting up very early or working less time outside. Furthermore, women have more time for earning incomes, e.g. in farming. Children have a better light for studying and doing their homework at home, which may certainly have a positive effect on the quality of education they receive.

Lastly, however, there is no proof of a significant impact on income generating activities. This is of course fairly logical since SHS are

designed for providing electricity to households and not to firms which require high load factors. One reported case of impact on income is that of the Dominican Republic, where some stores saw a rise in their sales due to a longer opening time in the evenings.

On the other hand, as regards empirical evidence concerning centralized rural electrification projects, there is another World Bank study of Asian projects (see World Bank, 1995). It reviews the World Bank international experience in rural electrification in ten countries, mainly through grid-extension. Its main conclusion is that rural electrification has not, by itself, stimulated development. Indeed, the report remarks that the availability of electricity in rural areas is a necessary, but not a sufficient, condition for development. If such electrification projects are to be an motor for rural growth other conditions need also to be met. In this sense the agricultural sector plays a key role. The World Bank points out that rural electrification has supported growth when it has been led by a dynamic agricultural sector.

In this framework, electricity provision plays a role in rural development in an integrated approach to the problem of development. Such approach would have to take into account that solving the under-development problem is a complex and formidable issue. It implies at least to consider the basic infrastructures required by the community and, in addition, to implement measures intending to stimulate the agricultural sector in rural areas. This is however beyond the scope of this article.

The empirical conclusion is that, when the level of development is low, rural electrification permits only an improvement in development through the rise in the quality of life, but it does not necessarily lead to the stimulation of income generating activities. It seems that electricity may play a role in development if there are productive activities demanding it. Electricity by itself does not create those productive activities.

5. Conclusions

There is a growing market potential for SHSs in developing countries, given that it is the least-cost option for rural electrification in large areas where population is dispersed and electricity demand is low. Yet the market penetration of SHS is at present very low, even for middle and upper income rural families who can usually afford SHSs. This can be explained mainly by the lack of access to credit and of adequate delivery mechanisms in rural areas. In this respect, there is some scope for public intervention in order to improve the market for the private implementation of PV programs, but not to substitute it.

Concerning the socio-economic effects of rural electrification projects, though they improve the living conditions of the local population, this does not necessarily mean that the poverty problem is solved. Most ex-post evaluations of running projects conclude that the electrification of houses in rural areas does not spur growth, that is, a continuous and sustained increase in incomes. This seems to be a gloomy message.

Nevertheless, there remain real possibilities of improving the living conditions of rural populations in developing countries through electrification programmes, including the worse-off, especially women and children. However, providing electricity to the worse-off is not perhaps the best strategy for improving their living standards as long as other very basic needs are not covered, e.g., water, minimum health standards, road access, education, etc. The best strategy for facing local problems is to take into account the local realities and let people show their preferences.

The availability of electricity is a necessary, but not sufficient, condition for development. The World Bank points out that rural electrification has supported growth when it has been led by a dynamic agricultural sector

Keywords

photovoltaic technology, rural electrification, solar home systems, socio-economic evaluation analysis, developing countries

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Notes

1- The sizing of the SHS depends on the energy-service preferences of rural people and on their income level. For instance, in some rural electrification projects 50 Wp SHS have seemed to be insufficient because many people that could afford a colour TV set had a strong preference for it. This is the reason why it is key to assess the preferences and income constraints of rural households (through field questionnaires) before implementing an electrification project.

2- These conditions must be fulfilled along the life cycle of the SHS. In particular, SHS remains the least-cost option as long as the demand for electricity does not increase very much with the improvement in living standards. In this sense, the forecast of the electricity demand is an essential issue of any electrification project.

3- This seminar, held in Marrakech, was organized by an international programme committee including representatives from France, Morocco, Germany, Spain, the European Commission, the United Nations Development Programme (UNDP) and the Energy Institute of French Speaking Countries (IEPF).

4- The first recommendation of the Séminaire de Marrakech sur l'electrification rurale décentralisée (1995) remarks that rural electrification can be a key instrument to allviate poverty in the rural world.

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Contacts

Juan Carlos Císcar, IPTS,
e-mail: juan-carlos.ciscar@jrc.es. Tel.: +34-5-448 82 70. Fax: +34-5-448 82 79.

About the author

Juan Carlos Císcar holds a graduate degree in economics from the University of Valencia and a M. Phil. in Finance and Monetary Economics from CEMFI (Bank of Spain). He has worked as an advisor for the Spanish Ministry of Economics and Finance. Within the IPTS his main areas of interest are energy economics, in particular energy-economic-environmental modelling, and the economic effects of renewable energy projects in developing countries.

Information and Communication Technologies

"Network Enterprises" and the Information Society: Issues for EU Regional Policies

Marco Lopriore

Issue: The transition from mass production towards a knowledge-based and information-intensive economy, set in motion by the 'information society' or 'network economy', have profound implications at both macro as well as micro-level for enterprises.

Relevance: There is an important role for EU regional policy measures to support those enterprises located in peripheral areas of the EU in order to help them strengthen these processes of networking so as to allow them to compete on the global arena.

Introduction

The necessity of a pro-active attitude to encourage enterprises and in particular SMEs to network and to use new ICT technologies in order to improve their effectiveness and to develop their business is well understood. The European Commission White Paper 'Growth, Competitiveness, and Employment' finalized at the end of 1993 stressed the need to foster co-operation between firms, especially SMEs, by 'providing support for participation in enterprise networks aimed at introducing flexible and specialized production systems.

Unfortunately efforts to support the emergence of 'information society' or 'network economy' through these structural funds in less favoured areas of the EU do not come up to the challenge. According to the European Commission only a tiny portion (approximately 2% of total expenditure) of Community Support Frameworks (CSF) is dedicated to information society measures.

Analysis

At the macro-economic level the new knowledge and information-based "network economy" has important repercussions for small and medium sized firms, who can take advantage of real opportunities if they are reactive and innovative. However, the increased competition, instability and versatility of markets, and the changing definition of added value are also potential threats.

At the micro-economic level the new "network enterprise" is traditional replacing Taylor and Ford models of business organization. Such firms, although "embedded" in the the economic and social context of their local geography, are able to compete globally. The promotion and supporting of this kind of firm by bolstering telematic services has been identified as powerful tool for growth and employment in Europe (Bangemann Report, "Europe and the Global Information Society). Moreover, this kind of firm is of particular interest

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for peripheral and less-favoured areas of the EU. Some experience was gained in this area in the late 80's and early 90's in the STAR and Telematique inititatives.

In this article we will first reflect on the new network enterprise and its link with local environment. At the base of this first section lies the paradox of network economy that has to be implemented at both the local and the global environment. Network economy starts at the very bottom (the grassroots, the local environment) to reach the global (the world-wide economy).

The second part of the article will analyse the implications for EU regional policies giving some indications to which measures could be set up for supporting networking SMEs. It will focus on infrastructure measures as well as on demand-stimulation.

The "network enterprise"

There is no doubt that in this, the last quarter of the 20th century we are witnessing a turning point in the sphere of the economy. The reasons for this are well documented and include new ICT (information and communication technologies), liberalization and deregulation and globalization of world markets.

A few figures demonstrate the magnitude of the changes that still lie ahead. A recent ITU report forecasts that in the year 2000 there will be 300 million 'cybernauts' compared to 40 million in 1997. Forrester Research forecasts that the market on the Net will be worth 327,000 million US dollars in the year 2000, compared to 8,000 million of US dollars in 1997.

It is also clear that enterprises are having to come to terms with these fundamental changes, not only at macro-level but also at micro level. New theories of enterprise are explaining how the new network enterprise functions (Miles, Snow, Imai, Eccles, Nohria, Westney, and others). Different terms are used such as 'open system enterprise', 'agile manufacturing', 'plug-in companies' (Merli and Saccani 1994).

Indeed, these authors confirm that enterprises can be successful without necessarily growing in size (following the 'small is beautiful' paradigm). In a world of bits, you can be small and global at the same time. Also, it is no longer sufficient to be linked through agreements, joint-ventures, etc. What is becoming more important is the capacity of enterprises to network between themselves in order to respond to market needs in a creative and rapid manner. The main success conditions for territories to take on board this model are a high degree of flexibility, a wide diffusion of entrepreneurship, and extensive use of ICT technologies.

Furthermore, in the network enterprise, the main commercial, organizational and managing actions do not take place within the traditional legal and organizational borders of the central enterprise: the frontiers of enterprises are becoming, at the same time, broader and less clear. This results in enterprises becoming part of a system which is broader than the legal borders of a single enterprise, in order to move towards new forms of competition and co-operation in a new capitalist system.

Today, this networking behaviour is no longer limited to small number of 'leading edge' firms but is also spreading to SMEs as well as to less favoured areas.

'Proximity and embeddedness' of network enterprises

The concept of network enterprise or flexible association of complementary partners to respond

The knowledge and information-based society is creating a 'network economy' in which even small firms can compete globally by means of telematic services

The market on the Net looks likely to rise to $327,000m in the year 2000 as the number of people on the Internet climbs from 40m to 300m

The capacity of firms to link into networks in order to respond rapidly and creatively to market needs is becoming more important than expanding in the traditional sense

Network enterprises are highly embedded in their local environment, and it is there that they acquire knowledge and skills and develop or adopt innovations

Structural funds have the potential to play an important catalytic role

to a market need is built on proximity. Indeed, while being connected with global networks, enterprises are at the same time part of a thick local texture of interdependencies between enterprises and the community (Bellandi 1989). This dense texture where mutual trust is a dominant feature allows enterprises to acquire knowledge, skill, develop or adopt innovations, and stimulates the further use of ICT technologies. These processes are strongly influenced by spatial proximity and determine the survival of enterprises in a way similar to that of organisms in an eco-system.

An example of such networks is given by the cluster of Italian firms in what is called 'industrial districts'. Many of these districts located in northern and central Italy are able to compete at global level but those in Southern Italy are not so lucky. The reason behind this lies in systemic factors; i.e. on the harmonic development of structures, use of ICT technologies, functioning of the social system, and cultural aspects.

Another aspect of this proximity is that the strong link between firms and their immediate environment is not only a one-way relationship. On the one hand, the network enterprises is deeply routed its local environment and is influenced by it. On the other hand, it is the network enterprise that builds the economy and society and thus the network enterprise carries the responsibility of 'institution building'. What is expressed here is the idea of 'embeddedness' of network economy into a deeper social fabric (Asheim, 1994).

This form of embedding economic relations is even more pronounced in peripheral or less favoured areas of the European Union and in particular in the case of SMEs, as the latter dominates peripheral economies. It is also becoming more apparent as we move to the 'information society' or 'network economy'.

The 'Network economy', the 'information society' and regional policies

Important efforts have been made to encourage SMEs to network and to use more ICT technologies in less-favoured areas. EU projects have been launched within the Telematics and ESPRIT programmes, as well as in the EU multiannual programmes for SMEs, and also recently from the art. 10 pilot initiatives of the ERDF (European Regional Development Programmes).

Structural Funds can have the potential to provide a catalytic effect resulting in a disproporionate impact by moving well focused strategies forward. The concept of 'information society' with a strong strategic role for regional development is in the meantime being introduced within the revision of Objective 2 for 1996-1999, and within the new guidelines for Objective 1 in mid-1997.

In this process, CSF (Community Support Framework) Monitoring committees as well as Regional authorities have a major role in integrating the information-society-related strategies and priorities into the Structural Funds.

This has been the case in the re-negotiation of the SPD (Single Programming Documents) of Objective 2 regions (Piedmont, Nord-Pas-de Calais) for 1997-1999 by allowing a more explicit mention of information-society applications in the development plans. Regional authorities of Objective 2 regions have therefore the opportunity to seek to incorporate appropriate sub-measures that will allow information society related proposals to be considered eligible. The same should happen to Regional Authorities and CSF Monitoring Committees with the mid-term re-programming of the Objective 1 funds for 1997-1999.

Since the publication of the Cohesion Report of December 1996 the debate is now on the way forward into the next millennium when the 'islands' of agrarian and industrial society that we still find in less-favoured areas will be outgrown by network economy/information society.

Today, the window of opportunity to increase the number of actions related to network economy/information society, is created by the current revision of Structural Fund regulations that will set the guidelines for EU regional policy for the next programming period 2000-2006.

But how can EU regional measures remain in line (updated) with the needs of network SME and the 'cybereconomy'? Which measures are needed to sustain the emergence of network enterprise or strengthen it in peripheral regions?

Consequences for EU regional policies

The information society, the network enterprise, their 'proximity and embeddedness' in local situations as well as the increase pressure from global markets all carry important implications for EU regional policy.

Some of the most urgent needs in revising EU regional policy were expressed at the conference (30-31 January 1997) on 'Information Society and Cohesion' and were partly addressed in the Communication of the European Commission on 'Cohesion and Information Society' of 22.01.1997.

In this article, we would emphasize two fields of actions for EU policy makers to build on.

A first action will be to respond to the need for appropriate infrastructures for network SMEs. There is indeed a risk that, under the pressure of large companies which are mainly interested in the implementation of world-wide intranets, most of the investment of the telecommunication operators will be focused on extending the bandwidth of network highways to the detriment of the local loop.

Such strategy will be detrimental to SMEs which will then not get the bandwidth necessary to deploy their local activity. As we have seen above in the article an important part of the data are indeed exchanged with local partners (public administrations, Chambers of Commerce, suppliers, local plants, etc.) even if network enterprises develop their international activities and register an important revenue stream from abroad. Local network SMEs need excellent local communication services and fluid high bandwidth communications between partners.

Large companies will tend to focus investment on increasing the bandwidth of network highways rather than local loops

A second course of action will be of making proper use of, and encouraging, intermediary institutions or 'bridging institutions' (chambers of commerce, business associations, regional technology centres and development agencies). Such institutions, being deeply routed in the local environment as well as globally connected, should be used more forcefully in the future to fulfil two roles:

- to stimulate networking processes among SMEs and try to make them more dynamic;
- to sensitize SMEs to demand for ICT technologies and ICT services in order to encourage them to join the 'cybereconom'.

Bridging institutions can play a role in stimulating networking by exploiting their existing international and local links

The need for such intermediary institutions is paradoxically increasing as we move into a 'cyberspace' and into electronic commerce (Takeda, 1997). What we therefore need to develop at EU level is 'network policies' (local networks, regional networks, global networks) and to ensure that network strategies SMEs are largely diffused among enterprises.

Finally, a decisive task will also fall on institutions such as national, regional and local authorities to provide pro-active self-reliant strategies at territorial level to anticipate the 'information society' and the 'network economy'. Networks of Regional Administrations, such as the one promoted in the IRISI (Inter Regional Information Society Initiative) project funded by DG XVI and XIII, are examples that should be promoted in less favoured areas of the EU.

Keywords

information society, SMEs, network enterprises, objective 2 regions

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Juan Stamm'ler Jaliff, IPTS

Contacts

Juan Stamm'ler Jaliff, IPTS
Tel. +34-5-448 8356, Fax: +34-5-448 8339, e-mail: juan.jaliff@jrc.es

About the author

Marco Lopriore graduated with a Masters degree in development economics from the Economics Faculty of the Free University of Amsterdam. He is currently Assistant to the Director at the Brussels Headquarters of Unioncamere (Italian Union of Chambers of Commerce and Industry) where he follows issues relating to regional policy and R&D policy with special attention to information and communication technologies and the impact on small and medium enterprises (SMEs). Prior to this he worked as expert in Directorate General XIII International aspects of telecommunications in Brussels.

26 Industrial Competitiveness

Competitive Complex Product Systems: The Case of Mobile Communications

Andrew Davies, SPRU

Issue: One area where Europe might have a lead over East Asian suppliers is in the design and production of high cost, engineering intensive, complex products and systems. Europe has an opportunity to build on its competitive strength in global markets in the supply of complex products, such as mobile communications systems, and gain a strong position in promising emerging technologies.

Relevance: Through the promotion of standards and R&D EU institutions play an important role in enhancing European competitiveness in complex products and services.

Introduction

The EC's 1995 Green Paper on Innovation recognizes the importance of promoting new technologies across a wide range of manufacturing and service sectors to improve Europe's industrial competitiveness. In telecommunications and financial services, some of the world's leading companies are European. But many European companies now face strong competitive challenge from East Asian suppliers in mass produced consumer goods, such as consumer electronics, household goods and cars. For example, Olivetti, Bull, Amstrad and other European companies have failed to develop strong international businesses in personal computer markets which remain dominated by US and East Asian companies.

European companies face strong competition from East Asian suppliers in mass produced goods, but its lack of competitiveness in this area should not be seen as a symptom of a more general inability to compete in the industries of the future

Europe's lack of competitiveness in high-volume consumer goods should not, however, be seen as a symptom of a more general European inability to compete in the industries of the future. One area where Europe has a maintained and possibly increased its competitive advantage is in the supply of Complex Product Systems (CoPS).

A New Industrial Category

CoPSs are high-value added, engineering-intensive capital goods, systems, networks and constructs produced as single items or in small, tailored batches (Miller et al., 1995). CoPS may be assembled using increasingly standardized components produced in higher volumes, but the design and integration of components into the final product involves production of a 'one-off' kind, to meet the requirements of individual customers. Early research suggests that CoPS represent a major proportion of the industrial output of member states. For example, CoPS accounts for around £50bn of GDP in the UK. There are several key differences between CoPS and mass production industries in terms of technologies, markets and industrial structures

which suggests new approaches to industrial and competition policies may be useful:

- in contrast to highly standardized goods, CoPS involve a high degree of customization in the final product and its key components or subsystems;
- CoPS are designed by project organizations and produced as units or in small batches rather than in high-volume;
- CoPS industries are usually bilateral oligopolies (with a few large suppliers facing a few business customers in each country) and governments are often directly involved as purchasers, users or regulators of CoPS.

In oligopolistic CoPS markets, reputation, experience, service and support are often as important as price in winning contracts. The buying process is lengthy due to the difficulty of evaluating risk and planning implementation.

The sequence in CoPS production begins by obtaining the order, modifying the design to suit the requirements of the customers, producing the required volume of components and integrating them into a tailor-made system. In mass production, by contrast, product development is undertaken first, then production, followed by marketing to final customers.

Users are heavily involved in CoPS development and implementation, since their competitive survival often depends on the technical quality and performance of the final product. High quality in design and production requires continuous feedback of commercial and technical information concerning the product's operational performance from a small number of sophisticated and demanding buyers, such as mobile phone operators, air traffic controllers, airlines, etc. Suppliers have to develop strong problem-solving capabilities to address specific user needs.

Member states and the EC are directly involved in the supply of CoPS:

- as potential purchasers (e.g. public procurement policies, tender process);
- to establish technical standards (as in air traffic management systems);
- to prevent excessive concentration of market power (e.g. national policies and EC telecommunications directives);
- to guarantee safety (as in transportation and nuclear power plants);
- to promote the emergence of new technologies that enhance industrial competitiveness (e.g. the fifth framework programme).

As a result of this involvement, the establishment of standards and purchasing decisions are often highly politicized to promote the competitiveness of a particular CoPS industries.

Mobile Communications: A European Success Story

The case of Europe's cellular mobile systems industry provides an opportunity to explore some of the above arguments in relation to one of Europe's globally competitive CoPS industries.

Cellular mobile communications systems form two distinct market segments: mobile handsets and the cellular system infrastructure. In 1996, three companies - Ericsson and Nokia from Europe and Motorola from the US - accounted for two thirds of the world's combined mobile phone system and handset markets. The mobile handset is an example of a mass produced consumer good. As handsets become increasingly standardized low-cost goods, "European companies wishing to compete successfully in this market must reach the levels of efficiency in production achieved by Asian manufacturers of high-volume consumer goods. The associated dynamics of manufacturing design and marketing

Complex Product Systems (CoPS) are high-value added, engineering-intensive capital goods, systems, networks and constructs produced as single items or in small, tailored batches

CoPS production, unlike mass-production, begins with the order and modifies the design to suit. Thus users are heavily involved in development and implementation

In the design, manufacture and installation of cellular systems for individual cellular operators, on the other hand, European companies have a lead over the US and are well ahead of East Asian suppliers

of products with short life cycles must also be mastered" (CEC, p. 158, 1994). In the design, manufacture and installation of cellular systems for individual cellular operators, on the other hand, European companies have a lead over the US and are well ahead of East Asian suppliers. Ericsson is the world's leading supplier with 40% of the global market for cellular systems covering all standards.

Unlike handsets, the cellular system is not a commodity item assembled from off-the-shelf standardized components. Cellular system products are comprised of two main subsystems: the switching subsystem of subscriber databases, management and mobile switching centres (MSC) which route calls in the core network; and a base station subsystem of intermediate switching or base station controllers (BSC) and radio base stations (RBS) which define how the air interface is established between the mobile handset and switching components.

The pattern of industrial leadership and competition in the cellular system industry has been rearranged by the rise of three different generations of cellular system technology (see Box 1). In the rise of each generation, companies have attempted to master the dynamics of innovation associated with the new technology and governments have had opportunities to promote technical standards and influence demand through standard-making, procurement and spectrum allocation polices.

The success of European companies in global cellular system markets has been made easier by the coordinated efforts of the EU member states, standard-making bodies and leading European manufacturers in the 1980s to promote the Global System of Mobile communications (GSM) standard and the failure of the US to select a preferred standard for digital systems. In 1987, a Memorandum of Understanding (MoU) was signed by 13 EU signatory countries which gained the agreement needed to define and implement GSM on a pan-European basis. Europe's latest microcellular 2G systems, called Personal Communications Networks (PCN), uses Digital Cellular Systems operating at 1800 MHz frequency (DCS-1800), are based on the GSM standard to allow manufacturers and operators to

Box 1. Three Generations of Cellular Technology

Cellular systems make efficient use of a scarce resource - the radio frequency spectrum. By progressively reducing the cell size, cells can be served by low-powered transmitters and cells only a few miles apart can use the same channels for different calls. Each generation of technology reaches a level of maturity when it is surpassed by a new standard. Three generations of cellular systems include:

- 1st generation (1G) analogue systems introduced since 1983 (e.g. AMPS, NMT, TACS) use digital switching technologies for MSC and BSC components, but use analogue transmission over the air interface between the subscriber handset and RBS.
- 2nd generation (2G) digital systems for narrowband voice and low-speed data services. Introduced since 1993 (e.g. GSM, PDC, CDMA), they use an all-digital connection over the air interface between the subscriber handset and RBS, resulting in large increases in capacity.
- 3rd generation (3G) systems are currently being developed to supply a future potential mass market with wideband voice, data and videoconferencing services (see The IPTS Report, February 1996). The preferred air interface technologies are versions of CDMA.

exploit the advantages of backwards compatibility when upgrading GSM systems. With nearly 100 companies now offering licences to operate GSM networks, GSM is the dominant worldwide standard for 2G digital systems.

EU standard-making and procurement permitted a number of European telecommunications equipment companies (e.g. Ericsson, Nokia, Siemens, Alcatel and Philips) to enjoy the benefits of technological learning and economies of scale in component manufacture allowed by the early adoption and growth in world markets for the GSM standard. Unlike the other European equipment suppliers, however, Ericsson and Nokia never enjoyed the status of 'national champions' and benefits of protective home markets during the 1970s and 1980s. Domestic rivalry at home, the rapid growth of Scandinavian mobile phone markets in the early 1980s, and their involvement in many geographical markets, are some of reasons why Ericsson and Nokia were quick to take advantage of the liberalization of cellular markets in the mid- to late-1980s.

But the emergence of Ericsson and Nokia as Europe's major players stems from their ability to be the first companies outside of the US to master the special problems associated with:

- developing new generations of cellular system technology based on different standards in co-operation with leading users and alliances;
- acquiring the capabilities to implement and configure cellular systems to meet the demands of knowledgeable customers in many geographical markets.

New Technology Development and System Integration

First, Ericsson and Nokia have remained at the technological frontier through large R&D expenditures and continuous innovation in component and interface technologies which are behind each new generation of cellular system technology. Ericsson's spectacular success, in particular, owes much to its early development of computerized, digital switching technologies in the 1970s, the core technology used in cellular switching components, which allowed the diversification into the new cellular mobile business in the 1980s. Although external sourcing of technology and close links with key customers such as Telia were important, new cellular technologies have been developed and sourced mainly in-house.

Successful cellular system suppliers have to acquire the capabilities in component design and system integration to cover the emergence of different standards and the shift from one generation of cellular technology to the next. However, product cycles for different cellular components advance at different speeds (PNE, 1997). Whereas the core switching subsystem has a long-life expectancy, RBS components are improved every 3 years, and mobile handsets are replaced every 6 months. The task facing cellular suppliers is to manage the introduction of components with different life cycles into an overall system architecture, while ensuring that new components are backwards and forwards compatible with the GSM standard.

Ericsson and Nokia have minimized the risks of being locked out of the US and Japanese markets by acquiring design capabilities in different technical standards. Ericsson is the only manufacturer with the technological competencies to supply cellular systems for all 1G and 2G standards (TACS, AMPS, GSM, DCS 1800, NMT, PDC, and PCS). Nokia is closely following the evolution of CDMA technology, the preferred US standard for 2G systems, through its membership of the CDMA Development Group. Around half of the US cellular operators to receive Personal Communications

Industrial Competitiveness

The success of European companies in global cellular system markets has been facilitated by the coordinated efforts of the EU member states

The European firms Ericsson and Nokia have remained at the technological frontier through large R&D expenditures and continuous innovation in component and interface technologies which are behind each new generation of cellular system technology

Services (PCS) licences have adopted CDMA technology while the others have chosen GSM or a variation of GSM, such as Ericsson's PCS 1900 product developed for the US market.

Ericsson and Nokia are jointly supporting the adoption of wideband W-CDMA technology as the standard for Third Generation (3G) systems. A consortium led by Ericsson and Nokia with a number of Japanese manufacturers is developing an experimental W-CDMA for the Japanese market. W-CDMA is backwards compatible with the core GSM switching subsystems already installed and would allow a smooth migration for GSM users - estimated to reach 300m subscribers by 2001 - to the new 3G system. Its widespread adoption would establish the same 3G standard for Japan and Europe.

Second, Ericsson and Nokia have continuously improved their capability to install and configure cellular systems to meet the particular requirements of operators in different national markets. Advanced project management skills are required to ensure control of time-scales, logistics and budgets throughout the project life cycle, and to solve problems that arise in the design, integration and testing of components or systems using mature products, as well as in the periodic introduction of new component and interface technologies.

Ericsson and Nokia have continuously improved their capability to install and configure cellular systems to meet the particular requirements of operators in different national markets

The growth of systems integrators and 'turnkey' solutions in the cellular equipment industry suggests that the added value accrued in the supply of bundled systems is greater than in the supply of components. Bundled GSM systems can be integrated, tested and ready for service more rapidly than is possible with multivendor solutions, and provide a single point of purchase and after-sales support.

Conclusions

As the GSM example suggests, European companies may have a competitive advantage in the development, manufacture and installation of CoPS. Europe's established reputation in CoPS derives from the development of core capabilities in system integration, project management and turnkey solutions, and to use these capabilities to meet the requirements of individual customers. Through the promotion of standards and procurement policies, EU institutions play an important supportive role in creating an environment to provide opportunities for European CoPS suppliers to emerge as competitive global players.

The importance of CoPS is often implicitly recognized in EC policy documents. For example, the proposed Trans-European Networks (TENS) initiative would create a huge internal market for complex infrastructural components and systems, such as electricity plant, air traffic management systems and broadband telecommunications networks, supplied by European CoPS companies. Given the potential importance of CoPS on the EU economy, there is a need for a more coordinated approach towards this category of products.

Keywords

Complex products systems, mass production, standards, GSM, CDMA

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Notes

1- TDMA divides a slice of the radio spectrum into time slots, or channels. CDMA is based on unique digital codes which differentiate between subscribers, rather channels.

Acknowledgements

James Gavigan, IPTS

Contacts

Andrew Davies, Complex Product Systems Innovation Centre, Science Policy Research Unit, Mantell Building, University of Sussex
e-mail: A.C.Davies@sussex.ac.uk

About the author

Andrew Davies, a Fellow at the Science Policy Research Unit (SPRU), is trained as a social and political scientist. Specialising in telecommunications policy and corporate strategy, he is author of Telecommunications and Politics: The Decentralised Alternative' (Pinter, 1994). He is now working in the ESRC's Complex Product Systems (CoPS) Innovation Centre.

32 Environment

Environmentally Sound Technology Development and Innovation in SMEs

Paulo Partidario

Issue: Environmental policies based on increasingly stringent environmental standards met by the adoption of curative (end-of-pipe) approaches to pollution control have resulted in an increase in indirect production costs, but have failed to prevent an overal degradation of the environment in many areas of Europe.

Relevance: Well-managed technology development and innovation in the framework of the EU science and technology system and regional deveolpment policy may help guide manufacturing SMEs towards more environmentally-benign operation.

The European Commission's goals for innovation seek to balance economic and environmental needs, whilst offering solutions to employment, growth and competitiveness issues

SMEs account for a large share of business in Europe, but face a number of obstacles to implementing environmental performance measures, such as lack of awareness, limited resources, etc.

Introduction

The overall impact of manufacturing and related services on the environment is generally negative, resulting in emissions, waste by-product generation and the consumption of resources. The aim of both past and present goals of the European Commission with regard to innovation is to attain sustainability in manufacturing and its related activities and eliminate the current trade-off between the environment and the economy whilst also offering solutions to the issues of employment, competitiveness and growth. Raising awareness about environmental issues and technologies is a fundamental part of the process of reshaping the production paradigm. The strategies that are being promoted in order to reformulate the current manufacturing paradigm and monitor the role of consumers include:

I. Establishing environmental goals, regulations, incentives and standards;
II. Making more efficient use of economic instruments;
III. Broadening environmental assessments;
IV. Encouraging action by manufacturing industry aimed at setting up more environmentally-efficient production processes (cleaner production technology, best practices, reduction of wastes, etc.);
V. Increasing capacity to deal with industrial hazards;
VI. Strengthening international efforts to help developing countries;
VII. Bolstering the science and technology system in its continual search for new solutions.

99.8% of all companies in Europe are SMEs (over 80% of Europe's industry) and they account for 66% of total employment and 65% of business turnover. Nevertheless, they are hampered by limited human and financial resources and limited access to RTD (Research, Technology, Development) support. A recent EC study (EC-DG II, 1995) has shown them to suffer a range of difficulties which stand in the way of their compliance with environmental management standards. Limited resources make it difficult for them to assess their environmental performance

and so make improvements. Moreover, industry's environmental performance varies greatly both between sectors and between regions. Clearly, sustainable development will remain unattainable if industrial SMEs are not included in the effort.

Industrial pollution is primarily the result of bad practice, inefficient processes and poor organization. Only companies taking a long term view, and which are flexible and sensitive to environmental issues, are likely to be able to see improved environmental performance as the key to competitiveness. Organizations need to be able to look objectively at how all their sectors, functions and divisions interact with the environment in order to improve environmental performance.

Businesses need to come to see environmental concerns not simply in terms of controlling pollution, but rather as an area in which to undertake strategic innovations. Policymakers, on the other hand, should look at the innovation process not only at micro-economic levels (generation and diffusion) but also at the macro-economic level (the economic system as a whole).

Pollution Prevention: a Source of Strategic Innovation

Mechanisms promoting innovation, particularly those relating to interactive learning effects, are essential ingredients of companies' survival in open markets. The goal of sustainable development is both a major challenge and an important opportunity. Both managers and engineers involved in design, production and maintenance need to bear certain fundamental concepts in mind. One of the keys is maintaining a constant overview of the company's portfolio of technology resources, as this needs to be subjected to constant rethinking and discussion. This self-questioning needs to consider the environmental soundness of the production processes; the "eco-design" of products; the level of quality awareness in the organization; the motivation, capability and competence of the human resources; the company's ethical standpoint and its relationships with the community at local and regional levels (Gavigan et al. 1997).

Pollution Prevention (P2) in manufacturing goes beyond pollution control and exploits the complementarity which exists between eco-efficiency (simultaneous economic and ecological efficiencies) and cleaner production (CP) concepts (Larderel and de Hoo, 1996). It achieves gains in resource efficiency and reduces pollution at source rather than simply shifting pollution from one medium to another. By definition, CP entails the constant application of preventive environmental strategies to both products and processes in order to reduce risks to both people and the environment. CP implies reducing both energy and raw-material inputs to manufacturing processes, the elimination of toxic raw materials and a reduction in both the quantity and toxicity of all wastes. For products it means reducing environmental impact throughout the entire life-cycle, from raw material to final disposal.

Pollution Prevention is increasingly becoming recognized, along with economic instruments and voluntary approaches, as one of the keys to progressive changes in current patterns of production and consumption, affecting all key actors, whether manufacturers, public authorities or consumers. Companies need to look upon environmental requirements as an integral part of production and management processes, and set up the necessary innovation mechanisms within the framework of programmed upgrading cycles combining inputs from various different sources: people, organization, processes and products.

The EU is focusing its activity in this area on product, process and technology innovation in SMEs. A major concern is the difficulty SMEs have

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in participating in RTD programmes and particular efforts are being made to improve their technological base and internationalize their network of contacts and research partners. Initiatives being undertaken in the context of the Eureka programme cover a number of areas including Environment and Climate, Production and Materials RTD, Technology Stimulation, Innovation/Diffusion. These RTD programmes are generally market oriented, however, only recently has attention been paid to the innovation diffusion and adoption mechanisms needed to overcome long-standing barriers (such as the low profile of economic, technical and environmental effects, the need for support to end-user learning, poor social reception of relevant emerging technologies, the need to overcome communication gaps between communities of actors, etc.) Emphasis has also been placed on interrelated and coordinated joint programmes as a means of overcoming inadequate financial resources.

The issue of environmental performance for SMEs is complicated by uncertainties concerning the trajectories likely to emerge from the current paradigm which will allow a transition to pollution prevention options. Although some pollution prevention options can be achievable within the framework of current paradigms it may be necessary to induce radical changes in order to meet more stringent factor 10 (or factor 4) "eco-efficiency" requirements.

In a macro-economic context public policy can play a role in stimulating either supply or demand, generating innovation and promoting its dissemination

Innovation in Industrial SMEs: Opportunities and Obstacles

Pollution Prevention (P2) implementation aims to meet the challenge of maximizing long-term benefits, however unlike end-of-pipe (EOP) technologies it deals with novel production and product paradigms and encourages both incremental and radical innovations, as has been stressed in both the EC Green Paper on Innovation and the Davignon Report. As well as dialogue between business and government a need has been identified by the Fifth Framework Programme for cooperative teaching actions and partnerships. These initiatives include both horizontal and thematic programmes which mechanisms for the participation of small and medium-sized companies in innovation, competitiveness and growth issues.

A company-wide perspective involving a commitment by both management and employees would undoubtedly contribute to progress in this area. However, it represents a major shift for companies and creates inevitable concerns about investment requirements, risks to production quality resulting from process modifications, etc. and thus there needs to be an awareness of the potential economic, technical and environmental benefits as well as of possible internal obstacles, which may be of the following types:

I. Economic (increased production costs)
II. Technical (related to processes and products)
III. Regulatory (favouring short-term decisions)
IV. Cultural (lack of awareness, poor communication, resistance to change, lack of organizational flexibility, etc.).

In a macro-economic context public policy can play a role in stimulating either supply or demand, generating innovation and promoting its dissemination. Thus technology policy can have an impact on the environment in two main ways:

I. Direct impacts (eg. stimulating technological and environmental R&D, supporting technical follow-up, financial support and international marketing, etc.)
II. Indirect impacts (stimulating demand, regulations, financial incentives, voluntary agreements).

The timing of policy implementation is crucial, moreover dissemination-orientated actions (promoting new technologies as widely as possible) should alternate with actions (missions) which seek to promote new innovations and technology trajectories directly. Cooperation is needed between key actors in order to identify, select and define the key technologies that need to be addressed, and outline feasibility and implementation plans.

Environmental standards and regulatory mechanisms are still the main driving force behind decision-making on both supply and demand sides when it comes to avoiding or limiting environmental impact. There is often no stimulus to improve beyond the limits fixed by law and so companies lack the motivation to make continual investments in more radical innovations. Other mechanisms by which environmental policy could operate include:

I. Market mechanisms.
II. Premium based mechanisms.
III. Cooperation and agreement mechanisms.

Other approaches which seek to combine environmental quality with economic feasibility, should market regulation and consumer awareness fail to ensure that all dimensions of environmental quality performance are explored, could include:

I. Promoting environmentally sound technologies, practices and processes.
II. Improving awareness of particular environmental problems among consumers and businesses (training programmes, awareness campaigns in schools and universities, etc.)
III. Support services to help companies move towards more sustainable paradigms (government support agencies, research and innovation funding, etc.)
IV. Cooperation between scientific and technological communities, the general public and decision-makers.
V. Close interaction between research centres and industry.

Many of the obstacles identified for P2 are basically those facing technological innovation in general, but P2 also suffers from some specific problems of its own. These are political, economic or technological in nature and include:

I. The dynamics of environmental legislation, which tends to create an uncertain context for investment decision-making and so favour short-termist, end-of-pipe approaches.
II. Economic constraints given the capital-intensive nature of modifications and investment risk they imply for businesses.
III. Lack of awareness of the advantages of innovative environmentally sound processes and products.
IV. Shortage of adequate human (for technology and environmental awareness and training programmes) and financial resources in both the public and private sectors.

Experience from past initiatives

Europe can already learn useful lessons from a number of different initiatives relating to pollution prevention and cleaner production technologies (Christiansen, et al. 1995). Two important initiatives deserve a special mention: the PRISMA project (NL) and the Aire and Calder project (UK). A number of other interesting examples in the field exist worldwide and vary according to the degree of development of the market economy in the countries in question and the different sectors of industrial activity involved (i.e. variations in company sizes and social conditions).

The Prisma project was launched in 1988 (Dielman and de Hoo, 1993) and it had two main aims:

The dynamics of regulatory legislation create uncertainties which favour short-termist, end of pipe approaches

Other approaches, apart from market forces exerted by consumers or direct regulation, need to be examined

Successful programmes have already been run in the Netherlands and the UK

Pollution prevention needs to be seen as an investment, enhancing innovation and competitiveness

A consensual approach involving all actors and stake-holders is essential if change is to be possible

I. To show Dutch industry that the prevention of waste and emissions is possible in the short term and that it offers benefits to both companies and the environment.
II. To formulate recommendations for an effective pollution prevention policy.

The project involved 10 SMEs and identified 164 opportunities for cleaner production, many of which could be implemented in the short term: 34% of the possibilities for prevention/minimization identified had a payback time of less than a year and 49% between 1 and 3 years. 35% of the opportunities for improvement were related to process modifications; 25% related to substitution of materials; 20% related to adoption of best practices; 10% related to on-site recycling and 5% related to product modifications.

In addition it was possible to draft a procedure manual (tailored to each company) requiring only limited resources (including external supervision) demonstrating the effectiveness of the project approach and methodology.

The Aire and Calder waste minimization project started in 1992 (Johnstone, 1996). Its main aims were:

I. To demonstrate the benefits of a systematic approach to emission reduction.
II. To focus on procedural changes and cleaner technology.
III. To identify shortcomings in current technology.

11 companies participated in the project, which identified 542 opportunities for waste minimization, mainly comprising good-housekeeping options and modifications to technology. Cost savings of over 2 million pounds per annum were obtained. 10% of the minimization options were cost neutral and 70% had a payback time of less than a year. In environmental impact terms, water consumption was reduced by 10% (with potential to reach 25%) and initial reductions in effluent of 15% were achieved (with potential to reach 35%).

Conclusions

As they are progressively incorporated into business and social structures environmental concerns may become a driving force for innovation. Companies need to pollute less and produce more output per unit of input, thus calling for a shift in production and consumption paradigms. This process will involve industry, consumers and public authorities. Greater involvement of SMEs in R&D programmes at all levels is a key issue in technology development, innovation and particularly uptake, given their important role in Europe's economy. Broad dissemination of results is obviously also essential.

Pollution prevention and minimization has to be considered an investment. As well as being necessary tools for sustainable production these principles can be a motor for innovation and in the right framework can enhance the diffusion of technology and related social developments at regional level. Business structures may thus become more efficient, improving firms' competitiveness and public image by means of increased productivity and product quality and reduced risks for human health and the environment.

Policymakers have already recognized enforcement of regulations to be a complex issue. Multimedia compliance through the IPPC Directive or Environmental taxes and charges in the context of the Single Market are examples of recent alternative approaches. Standards need constant updating in order to favour an incremental approach to technology innovation, particularly in the mature stages of a technology.

More radical approaches are needed when new technologies are required but have yet to appear. Thus, a balance needs to be struck between environmental policy needs and industrial policy actions. This can best be met via two key approaches: firstly by seeking consensus between all actors in order to overcome existing conflicts between short-term and long-term goals and to establish a dynamic and constructive dialogue fostering agreement and cooperation; secondly by optimizing R&D goals, disseminating environmentally sound innovations throughout Europe and promoting voluntary agreements as an alternative to an excessively complex regulatory framework.

There is clearly an urgent need for greater integration between environmental, R&D and industrial policies, and this integration needs to take place within the context of negotiated targets. Policies need in particular to promote environmentally sound technology trajectories oriented towards particular industry sectors so as to promote the necessary shift in the production paradigm. High priority areas, from the point of view of all actors and stake-holders, include pollution prevention, combining incremental and radical approaches to innovation, targeting of environmentally sound technologies and the quest for solutions to technical problems relating to new and existing products.

Voluntary agreements may be preferable to complex regulation

Keywords

Manufacturing industry, technology innovation, eco-efficiency, cleaner production technology, integrated pollution prevention and control

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Contact

Paulo Partidario, INETI - Inst. Nac. Engenharia e Tecnologia Industrial, Azinhaga dos Lameiros, 1699 Lisboa Codex - Portugal.
Fax: +351.1.7154084
e-mail: paulo.partidario@mail.ineti.pt

About the author

Paulo J. Partidario is a Researcher/ Chemical Engineer at INETI. He holds a Masters degree in Technology Management and is currently doing PhD research in environmental technology dynamics. His main areas of interest include innovation, the greening of industry, ecoefficiency, and Best Available Techniques (BAT) in the framework of DG XI's IPPC Directive.

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

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

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

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

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

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

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

The IPTS Report is published in the first week of every month, except for the months of January and August. It is edited in English and is currently available free of charge in four languages: English, French, German and Spanish.

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IPTS - JRC - European Commission
W.T.C., Isla de la Cartuja s/n, E-41092, Sevilla, Spain
tel.: +34-5-448 82 84; fax: +34-5-448 82 35; e-mail: ipts_secr@jrc.es

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