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The IPTS REPORT

EDITED BY THE INSTITUTE FOR PROSPECTIVE TECHNOLOGICAL STUDIES (IPTS)
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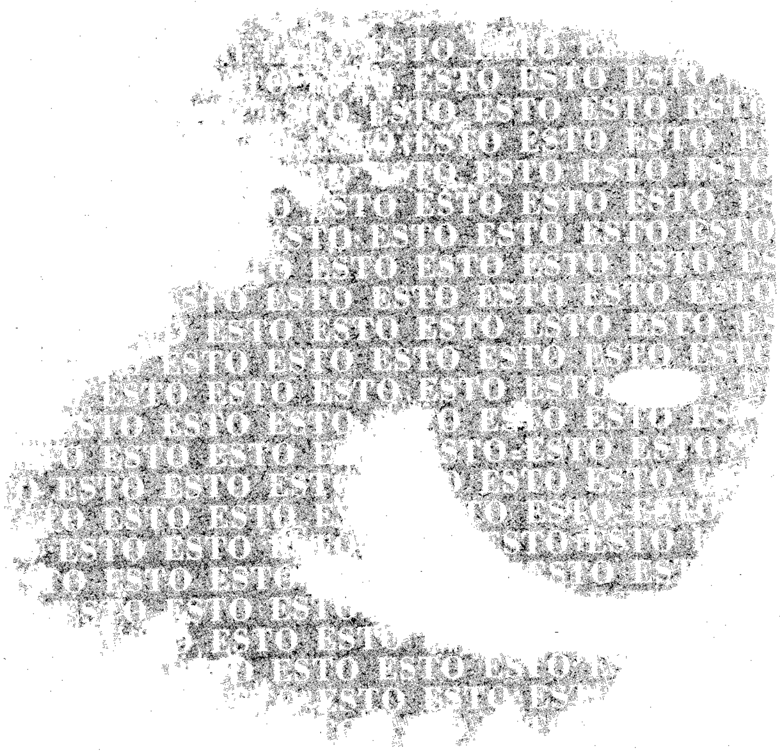

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C O N T E N T S

equilibrium, in an uncharacteristically pensive tone by Harold Kuhn - whose mathematical genius was usually matched by his contagious enthusiasm.

Still, scientific breakthroughs, even if accompanied by an incredible tenacity to overcome mental disease, to 'think his way out' of schizophrenia as Nash put it, might not have been enough to justify the '60 minutes' segment. What did tip the balance was that his intellectual brilliance, eventually crowned by a Nobel prize, and his life as a testament to the power of the human will to overcome adversity, made for, and indeed gave birth to, gripping movie material. The nomination of the resulting movie ("A Beautiful Mind") for several 2002 US motion picture academy awards stirred debate, and triggered the TV segment in question.

This was a case of science coming under the news flashlight, not thanks to the Nobel prize spotlight, nor the daylight of his recovery from schizophrenia, but rather the Hollywood limelight.

On the same day, March 17, 2002, something perhaps even more striking happened involving science and the press. Ohio State University biophysics Professor Pierre-Marie Robitaille took out a one-page ad in the national report section of the Sunday New York Times, presumably at more than considerable personal expense. He dedicated that page to an academic piece on the problematic character of attributing a gaseous nature to the sun; One would assume he should be able to publish this for free in an academic journal – he suggests he "is at a loss in dealing with the scientific publication of this material. The ideas are too simple and unexpected to stand any chance of publication in the peer reviewed physics literature."

The point here is not the veracity of the allegations; rather the point is that if Prof. Robitaille did not have – or was not willing to spend – the large amount of money a NYT one-page ad costs, his challenge would not have drawn much attention.

Indeed, it may well be the case that through such largesse Prof. Robitaille reached more physicists than he would through publishing in some of the lesser known physics journals. If this is the case, then a new host of issues comes to surface: if one has money to spend one can circumvent academic journals to make his ideas known, reach more scientists (and the public at large) at the same time, and spark more research and/or refutation by his colleagues.

Perhaps the Internet can prove a helpful venue in this regard. Indeed there are web-sites where scientists can post their research results, without having to submit them to peer-review (note that even so, those who can afford the ad-page will get more prominence than all those vying for the web-site visitor's attention).

This alternative publication case has several dimensions that cannot be dealt with here; we may address some of them in a future editorial. In any case, we are all fortunate that in the fifties Prof. Nash did not have to resort to buying NYT advertising space to make his theories known – it is unlikely he could have afforded it.

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[illegible] a Future Chemicals Policy

[illegible] dealing with chemicals within the boundaries of the [illegible] policy considerations. Firstly, the idea of creating [illegible] as well as old substances, so that the same amount of [illegible] substances. Secondly, the tenet that the manufacture [illegible] move to an "approval system". The first consideration [illegible] Chemical Substances (EINECS), established in 1981, [illegible] substances introduced into the market between 1971 and [illegible] are affected by the proposed future chemicals policy. The [illegible] human health and the environment and should provide [illegible]

[illegible] policy is known is REACH. This stands for:

[illegible] tonnes/year

[illegible] tonnes/year, as well as all substances that are of high

[illegible]

[illegible] volume triggered. What is totally new for EU [illegible] admission procedure that singles out especially hazardous [illegible] importers have to prove that the proposed use of the [illegible] approved only for those purposes licensed, every other [illegible]

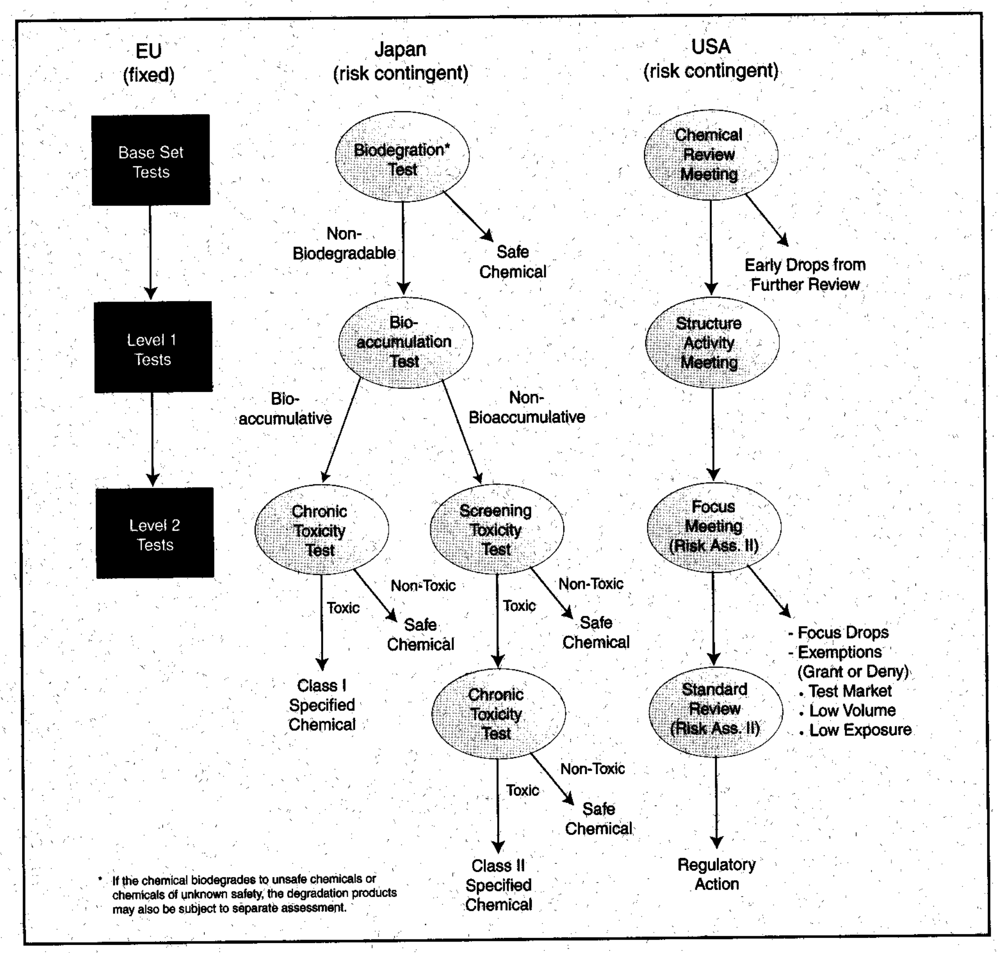
The purpose of chemicals policy is the observation and regulation of the possible toxicological and ecotoxicological consequences of the use of chemicals

nance of industrial health and safety standards. Four specific periods of European chemicals policy can be observed and distinguished (van der Kolk 2000), each corresponding to roughly a decade. The first decade begins around 1960 with the "Yellow Book", in which the health and safety data covering literally hundreds of chemicals was summarized. The major concern of the Yellow Book was establishing the hazard classification and the labelling of chemicals. This work was continued during the following (second) and it was during this period that the first limitations on use were issued, for health and environmental reasons. The third period was characterized by a heightened awareness leading to a more preventive approach towards chemicals. It included the 6th Amendment of the Directive 67/548/EEC (the so-called Dangerous Substances Directive) in 1979. The 6th Amendment introduced the requirement that manufacturers and importers of chemicals notify new chemical substances by providing data on the properties of the substances. This decade signified a new era, one in which the industry began to adjust its attitude towards a clear commitment to health and environmental goals. Still, it took a number of years until the industry as a whole implemented the worldwide Responsible Care Initiative, which was an important contribution of the chemical industry to sustainable development. The Responsible Care Initiative began in the late 1980s and became truly effective in the fourth decade (i.e. the 1990s). The fourth period of chemicals policy in the EU focused on the improvement of the chemicals control system. The 7th Amendment, in 1992, which required that the principles of risk assessment for new substances be laid down, is particularly relevant for this study.

There is another key issue of the fourth decade, however, which should be mentioned—a lack of data on existing chemicals. This has to do with the filling of knowledge gaps concerning the hazards and risks of existing chemicals.

The regulatory system has evolved steadily since the "Yellow Book" summarized health and safety data for hundreds of chemicals in 1960

Figure 1. Risk Contingent Testing vs. Fixed Testing Requirements



State due to differences in criminal law. The "Three Year Report" of the European Commission (1998) provides an overview of the penalties for non-compliance with the various national legislations. For example, the fines for the most severe breaches (failure to notify new dangerous substances) vary from €2,050 (Ireland) to €76,000 (France).

In contingent testing requirement systems, information generated during the testing procedure can be used to decide about further tests. This is done in the US system, which is called a risk contingent system since it works with a contingent testing strategy. This strategy is implemented early with a finely tuned process, starting with the review of notified chemicals and the development of an information search strategy. At a very early stage approximately 86% of notifications ('pre-manufacture notice', PMN) are dropped from further review. The procedure begins with an inexpensive evaluation of existing information. If the initial data have not provided clear evidence, additional test information is requested from the notifying company. Altogether this procedure is cheaper and more informative than the block-testing strategy applied by the EU regulation. However, the US system leaves a considerable degree of uncertainty for about 14% of the submitters of PMNs. For example in 1997, 10.8% of PMN submissions made to the US Environ-

In contingent testing requirement systems, information generated during the testing procedure can be used to decide about further tests. Overall, this procedure is cheaper and more informative than block-testing, whereby all substances are subjected to the same procedure national innovation system, which comprises public R&D activities in their entirety, in particular at universities and research facilities outside universities. The notification procedure for new chemical substances may lead to a conversion of resources in other areas of the company and to a higher degree of uncertainty in the final outcome of R&D, and thus also lead to uncertainty concerning the commercialization of new products.

Innovation strategy is also directly influenced by chemicals regulation. The regulation cost entailed by notification of new chemicals increases the cost of innovation (and also increases time-to-market). As we can see in Table 2, there are significant differences in the cost required to fulfil the notification requirements of the EU, Japan, and the US. The costs, particularly for Japan, but also in the US, depend very much on risk-dependent data requirements—they must be calculated for each specific chemical. In contrast to this situation, a recent survey by the UK Institute for Environment and Health (2001) estimated a figure of €120,000 for the EU Base Set requirements package as the median value of 16 Europe-based contract research organizations. Table 2 uses the comparable figure of $117,000. The differences between the notification cost for the EU and the US are primarily due to a few specific tests generally being required for the EU Base Set (see, for example, Neven et al. 1998).

For the analysis of the impacts of regulation the question of whether a company develops new substances for product innovations or whether it uses existing chemical substances in mixtures or formulations is decisive. In addition to cost differences the highly divergent rules covering exemptions in the EU, Japan, and the USA must be taken into account when regarding the possible impacts on innovative performance.

The impact of the regulation of new chemical substances - through the innovation strategy - on innovation performance depends essentially on the success rate of the specific product group, i.e. the number of tests needed for the successful market introduction of a product innovation. If the success rate is low (e.g. 1:10), the regulatory costs are higher than with a higher success rate (e.g. 1:2). In this example the cost of the lower success rate would be five times that of the higher one, because the expenditures in terms of cost and time attributable to regulation would have been incurred for each attempted market introduction for each product innovation. Consequently, regulatory costs can be prohibitive for product groups with a lower success rate, leading to a situation where new chemical substances are no longer developed.

The impact of the regulation of new chemical substances will depend on the success rate. For product groups with a lower success rate, regulatory costs can be prohibitive, leading to a situation where new chemical substances are no longer developed

A Digression on Non-compliance

Finally, there may be either deliberate or unknowing non-compliance with the regulation of new chemical substances. Two specific EU inspection programmes - the SENSE and NONS inspection programmes - have shown that between 32% (SENSE) and 47% (NONS) of inspected companies (including importers) did not comply with the Dangerous Substances Directive. As a result of the follow-up actions of the NONS project, the number of substances that could not be identified decreased from 644 to 163. In 14 cases, the import or production of new, non-notified dyes (11) or non-identified dyes (3) was prohibited (European Commission 1998).

Sanctions should serve as an instrument to change individual company behaviour from non-compliance to compliance with the regulation. Advocates of sanctions regard them as an important instrument. Sceptics question whether sanctions are an effective stand-alone instrument. There is no systematic data on the success of sanctions as applied to the violation of chemicals regulations in the EU, USA, and Japan. However, the public enforcement of chemicals law is

Sanctions should serve as an instrument to change individual company behaviour from non-compliance to compliance with the regulation, although there are arguments about their effectiveness

Table 1. Selection of the Global Top 50 Chemical Companies (1999) Included in the Analysis

Rank No.	Company	Country	Chem. Sales 1999 ($ mill.)	Chem. Sales as % of Total Sales
1	BASF AG	DEU	31250.3	90.1
2	Du Pont (E I) De Nemours	USA	27688.0	93.1
3	Bayer AG	DEU	20192.5	69.4
4	Dow Chemical	USA	18600.0	98.3
6	ICI plc	GBR	13671.5	100.0
8	Akzo Nobel Ny	NLD	12323.5	80.1
13	Sumitomo Chemical Co Ltd	JPN	8136.5	97.5
15	Mitsui Chemicals	JPN	7762.7	100.0
16	Henkel KgaA	DEU	7324.6	60.5
19	Solvay SA	BEL	6791.9	85.6
20	Dainippon Ink & Chemicals Inc	JPN	6696.9	81.2
21	Air Liquide (L) SA	FRA	6617.3	95.0
22	DSM NV	NLD	6609.7	98.0
23	Mitsubishi Chemical	JPN	6472.7	44.2
28	Union Carbide Co	USA	5870.0	100.0
29	PPG Industries Inc	USA	5502.0	70.9
31	Rohm & Haas Co	USA	5339.0	100.0
33	Monsanto Co	USA	5102.0	55.8
34	Boc Group plc	GBR	4947.6	92.3
35	Norsk Hydro A/S	NOR	4726.5	36.0
38	Air Products & Chemicals Inc	USA	4653.8	92.7
39	Praxair Inc	USA	4639.0	100.0
41	Eastman Chemical Co	USA	4590.0	100.0
42	Asahi Organic Chem Ind	JPN	4555.0	43.4
44	Borealis	DNK	4334.0	100.0
48	Lyondell Petrochemical	USA	3693.0	100.0

Source: Short (2000), Chemical & Engineering News

Empirical studies show companies from the EU and Japan to have a lower R&D productivity than US companies

R&D capital as a third factor of production in addition to capital and labour. Second, a method determining the patent productivity of R&D using a Poisson model. For details of the models used and the definition of the variables see Fleischer et al. (2000). A comprehensive overview and sensitivity analysis of various models of R&D productivity measurement can be found in Lööf and Heshmati (2001). A more detailed analysis of the determinants of R&D in the chemical industry is given in Gambardella et al. (2000). R&D productivity estimates for European countries and sectors of the chemical industry can be found in Albach et al. (1996). These estimates are based on data from the European Union's First Community Innovation Survey.

Findings from the first method used show that companies from the EU and Japan have a lower R&D productivity than US companies. This model was based on a production function with operating income as the dependent variable and the independent input factors of capital, labour and R&D expenditure. The operating income was defined as the difference between sales from normal business operations and operating costs. Fixed assets were used as a proxy for capital, the number of employees was used as a proxy for labour, and the annual R&D expenditure was used as a proxy for R&D capital stock.

The second R&D productivity measure is based on the number of US patents granted. The differen-

In terms of patents, productivity is the highest among US companies, although Japanese companies hold the largest number of patents [illegible] compute comparable annual notification statistics, [illegible] the number of PMNs was used, not the total number [illegible] would have meant including data on a number [illegible] the EU and Japan. These exemptions are about low [illegible] low release/low exposure, and polymers. They [illegible] Japan, and the US. Furthermore, there is a lack of data on [illegible] Second, it was assumed that notifications in the EU [illegible] market introduction of new chemical substances due [illegible] US the situation is different. Over the period 1979-1999 [illegible] commercial manufacture as indicated by the [illegible] there were only very few polymers included in the [illegible] US PMNs for polymers was necessary. It was assumed [illegible] "could have been a polymer exempt chemical" [illegible] used by the notifying company. In these cases [illegible] polymer then gets registered in the TSCA Inventory. [illegible] to annual averages as reported in the preceding paragraph.

the static EU EINECS register covers about 100,000. Three thousand new substances which have been notified in the EU are also recognized. The most important aspect, however, is the fact that all inventories of existing substances include substances which were not on the market at the time when the obligation to notify new chemicals became effective. It is not possible to quantify the numbers of these substances, which subsequently led to a de facto reduction in notifications in the first few years after the introduction of the legislation.

To solve this problem we have used the number of new chemicals notifications available for the last ten years for which comparable data were available—the period 1987-1996. The outcome of the second calculation was established in this way: In the EU, in the last 10 years companies have notified an average of 274 new chemicals per year; in Japan, companies have made 265 notifications annually, and the gross number of new chemical substances (excluding polymers) notified per annum in the USA was 1,720. However, this average has to be adjusted according to our assumptions. The number of chemicals notified in the US and which then were finally manufactured ("Notices of Commencement") averages 642 per annum for the period 1987-1996, or 37.3% of the PMNs (pre-manufacture notices). Assuming that 25% of the PMNs are polymers we get a comparable annual average of 482 notifications for the US. That is, in the period 1987-1996 the US "produces" 1.8 times more new chemicals notifications than the EU and Japan.

Thus, depending on whether we take the overall averages or the averages over the period 1987-1996, the comparison leads to the following conclusions: The US "produces" between 3.0 and 4.4 times more new chemicals notifications than the EU. For Japan these figures are 2.8 and 4.6. If we assume that all new chemicals notifications in the EU are going to be manufactured, thus the number is comparable to the US figures for the "Notices of Commencement", then the US system produces 2.3 times more new chemicals than the EU.

The question remains as to how the number of new chemical substances notified per year influences the number of new chemical products introduced successfully onto the market. We have assumed that there is a significant impact and that the number of notifications is a good indicator of

The strategy of secrecy pursued by companies and the complexity of innovation efforts in large companies make it difficult to determine how numbers of new chemical substances notified per year relate to the numbers of new chemical products introduced successfully onto the market innovative performance. Due to the confidentiality of the notification data it was not possible to make a quantitative analysis. We asked this question during the interviews we conducted with experts from the chemical industry. However, the results were unsatisfactory for two main reasons—the strategy of secrecy pursued by the companies and the complexity of innovation efforts in large companies. The companies obviously do not want to make public which new chemicals they have notified, and thus do not want to tell us which innovations have a "notification impact". There is certainly the possibility of speculating on these issues. For instance, for dye-related innovations new chemical substances are needed. If a company is making new dyes and complies with the law then it is obvious that these dye-related innovations are affected by the new chemicals regulation. Obviously the company would prefer to produce its new chemicals under a regime which is more favourable to innovation.

This is amplified by the articles provision, under which new chemicals regulations in general do not regulate the so-called articles, that is, the final products which include the new chemicals. Thus, a manufacturer in the EU who seeks new chemicals would try to get these new substances from outside of the EU, and would then set up the manufacturing of the final products outside as well. Thus, he would be able to assure more cost efficient access to the new chemicals. Again, this is a further reason why a risk-oriented regulatory system based on a two-side learning strategy is recommended for the EU.

Conclusion

Currently the EU is in the final stage of the process of developing the details of a new strategy for regulating chemicals. In order to gain a better understanding of the details of this strategy it is useful to compare the most significant differences of the EU, Japanese, and US systems, as illustrated in Table 2. This overview further includes the regulation of existing substances. Based on the outcomes in particular of our qualitative analysis, it is recommended that a risk-oriented regulatory system be considered in the EU. Such an approach would allow a unified chemicals control system for new and existing chemical substances. It should be noted, that the White Paper on a "Strategy for a Future Chemicals Policy" applies a similar approach, although the details are still under discussion. The reformed regime for chemical substances should focus on an efficient strategy for obtaining information and assessing the risks of chemical substances, following a pragmatic (and not a bureaucratic) philosophy by implementing a continuous "two-sided learning" strategy. This would be backed up by penalties in order to achieve an optimal chemicals control. Moreover, exemptions for substances to be used for R&D purposes should be brought in line with those in Japan and the USA. Exemptions should be handled in a way that gives due consideration to connected risks.

The EU is currently finalizing details of a new strategy for regulating chemicals. In order to gain a better understanding of how the strategy will work in practice, it is useful to compare the most significant differences of the EU, Japanese, and US systems

The most important issue is to create a knowledge base at the level of the national competent authorities and at the level of the EU Commission in order to handle in a very professional way the evaluation of chemicals and enable appropriate information search strategies to be designed in order to meet the EU conditions as laid down in OECD (1994). The tasks of the chemicals committees of the EU should be integrated in a single agency. Eventually, such reform should also lead to a more flexible and more responsive system for the regulation of new chemicals. In a great number of cases the Base Set testing requirements would be reduced, in a few other cases not. This would also make it necessary for the EU to adopt a pragmatic approach to the application of the (Quantitative) Structure-Activity Relationship ((Q)SAR). (Q)SAR is a method of estimating the toxic properties of a compound using the physical and structural make-

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About the author

Manfred Fleischer is a Senior Research Fellow in the research area "Markets and Political Economy" at the Social Science Research Center Berlin (WZB). He has written several papers and studies exploring innovation, regulation, and the competitiveness of industries.

business as usual scenario (EC, 2000a). It is crucial for the competitiveness of the EU industry to be in the lead in new advanced and clean energy technologies, as their market share is rapidly increasing and they may, in the long term, replace a significant number of conventional energy technologies. The long term targets for cost reduction, the potential of individual technologies, and other issues will be discussed below for those technologies which may be expected to make an important contribution to a sustainable energy supply.

The cost and potential of renewable energy sources (RES)

Wind Energy

Electricity generation from wind energy has, on average, doubled every two years since 1990. European wind energy capacity increased from 400 MW in 1990 to 13.000 MW in 2000. However, the current share of EU electricity production is still only 1.25%. In view of this rapid development, the European Wind Energy Association updated the target for wind energy capacity from the original 40 GW in 2010 to 60 GW (or 6-7% of the current electricity production). Offshore wind energy is set to represent an increasing share of this.

The potential of wind energy was estimated by a study "Wind force 10" (Greenpeace, 1999) to be around 3127 TWh of which 2500 TWh is offshore (< 30 m deep and < 30 km from the coast) and 627 TWh onshore. This would be sufficient to cover the electricity demand in the EU, which currently amounts to 2500 TWh. Other sources from the British Wind Energy Association estimate the potential in the UK alone at 2500 TWh (1000 TWh offshore and 1500 TWh onshore). There are, however, a number of limiting factors which may make the maximum potential unachievable, such as environmental and visual impact. Taking visual impact into account, Wind Force 10 estimated that the offshore potential would drop from 2500 TWh to 313 TWh, which together with the onshore potential of 627 TWh, could cover around 40% of EU electricity demand. With less conservative assumptions, in particular for visual impact, a much larger share could be covered using wind energy; the potential of wind energy therefore is expected to lie between 40% and 100% of EU electricity demand.

The high cost of wind energy is a major bottleneck. Current prices of wind electricity are between 0.04 and 0.09 €/kWh whereas the cost of conventional electricity is around 0.04 €/kWh (at the power plant end) (EC, 2000b). The strong increase of wind energy in the nineties, is mainly due to promotional measures, subsidies, tax reductions, etc. It is not likely that this support will remain forever and particularly short/medium term RTD is needed to reduce the cost of wind electricity. There is still scope for a reduction to 0.03 – 0.05 €/kWh.

Another problem is the intermittent character of wind energy (see below).

Photovoltaics (PV)

PV is attractive as it could, in theory, cover the total energy demand. Nevertheless, current PV share of the EU electricity production is still only 0.15%. Although the cost of PV electricity is still 5-10 times higher than electricity from conventional sources (0.25 – 0.5 €/kWh), installed PV capacity in the EU is increasing by 25-30% per year. With a continuation of this rate of increase, PV could produce a large part of the EU electricity demand 25 - 30 years from now. This trend should therefore be sustained and accelerated by significant cost reductions. It may be expected in 10-15 years that, with a greatly increased RTD

Electricity generation from wind energy has, on average, doubled every two years since 1990. However, it remains expensive compared to conventional energy sources

- 20 x 10^6 ha of the 140 x 10^6 ha arable land in the EU can be used for fuel crops;
- the current yield of fuel crops is 5 toe/ha but higher yields up to 10 toe/ha may be feasible in the future;
- there is also a considerable potential in the candidate countries;

Biomass could be transformed into electricity (50-80% of current electricity demand) or into 170 – 240 Mtoe liquid bio fuels. In the long term, priority should be given to the transformation of biomass into bio fuels for transport applications. There are two main arguments for this approach:

- Security of supply. The transport sector is 100% dependent on oil, 60% of which is imported from outside the EU;
- Bio fuels are one of the few options for the transport sector offering zero net emissions of CO_2.

Long-term potential and cost of renewable electricity

Final energy demand in the EU in 1998 was around 1000 Mtoe, of which 80% was fuel for heating and transport and 20% electricity (of which 32% is nuclear electricity and 12% hydropower). The cost of electricity is around 0.04 €/kWh (at the power plant end) and 0.1 €/kWh to the user.

Table 1 gives the estimated long term potential for electricity production from various different RES technologies (as a percentage of current EU electricity demand) together with their current and long-term target cost. The values for wind, PV and biomass are discussed above. Important contributions may, in the long term, also be made by other technologies such as geothermal and solar thermal energy. Geothermal *"Hot dry rock" (HDR)*, is based on the idea that in many areas of the EU heat of 200-250°C is available at a depth of 5000m. By drilling two holes at a distance of typically 500 m and forcing water at high pressure from one hole, through fissures in the rock, to the other hole, steam at 200°C is produced which can be used for electricity production. The long-term potential in the EU has been estimated to be 20% of the EU electricity demand; in addition heat can be produced at no additional cost. HDR has the advantage that it is not intermittent. A pilot project is currently underway in France to demonstrate the feasibility of this technology. Also solar thermal electricity is expected to have a long term potential of around 20%, particularly in southern European countries.

The reduction of GHG and security of the EU energy supply are the main drivers for the introduction of RES technologies. As for GHG, thermal electricity plants in the EU, which produce 56% of the EU electricity, contribute 30% to the total EU CO_2 emissions (of which 2/3 are from coal). The remaining 44% of EU electricity is produced by nuclear and hydro-electric power plants, which do not emit CO_2.

The long term potential of all RES technologies together ranges from 180% to 320% of the total current EU electricity demand. Just 56% would be sufficient to replace all thermal electricity plants and therefore reduce CO_2 emissions by 30%

Table 1. Long term (30-40 year) potential and cost of RES

	Long-term potential (in %) of EU power demand (2500 TWh)	Electricity price in Euro cent per kWh	Long-term target costs in Euro cent per kWh
PV	50 - 100%	25 - 50	6 - 10
Wind	40 - 100%	4 - 9	3 - 5
Biomass	50 - 80%	4 - 8	3 - 5
Geothermal			
Hot dry rock	20% + heat	12	4
Solar Thermal	20%	12	4

the cost of hydrogen production by electrolysis consists of electricity costs, cheap renewable electricity is the key to cost-effective hydrogen production.

- Hydropower is a source of cheap electricity and the potential for hydrogen production with hydropower in countries such as Iceland, Greenland, Sweden, Norway is around 100 Mtoe. The cost of hydrogen via this route is estimated to be 11 €/GJ;
- Wind energy is another RES which in the long term may be able to produce cheap electricity. The potential for hydrogen production by electrolysis using electricity from wind power is around 36-90 Mtoe (the efficiency of electrolysis in terms of energy content is 90%). The cost of hydrogen with wind electricity at 0.03 € per kWh, in the long term, is estimated to be 14 €/GJ. An advantage is the fact that transportation of hydrogen in pipelines makes it possible to mitigate the intermittent character of wind energy due to the fact that hydrogen storage is possible for up to one day by regulating the hydrogen pressure in the pipelines.

The long term potential of bio fuels and hydrogen is expected to lie in the 300 - 430 Mtoe range. This is far below the current demand for heating and transport fuels, which is around 800 Mtoe. The use of hydrogen produced from natural gas (and possibly coal, which has the drawback of producing twice the amount of CO_2 per unit of electricity produced) where CO_2 is captured and stored underground could be a possible solution. This is the cheapest way of producing hydrogen and the underground storage capacity for the total current EU CO_2 emissions, is sufficient for hundreds of years.

Heat

The discrepancy between supply and demand mentioned above could also be diminished by the following technologies:

- Electrical heat pumps, which can transform electricity from RES into low temperature heat for buildings. 45% of the current electricity supply in the EU would be sufficient to produce the heat demand in buildings i.e. around 270 Mtoe.
- An increase in decentralized electricity production will allow large scale introduction of co-generation in buildings and industry which could lead to energy savings of 50 – 100 Mtoe; fuel cells are expected to play a major role in this process.
- Other forms of energy savings remain important to make the RES-based energy supply go further; here again, fuel cells are expected to make an important contribution due to the fact that they are generally more efficient than combustion systems.

The long term cost for fuels and heat from RES is expected to be comparable to, or lower than, the current cost of heat and fuels derived from fossil sources. However, the long term potential of renewable fuels and heat (mainly biomass) will not be sufficient to cover the current fuel and heat demand. This gap could be bridged, in 10 to 20 years, by the use of clean hydrogen from natural gas. In the very long term, if the potential of RES (180-320% of the current EU electricity supply) is realized, surplus electricity could be used for the production of fuels (e.g. hydrogen), heat (electrical heat pumps) and RUE (Rational Use of Energy) (e.g. co-generation with fuel cells).

The use of more efficient technologies such as heat pumps, fuel cells and more decentralized generation, all have a role to play in making it possible to meet energy needs from renewable sources

Past and ongoing EU Non-Nuclear Energy RTD

In the past, EU Non Nuclear Energy (NNE) research was carried in the JOULE programmes (DG RTD), which since 1984 have formed a part of the EU Framework Programmes (FPs). The THERMIE programme (DG TREN), which remained outside the FPs until 1994, dealt with energy-

Fuel cells which use hydrogen from RES are intrinsically clean. Together with RES and electrolysers, which produce hydrogen from water using electricity from RES they will form an integral part of any future RES based energy supply. Below some main *fuel cell types* are briefly described:

Proton Exchange Membrane Fuel Cells (PEMFC)

PEMFC is currently the most advanced type of fuel cell. It operates at 80 - 150°C, has efficiencies of 40-60% and generally uses natural gas, methanol or hydrogen as its fuel. For transport applications many major car manufacturers have started to explore fuel-cell powered vehicles. In particular Daimler Chrysler, which has earmarked a budget of €1.5 billion over 7 years, has made a strong commitment. The cost targets are 50 and 150 €/kW for private cars and buses respectively. With the current state of the art, PEM fuel cells could most probably achieve costs of 300 €/kW if they are mass produced on a large scale (e.g. 1000 MW per year); in the medium and long term lower costs, down to 50 €/kW, are believed to be possible. If the above cost targets can be achieved, fuel cells could also find a large market for applications in buildings, where boilers currently producing only heat could be replaced by fuel cells producing both heat and electricity, which could lead to major energy savings.

Solid Oxide and Molten Carbonate Fuel Cells (SOFC and MCFC)

These fuel cell types operate at 700 - 1000°C and generally use natural gas or hydrogen as a fuel. They can achieve electricity generating efficiencies of up to 70-80% (for hybrid FC/ gas turbine systems where also the exhaust heat is transformed into electricity with a gas turbine). These fuel cells are likely to have a higher cost than PEMFC due to more expensive high-temperature manufacturing methods and 5 to 10 times lower current densities; this will require 5-10 times more cell surface per kW and lead to a higher cost. The long term cost target is 400 - 600 €/kW. Applications are foreseen in decentralized electricity production and co-generation in industry (high temperature heat) in the 0.1 - 50 MW range

Electrolysers/hydrogen

Electrolysers use electricity to produce hydrogen from water. They are in fact reversed fuel cells and both technologies are closely related. They are essential in a largely RES based energy supply which, in the long term, is expected to have an excess of electricity and where hydrogen will be needed to adapt fuel and heat supplies to their demands.

Currently PEM and alkaline based electrolysers produce hydrogen with an efficiency of 90% in terms of energy content. Their current cost is around 3000 €/kW, but it is expected that this cost, like that for fuel cells, can be reduced to 100-200 €/kW in the long term.

As electricity forms 80% of the cost of hydrogen production by electrolysis (in continuous operation) the cost of renewable electricity has to be low for hydrogen to be competitive with conventional fuels.

Hydrogen for transport applications could be produced from hydropower at a cost of around 11 €/GJ and from wind for 18.5 €/GJ, assuming the lowest current cost of wind electricity (0.04 €/kWh). This would be lower than petrol (excluding tax), at 10 €/GJ (taking into account the fact that fuel cells using hydrogen are twice as efficient as combustion engines running on petrol or diesel). It should be noted that hydrogen can also be produced from natural gas by reforming. A cost of 7 €/GJ can probably be achieved in the short and medium term (the current cost of natural gas is 5 €/GJ). A drawback is the emission of CO_2, which can be avoided by capture and under-

Proton Exchange Membrane Fuel Cells are currently the most advanced type of fuel cell. It operates at 80 - 150°C, has efficiencies of 40-60% and generally uses natural gas, methanol or hydrogen as its fuel effectiveness and to obtain the maximum potential from the various RES;

- An accelerated market introduction of clean technologies requires the right balance between the building up of production facilities, RTD funding and support measures such as promotional measures, subsidies, tax rebates, etc.
- Huge public and private investments are needed for a new energy infrastructure (active electricity grids, new refuelling networks e.g. for hydrogen);
- Dispersed RES will have to be transformed into concentrated energy production plants (large industries, towns). Energy carriers such as hydrogen will be indispensable to this and hydrogen fuelled gas turbines will remain important well into the future;
- Land use in the EU could be revised to take into account EC priorities related to energy and environmental objectives (e.g. energy crops, cheap land for PV installations, city planning leading to reduced emissions from transport, etc.)

Keywords

renewable energy, fuel cells, hydrogen, CO_2 sequestration

Note

1. As is the case with all IPTS Report articles, the views presented here do not necessarily reflect the position of the European Commission.

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no matter how ill-suited these may be to radically new situations, opportunities and dangers. If the result of the lag is a delay in using opportunities for the better, this is a pity but not a tragedy. However, the looming danger is that the interval between increases in human power on the one hand and human abilities to utilize these powers for the better on the other, may result in uses of the power for the worse, with the spectre of anything from irreversible damage to endangering of the survival of humanity.

The power to shape the future that science and technology gives can easily be used for the worse. The greenhouse effect and nuclear war are just two potential harbingers of other ills likely to come, such as ruinous interventions with human biology, increasing parts of humanity becoming absorbed with virtual amusement, and mass-killing or collective suicide of humanity enforced by mad "true believers" sure that this is the way to the Kingdom of Heaven and equipped with the knowledge and instruments to engineer an unstoppable killer virus, or the like.

To prevent catastrophe and speed up the utilization of science and technology for the good of humankind, it is necessary to try and "compress the learning time" of crucial social institutions in charge of collective choices. This is made all the more necessary by the speed with which decisions must often be made, in part because of the rate of science and technology innovations, and growing uncertainty and inconceivability. To cope with all this, the prime institution that has to go on a crash-course in improvement is government.

The fateful role of government

Whether we like it or not, government plays a fateful role in "weaving the future",[1] despite all the uncertainties and partly in order to contain them. Thus, in spite of the growing importance of other institutions and processes, governments constitute the main social structure legitimately entitled and able to make critical and authoritative collective choices, including on the uses or misuses of the potential of science and technology.

This statement in no ways disparages the importance of markets, non-governmental actors and civil society. But governments are the main social unit responsible for making –and able to make– normative choices and for regulating and guiding other actors of collective significance. And, thanks to science and technology, these governmental choices and actions include "fateful" ones, where the prosperity, decline or even destruction of humanity are at stake.

A growing capacity deficit

What is dismal about all that is that while the impact, direct and indirect, of governmental choice and non-choice on the future is increasing by orders of magnitude, the quality of governmental decision-making processes seems to be declining rather than improving. To take just one example, the impact of the mass media forces even otherwise commendable decision-makers to give more weight to short term political effect than long-term goals. There have been some outstanding improvements in capacities to govern, such as the European Union — which is a major invention in governance well suited to the needs of the twenty-first century. And some norms applied to contemporary democratic governments, such as "transparency", are in some respects an improvement (though their impacts on the quality of choice are at times doubtful). But, all in all, capacities to govern remain totally inadequate for using appropriately the awesome power for impact provided by science and technology.

Hence my conclusion that there is a growing capacity deficit — with a widening and deepening

To use this change for the good of humankind, those institutions responsible for collective choices need to accelerate the rate at which they learn and adapt

Although markets, non-governmental actors and civil society are important forces in shaping the future, governments are the main social unit responsible for normative choices an average of half of the articles published in a periodical such as *Scientific American* and to be able to write a good essay or memorandum on the societal implications of one of them. However, this apparently is often not the case.

I could not find any reliable surveys of science and technology literacy among politicians and civil servants. But my strong and partly evidence-based conjecture, supported both by data on educational background and in-service training, and on many years of direct personal contact with politicians and government staffs in many countries, is that far too many lack adequate science and technology literacy, even if many counter-examples can be found. In addition, despite a fairly diligent search, I failed to find anywhere systematic efforts to provide government elites with science and technology literacy, with various public policy schools and civil service training institutes also not entirely addressing this need. This epitomizes the obsolescence of present policy-making systems and raises lack of knowledge as one of the main causes of incapacity to govern.

The expectation that governments can guide and regulate knowledge-economies and facilitate knowledge-societies without themselves being "knowledge-intensive", in a strong sense of that term, is preposterous. Knowledge is only one of the requisites of adequate capacities to govern and is no assurance against evil values, thus their moral quality is also important. Also, the pluralistic nature of salient knowledge and the differences between politicians and professional staffs should be taken into account. But the case for much more core knowledge to be widespread in government elites as a pre-requisite for adequate capacities to govern is overwhelming.

Thus, all government elites should have a good understanding of the main processes in their countries, their regions and the world. Familiarity with the variables shaping the future, such as value transformation, migration and violence is a must. A minimum of both numeracy and "thinking in deep history", as contrasted to exclusive preoccupation with surface phenomena, are essential. Basic knowledge in government-salient disciplines is required, such as economics, social sciences and public law (the latter has received much, and often too much, attention in the preparation and training of civil servants). And cognitive frames for policy deliberations, such as applying systems dynamics and thinking in long-range strategic terms of "rise and fall", are vital.

Also, thanks largely, though not exclusively, to the unpredictable and rapid progress of science and technology, more and more governmental choices are in essence "fuzzy gambles". Therefore, sophistication in the face of uncertainty and inconceivability is an increasingly crucial requirement for upgrading public choice.

To help meet such requirements, highly qualified "knowledge-experts" working on main policy spaces in interdisciplinary settings are now needed in governments. Also, the roles of scientists in government need to be rethought, and a determined effort made to overcome the "two cultures" syndrome. Thus, it is a mistake to confine scientists and technologists to science and technology policies. Rather, after acquiring the necessary background, they could beneficially contribute their cognitive frames and ways of thinking to all critical choices. And, vice versa, social science and history professionals, as well as the new breed of "policy professionals", could fruitfully take part in science and technology choices after acquiring the necessary background.

Knowledge-intensive government is in principle not difficult to promote, the main barrier being lack of awareness and the "tyranny of the status

With science and technology being one of the main drivers of change one would expect greater scientific literacy from decision-makers

It would seem unreasonable to expect governments to be able to guide and regulate knowledge-economies and facilitate knowledge-societies without themselves being "knowledge-intensive"

It is a mistake to confine scientists and technologists to science and technology policies. Rather, they could beneficially contribute their cognitive frames and ways of thinking to all critical choices

Prime Ministers and Presidents, with good access to the power holders. Such staffs are also essential for liaison between actual choice processes and innovative policy thinking in think tanks and society at large.

The trouble is that both the author's survey already mentioned, and the relevant literature, show a shocking scarcity of such staff, the vast majority of heads of governments (and senior ministers and governments as a whole) not only lacking appropriate professional policy staffs, but moreover not realizing that they are short of an essential support for their critical choices.

This is not the place to detail the causes of this glaring hiatus, which range from fear of leaks to unwarranted self-assurance. Clearly, this lack relates to the underdevelopment of knowledge and resistance to innovativeness in governments. But the lack of appropriate policy staffs is a failure which is not too difficult and time consuming to overcome if there is a will to do so – as illustrated by the few cases where a determined prime minister or president has set up a suitable advisory staff despite resistance from his colleagues and civil servants.

Back to science and technology

Returning to science and technology, there is a major gap in current research and engineering in that there is insufficient concern with the necessary government redesigns which are essential if the positive potential of science and technology is to be exploited while preventing their misuse. This need goes far beyond "science and technology policy" and the uses of some of the tools provided by science and technology, such as the Internet, in governments. This is even less a matter of applying "scientific methodologies", as successful in the natural sciences, to the radically different social domains of governance and politics.[6] But without a new type theory and practice of governance, only some beginnings of which can be discerned in ongoing discourse, the essential cognitive and normative grounding for a quantum leap in government, needed to cope with the awesome future-impacting power of science and technology, are missing. Tinkering will not do.

Maybe it is time to have a kind of "Nobel prize" for ideas, theories and proposals on how to radically improve capacities to govern, as a necessary supplement and counterbalance to the Nobel Prize given for scientific creativity, the practical results of which are beyond the capacity of present versions of government to handle.

The Future of Online Media Industries: Scenarios for 2005 and Beyond

Yves Punie, Jean-Claude Burgelman and Marc Bogdanowicz, *IPTS*

Issue: Initial technology-oriented assumptions that the Internet would enable content provision to become completely tailored to the needs of small-scale groups and individual users have proven to be one-sided and overly optimistic. Also the point-to-point model – based on the technical possibility of everyone becoming a content producer – is not expected to overturn existing media value chains.

Relevance: Though the Internet could potentially lower the entry levels for content production and distribution, it does not guarantee sustainable digital media. Old media market dynamics are here to stay. Policy actions can support SME-based European online content media and help develop public online content.

Changes in the online media market

At the height of the Internet boom, the mainstream technology-oriented assumption was that there would be a shift from the predominance of "content push" from suppliers towards "content pull" from users.[1] Digital technologies had lowered the costs and complexities of production and distribution to such a degree that, potentially, every individual or group could become a content producer, thus offering an important development potential for Internet-based start-ups. Digital technologies had also made on-demand design of content and on-demand retrieval possible at the individual level, suggesting there might be a shift from pre-packaged content to customized and modularized content defined by the users themselves. Finally, new types of content demand were expected to arise, generating a full range of innovative content production meeting tightly defined needs.

At the height of the Internet boom, the fact that digital technologies had made customized on-demand media content possible suggested there might be a shift from pre-packaged content to content defined by the users themselves

The prevailing view was that these demand-related drivers – whereby everyone becomes a content producer, content is customized and new types of content demand emerge– would eventually overturn market structures in the media sector and would challenge the power of the incumbent media content companies. One of the major examples of grassroots Internet growth was undoubtedly Napster. It attracted more than 60 million users to it its free, unlicensed music-swapping service over the two years it operated, until it was forced to close down the free service in in attitude compared with two years ago when they expected revenues to follow the launch of new online services automatically. Then market share was equated with growth or profitability. Now, many companies are more concerned with achieving a return on investment rather than rapid growth. However, it is not clear (yet) what the revenue model for healthy online content provision will look like.

Finding a revenue model is linked to the way content is offered. It is expected that content will continue to be "pushed" by suppliers rather than "pulled" by users. The non-individualized, point-to-multi-point content model is prompted by the need for economies of scale. Media companies favour pushing their content to wide audiences rather than servicing customized small-scale markets. Customization of content may still be possible but it will be offered only if users are willing to pay extra for it.[6] Online media innovation will most probably be driven by pay-for-content initiatives. It also means that some user demands will not be met because they are not expected to be profitable for suppliers.

Most media companies consider they have to rely heavily on their brand to be able to promote their content. Gatekeepers have to considered trustworthy by users, thus favouring the so-called editorial content model. Well-known, trusted news companies, it is argued, can help users to deal with problems of information overload on the Internet.

Internet users seem to prefer the big brands as well. A survey from Jupiter Media Metrix found that just four companies account for half of all web surfing. Yahoo!, Microsoft, AOL Time Warner and Napster, along with their various online properties and applications, reach the majority of Internet users. It is important to note, however, that in all the European countries, nationally based brands are also strong. For example, in Spain, Terra reaches 60% of Spanish users; in Germany, T-online is first, also reaching 60%; and in France, Wanadoo is the top Internet Service Provider (ISP), reaching 50% of French web users.[7] These Internet access providers, most of them launched by the incumbent telecoms operators, are increasingly moving up the value chain towards content provision, thus challenging existing content providers.

The major media and telecoms companies, together with a few independent on-line enterprises, are clearly joining forces to get the biggest slice of a shrinking advertising and revenue pie. The trend towards consolidation is therefore increasing on the Internet. The online content market no longer favours many more or less equal players, but rather is being taken over by the big companies. The most visible evidence of this change is the rise of general interest portals, meeting a wide range of user needs.[8] Though these sites offer customized features, it seems that the old broadcasting model, offering something for everyone to pick from, is still on the agenda.

While recognizing that anyone can potentially become a content producer, at the same time, the low barriers to entry do not necessarily guarantee survival in the longer term, nor do they constitute a real threat for the existing media companies. Therefore, what was seen as the most important driver of change during the Internet boom is now seen as the least important (See Figure 1). Compared to two years ago, the demand-related drivers are now ranked least important (depicted in green) while industry-related drivers are of primary importance (depicted in red).

Scenarios for the future of media content industries (>2005)

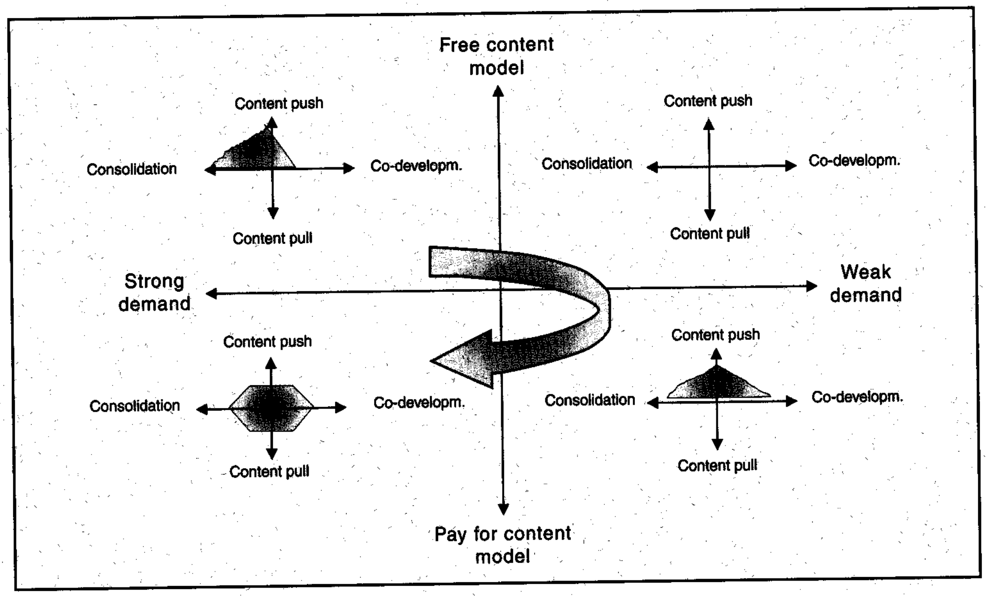
As a result of this analysis, a new cluster of scenarios for the future of media content industries has emerged. It is organized around three dimen-

Now that companies are more concerned with achieving a return on investment, as a way of achieving economies of scale, media companies favour pushing their content to wide audiences rather than servicing customized small-scale markets

Most media companies consider they have to rely heavily on their brand to be able to push their content

Internet users seem to prefer known content "brands", with the largest companies taking the lion's share of Internet traffic. Increasingly, however, Internet access providers are moving up the value chain and challenging established content providers

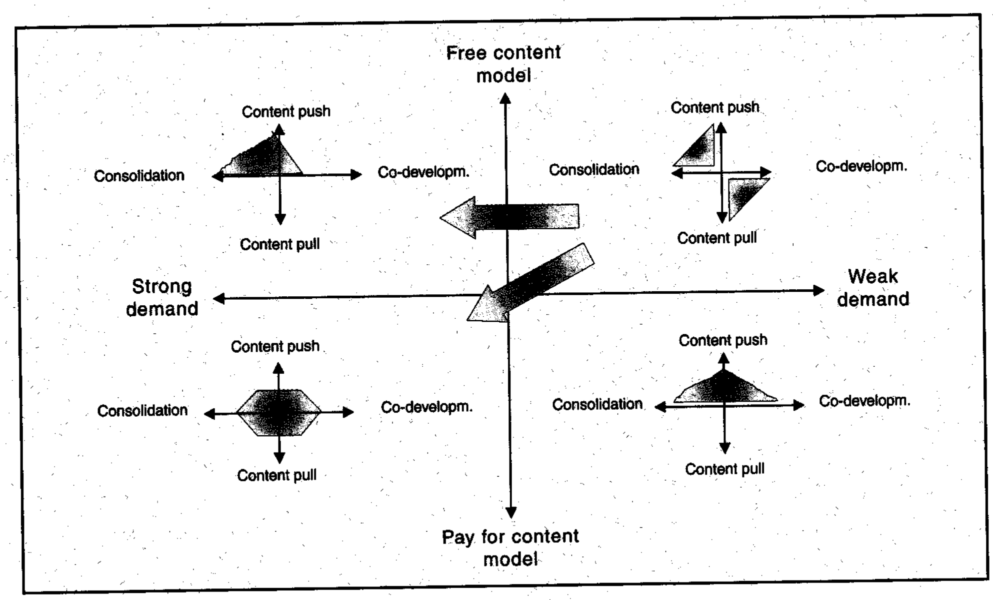
Figure 2. Integrated scenario on the future of private online content media



the creation of one central government portal, the so-called "one-stop shop".[11] This can be seen as consolidation as well, in contrast with the current proliferation of public service websites. Content is free but demand is still relatively weak because these initiatives are still in the start-up period. In the future, they should develop towards the top left quadrant where there is a strong demand for free online information and communication between governments and citizens.

Another trend is that of public service content, such as on-line government information, moving towards a centralized "one-stop shop"

Figure 3. Integrated scenario on the future of public online content media



looks at supporting market enablers, for instance by bridging the gap between investment capital and content companies.

Apart from trying to influence market dynamics with their policies, governments themselves are also important content producers. Public sector information has both considerable economic impact and social value. With the current economic downturn in online media, it is expected that governments will trigger the online content market via the provision of online public service information whereas two years ago, market forces alone were expected to drive change in online media. Public sector information has been recognized as a policy issue, for example at the recent the eGovernment Ministerial Conference in Brussels. The European Commission has, in the meantime, launched an action plan to overcome market barriers to commercial exploitation of public sector information at the European level.[14]

Finally, research and development in multimedia-based Information Society Technologies (IST) such as automatic translation software, human language technologies and information filtering and handling tools may prove to be useful for allowing online content initiatives to be viable at SME level.[15] ISTs can enable Europe to develop and sustain its creativity in the content industries, but technology alone cannot change media markets.

Governments are an important source of information with considerable economic impact and social value, and so can play a role in stimulating the content market

Keywords
digital content, media industries, future scenarios

Notes/References

1. This article presents an updated view on drivers of change and future scenarios in the media content industries. During the Internet boom, the IPTS – together with a group of media experts – produced a scenario document on expected changes in the media industry, with a time horizon of 2005 and beyond. See Ducatel, K., Burgelman, J.-C., Bogdanowicz, M., *Employment outlook and occupational change in the media content industries* (2000-2005). IPTS Technical Report Series EUR 19658, Seville, September 2000. Two years later, after the bursting of the Internet bubble, the analysis was submitted to a new validation workshop. This was organized by the IPTS with media executives, in the context of MUDIA, an IST project. MUDIA (Multimedia in the Digital Age) monitors and analyses current and future trends in the European multimedia news markets, looking at the implications of new technologies for changing trends in the production and consumption of news media (www.mudia.org).
2. See for instance: Oram, A. (ed.) (2001) Peer-to-Peer: Harnessing the benefits of a disruptive technology, O'Reilly & Associates, USA.
3. The Economist.com, The dotcom wreckage, March 21st 2001; Business 2.0, Yahoo! on the rebound, January 14, 2002 (**www.business2.com**).
4. BBC News, January 19, 2001; See for the numbers of jobs lost: **http://www.iwantmedia.com/layoffs.html**
5. Obviously change occurs in many other directions not covered in this article. The development of online media impacts offline media as well for instance, but not always by substituting them. The history of the introduction of mass media shows both complementarity (Eg. Radio and TV) and substitution (general interest magazines of the sixties were displaced by TV). It also shows that new media such as the Internet can revive or give life to new magazines (Eg. Internet and PC magazines). See: Randle, Q.(2001)

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Mobile Phones as Carriers of Cash and Tickets: The Outlook in Europe

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Issue: Initiatives to create replacements for cash, in particular for low-value payments, have had difficulty getting off the ground. Market players continue, however, to develop electronic cash for use at the point of sale, in vending and public transport, as well as for mobile and Internet commerce. Following the physical introduction of the Euro in the single market, electronic cash which can be used universally throughout Europe has the potential to boost trade, while regional or national substitutes for cash could hinder it.

Relevance: There are a variety of technologies aiming to replace cash, including some based on mobile phones. It is currently not clear which of the existing alternatives will find acceptance, and whether they will be open. The need may arise to adopt measures to ensure the openness of the solutions.

The current state of technology

For something over a decade, there have been various approaches aiming to provide electronic substitutes for traditional cash. Apart from various types of electronic money which could be stored on the hard drives of personal computers, most of which have failed, a key vision guiding research and development in this area is the idea of a universally accepted electronic purse with stored value, which could be used in both the "bricks-and-mortar" world and, for example for shopping, on the World Wide Web. While such purse schemes exist in most EU member countries, actual use of them has been very modest and little headway has been made towards implementation of standards and agreements enabling universal use of the various national schemes throughout Europe.

Elsewhere in the world, there have been notable "success stories", such as the "Octopus" system in Hong Kong, but these cannot be repeated easily in Europe (see Box 1).

In the meantime, there have been several initiatives of various types, each of which has been greeted by *some* experts or stakeholders as *the* solution to the problem. Although each of them has met with some measure of success, these solutions are far from ubiquitous and usually do not (yet) work throughout Europe.

Kingdom). These are designed to allow check-ins and check-outs faster than with any of the above schemes. However, currently they are being implemented by regional operators, and their prospects for trans-border usability are unclear.

Lessons learned

What can be learned from looking at existing experience is that there several important factors for the success or otherwise of payment schemes:

- Widespread acceptance by both consumers and suppliers of goods and services in both the "real" and "virtual" worlds. The chances of acceptance are favourable if the scheme builds upon what is familiar, or it uses familiar technology already available for other purposes or in other contexts.
- Transparency. Balances and statements of transfers should be readily comprehensible to the parties involved. Achieving this transparency should not require expensive equipment or devices especially for this purpose.
- Convenience similar to that of cash, or in some circumstances offering advantages over cash. For instance, if there is a need to reload electronic payment systems in ways similar to withdrawing cash, there must be some additional value, otherwise the user might just as well withdraw traditional cash. Such properties could be greater security in certain situations, such as use for remote purchases or in unsafe environments (basement garages etc.). The example of "Octopus" in Hong Kong is due to a large extent to the advantages that the payment system offers over cash under the prevailing conditions (lack of season tickets, acceptance of single ticket by all service providers, speed etc.)
- Privacy and data protection. There is a certain amount of demand for the possibility to pay for goods or services anonymously, as paying with traditional cash, in particular for journals, transport tickets, etc.

A possible solution

In the case of Europe, Euro-based electronic payment systems universally usable throughout the continent would probably find widespread acceptance if there were situations in which they offered advantages over cash. The rapid spread of the mobile telephone means a device capable of transmitting and displaying monetary transactions is now widely accepted by all age groups in the member states. It is technically possible to integrate electronic payment systems in mobile handsets (Box 2), in particular in future generations of these devices. These would then be able to store, transmit and receive electronically encoded money. If equipped with the appropriate transmitters, they could even find uses as a way of making rapid payments for public transportation services. Tickets for this and other purposes could be stored in the handsets. This would enable a large number of consumers to use electronic money, e.g. in transportation systems with barrier-controlled access (as in Paris or London) or those employing tickets (such as in long distance transport), to purchase tickets for events, or to pay for downloading of entertainment information. The phones could also be used for peer-to-peer transactions, such as giving children their pocket-money or paying for items bought on Internet auctions. The ability to use such payment systems spontaneously in virtually any situation would definitely enhance their acceptance so that there are good chances of a breakthrough (Box 3).

The chip and the contactless interface could probably be integrated in the handset, although there obviously might be an advantage in providing a slot and reader while there are still stationary terminals which do not accept the new interface. There is also a need for the system's

Existing experience suggests that there a several important factors for the success or otherwise of payment schemes, such as transparency, convenience, use in a variety of applications and clear advantages for users

In the case of Europe, Euro-based electronic payment systems universally usable throughout the continent would probably find widespread acceptance if there were situations in which they provided advantages over cash approval. This indicates a need for simulation and testing if market players are to reach agreements in this area. For payments from one handset to another (peer-to-peer, or person-to-person), the transaction should not have to go through a central system (if the sum exchanged is small enough).

- In order to ensure the monitoring and auditing of such a system despite P2P (person-to-person) transferability, it would make sense to exchange money received via the mobile telephone network. This exchange of money would take place in a way undetectable for the user, e.g. via an inexpensive permanent on-line connection (i-mode, GPRS etc.).
- As there is always a risk of handsets being stolen it may need to be possible to store accounts, tickets or keys on small portable storage media, which can be kept safely in a separate place from the handset. This means that the module requires a secure channel to the user interface of the telephone. These could be separate modules for separate applications, and such modules should be used in devices owned by children.
- There could also be modules for separate applications and other interfaces than contact-less ones, so that it will be simpler to achieve compatibility with existing systems, such as road pricing systems etc. It is not at this stage possible to state generally which contact or contactless interface is likely to be required in each situation.

To the best of our knowledge, typical current mobile payment solutions or projects aim at using existing phone devices, or envisage server-based solutions. The latter has the advantage – for the operator – of revenue through offering the connection, but the disadvantage – for the user – of costs and lack of usability if the network is not available, and – for some transport operators – a lack of speed. Hence, more comprehensive cooperation would be needed for making positive network effects possible. The prototype coming closest to this is operated in Sapporo, but it is currently operated through a relatively large PDA (Personal Digital Assistant) (Mobile e-Commerce project 2001).

Discussion

The greatest challenges do not lie in the technical field, but first of all, in convincing all the parties to cooperate so that an economically viable system can be created. A ticketing system based on mobile telephones could reduce costs for vending machines, barriers and booths more than a card based system. However, for each individual operator, distributing cards might be a more viable approach, since universal solutions make it necessary to agree on a number of standards, involving many actors. For instance, mobile phones are basically dependent on the telecoms service providers who distribute the SIM (Subscriber Identification Module) chips to their subscribers. As long as the phones contain this single chip, anyone wishing access the SIM will have to come to an agreement with the telecoms company. It is already apparent that this is an area where economic interests might clash – some telecoms operators are trying to conclude exclusive contracts with major potential clients, such as airlines or railway companies. These on the other hand have an interest in having access to all potential customers, and not simply to the subscribers of one of several telephone companies.

The alternative solution is a second chip. This has already been alluded to as a storage device for tickets and the like, but here the standardization issue is acute – there are several alternative solutions available – one need only mention flash cards, chips and memory sticks - and no obvious technical or business favourite. One possible

In order for mobile phones to be used extensively as payment devices, issues such as payment authorization and physical security of the handset will need to be addressed

For individual operators it may be more effective to issue an individual card rather than try to reach an agreement on standards with a number of other actors who may have divergent interests

Keywords

electronic payments, mobile phones, ticketing

Note

1. Held in Brussels on 19 February 2002

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