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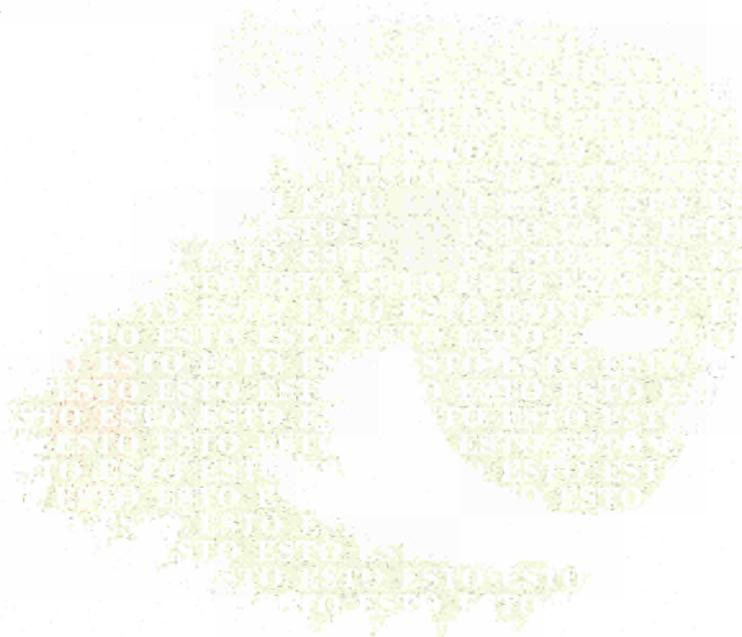
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REPORT

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EUROPEAN COMMISSION
Joint Research Centre



ENGLISH VERSION

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's 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 clearest indication of the report's success is that it is being read. An initial print run of 2000 for the first issue (00) in December 1995 looked optimistic at the time, but issue 00 has since turned into a collector's item. Total readership rose to around 10,000 in 1997, with readers continuing to be drawn from a variety of backgrounds and regions world-wide, and in 1998 a shift in emphasis towards the electronic version on the Web has begun.

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 ENEA and 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 out 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.

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EXECUTIVE EDITOR
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Isla de la Cartuja
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Tel: +34-95-448 82 97
Fax: +34-95-448 82 93
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Lifestyle changes and an ageing population are causing the incidence of diabetes to rise at an alarming rate. Effective strategies for prevention, screening, treatment and public awareness are needed if an epidemic is to be avoided.

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EDITORIAL

Dimitris Kyriakou, *IPTS*

In one of the many anecdotes regarding Einstein he was asked why politicians and social scientists were not able to harness the threat of nuclear weapons, whereas physicists were able to harness the energy released in nuclear reactions. He wisely replied that this was no surprise, as politics and everyday life is much more complex than physics.

The fact that we may know more about the exotically microscopic, such as elementary particles, or the macroscopic, such as the movement of the galaxies, than we do about everyday life or more common practices sometimes produces surprising contrasts. In the case of medicine for instance, aspirin (acetylosalicylic acid) is probably the most common medication prescribed in the last 100 years – yet we are still not fully sure of its various effects (for instance it has been discovered long after its use became widespread that it may have beneficial impact for circulatory conditions).

An even more glaring example is that although we can perform open heart surgery in routine fashion we still are not sure of the precise cascade mechanism in which anaesthesia works. The effect of specific sedatives is largely based on empirical information, and this explains why still today a non-trivial part of the risk involved in major operations has to do with the work of the anaesthetist, and not that of the surgeon per se.

The article on type II diabetes in this issue brings to the attention of policy makers a crucial example of a very common disease which is close to assuming epidemic proportions. As the issue is

being put together the article's suggestions are being corroborated by major news organizations and well known medical journals.

For instance Reuters reports on May 18, 1999 that diabetes cases are expected to climb 170 percent in developing nations over the next three decades, compared to a rise of 42 percent in developed countries, adding that diabetes is far more common in poorer communities but a socioeconomic tie has not been well-established.

Reuters also reports that an intensive approach to diabetes control studied in Denmark reduces the risk of disease-related complications such as kidney failure and blindness, researchers report. "Our encouraging results should be translated into clinical practice" conclude researchers at the Steno Diabetes Center in Copenhagen, Denmark. Their findings are published in the February 20th issue of the British journal *The Lancet*. Patients with diabetes are at increased risk for kidney disease; retinopathy, degeneration of the retina; and neuropathy, nerve degeneration resulting in a loss of sensation, particularly in the feet.

According to the Reuters report, in their 4-year study, the Danish team followed the health of 160 middle-aged individuals diagnosed with adult-onset type II diabetes, the most common form of the disease. Urine tests indicated that all of the subjects had impaired kidney function linked with their illness. The authors directed half of the group to receive standard treatment, while the other half received "intensified" therapy. Intensified therapy included counselling on behaviour modification (for example, diet

and exercise), and drug therapy targeting high blood sugar levels and high blood pressure.

The team found that, compared with subjects in the standard-therapy group, individuals receiving intensive therapy experienced a 73% lower rate of kidney disease, a 55% lower incidence of retinopathy, and a 68% lower rate of neuropathy.

We have here a disease which has not received perhaps the attention it deserves, although its incidence is very wide, largely because it does not kill directly but because it creates the preconditions that allow other ailments to take a patient's life (often circulatory complications).

Moreover we have a case of disease with two manifestations, one of which (type I) is common among younger people in Northern countries and whose incidence falls drastically, with few notable exceptions requiring studies (Sardinia, Kuwait) as one moves from north to south. The second manifestation afflicting usually older people is common in both northern and southern countries, but is showing very high incidence rates in recent years in countries in the southern littoral of the

Mediterranean, raising questions about the role of dietary habits, changing lifestyles, etc. Furthermore it may forebode a crisis in terms of health as well as health care spending in these low or middle income countries.

Finally, what became clear thanks to the IPTS Mediterranean initiatives - the Techno-Economic Analysis for the Mediterranean (TEAM) network, and in the platforms/fora provided by these initiatives, is the lack of communication and cooperation among countries in the aforementioned region. It was in these IPTS fora that high level participants from various Mediterranean countries discovered that high incidence of diabetes II was not a problem unique to their country but rather quite common in the region as a whole. Once more information about a problem with strong 'southern' dimensions had not been South to South, but it rather had been going through the filter of governments, research centres, universities, hospitals, journals, etc. of 'northern' countries, where quite naturally, the possibilities of South to South collaboration and exploration of problems or solutions relevant to the South was not necessarily highlighted.

Diabetes Mellitus: the Epidemic of the 21st Century

Mordchai Ravid and Rita Rachmani, *Meir Hospital, Israel*

Issue: Diabetes mellitus and its complications account for one third of the health-care budget for elderly North Americans. Most European, Mediterranean and some Middle Eastern countries are also coming close to this level. In a number of these countries, 20% or more of over 65s have diabetes, and this is predicted to increase to over 30% by the year 2010. The projected increase in the incidence of diabetes, together with increasing life expectancy and the development of new medical technologies could place an intolerable burden on national health-care expenditures.

Relevance: Most cases of diabetes can be postponed or even prevented by proper diet and exercise. Early detection and treatment can greatly reduce the impact of complications. An integrated international effort is needed to develop improved strategies for prevention, screening, treatment and to raise public awareness if the potential epidemic is to be brought under control.

Diabetes affects around 4-5% of the population in Europe, and is a major risk factor for cardiovascular diseases, blindness and loss of kidney function

Introduction

Diabetes mellitus is a metabolic disease characterized by elevated values of blood sugar. This may be caused by either absolute or relative deficiency of insulin in conjunction with resistance to the action of insulin. The metabolic dysfunctions, especially in the glycation of proteins, which parallels the blood sugar levels, are associated with an accelerated process of atherosclerosis. Diabetes is, therefore, a major risk factor for cardiovascular diseases, including heart attacks, heart failure, stroke and circulatory problems leading to lower extremity amputations. Diabetes is also the main cause of blindness and loss of kidney function among people of working age.

The prevalence of diabetes in most European countries is estimated at 4-5% of the total population. However, these patients comprise almost 20% of the adult hospital population and one third of cases on chronic dialysis (Ritz 1997, Parving 1998).

Diabetes has become a particularly serious problem in a number of North African and Middle Eastern countries. For example, in Jordan, 1 out of 4 people will develop diabetes by the age of 65 (Ajlouni 1998). Most of these cases are preventable. Furthermore, it has been shown that if the disorder is adequately monitored, and if patients are properly informed, diabetes sufferers can come to terms with their condition as a life-style restraint rather than a disease. Diabetes

mellitus therefore needs to be placed much higher on health authorities' list of priorities in all countries, but particularly in those where the illness is most prevalent.

Clinical forms of diabetes

Diabetes mellitus (DM) has two main forms, referred to as DM type 1 (Insulin dependent or Juvenile diabetes) and DM type 2 (non insulin-dependent or adult type diabetes). DM type 2 will be discussed first because, worldwide, it accounts for more than 90% of all cases of diabetes.

About one in 10 people in Europe and 1 in 8 in the Mediterranean area will develop type 2 diabetes during their lifetime. This amounts to 50-60 million cases of diabetes. The known prevalence of diabetes has doubled since the early 1980s and is expected to double again by the year 2010 (Amos, 1997). The explosion of type 2 diabetes is mainly a result of three factors: genetic predisposition, increasing prevalence of obesity and declining physical activity. No single gene appears to be responsible for DM type 2, but it is nevertheless clear that genetic predisposition gives an accurate prediction of the likelihood of the disease's appearance during adult life. Identical twin siblings of DM type 2 sufferers have been found to have an 80% likelihood of developing the disease. Furthermore, 20% of first degree relatives of patients with DM type 2 show reduced glucose tolerance (compatible with a pre-diabetic state) as compared to about 8% in the general population.

The inherited potential for developing DM type 2 may materialize early or late in life or, possibly not at all, depending on external factors. The most important influencing factors are high body mass index (obesity) and physical inactivity. In western countries the correlation between body mass index and DM type 2 is exponential.

Also, irrespective of relative weight, the risk for men of developing diabetes doubles in the case of poor physical fitness. The prevalence of DM type 2 around the Mediterranean varies greatly and data is unavailable or incomplete in some countries. The prevalence in Jordan and Tunisia is high, at 13% and 10% of the total population, respectively. The rate in Greece and Israel is lower, at 4.5%. A population survey in Turkey in 1997 revealed a prevalence of 7.4% in the population aged over 20 (corresponding to an extrapolated 5% of the total population). Data for Egypt are incomplete, but limited surveys quote figures as high as 20% in people aged over 20 in urban communities as against 6% in rural areas – accounting for roughly 11 and 4% of the total population, respectively (Data gathered during the IPTS conference on Diabetes, Seville 1998). There is also very limited information about the correlation between prevalence figures and socio-economic factors such as literacy, family size, occupation, income, habits, etc. This is compounded by a paucity of data about the prevalence of obesity and its relation to culture, tradition, modernization of lifestyle and geography. Some recently published figures are quite alarming. If obesity is defined as body mass index above 30 kg/m² the prevalence of obesity in England is 14% for men and 17% for women, (Kopelman 1998). In Jordan, by comparison, the respective figures are 30 and 60% (Ajrlouni 1998).

Increasing life expectancy can be expected to bring with it both greater prevalence of the disease and its complications. For example, 65% of the patients with diabetes succumb to cardiovascular disease, as compared to 35% of the general population (European Arterial Risk Policy Group, 1997). The majority of diabetics will develop hypertension during their lifetime. The annual mortality rates of middle-aged patients with diabetes and hypertension are 6 to 8 fold higher than those of non diabetics of comparable age

The known prevalence of diabetes has doubled since the early 1980s. This explosion is due to a combination of genetic predisposition, increasing prevalence of obesity and lack of exercise

Important influencing factors include high body mass index (obesity) and physical inactivity. In western countries there is an exponential relationship between body mass index and type 2 diabetes



A number of recent surveys carried out in Mediterranean countries indicate that only 60% of diabetics are aware that they are suffering from the disease

Type 1 diabetes represents the most serious form of clinical DM. The disease primarily affects children, but it can also develop later in life

groups. Disability and suffering caused by diabetes-related complications are also a matter of concern. The proportion diabetics chronically ill diabetics as a result of either macrovascular (cardiac, cerebral, peripheral vascular) or microvascular (retinopathy - blindness, nephropathy, neuropathy) disorders is more than double that in non-diabetics of comparable age (Roth 1998).

A number of recent surveys carried out in Mediterranean countries indicate that only 60% of diabetics are aware that they are suffering from the disease. Among known and treated diabetics only about 20% show an acceptable degree of metabolic control (values of HbA1c, a haemoglobin-glucose complex that is at a high concentration in the blood of diabetics, of 7% or less) and less than 20% of hypertensive diabetics show well controlled blood pressure (Murlow 1998). Weight control policies among diabetics have, so far, been universally ineffective. In fact, most diabetics gain weight during treatment. Another very important risk factor for cardiovascular mortality, more prevalent among diabetics, is hyperlipidemia (high blood levels of cholesterol). Despite the growing use of lipid lowering medications the proportion of diabetics with normalized plasma lipid values is alarmingly low even in countries in the centre of Europe. In the Mediterranean area awareness is low and the success rate even lower. With the present trend diabetes mellitus and its complications will assume epidemic proportions and consume more than one third of the health budgets in only 15 to 20 years if vigorous steps to slow the progress of this "epidemic" are not taken (Orahilly 1997).

DM type 1 accounts for 6-10% of the cases of diabetes in different Mediterranean countries. With a few outstanding exceptions (Sardinia, Kuwait) the prevalence of this type of diabetes seems to be fairly stable. It is noteworthy that DM type 1 comprises 25-30% of the diabetic

population in the Scandinavian countries with a declining incidence from north to south.

Type 1 diabetes represents the most serious form of clinical DM. The disease primarily affects children, but it can also develop in the middle aged and elderly. The aetiology of type 1 is largely unknown, but the most widely accepted hypothesis is that the disorder is multifactorial in origin, involving a complex interaction between genetic predisposition, immunological determinants and environmental agents. This results in the autoimmune destruction of the insulin-producing b-cells in the pancreatic islets. In type 1 diabetes certain genetic combinations are now well established and the histopathological lesions (insulinitis) have also been well defined. However, it is still unclear what primary event(s) trigger the immune system to initiate the aggression against the b-cells, thus producing the autoimmune aberration. The autoimmune attack often begins several years before the clinical onset of diabetes. This concept has led to pilot screening, for the presence of islet cell antibodies (ICA), in first degree relatives of patients, identical twins discordant for diabetes and normal school children. Since 1989, the European Union has been supporting a project whose aim is to define the epidemiological characteristics of type 1 DM in a number of European countries. This study, initially called EURODIAB-ACE (Europe and Diabetes-Aetiology of Childhood Diabetes, an Epidemiological Basis) is analysing statistics on the incidence of type 1 DM in children aged 0-14 years together with data on the genetic and immunological aspects of the disease. The age range covered by the study was extended to 29 years. The overall results continue to confirm the North-to-South European gradient, with the highest incidence of type 1 DM in Finland and in the other Scandinavian countries (Bottazzo 1997).



Though much less prevalent than type 2, DM type 1 is a major concern for the health authorities. As victims are mostly children complications develop at a relatively early age and may render patients chronically ill and often disabled for many years. Modern therapies (e.g. pancreas and kidney transplant) may prolong life but are expensive.

Preventive strategies

DM type 1 - Neither the genetic code nor the nature of the environmental factors responsible for the development of DM type 1 have yet been identified. Research efforts currently concentrate on identifying regional variations in incidence and matching these with suspected environmental factors (Diabetes Epidemiology Research International Group). Also a great deal of emphasis is being placed on the identification of the best markers enabling predictions to be made of subsequent development of the disease in order to try and implement preventive measures.

DM type 2 - In some of the countries around the Mediterranean there is still a problem of awareness on the part of both the population and the health authorities. The growing burden of diabetes is not met by appropriate preventive or therapeutic policies. Limited preventive efforts have been examined in Europe, the United States and in China. The Da Quing Study in China showed the effectiveness of lifestyle intervention in slowing the progress of glucose intolerance (from pre-diabetes to diabetes) (Pan 1997). The relevance of this study to other populations has, however, been questioned. Two programmes in Europe (The Diabetes Prevention Programme and the Study to Prevent Non Insulin-Dependent Diabetes Mellitus) hope to build on this experience. The largest study yet investigating the delay of DM type 2 is now underway in the USA.

The effectiveness of a 7% weight loss together with increased calorific expenditure is compared to standard lifestyle change recommendations and to either a placebo or active medication which increases insulin sensitivity. The study hopes to demonstrate delay or prevention of the development of DM type 2 as well as the reduction of risk factors associated with cardiovascular disease. The cost effectiveness of screening for DM type 2 was recently examined by the CDC (Centers for Disease Control) Diabetes Cost Effectiveness Study Group (1998). The cost may be prohibitive even for Western health-care budgets let alone countries with lower GDP.

Early treatment

DM type 1 - Preliminary efforts with early insulin treatment or immunosuppression met with limited success. The future is believed to lie in genetic engineering (Leslie 1998). Efforts are also being concentrated on retarding the development and progression of diabetic complications. The DCCT study done in the US showed that keeping blood sugar levels close to normal in children with DM type 1 may reduce the progression of complications by 50-70%. Therapeutic strategies under investigation include mainly improved insulin delivery systems (e.g. implantable insulin pumps, non-invasive glucose level monitors and improved insulin) and novel methods of transplantation of insulin secreting pancreatic cells which would obviate the need for continuous immunosuppressive therapy.

DM type 2 - The UKPDS study done in the United Kingdom showed that also in adults with DM type 2 tight glucose control is of value in retarding the progress of all types of diabetes-related complications. Furthermore, it was shown by many studies that lowering blood pressure gives a more significant benefit, in terms of

Although type 1 diabetes is much rarer than type 2, victims are mostly children so complications develop at a relatively early age and may render patients chronically ill and often disabled for many years

Studies suggest that promoting lifestyle changes, particularly weight loss and exercise, is the most cost-effective way of tackling the risk of type 2 diabetes

Improved insulin delivery systems are among the therapeutic strategies being investigated to help sufferers of type 1 diabetes. A US study has shown that keeping blood sugar levels close to normal may reduce the progression of complications by 50-70%

A study done in the United Kingdom has shown that in adults with type 2 diabetes strict control of glucose levels is also of value in retarding the progress of all types of diabetes-related complications

reducing cardiovascular and total mortality, than in non diabetic populations. Since diabetic patients of both types are at high risk for cardiovascular, ophthalmic and kidney diseases any intervention in these patients will result in greater relative benefit compared with low-risk populations. It is therefore generally accepted that risk management strategies will have a better cost-benefit ratio in diabetic than in non-diabetic subjects.

Conclusions

Diabetes mellitus will affect one in 10 adults in Europe and up to one in 4 people in certain Mediterranean and Middle Eastern countries. If the present trend continues, the toll of diabetes and its complications on national health-care budgets may, within the next two decades, rise to the degree of endangering the integrity of the systems as a whole or force drastic cuts in other (no less critical) areas.

The most important goal of medicine in this domain is to prevent or delay the onset of diabetes and retard the progress of its complications. Changes in lifestyle may significantly improve the prognosis of diabetics as well as reduce the incidence of cardiovascular disease in the general population.

These changes include the maintenance of normal body weight, increasing physical fitness, maintaining normal blood pressure values and lowering plasma, glucose and lipid levels. The impact of these measures is more significant than of any other known medical intervention. The impact on prevention of complications of intensive glucose and blood pressure control was recently highlighted when the results of the long term prospective United Kingdom Diabetes Study (UKPDS) were published. In order to exert an impact on the general health and life expectancy

of diabetics (and, to a somewhat lesser extent, also of non-diabetics) these measures have to be widely implemented.

Diabetes experts agree that in practice the proportion of patients under proper control is alarmingly low even in western European countries and is substantially worse in some Mediterranean countries. Intensive research in a framework of international cooperation is therefore needed in order to explore the most (cost) effective ways to increase the share of adequately treated patients, expand the use of known preventive and therapeutic measures alongside the search for improved and new technologies. Research and strategic planning need to concentrate on the following themes:

a - Establishing national guidelines regulating methods for early detection of diabetics and defining high risk populations who need intensive therapy. A prerequisite for this approach is to determine the prevalence of diabetes in all participating countries in correlation with demographic, geographic and socioeconomic parameters. The epidemiological methodologies need careful evaluation and adaptation to the different countries.

b - A multi-national Euro-Mediterranean effort is needed to enhance the process of modernization and the modus operandi of the relevant health-care services in certain Mediterranean countries with the goal of improving their ability to cope with their present and future needs in the field of diabetes control.

c - To develop both general and nation-specific strategies of patient education towards increased awareness of the risks and improved compliance with therapy and life-style changes.

d - Raising public awareness of the dangers of diabetes and to the potential to prevent or delay



its appearance by the adoption of a "healthier" life style is only possible by mobilizing the mass media. Special programmes have to be designed, and awareness of diabetes and its complications have to be incorporated into regular family or health oriented programmes.

e - Further genetic research is also of great importance. It is only through this discipline that true early detection of potential candidates to develop DM type 1 (and possibly also type 2) is possible. International cooperation is required in

order to establish standardized research methodologies, timely comparison of data and rapid widespread implementation of the conclusions drawn from new information.

In the western world diabetes mellitus is threatening to become the epidemic of the next century. Efforts in basic and clinical research along with aggressive public health policies have to be supported in order to confront this epidemic and control its potentially disastrous impact on public and individual health. 

Keywords

diabetes mellitus, cardiovascular disease, preventive strategies

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About the authors

Mordchai Ravid holds a doctorate in Medicine from the Hebrew University in Jerusalem.

He is a Professor of Medicine at Tel-Aviv University, Director of a Department of Medicine and member of the scientific committee of ICTAF. His interests are in research into diabetes and hypertension and in socio-economic issues of medicine. He was recently elected president of the European Hypertension in Diabetes Study Group (HID-EASD).

Rita Rachmani holds a doctorate in Medicine from Tel-Aviv University.

She is an associate director of a department of Medicine and conducts research projects in diabetes and hypertension.

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Contacts

Mordchai Ravid. Sackler Faculty of Medicine, Tel-Aviv University, Israel

Tel.: +972 9 747 29 29, fax: +972 9 741 21 35, e-mail: ravidm@netvision.net.il

Irving Spiewak, IPTS

Tel.: +34 95 448 83 86, fax: +34 95 448 83 39, e-mail: irving.spiewak@jrc.es

Genetic Testing: Ethics and Quality

Dr. Marie Janson, *CEST*

Issue: The use of genetic testing is becoming increasingly frequent, with tests of this kind finding applications in diagnostics, forensics and pharmaceutical areas. This brings with it the risk of the indiscriminate use of genetic testing and the information generated. Once limited to a minority of patients –mainly families with a high risk of carrying a particular disease-related gene, and within a clinical setting backed by counselling and other clinical services– it has now moved into the mainstream. However, widespread testing of the general population implies the risk that tests will be offered without proper support or appropriate clinical / technical expertise.

Relevance: The use of genetic testing as a diagnostic tool by both commercial and non-commercial laboratories, serving clinics, pharmaceutical companies and individuals, is on the increase. Nevertheless, it still lacks adequate regulation and standards are not consistent across Europe. This raises important questions and concerns about both the ethics of testing and the technical reliability and accuracy of genetic tests on offer.

Genetic Testing

Only recently genetic testing was rare. It was a technically very advanced diagnostic method using both expensive chemical and radioactive ingredients and requiring highly trained laboratory staff in specialist genetics laboratories. Moreover, only a small group of patients were tested, mainly families where there was an increased risk of having children with certain known debilitating genetic disorders, such as cystic fibrosis, Duchenne muscular dystrophy and haemophilia.

This situation is changing rapidly. The technology has become more streamlined and user-friendly and there are now several manual

kits on the market, enabling a lab technician to extract and analyse DNA relatively simply and quickly. In the near future automated DNA extraction and analysing systems requiring very little manual input will become available. There has also been a dramatic increase in our knowledge of human genetics, not just about “classic” genetic disorders, such as cystic fibrosis, but also about the genes linked to the risk of developing diseases such as cancer and diabetes, or traits such as high blood pressure and athletic endurance. By the beginning of the next century it is anticipated that all fields of medicine will be utilizing genetics as a matter of course. The combination of these trends will mean that we are more likely to be offered genetic testing during our life time, and that laboratories will

Improvements in genetic testing techniques have made this kind of testing much more widely available, expanding the range of situations in which it is applied

Genetic tests require skilled interpretation and there are as yet no guidelines in Europe for their use by general practitioners or the public at large

increasingly offer services and products, not just to specialist clinicians, but also to general practitioners and directly to the public. This raises several questions regarding the ethical, genetic and technical standards of genetic testing that will be on offer, and who should be responsible for setting and maintaining them.

Though current DNA-testing technology makes it an easy and commonly used technique, the genetics associated with it or interpreting the clinical picture may not be so simple. This raises both ethical and technical questions about offering genetic testing directly to the consumer or the non-specialist. There are currently no common European standards ensuring a minimum standard for services provided, meaning consumers currently have very little protection and tests may be of little or no value. This is particularly dangerous in conjunction with an uncritical over-reliance on genetic test results. There is also no clear advice about who should have access to the information produced by the test.

In the US, with its history of private health care, private health insurance and a strong biotechnology industry, the trend towards more widespread use of over-the-counter genetic testing has gone further than in Europe. Many laboratories have developed commercial services, directed at specialists, non-specialists and the general public. Outside the forensic field, the most common tests on offer are for breast cancer, cystic fibrosis and paternity testing. One well known genetic service provider is Myriad Genetics Inc., which offers testing for mutations in BRCA-1 and BRCA-2, both associated with an increased risk of breast cancer. Though targeting the public directly via advertising on the Internet, it claims that most customers are specialist cancer clinics. This could to some extent be due to the price of the testing, around £1500. In any

case, they do offer counselling and information services to anyone purchasing their tests.

Questions have been raised about the introduction of genetic tests before they have been proven safe and useful. Questions have also been raised about the standard of laboratories offering tests and the often insufficient information provided to users. According to Francis Collins, Human Genome Project, several hundred people who are at risk of developing future illness because of their genetic make-up are known to have lost jobs or insurance cover. This has prompted the National Institute of Health and the Department of Energy to set up a Task Force to Promote Safe and Effective Genetic Testing in the USA. Their report was published in September 1997 highlighting not just problems, but also providing recommendations for better practice.

Quality issues

There are several technical issues that influence the reliability of the test result. The first and simplest is the risk of sample confusion and mix-up. This is a problem common with all clinical laboratories handling large numbers of samples. There are now well established techniques and routines for preventing this by the commonly accepted quality standards required from clinical and commercial labs. There is no reason to believe that genetic tests should differ from other clinical chemistry tests in this respect, as long as the laboratories are reputable and apply similar standards.

The second issue concerns problems unique to genetic testing and arises out of the technology. One problem is the risk of sample contamination in PCR. PCR (Polymer Chain Reaction) is an enzyme-driven method in which small parts of the DNA are copied several thousand times over to create an amount of DNA large enough to be used

for testing. This technique is so sensitive, that in theory a single molecule of DNA present in the sample is sufficient for detection after amplification. In the early days of its use, this caused major reliability problems, when minute amounts of DNA, floating in the air or stuck to a pipette from a previously drawn sample, would contaminate samples and create false positives. Lessons have, however, been learnt, and the various steps in the process are now separated, and all sample handling is done in ultra-clean environments to avoid contamination. Another practical problem can be the running of the gel, where it is important to ensure that there is no overflow between lanes. There has been at least one US court case where DNA overflowing into the next lane caused a false match between the accused and the forensic sample.

Some diseases, such as cystic fibrosis, are linked to a mutation at a single gene locus. However, most diseases defy this simple categorization and seem to be linked to different parts of the human genome in different families. Familial Alzheimer, for example, was originally linked to a gene on chromosome 21. However, this gene is probably only involved in a small minority of all Alzheimer cases. Some families in which Alzheimer's disease runs have linkages instead to the gene Presenilin 1 on chromosome 14, others are linked to Presenilin 2 on chromosome 1, while sporadic Alzheimer, with onset at an older age than the familial variant of the disease, has been positively associated with a gene for a variant of Apolipoprotein E, called ApeE-e4.

Therefore, carrying out conclusive genetic analysis on a multi-gene disease such as Alzheimer would mean looking in detail at all genes so far implicate, and it may be difficult to guarantee that all possible genes involved have been uncovered. It is important that this

information is passed on to the patient or treating doctor so as to put the results into perspective.

Even when only a single gene is involved the disease can arise from several different types of mutations affecting that gene. Though in the case of many diseases, some mutations are more common than others within a particular population. One example of this is Cystic Fibrosis, which is one of the more commonly inherited recessive disorders in the European population. The cystic fibrosis gene was one of the first to be identified and sequenced, this in combination with the large number of healthy carriers in the population has turned it into one of the most frequently offered genetic tests, both clinically and commercially. The United States is the leading market for genetic services and biotechnology companies, but a study recently published in the American Journal of Human Genetics concluded that many laboratories offering genetic testing for cystic fibrosis do not test for enough mutations to give reliable results. To identify 90% of the carriers it may be necessary to test for 20 of the most commonly known mutations. However, of the 45 laboratories asked, only 10 of them tested for 20 or more mutations, and some of them didn't even look for some of the more common varieties. Admittedly, the situation is slightly different in Europe, where the population is much more homogeneous, and though 160 mutations have been identified world-wide, one particular mutation, $\Delta F508$, is found in 70% of European carriers. This highlights the fact, that the validity of a genetic test is influenced by the quality of the technical analysis as well as by the ethnic origin of the person tested. Any standardization should leave room for differences between populations to be taken into account appropriately.

However, even though a very thorough approach is taken and every mutation is identified, for example through sequencing, it

The intrinsic technical difficulty of genetic testing is compounded by the complexity of the relationships between genetic mutations and disease

does not automatically mean that all detected mutations are linked to the disease process. Some mutations are just variations of the normal pattern and have no impact on the individual.

Again, this proves that the tester not only has to have in-depth knowledge of the technology used, but also be able to interpret the results accurately. All these technical factors taken together indicate that for the more commonly performed genetic tests a minimum standard or symbol of approval from a standards authority would be helpful to enable an informed choice.

Ethical Issues

As genetic testing becomes more widespread, so the important ethical questions regarding the implication of test results will become more

pressing. Medical tests give the physician and the patient a snapshot of the here and now. Genetic tests, unlike medical tests however can reveal information about possible futures, not only affecting the individual but also his or her family. (A summary of some late-onset disorders is given in Table 1.)

Genetics tests are commonly used to detect **healthy carriers** of recessive genes, for example, in the case of cystic fibrosis. These individuals, who carry only one copy of the defective gene, will never develop the disease, but their children may if they inherit mutations from both parents. Some single gene diseases have proven to be so common that once genetics testing was developed many asymptomatic carriers have been diagnosed. One case of this is haemochromatosis, which as a genetic condition now seems likely to be the most

Table 1. Categories of late-onset genetic disorders

<p>a. Hereditary neurological disorders</p>	<ul style="list-style-type: none"> • Huntington's chorea • Familial Alzheimer's disease • Familial prion dementia • Familial motor neuron disease
<p>b. Hereditary late-onset disorders involving other systems</p>	<ul style="list-style-type: none"> • Mendelian cancer syndromes, such as Multiple Endocrine Neoplasia, • Adult polycystic kidney disease • Myotonic dystrophy • Haemochromatosis
<p>c. Common disorders, with a hereditary subset</p>	<ul style="list-style-type: none"> • Colon cancer • Breast cancer
<p>d. Common disorders with genetic susceptibility</p>	<ul style="list-style-type: none"> • Diabetes mellitus • Schizophrenia • Manic-depressive illness • Coronary heart disease • Hypertension

Source: Adapted from Harper and Clarke, 1997



Unlike standard medical tests which deal with the present, genetic testing reveals information about possible future illness of both the patient and his or her descendants

common single gene disease in the Western population, with 10% of the population carrying one copy of the affected gene, and 1 in 400 having the condition. However, the majority show no (or almost no) symptoms and may never develop the disease. Some, however, will develop very severe problems such as diabetes and cirrhosis of the liver. Fortunately there is preventive treatment available for this condition, through regular venesection to remove excess iron.

Genetic testing is also used for **pre-symptomatic testing**, as in Huntington's chorea, where symptoms do not usually appear before the age of forty. However, a positive genetic test means that the likelihood of developing the disease is almost 100% though the time for onset is not predictable. Genetic testing can also be used for **predictive testing**, as in testing for BRCA1 and BRCA2, which are linked to breast cancer. However, testing positive for one of these genes, is not a definite diagnosis of cancer but rather an estimate of the overall lifetime risk of developing breast cancer, which has been estimated to 60% if carrying either BRCA1 or BRCA2, though various figures have been quoted. Though this test is predictive, there is no prophylactic treatment on offer, except bilateral removal of breast tissue and regular monitoring.

As alluded to above, performing a genetic test may raise as many questions as it gives answers, for the individual concerned as well as their families and their doctor: Will I develop the disease and if so when? How likely is it? Will my children become ill? Is there any treatment / preventive therapy available? It is therefore essential that the test result is followed up by information and counselling relevant to the individual that helps to put all this into perspective and reduce the risk of people misinterpreting the test result given. Without proper advice people may interpret a normal test

result, as for BRCA1, as total reassurance that they won't get breast cancer, or an abnormal result, as in CF carrier status, as likely to affect their health.

For some laboratories the number of tests performed will of course be of great interest. Pressure to maximize testing may influence the way information is presented, and there is potential danger of testing being encouraged, regardless of individual benefit. An unscrupulous approach could ruin consumer confidence in all genetic testing and give responsible companies a bad name. Regulations protecting consumers and setting standards for industry could therefore be of great benefit to all parties involved.

Towards European regulation

There are many national initiatives in regulating genetic testing. As mentioned earlier, the National Human Genome Research Institute in collaboration with the National Institute for Health and Department of Energy in the United States launched the Task Force on Genetic Testing, whose report was published in September 1997. The report came up with several recommendations, including the setting up of an Advisory Committee on Genetic Testing made up of the various stakeholders, that research protocols are approved before use and that any genetic testing falls under the scope of the same control mechanisms as other clinical tests.

In the UK, the government has set up a Human Genetics Advisory Commission (HGAC) in December 1996 to consider the implications of developments in human genetics. The UK government has also set up an Advisory Committee on Genetic Testing (ACGT) to consider the issues and advise ministers on developments in genetic testing (ACGT). The ACGT has now issued a voluntary code of

The genetics testing industry is still in its infancy, but clear guidelines and directives for best practice will ensure that it develops in a way that is beneficial to its customers, be they health professionals or the public

About the author

Dr. Marie Janson has an M.D and Ph.D. in Clinical Genetics from the Karolinska Institute in Stockholm, Sweden, where her main work was on hereditary tumours. She has previously worked as technology and business consultant for Scientific Generics in Cambridge, UK, and now works at CEST, Centre for Exploitation of Science and Technology, in London, where she heads life sciences and biotechnology initiatives. Currently she is working on collaborative projects in the areas of genetic testing and genetically modified food with industry, academia and legislators.

practice for genetic testing services supplied directly to the public (ACGT, 1997). The code covers aspects of standards for testing, confidentiality and storage of information, customer information and genetic consultation. The aim is to publish the names of companies or laboratories that comply with the ACGT code of practice, as well as those suppliers they are aware of that do not. They are currently working on more detailed guidelines for the testing of children and pre-symptomatic testing.

The genetics testing industry is still in its infancy, but clear guidelines and directives for best practice will ensure that it develops in a way that is beneficial to its customers, be they health professionals or the public. The European tradition of a public health care structure is different from that in the USA, and an initiative that takes these factors into consideration is more likely to provide a successful working framework.

The issues highlighted in this article are just some of the technical and ethical concerns arising from the more widespread use of genetic testing. What is needed is a debate on how we want genetic testing used so we can harness the beneficial effects for society and the individual. Ideally there should be coordination between what society wants from genetic testing and what the technology and industry can provide. No doubt we will learn as we go along, but meanwhile, there is very little protection for the general public and health professionals who may request tests in this mainly unregulated market. It is also difficult for serious laboratories to distinguish themselves from less reputable operators, whether through higher standards or by following regulations. There is a need for a European initiative to develop pan-European standards and guidelines for genetic testing offered to the public to protect consumers and a small but growing European biotechnology industry from unscrupulous or careless laboratories.

Keywords

genetic testing, ethics, predictive testing, pre-symptomatic testing

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Contacts

Dr. Marie Janson, CEST

Tel.: +44 171 354 99 42, fax: +44 171 354 43 01, e-mail: mjanson@cest.org.uk

Thomas Muenker, IPTS

Tel.: +34 95 44 88 232, fax: +34 95 44 88 326, e-mail: Thomas.Muenker@jrc.es



New approaches to land-use planning: transport policy and sustainable urban development

Andreas Dorda, *IPTS*

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Transport

Issue: One of the aims of spatial planning is to achieve compact and multifunctional city structures as part of an effort to limit urban sprawl and slow the steady increase in demand for transport. To be effective new tools for urban development and land-use planning are needed which go beyond traditional planning regulations. These could include encouraging professional stakeholders to broaden their development portfolios and influencing choices through information campaigns aimed at potential house buyers.

Relevance: Sprawling suburbs, declining economic activities in inner cities, the spread of out-of-town shopping centres, are all trends which increasingly endanger Europe's urban environment, economic development and cultural tradition. Thus the European Commission has envisaged a key action within the Fifth Framework Programme for research called "The city of tomorrow and cultural heritage". Policy makers increasingly acknowledge the powerful impact of housing patterns on energy consumption, social interaction, patterns of consumption and particularly on transport demand. Better co-ordination of land-use planning and transport policy could be a key factor in achieving sustainable mobility, as could encouraging changes in property developers' practices and house buyers' preferences.

Institutional obstacles

Housing patterns have an enormous influence on the social, economic and environmental impact of human habitation. Sufficient population density and mixed-use city structures bring numerous positive effects by reducing transport demand, ensuring public transport and local shops are profitable, and enabling communities to share infrastructure costs. Multifunctional land-use patterns also facilitate social cohesion by

ensuring a feeling of community and making neighbourhoods safer and pleasanter places to live.

Unfortunately coordination between urban land-use planning and transport policy has tended in the past to be rather poor. This is mainly due to the fact that spatial planning and transport policy tend even today to be the responsibilities of entirely different departments within regional authorities. Although this is beginning to change towards a more holistic style of administration, there is still a lack of coordination between city

A multifunctional mix of housing and other land uses can have considerable influence on a variety of environmental and social parameters. Nevertheless, transport and planning have tended to be dealt with as entirely separate issues

As a relatively densely populated region, Europe faces considerable pressure on land, exacerbated by changes in lifestyles and patterns of production

Care has to be taken when determining the level at which planning decisions should be taken. At high levels it is hard to take local issues into account, but at very local levels authorities may find their freedom to act limited by the risk of businesses moving to other areas

and transport planners for reasons of educational background and differences between the administration's external partners, as well as historical factors.

However, conflicts in land-use planning in many countries in Europe are not just a result of a lack of coordination between different policy fields. On the one hand, rapid changes in patterns of production and life styles have increased demand for space in Europe, a continent with relatively high population density where space has to be regarded as an increasingly valuable resource. And, on the other hand it seems unclear at what administrative level, geographically speaking, (i.e. local, regional or national) spatial planning decisions should be taken. Making decisions at high levels may mean local circumstances fail to be taken into account. Local authorities, however, frequently come under tremendous pressure from professional and private stakeholders when they try to achieve solutions optimizing the public good.

Towns compete for local tax revenues from businesses, thus professional developers can shift their investment plans from one place to another if the municipal administration tries to impose more stringent conditions based on considerations of the common good in its building permit granting system. Particularly in smaller communities, private builders can have a decisive influence on local policy makers who may feel obliged to approve their building plan in order to produce the tangible economic benefits they need to show to be re-elected. These pressures on authorities at municipal level have meant that some countries have begun to move planning decisions up to regional authority level just as cities and their surrounding countryside set up coordination committees to avoid unfair competition. Sustainable land-use planning is therefore very much a matter of making decisions

at appropriate levels and in close cooperation of different parts of the administration.

Instruments to influence land-use

To achieve compact and multifunctional city structures public planning authorities may address different stakeholders and apply a number of strategies:

1. Guiding professional and economic activities towards sustainable development through regulations, incentives and subsidies.
2. Influencing private housing preferences and convincing citizens of the advantages of new architectural and planning solutions.
3. Shortening travel distances for commuting, shopping and leisure activities by involvement of employers, shopkeepers and the service industry

These three options will be discussed in more detail below.

Guiding professional and economic activities towards sustainable development

Public authorities should use spatial planning regulations, incentives and subsidies for inner-city shopping and leisure infrastructure and penalize out-of-town complexes by passing on the cost of infrastructure construction to them (e.g. by taxes for creating traffic flows). These instruments have to be based on sound legal justification to avoid appeals to the courts on the grounds of unfair competition.

Policy measures have to take differences between economic sectors into account. Small and light consumer products can be offered and bought much more easily in a decentralized urban retail system than bulky and heavy commodities, where the need for sufficient space for delivery and presentation means it is more or less inevitable that consumers will use their cars.

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But even in these cases innovative concepts are emerging. For example, home delivery of bulky goods avoids the need for the customer to have transport of his or her own. Moreover, if transporting purchased goods is left to the seller he can use optimized logistics to make delivery environmentally friendlier. The trend towards ordering via the Internet could encourage home delivery schemes yet further.

Influencing private housing preferences

Effective public awareness campaigns disseminating the advantages of new architectural solutions could stem the tide towards the suburbs. As suburban housing patterns are mainly motivated by a desire to escape from pollution and noise in inner cities, architects have to demonstrate that new materials and planning techniques can meet quality-of-life expectations in moderate to high population density areas.

Shortening travel distances for commuting, shopping and leisure activities by involving employers, shopkeepers and the service industry

Although it is of course preferable to seek to prevent unsustainable patterns emerging, spatial planning also has to take pre-existing problems of over-development, urban sprawl and functional segregation into account. Over the last few decades many large suburban shopping and leisure centres, factories and offices have been constructed remote from where people live, constantly increasing the need for travel. For some years now the planners' goal has been to reverse this trend and restore to European cities the mixed use of space that has been typical for so many centuries. Professional stakeholders, such as employers, shopkeepers and the service sector, are better suited to restore mixed city structures than consumers because they have sufficient organizational and financial means and they have a vested interest their potential customers' having

access. Special incentives and information campaigns could target small and medium-sized enterprises.

Voluntary measures

Spatial planning authorities have been implementing regulatory strategies for many years, thus we will concentrate here on the newer area of voluntary public-private partnerships involving professional stakeholders and citizens. Before establishing this relationship with private stakeholders, public authorities have to analyse where mixed and compact city structures seem appropriate and feasible (Haywood, 1998). The original motivation for functional segregation was to avoid annoyance from noise and pollution for residents and this need is still valid. However, the trend in industrial production processes towards clean technologies and the shift from manufacturing to services in the post-industrial world has changed the situation considerably.

Public authorities need to identify where it makes sense to encourage the development of multifunctional city structures with increased density of buildings. Although the situation could be quite different for factories, offices, shopping and leisure centres, the general goal should be to treat space as a valuable resource and to shorten distances both between different activities and between these activities and residential areas. For social sustainability public authorities have to ensure access of all citizens (including those citizens who are not drivers) to essential services (Vivier, 1998). In order to maximize the number of people who find work as well as shopping and leisure facilities in their neighbourhood, social considerations have to be kept in mind. Redeveloping inner city sites can often result in expensive housing, which can exclude less wealthy former residents or staff of local retail outlets from this area. The wealthier new residents

Appropriate instruments are needed to reverse the trend towards locating shopping facilities out of town on green field site, perhaps by passing on the cost of infrastructure to developers

Potential house buyers need to be convinced that their aspirations for a quality living environment can be met without their having to move to the suburbs

Although the situation for factories, offices, shopping and leisure centres clearly differs, the overall goal should be to treat space as a valuable resource and to shorten distances between different activities as well as between these activities and residential areas

It is not enough to simply build a quota of homes close to the workplace, the homes must be affordable to the same people who work there

Combining shopping complexes and transport nodes could bring significant economic benefits for both shop owners and transport providers

may tend to continue leisure or occupational activities outside the area, thus increasing travel needs for both these social groups.

Social segregation can lead to further problems such as rising crime or declining standards in education or medical services, as has been witnessed in some US cities. This is another example why an approach that cuts across departments and authorities is needed for integrated sustainable urban development.

In terms of concrete examples, some existing mono-functional sources and destinations of significant traffic flows might be suited not only for multifunctional use and higher population density but could also be the ideal candidate for a major public transport nodes. Conversely, public transport providers could profit from large passenger flows at their transport nodes to attract shops and other service providers. This would not only open up new sources of income, such as letting shop space in their stations, but also give them a competitive edge in attracting new customers for their transport services (Viegas, 1998). Planning authorities need, however, to bear in mind that public transport operators have already gone or are going through the process of being privatized. Profitability is now their most important motivation and municipal authorities can no longer simply order them to fulfil public services as in the past.

Guiding professional developers towards multifunctionality

A second step should be to analyse the available instruments (e.g. incentives or regulations) to achieve the goals set (Beckmann, 1998). One possibility would be to stipulate a minimum degree of multifunctionality and building density for development projects in the development plan. As a consequence, property

development companies would have to consider complementary uses of free space in their development areas from the outset. They may not in fact object to this obligation as it opens up a new field of business for them by offering additional products and services to their customers. Buildings over car parks could, for example, complement shopping centres with leisure parks or offices with apartments. Likewise, occupational and residential installations should be complemented by shopping and leisure facilities.

It is worthwhile analysing why this did not happen to a larger extent in the past. One reason is that professional developers specialize in property development, and a company extending its network of shopping centres is a specialist in analysing the retail market and constructing and running new shopping centres at targeted locations. There is little or no overlap between these two areas, and the players are normally reluctant to engage in professional activities beyond their original core competencies. Nevertheless, in malls where shops rent rather than own commercial space, the owners of malls have in the past shown their interest in achieving a balanced mix and optimizing revenues by including cinemas, restaurants and repair shops in their portfolio.

For the common interest of sustainable urban development and improved quality of life, public authorities could play a more active role in promoting voluntary intersectoral cooperation between professional stakeholders. Public administrations could act as a catalyst linking different areas of expertise, improving the attractiveness of locations and cross-fertilizing commercial opportunities for increased revenues. At the same time public authorities could fulfil their own interest in achieving policy goals in spatial and transport planning.



Only if the market driven motivation for multifunctional development patterns is not strong enough should public authorities seek to enforce them by imposing planning and building permission controls. Building contractors could be obliged not to produce just only dwellings but to envisage shopping, leisure and occupational facilities in their housing developments. With these spatial planning regulations leisure, occupational, shopping and residential land use could be linked closer together and the need to travel could be reduced substantially.

In this context it has to be stressed that the proposed strategy requires careful monitoring by the responsible authorities. They should strive for the advantages of increased multifunctionality and population density at focal points, as mentioned above (reduced transport demand, attractive and profitable stations for public transport, short distances between activities for citizens). At the same time they need to monitor developments closely to ensure undesirable side effects are avoided (such as segregation into 'self-sufficient' urban units).

As mentioned it is preferable to take precautions to ensure sustainable development by using spatial planning regulations to support economic activities within urban centres. However, the strategy must also take into account existing problems of over-development, urban sprawl and functional segregation. As sustainable urban development tries to safeguard the economic potential of organic historic inner-city centres, public authorities have to reconcile their competitive position carefully with the economic power of these emerging new centres. An especially important task is to achieve not only a variety of different branches but also a mix of company sizes. Failure to do so might mean bigger companies become excessively dominant. To avoid monopolistic structures the administration should

therefore encourage small and medium enterprises to set up in these new development centres.

Reducing demand for commuting

Tax deductible benefits for employers and employees could be granted if employees live within a certain distance of the workplace. Society would thus reward employers and employees for the common benefit of reduced commuting, pollution and demand for transport infrastructure. Incentive-setting must take into account the employer's organizational and financial ability to provide his employee with a place of residence close to the workplace. With the right financial incentives employers could be motivated to buy apartments nearby and rent them out to his employees. Or alternatively employers might even construct tied housing to provide accommodation for employees either as part of salary or under a tenancy agreement.

This would be an extension of the social activities of an increasing number of companies offering their employees benefits beyond the pure professional relationship like healthy food in the canteen, reduced price access to cultural events or quick and safe transport services for commuting. These employers consider the overall well-being of their employees to be a factor in increasing their motivation and productivity.

Employees on the other hand should be attracted by the tax-deductible benefits or other financial incentives from the public authorities. Less commuting would be an important additional advantage. Nevertheless, it must be stressed that this issue is a highly sensitive one and it is necessary to avoid any apparent encroachment by the state on the individual's freedom to choose where he or she lives or any suggestion that the employer is not respecting the individual's privacy. But on a clearly voluntary

Property developers need to be encouraged to envisage complementary uses of space in their projects from the outset. This may often be economically beneficial for them, but they may not have tended to consider it as it lies outside their traditional core competencies

Only if the market driven motivation for multifunctional development patterns is not strong enough should public authorities seek to enforce them by the planning and building permission controls

Tax benefits for commuters who travel shorter distances or employers who provide accommodation close to the office or factory are possible types of incentives to reducing distances commuted

A lack of information and the peculiarities of the market have meant that many valuable technological improvements are not being applied in practice

Housing patterns, such as the preference for detached homes, may make inefficient use of space and create low-density environments in which use of the private car is almost inevitable

basis this scheme could benefit employees, employer and society at the same time.

This active support by public authorities to dissuade occupational traffic take on more importance when we consider that companies and industry are less susceptible to the strategies to promote multifunctional land use described above. For them the contact with consumers is less important than for commerce and trade and lower prices of office space in out-of-town locations have created a strong incentive to move out of the city centre.

Influencing private housing preferences

Another important task for the public administration would be to influence private housing preferences not only concerning the place of residence but also regarding housing conditions. This is an even more sensitive area and the administration must make it completely clear that it does not want to deprive citizens of their freedom to choose their residential environment. Spatial planning regulations, however, are already guiding construction to avoid disturbance of neighbours and the public accepts in general the need for a basic framework of construction rules for the common good.

Unfortunately many recent technological improvements in building materials and new architectural solutions have hardly reached beyond the academic environment in which they were originally developed. The administration has to fulfil here its educational role, informing construction companies and house hunters about sound-proofing materials and innovative arrangements of apartments and other types of housing. Much of the population aspires to single-family, detached housing although this is hardly achievable in a sustainable way. If this demand were to be met in full the result would be sprawling semi-urban city structures without

public transport or local retail services. This in turn creates traffic congestion, and the result is a far cry from the pristine environment many envisaged when leaving the noisy and polluted inner cities.

Although the closed frontage of a row terraced houses actually isolates gardens much more from the noise and traffic fumes of the road, the detached family house is still the ultimate dream of millions of people. Nevertheless, detached houses make inefficient use of land, with a large part of the plot adjacent to the road and neighbouring homes hardly being used. Their attractiveness is less based on rationality than on the poor reputation of terraced houses in our social system of values. Here public awareness campaigns using up-to-date techniques could seek to convince citizens of advantages of new architectural solutions with a higher population density. Demographic studies show that families with small children are most strongly inclined to leave the cities, thus targeting awareness campaigns and optimizing proposed solutions to their needs could prove particularly effective.

Another factor behind urban sprawl is easy access to parking. A vicious circle is often created by people fleeing a lack of (parking) space, congestion and pollution in inner-cities only to create these conditions of congestion in rural areas far from their work and shops. There is, however, a new development in urban transport policy which might increase again the value of urban real estates. Municipal restrictions favouring neighbourhood parking over other car users force commuters to use public transport. A secondary positive effect for sustainable mobility is that suburban housing itself becomes less attractive.

The European dimension

The environmental, economic and social hazards of misguided urban development are such



that they could jeopardize the achievement of important goals of the Common Transport Policy, regional development and environmental protection in Europe. Support by the European Union to national authorities in their dialogue with citizens would be useful and appropriate. For this reason the European Union has proposed close cooperation with member states and regional administrations on the interrelated fields of policy making within a framework for action called "Sustainable urban development in the European Union" (DG-XVI, 1998). The European Commission stressed the importance of integrated planning and coordination as well in its Green Paper "The citizens' network" to increase the potential of public passenger transport in Europe (EC, 1995).

The achievement of the Common Transport Policy and of the emission and immission targets for pollutants at the European level are strongly dependent on land-use policy in the member

states and its potentially transport-creating effects. On the other hand, the decisions of the European Union on fair and efficient pricing in transport, on the internalization of external costs, and the construction of trans-European infrastructure networks, will have a decisive influence not only on the economy but on Europe's spatial development as well. An increased exchange of information on goals and tools of policy making between different levels of the European administration therefore seems appropriate.

Inadequate co-operation and conflicting interests between local, regional and national authorities can exacerbate these problems. Thus the European Commission can help public administrations by engaging policy makers at all levels in order to find a consistent and coherent position in their dialogue with private stakeholders beyond the traditional sovereign relationship between public authorities and citizens. 

Keywords

land-use planning, transport policy, sustainable mobility, spatial planning regulations, housing patterns, planning and building permission, urban development, public policy coordination

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Contact

Andreas Dorda, IPTS

Tel.: +34 95 448 83 56, fax: +34 95 448 83 26, e-mail: andreas.dorda@jrc.es

As studies show that families with small children are most strongly inclined to leave the cities awareness campaigns and optimization of proposed solutions could be targeted especially to their needs

About the author

Andreas Dorda studied Physical Chemistry at the University of Vienna. Before obtaining his Ph.D. he worked at the University of California at Berkeley and in industry in France, Austria, Switzerland and Argentina. He subsequently worked as an assistant professor at the University of Vienna, at the Austrian Academy of Science and at the Austrian Ministry for Environment. His research interests are in transport technologies and trends in mobility patterns. Before joining the IPTS as a National Expert in the Transport and Mobility Department he worked on environment and mobility at the Austrian Ministry for Science and Transport.



Environmental Education: towards promoting sustainability

Sebastian Krug, *VDI*

Issue: A great deal of progress has been made in the field of environmental protection over the last decade. Nevertheless, although the public seems to be aware of environmental issues, there is a discrepancy between expressed convictions and actual behaviour among broad segments of the population.

Relevance: Environmental education, aimed at adults as well as school children, might help to bridge the gap and to improve the pre-conditions for sustainability. Positioned at the intersection of information, education, technology and science, a number of unexploited routes into environmental education could offer alternatives that are also able to reach adults.

Introduction

Consensus and collaboration between the public, the administration and economic actors is a crucial prerequisite for the long-term achievement of environmental goals. In the field of environmental protection and careful use of natural resources there seems to be difficulty in turning existing public consensus and general approval of political (environmental) aims into concrete sustainable action. Investigation of the causes of this problem suggests that a lack of sound information, knowledge and in particular understanding of environmental issues among the public is an important factor.

Economic and environmental goals may often appear hard to reconcile, with the outcome that priority is usually given to economic aspects. Protection of the environment is thus treated as an

additional benefit, to be taken in account only in so far as it does not impose serious economic restrictions. Unquestionably, there are serious restraints for environmental sustainability, such as economic limitations and institutional constraints. But, as full sustainability requires balanced consideration of economic, environmental and social aspects, prioritizing practices may set a limit on achievable progress.

DG-X's latest Eurobarometer survey (March 1999) reveals widespread public consensus about the importance of environmental protection. According to the survey 86% of Europeans believe that the protection of the environment should be a priority for the European Union. And, on the subject of enlargement of the EU, 91% of Europeans feel that new countries should only be allowed to join the European Union if they undertake to

protect the environment (Eurobarometer, 1999). However, despite this relatively high level of support for pro-environmental measures, a discrepancy seems to exist between expressed convictions and actual behaviour.

The public *perception* of pollution seems to be a significant factor in this discrepancy, although regrettably, little research has been carried out on this subject. Surveys on pollution normally deal with it in a more general way (e. g. Eurobarometer polls). Others (e.g. those carried out by the EPA and local authorities in the USA) which do include aspects of perception usually apply to specific problems, sources of pollution or local surroundings. Thus little empirical data is available on the situation in Europe.

One of the few surveys that have taken the perception of pollution into account is the ALLBUS-questionnaire carried out in Germany. This showed that the perceived general pollution is plainly higher than the extent to which it is perceived to affect the individual concerned. One obvious conclusion to be drawn from these findings is that the perception of pollution and resulting public awareness are not primarily based on individual experience, but on (abstract) knowledge and (second hand) information. This fact could place a question mark over the feasibility and adequacy of current strategies for sustainability.

The Perception of Pollution

Starting from the assumption that social attitudes and patterns of behaviour concerning the environment are mainly determined by the perception of environmental conditions and interrelations, any evaluation of pollution inevitably tends to be subjective. Additionally, individual values and attitudes have turned out to be more decisive for the subjective perception of

environmental impacts than actual pollution itself (Hagstotz/Kösters, 1986). For example, extensive media coverage can mean that the environmental hazard caused by accidents is frequently perceived to be greater than that from longer-term but less dramatic effects, despite the fact that the consequences of the latter may possibly be much more serious overall.

This subjectivity of perception and evaluation can be highlighted by the fact that different kinds of pollution and environmental problems are often perceived and evaluated to a varying extent. These subjective impressions seem to be particularly influenced by the following factors:

- a) the extent to which the individual is or feels affected by the pollution;
- b) the extent to which the pollution and its effects are perceptible by the senses, especially visibility;
- c) the possibility of an occurrence or a change's causing an emotional reaction (particularly dismay or fear);
- d) the dimension of the area affected: too small an extent may lead to the impression of minor importance, too large an extent may exceed the powers of imagination. In both cases the perception will be relatively weak;
- e) the temporal dimension: on the one hand, the recollection of an impact is likely to fade after a short peak of attention; on the other hand, the effects caused by slow processes or steady changes are often hard to comprehend or even to perceive at all.

A conclusion to be drawn from this is that the resulting attitudes and patterns of behaviour will rarely respond appropriately to objective realities. This might also be a partial explanation

According to a recent Eurobarometer survey 86% of Europeans believe that the protection of the environment should be a priority for the European Union

Public perceptions of environmental problems tend to be shaped by the media, and consequently focus more on highly visible problems whilst downplaying longer-term, but less dramatic environmental damage

Measures to foster public understanding of science, thereby improving individuals' ability to perceive, comprehend, judge and finally act appropriately, could be a useful complement to existing information strategies

Since the beginning of the eighties environmental issues have been integrated into school education and environmental education has been established as a constituent component of the basic educational and training mandate of schools

for the discrepancy between generally high environmental awareness and indifferent implementation in practice.

At least three of the five influencing factors cited above show a close relation between individual perception and the range of knowledge and comprehension of science and technology. This observation goes with another result of the investigations mentioned above, namely that there are significant interrelations between school education and the perception of pollution. This becomes more significant the less a direct sensory perception is possible.

This situation would suggest that measures to foster public understanding of science, thereby improving individuals' ability to perceive, comprehend, judge and finally act appropriately, could be a useful complement to existing information strategies. This would require redoubling efforts, extending subject content and developing new and innovative means of environmental education.

Environmental Education

"In schools and also in vocational education, further training, adult education and higher education for many years an increasing level of importance has been assigned to the treatment of environmental issues and a corresponding development of environmental awareness." (Secretariat of the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany, 1992). Since the beginning of the eighties environmental issues have been integrated into school education and environmental education has been established as a constituent component of the basic educational and training mandate of schools. As environmental education is a function of natural science as well as of social science

subjects it is organized on a interdisciplinary and cross-curricular basis.

Beside various national activities within the European Member States, the European Union / European Community, the Council of Europe, the OECD Centre for Educational Research and Innovation (CERI) and UNESCO all run international programmes for environmental education. International non-profit-making organizations are also involved in starting and running programmes and setting up international networks to support the institutions mentioned above. Examples include the Foundation for Environmental Education in Europe (FEEE), founded in 1981, which runs programmes for school children and young people (e. g. the 'European Eco-Schools' initiative and the 'Young Reporters of the Environment' programme) as well as programmes aimed at adults, such as the 'European Blue Flag' programme for beaches and marinas.

The example given above demonstrates that environmental education is not entirely limited to the target group of young people. But, in general, the activities in the field of adult education on environmental issues are not yet being exploited to the full. Beside the establishment of a growing number of first-degree and supplementary courses of higher education offering the possibility of specializing in environmental studies, environmental issues have been partly integrated into vocational and further vocational training.

Continuing Education

Continuing education can be identified as one of the main fields of action to which attention should be paid when it comes to the extension of efforts on environmental education.

On the one hand, advanced information technology offers a broad range of applications in

the field of education, such as tele-learning, on-site learning centres, online information systems, the use of the Internet and learning-on-the-job with support of computer terminals located in or close to the workplace, which facilitate fast and flexible access to different kind of software and data banks. As an illustration of the increasing requirements for concepts in this sector the European Union co-funded ADAPT initiative could be mentioned. ADAPT ('Managing Change in Information Delivery Mechanism for SMEs'), which is administered on behalf of the EU, is an initiative to help European industry adapt to change and so retain its competitive position in world economy.

Obviously, many of these innovative technologies and concepts can also be used for environmental education measures. One example is LINC, a project associated with ADAPT which is about to be started in Hessen (one of the German Länder). LINC ('Information and Cooperation Network for SMEs') combines the fostering of the use of information technologies in SMEs and the application of these technologies to qualification in industrial environmental protection focused on environmental management according to EMAS and ISO 14001.

On the other hand, facing complexity of modern working processes, increasing interdisciplinary demands on employees and the accelerating rate at which knowledge becomes out of date, feasible concepts enabling and supporting lifelong learning will probably be in great demand. This means development in education tends towards integrated approaches. Study-and-practice-approaches integrate theoretical and practical aspects or, in other words, knowledge and experience. Another dimension of integration is fostered by the enhancement of soft-skills like interdisciplinary understanding, team spirit and social competence, which are essential

prerequisites for the emergence and success of learning organizations.

Environmental Education in the private sector

The second field which seems worth turning attention to is the private sector. This sector can be characterized mainly by the subject of activities and the subject of consumption. The subject of activities includes e. g. travel, tourism and leisure time mobility, outdoor sports and other outdoor activities as well as home activities. Efforts in environmental education might be driven primarily in connection with ecologically desirable sport and tourism - not to mention the sector of traffic and mobility, which goes far beyond the private sector. Furthermore, concepts which combine education and entertainment offer various exploitable starting-points. So called 'edutainment' stands out as an attractive and highly motivating learning experience offering the chance to reach broad swathes of the population, e. g. through science centres, exhibitions, events, competitions, television programmes or films shown at special screen cinemas which present natural scientific programmes (e. g. IMAX/OMNIMAX).

Sustainable consumption - as a fundamental component of overall sustainability - could be given priority within environmental education. The demand for suitable and effective ways of influencing consumer habits can be expected to increase. Sustainable consumption concepts have to be developed, leading one hand towards an overall reduction of consumption, and on the other, fulfilling economic requirements. Perhaps, initial stages can be found in relation with sharing models - which means attractive concepts for the collective use of goods and products. Anyway, this seems achievable only with the massive support of educational means - for the reasons mentioned above.

Continuing education can be identified as one of the main fields of action to which attention should be paid when it comes to the extension of efforts on environmental education



The willingness of citizens to engage in public decision processes depends on the extent to which they feel personally affected by the subject as well as on their individual sense of 'subjective competence'

One issue finally to mention in brief is the interrelation between environmental education and citizen participation in decisions concerning the environment. The willingness of citizens to engage in public decision processes depends on the extent to which they feel personally affected by the subject as well as on their individual sense of 'subjective competence' (Fiorino, 1990). In all probability, both of these criteria might easily be influenced through environmental education. At the same time, increased citizen participation might be seen as a valuable contribution to environmental education as well as to the quest for sustainability.

Conclusions

Chiefly, there are two possible implications for a policy strategy. To policy makers in the field of environmental policy it might be suggested that they focus attention on improving the overall conditions for sustainability. Taking measures aimed at improving the conditions of sustainability might be helpful in order to support current activities and to develop additional political actions aiming at long-term environmental improvements. Therefore, on the one hand specific investigations into these conditions should be taken in account, e. g. concerning the perception of pollution and the current barriers and restrictions on sustainability in order to bridge the gap between awareness and actual behaviour.

On the other hand additional concerted efforts and cooperation on these issues which go beyond the scope of single policy sectors seem to be advisable.

In the educational sector an extension of scope might be beneficial. As environmental education is currently focused on schooling - which means it is mainly applied to children and young people - more actions aimed at adults are perhaps needed. These might, for instance, consist of measures fostering continuous and holistic vocational training in support of and in addition to ongoing efforts; new information technologies and methods could be developed or adapted for use in environmental education; furthermore, legislative and educational means in order to increase citizen participation in decisions concerning the environment could be explored; finally, concepts could be fostered or developed which raise the attractiveness of ecologically desirable lifestyles and patterns of consumption. As environmental goals partly conflict with economic growth and increasing prosperity, it might be helpful, if the widespread interpretation of prosperity as 'affluence' could be replaced by an interpretation in terms of 'quality of life', which may include an expansion of non-material aspects of well-being. Such a change might be fostered and supported by technological innovation but its success depends on social innovation and a change in attitude. 

Keywords

environmental protection, education, innovation, sustainability, public understanding of science, perception of pollution

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Contacts

Sebastian Krug, VDI-TZ

Tel.: +49 211 621 44 72, fax: +49 211 621 44 84, e-mail: krug@vdi.de

Vera Calenbuhr, IPTS

Tel.: +49 95 448 82 87, fax: +49 95 448 83 39, e-mail: vera.calenbuhr@jrc.es

About the author Sebastian Krug

holds a degree in Biological Engineering and Environmental Technologies (Dipl.-Ing.) and was awarded the Hamburg Engineering Prize in 1995. He is currently working as a consultant at the VDI Technology Centre in Duesseldorf (Germany). Previously he has worked on environmental protection and management projects for Thyssen, Lloyd's Register, the German Association for Environmental Education and on a two-year scientific EMAS-project.



New battery technologies: promising developments

Miquel A. Aguado-Monsonet, *IPTS*, and Laurent Bontoux, *DG-XII*

Issue: Cheap and efficient storage of energy, in particular of electricity, remains a major technological bottleneck. Technologies for the storage of energy on both macro and micro scale can be equally important as new and renewable sources of energy or competitive and clean production and use of fossil fuels. This change is partly due to recent developments in battery technologies but is mainly driven by increasing demand for better electricity storage.

Relevance: The importance given by the European Commission to the development of cheap and efficient energy storage has been increased in the Fifth Framework Programme (1999-2002) where it forms part of the "Energy, Environment and Sustainable Development" area. A breakthrough in energy storage would have a fundamental impact worldwide. As well as being a major step forward in our progress towards sustainable development, such a breakthrough would be important for the development of the portable telecommunications market and market penetration of electrical vehicles.

A cheap and efficient means of storing electricity would enable more decentralized production of electricity and thus more effective exploitation of renewable resources

Introduction

Cheap and efficient storage of energy, in particular of electricity, remains a major technological bottleneck. A breakthrough in this area would have a fundamental impact worldwide. Firstly, it would decrease the energy losses from classic energy sources (e.g. off-peak electricity) and secondly, it would give a boost to renewable energy, in particular non-constant sources such as the sun and wind. This combined effect would significantly reduce both CO₂ production and reliance on fossil fuels. Moreover, it would bolster the decentralized production of energy and therefore give a better chance for progressive development in countries

lacking the financial resources for major infrastructure investments. It would also open up the market for electric vehicles, which are today hindered by the limitations of their batteries. Another secondary benefit could be a decrease in the production of waste batteries thanks to the extension of battery life and a reduction in the use of heavy metals. Such an achievement would be a major step forward in our progress towards sustainable development.

Electricity is the highest grade of useful energy and it can be easily transported over long distances with little loss. Nevertheless, it suffers from the major drawback that it has so far proven impossible to store it efficiently, thus electrical

production has always had to be adjusted to its demand. Current methods and technologies for the storage of electricity (EUR-11940-EN) include pumped storage, batteries, hydrogen, fuel cells with electrochemical storage and superconducting magnetic energy storage.

Batteries are probably the most important form of electricity storage. Their flexibility and ease of use has given chemical electricity storage an important position in the market. Batteries come in a variety of shapes and sizes, the most

important characteristics by which they can be defined are summarized in Box 1.

There are two common ways to classify batteries. The first is to separate them into batteries of single use (primary batteries) and rechargeable batteries (secondary). But, because the specifications of a battery are mainly defined by its use, this is what determines the most important classification. Accordingly, the International Battery Council divides batteries into three categories. First, the industrial battery group

Box 1. Technical characteristics of a battery

- **Specific energy** (Wh/kg): this is the amount of energy the battery can store per unit weight. The higher, the better. For the lead/acid battery, this is approximately 50 Wh/kg.
- **Specific power** (W/kg): this is the power the battery can deliver per unit weight. Again, the higher this figure is, the more possible applications the battery has. For a typical lead/acid battery, it is around 450 W/kg.
- **Energy density** (Wh/l): this is the amount of energy stored per unit volume. Again, the higher, the better. For a typical lead/acid battery, it is around 90 Wh/l.
- **Efficiency** (%): this is the fraction of electricity returned by the battery in proportion to the amount of electricity that was needed to charge it. The higher the better, ideally, 100%. It is also important for a battery to maintain its efficiency as a function of storage time. For a typical lead/acid battery, it is in the range of 95%. This value is also a function of the self-discharge value. For a typical lead/acid battery, it is in the range 3-4 % monthly.
- **Number of charge-discharge cycles**: this is the number of times the battery can be recharge back to full capacity after use. It is an indication of the lifetime of the battery. Again, the higher, the better. For a typical lead/acid battery, it is in the range of 800.
- **Time for normal recharge** (h): this is the time needed to fully recharge the battery. The shorter the better. For a typical lead/acid battery, it is in the range of 3 hours.
- **Time for rapid recharge** (50% and 99%): these are the times needed to recharge the battery to half or to 99% of capacity. This characteristic is only useful if the recharge of the battery is slow. Of course, the shorter this time, the better. For a typical lead/acid battery, it is in the range of 8 minutes for half charge and 30 minutes for 99% charge.
- **Cost** (€/kWh): the cost of the battery per unit of energy stored, essential for economic applications. For a typical lead/acid battery, it is in the range of 350 €/kWh. By comparison, the average cost of electricity in Europe is around 8-10 € cents/kWh.

Note that many of these characteristics are interdependent and that they may depend on the way the battery is used.

Chemical storage of electricity has the fundamental limitation that the inert components forming the battery's structure make its energy density considerably lower than that of fossil fuels

that include motive-power batteries (e.g. industrial trucks) and standby-power batteries (e.g. telecommunications, uninterruptible power supplies, photovoltaic batteries, bulk energy storage). Electric car batteries comprise the second category and small batteries, the third.

Table 1 shows a comparison of batteries according to their main technical parameters and indicates the main application of each type of battery (ETSU report, 1994).

The ideal values for all these parameters vary according to the applications and chemical

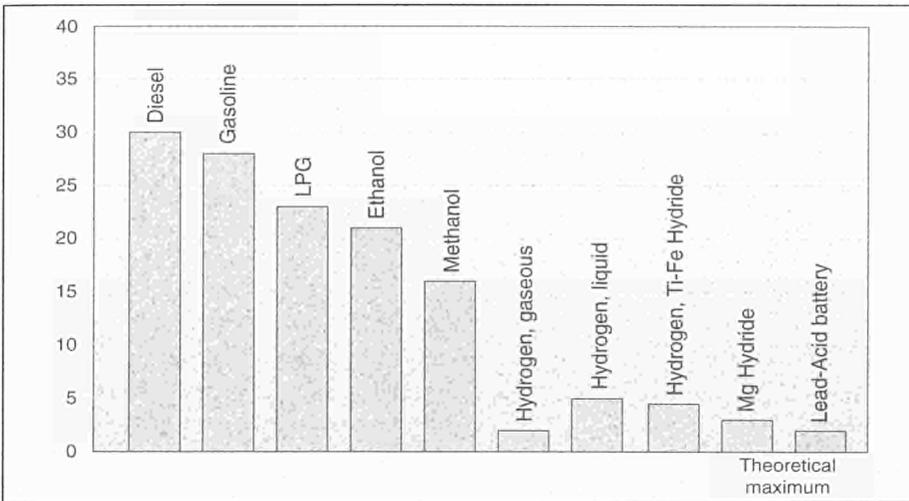
theory indicates there is still room for improvement. Chemical storage of electricity has intrinsic limitations. First, in a battery, electricity must be stored in the chemical components, generally inorganic solids, which should be packed and shaped into useful forms. Second, when they are compared to fossil fuels, their energy density is much lower because all the chemical components of fossil fuels can be transformed into energy (there are no inert components). This "limitation" is the main factor responsible for the low specific energy factor of batteries. For instance, the energy density of fuels is 15 times higher than the theoretical maximum of

Table 1. Technical characteristics of different types of batteries

Type of battery	Cost (€/kWh)	Specific energy (Wh/kg)	Specific power (W/kg)	Charge/discharge (cycles)	Efficiency (%)	Main Applications
Primary batteries (non rechargeable)						
Carbon/Zinc	200	65		-		Flashlights, transistor radios, toys and games
Lithium	1000	260		-		Calculators, garage door openers, photographic equipment
Alkaline/Manganese				-		Alkaline applications, walkman, toys
Mercury	800	105		-		Watches, calculators, small electronic goods
Zinc/air		100	100	-	50	Lamps, toys, medical devices
Secondary batteries (rechargeable)						
Lead/acid	400	35	100	300-400	70-80	Cars, emergency power supplies etc.
Li ion	2000	200	300	>1000	98	Electronic goods, Portable electronic products
Ni-hydride	1200	100	200	500	75	Portable electronic products
Ni-Cd	800	1000	50	1000-3000	60-85	Toys, lamps, electronic goods, portable electronic equipment
Sodium sulphur		150	170		60-90	
Na/NiCl ₂		90	110	>110	90	
Polymer		200	400	100	60	Portable electronic products

These comparisons are approximate because there are no standard methods for comparing the values shown.

Figure 1. Energy density (MJ/l) for different energy sources



Source: Int. J. Hydrogen energy, Sept. 1996.

a lead/acid battery. Figure 1 shows the differences in energy density of different fuels and batteries.

In general, commercial batteries are too heavy, contain too little power, take too long to charge and are still too expensive to make (c.f. the commercial viability of electric vehicles in the consumer market). More specifically, in terms of energy, lead/acid batteries are inherently limited by the high atomic weight of lead and the relatively poor utilization levels given by the positive-plate chemistry of the battery. Ni-Cd batteries have a high energy capacity but they need to be recycled. Lithium batteries, for their part, have the highest theoretical energy density of all commercial rechargeable batteries but they suffer from high costs of manufacturing and R&D. A future limitation of batteries could also be the scarcity of some elements (e.g. cobalt) especially if they are to be widely used. Polymer batteries benefit from reduced weight but they suffer from polymer instability and a high self-discharge rate.

An additional problem of batteries is their low performance. For instance a commercial lead/acid

battery delivers around 55 Wh/kg, i.e. only 21% of its theoretical maximum. The reasons for this low performance are the energy losses that occur in the sulphuric acid solution, water, grids, connectors, separators of the cells, and other battery components.

The disposal of batteries can also be a source of environmental and health concern. Lead, mercury and cadmium are the most dangerous metals used in batteries. However, all types of battery technology use potentially hazardous compounds. Recycling or controlled disposal are the only options for minimizing risks as long as heavy metals remain essential battery components. Along these lines, the European Commission Environment Directorate (DG-XI) is discussing with European battery manufacturers a proposal to ban sales of batteries containing heavy metals as of 2008. Additionally, a recent European directive (98/101/EC, 22 Dec. 1998), instigated by the industry, will limit the marketing of batteries containing mercury from 1 January 2000. DG-XI is also studying the collection and recycling of consumer and industrial batteries.

Lithium batteries have the highest theoretical energy density of all commercial rechargeable batteries but they suffer from high manufacturing and R&D costs



All current battery technologies use potentially hazardous substances, thus battery disposal can be a source of environmental concern

Demand for batteries is projected to continue increasing, spurred on by growth in the market for personal computing and communications devices

However, even countries like the Netherlands and Switzerland, which have had battery collection schemes in place for ten years, are not achieving very high collection rates. Moreover, even successful collection schemes have simply led to large stockpiles of batteries waiting for recycling schemes to become operational. In Europe, Japan and the USA, there are recycling facilities with ample capacity but they can only recover 80% of the cadmium from the batteries (Renewable energy world, Jul 98). However, some demonstration projects along these lines are achieving higher recovery rates of heavy metals from batteries.

Another problem is that current battery designs are not suited to certain applications. For example, about 80% of the photovoltaic modules are used in stand-alone systems. Obtaining continuous energy from such systems requires buffer storage, typically in the form of rechargeable batteries. However, a battery behaves differently in photovoltaic applications than in more traditional purposes such as transport because of different operating conditions, which can reduce battery lifetime (Renewable energy world, 1998).

The expanding market, and recent R&D developments

The size of the world battery market is around €30 billion per year. Battery production in Europe is larger than in the United States: €800 million in comparison to €500 million (1992). Over 200 companies manufacture batteries worldwide, but most segments are highly concentrated in a few branches. The world battery market is expected to increase sharply in the future. For instance, the aggregate demand for primary and secondary batteries in the USA is projected to increase by 6.6 % per annum in the next few years and 7% for secondary batteries alone. The market for

batteries for portable computers and next-generation personal communications devices (e.g. smart cards) continues to provide strong growth in demand for rechargeable batteries. In addition, some sales of batteries for electric/hybrid vehicles are expected over the next few years, further contributing to growth. The future demand for better batteries is therefore guaranteed.

Nickel-metal\hydride, lead-acid, nickel-cadmium, rechargeable lithium and nickel-hydrogen are among the battery chemistries presently vying for leadership in the secondary battery market. Lithium-based rechargeables are emerging and may be the main successors to the nickel-cadmium chemistry which has dominated portable electronic equipment applications to date.

Based on market expansion forecasts, a strong R&D effort is predicted for the next decade in these technologies. Aware of this fact, the European Commission has significantly increased R&D funding in this area.

There are today four main drivers for research and development for batteries. The first is the general regulatory pressure to reduce environmental exposure to hazardous substances. The second is the pressure to come up with an electric car, largely in response to environmental legislation to reduce air pollution in cities. The third is the European regulatory pressure to improve the collection and recyclability of batteries and the fourth is the desire to improve the "portability" of many electronic goods such as portable computers and personal digital assistants by increasing the performance of their batteries.

High efficiency, the ability to remain on standby in any state of charge and the choice of fast charging by change of electrolyte or by electric charging, makes the Vanadium battery an interesting

alternative to the lead/acid battery for both stationary and traction uses. A large battery of 200 kW/800 kWh is now undergoing tests in Japan. The supercapacitor is another new electricity storage system. Based on carbon electrodes, the double layers give it a high power density for a fast discharge. By adding a redox couple, the discharge time will increase and make the supercapacitor useful as a booster battery, e.g. for electric vehicles.

The bipolar lead/acid battery is an alternative lead/acid battery design with potential applications in electric and hybrid vehicles. It is designed for high discharge and charge currents during short periods (30 - 60sec). The concept is based on a partitioning wall made from thin porous ceramic plates, rendered conductive by electroplating lead into their pores. A lead foil is attached to the ceramic disk by electroplating and then transformed to active lead and lead dioxide. The bipolar battery will also function well as a starter battery with a weight only 1/3 that of an ordinary battery.

The Ni-Cd battery contains materials, in particular Cd, that are potentially hazardous. The OECD therefore recommends precautions being taken to reduce the risk from this type of battery, in particular effective collection and recycling schemes. Nevertheless, in spite of the proposed European ban, Ni-Cd will continue to be used for many years in Europe and also in countries like China and India, where the battery industry is expanding. Research into the kinetics of the cadmium electrode is therefore justified since more efficient electrodes will in the long run reduce the amount of cadmium required. Research into this battery system is also examining factors that shorten the life of the battery.

The nickel-metal hydride (Ni-MH) battery is a more environmental friendly system than Ni-Cd. MH-electrodes may gradually substitute for the cadmium ones. Ni-MH batteries for electric

vehicles still have problems to overcome: their cost will be higher than for Ni-Cd and their performance tends to deteriorate progressively during use.

Lithium (Li) based batteries (offering high drain discharge and low temperature utilization) are very promising for both portable equipment and electric vehicles. The most interesting properties of Li ion batteries in vehicle applications are the high specific energy and energy density that provide for current car ranges of up to about 200 km. An optimized complete battery system reaches 120 Wh/kg and 200 Wh/l.

As an example of results of the research into batteries, Japanese researchers have developed a battery for electric cars that triples the current capacity of the batteries and significantly reduces recharge time (El País, 1998). Along the same lines, tripling car battery voltage is being investigated as a way of decreasing hazardous emissions from cars propelled by internal combustion engines.

The maturity of battery R&D has been demonstrated by bibliometric analysis examining all battery-related publications appearing in 1998 listed on three on-line scientific databases (Pascal, Compendex and Derwent). From the 346 articles analysed, 65% of the collaborative work was between universities, 30% between universities and companies and the rest was between companies. These ratios are typical of a mature technology.

Analysing the words in the titles and keywords of the publications revealed the importance currently being given to research in lithium batteries. The word lithium (or words related to it) appeared eight times more than lead, nickel or cadmium. That figure reflects the R&D effort being dedicated to a very promising technology, not only in terms of efficiency but also in terms of



A variety of promising technologies are currently being investigated with a view to increasing power densities and eliminating the more toxic components

The structure of research into battery technology revealed by bibliometric analysis suggests the technology is maturing

About the authors**Miquel A. Aguado-Monsonet**

holds a doctorate in Chemical Engineering from the University of Barcelona and he won a Fulbright grant in 1990-91. After working as a professor of Chemical and Environment Engineering he started work at IPTS on projects related with renewable energies and is now in charge of the implementation of the IPPC Directive in the oil and gas refinery sector in Europe.

Laurent Bontoux

holds a diploma in Food engineering from ENSIA (France) and a PhD in environmental engineering from the University of California at Berkeley (USA). He is currently working in DG-XII at the European Commission. Previously he has worked at the IPTS as a scientific officer, and at Proctor & Gamble as a safety scientist. His expertise covers wastewater treatment, ecotoxicology, chemical safety, environmental management and waste management.

reducing battery weight. The bibliometric analysis also showed that a lot of effort is dedicated to adapting batteries to different types of use.

Conclusions

Electricity storage is the most attractive energy storage technology, but remains a major technological bottleneck. A breakthrough in this area would have a fundamental impact worldwide. First, it would dramatically decrease the considerable energy losses from classic energy sources (e.g. off-peak electricity) and second, it would give a boost to renewable energy, in particular intermittent sources such as sun and wind. This coupled effect would significantly reduce both CO₂ production and the need to rely on fossil fuels. Moreover, it would give a boost to the decentralized energy production and improve the prospects for progressive development in

countries lacking the financial resources for major infrastructure investments.

Among electricity storage technologies, batteries are particularly promising both because their technology can still benefit from development and because they have the potential to trigger a cascade of technological breakthroughs. For example, the current actual capacity of the best lead/acid batteries is still only 20% of the theoretical maximum. Recent developments in alternative battery technologies are promising.

This makes investing into R&D for batteries highly worthwhile and the recent increase in European R&D funding for battery research in the Fifth Framework Programme is a step in the right direction. The effort should lead to sustained until significant progress in battery technology. 

Keywords

batteries, electricity storage, Fifth Framework Programme

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Contacts

Miquel A. Aguado-Monsonet, Institute for Prospective Technological Studies (IPTS)

Tel.: +34 5 448 82 90, fax: +34 5 448 82 79, e-mail: miguel.aguado@jrc.es

Laurent Bontoux, European Commission DG-XII

Tel.: +32 2 299 13 63, fax: +32 2 296 43 22, e-mail: laurent.bontoux@dg12.cec.be

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IPTS - JRC - European Commission

W.T.C., Isla de la Cartuja s/n, E-41092, Sevilla, Spain

tel.: +34-95-448 82 97; fax: +34-95-448 82 93; e-mail: ipts_secr@jrc.es

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