Technology and Policy for Sustainable Development

Centre for Environment and Sustainability
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Preface

This paper on technology and policy for sustainable development was prepared for the European Commission on a request from the Environment Commissioner Margot Wallström to serve as a background for a Commission report to the EU Summit in Barcelona. A draft report was presented to the Commissioner on 11 January 2002.

The report is based on a number of research papers and contributions from the Göteborg University and Chalmers University of Technology, as well as official documents from the UN Commission on Sustainable Development, the World Bank, FAO, the OECD, the European Council, the EU Commission, the European Environment Agency in Copenhagen and the EU Commission Joint Research Center.

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Executive Summary

1. The mandate given by the European Council (Chapter 1).

At the European Council in Göteborg in June 2001 a strategy for sustainable development was agreed, completing the Union's political commitment to economic and social renewal by adding a third, environmental dimension to the Lisbon strategy and establishing a new approach to policy making. The European Council stated that clear and stable objectives for sustainable development will present significant economic opportunities. This *"has the potential to unleash a new wave of technological innovation and investment, generating growth and employment"*. The European Council invited industry to take part in the development and wider use of new environmental technologies in sectors such as energy and transport and in this way decouple economic growth from pressure on natural resources.

The Commission committed itself to present to the Spring European Council 2002 a report assessing how environment technology can promote growth and employment. This report, assessing how technology for sustainable development can promote growth and employment, is one contribution to the follow up by the Commission of the mandate from Göteborg European Council.

2. The role of technology for investment, growth and employment (Chapter 2).

The report takes the broad view of Agenda 21 on technology as a starting point. The integration of environment policy into a strategy for sustainable development and the broadening of the measures from regulations to more of market based instruments, leads by necessity to a situation where more and more of the technologies will be regarded as mainstream technologies, rather than regulation-driven eco-technologies. As a consequence of this choice of a broad definition of technology the report has the title "Technology and Policy for Sustainable Development".

The report confirms and elaborates on the main message from the Göteborg European Council that new technology offers a strong growth dividend, through investment in which new technologies are embedded. To attain a GDP growth rate of 3 per cent per year – in line with the Lisbon strategy - a rate of investment growth of about 4 to 6 per cent over several years seems necessary, which represents a significant acceleration from the 2 per cent average over the 1990s in the euro area. A higher rate of investment will create room for a faster replacement of old technologies. In addition, a strategy for sustainable development – including policies "to get prices right" – will make the introduction of new technologies more profitable and contribute to stimulate investment. Consequently, the EU strategy for sustainable development can both build on the macroeconomic efforts to stimulate investment and give a strong contribution to such an investment strategy.

3. The potential of new technologies for sustainable development (Chapter 3).

Technology is a double-edged sword. It is both a cause of many environmental problems and a key to solving them. It is a matter of fact that the technologies of the past, still dominating in transport, energy, industry and agriculture, are undermining our basic life supporting systems – clean water, fresh air and fertile soil. However, in each of these sectors there are new technologies available or emerging, that may, if widely used, essentially solve the

environmental problems. Thus, new technologies have the potential to contribute to a decoupling of economic growth from pressure on natural resources. The fact is that we face a choice between technological change at historically unprecedented rates or a change in atmospheric composition unlike any experienced since the dawn of humanity.

During the 1990s we have seen a substantial diffusion of renewable energy and transport technologies and further progress in industry and agriculture technology, not least biotechnology. The most promising for immediate investment is energy saving technologies in housing and the tertiary sector. A systematic introduction of best available technology could reduce the use of energy with 20-50 per cent. New technologies for waste management offers a great potential; the most recent investment in this sector shows a utilisation of more than 90 per cent of the energy content of waste. Even more fundamental are new technologies for "up-stream" resource management in industry, offering strong synergies for productivity in production, quality in goods and services and efficiency in the use of natural resources. In this way a dematerialisation can be brought about in a larger scale. In agriculture organic farming is increasing with 20 per cent a year, in spite of subsidies to traditional, non-sustainable farming methods.

Yet, in other cases the growth is not self-sustained. There are still significant obstacles to be overcome to reach the stage where the diffusion of renewable energy technologies is independent of government interventions and where these technologies have made a major inroad into the energy market. The extent to which more efficient technologies will be adopted by the market depends largely on the relative future price relations between different sources of energy, government policies to benchmark or to set standards for eco efficiency and voluntary commitments by industries. It is also of vital importance to consider consumer's preferences for eco efficient products as well as consumer protection.

4. EU policies of importance for new technology for sustainability (Chapter 4).

The European policy initiatives in the main policy areas are discussed in Chapter 4. Such policies can – if forcefully implemented by the Member States – have a strong effect on the demand for new technology in general and could give a strong push for investment. Of fundamental importance is the recommendation in the Broad Economic Policy Guidelines on a gradual but steady and credible change in the level and structure of tax rates until external costs are fully reflected in prices, to cope with the most fundamental structural problem in all developed countries, the unsustainable patters of production and consumption. There is a substantial scope for a rebalancing of prices, particularly on energy markets in favour of renewable energy sources and technologies by using both taxes and other market instruments. The implementation of the European Climate Change Programme (ECCP) and the directive establishing an EU framework for emissions trading will act as a strong driving force towards more sustainable price relations.

The setting of good environment standards to prevent the worst cases and measures to stimulate best practice, Integrated Product Policy (IPP), for the whole EU area will have a similar stimulating effect on investment in new technology. The European Single Market is the biggest market in the world for technology, and will become even more important through enlargement. The practices developed in this market will become global standards for all enterprises that wish to compete on this market. Thus, the integration of sustainable development in all policies, not least in research and development, can make the EU the

leading global actor in the renewal of products and processes, unleashing a new wave of technological innovation and investment, generating growth and employment.

This makes the Member States' sustainable development strategies, and a decisive implementation of these strategies, a matter of fundamental importance for growth and employment in the whole Community.

5. Enlargement and technology for sustainable development (Chapter 5).

The review of the situation in the candidate countries highlights the role of technology and investment as key to the EU strategy for sustainable development. Enlargement of the EU will create strong incentives for the candidate countries to speed up the modernisation process, phasing out old investment and technologies from the command and control period and phasing in the most recent technologies. The energy sector is the most prominent example, where the candidate countries need to increase their capacity substantially and, at the same time, replace old outdated plants with new eco-efficient technologies.

6. Policy conclusions (Chapter 6)

The integration of environment in the Lisbon strategy and the emphasis on new technology for sustainable development, agreed by the Göteborg European Council, will make the policies of each of the three pillars of the strategy mutually supportive:

- To attain a GDP growth rate of 3 per cent a year and to bring about a decoupling of economic growth from pressure on natural resources, a rate of investment growth of about 4 to 6 per cent seems necessary, increasing the investment share of GDP from around 20 per cent to 24-25 per cent.
- This higher rate of investment should be utilised to phase out old technology and phase in new technology, contributing to productivity, quality and eco-efficiency for health, prosperity and environment; to achieve these objective a forceful implementation of a strategy to "get prices right" is necessary to make the value of natural resources and eco-systems visible to the agents in the economy
- Economic growth and investment should be utilised to create more and better jobs and be made sustainable by policies, that facilitate participation in working life (see Guidelines for Member States Employment Policy 2002); in this way the EU should reach the employment rate of 70 per cent, agreed in the Lisbon strategy, making Member States' social protection systems, in particular their pension systems, more sustainable.

Content of the Report on Technology and policy for Sustainable Development

Chapter 1. The mandate given by the European Council.

At the European Council meeting in Lisbon in March 2000 the Union set itself the strategic goal to become the most competitive and dynamic knowledge-based economy in the world, capable of sustained economic growth with more and better jobs and greater social cohesion.

In June 2001 the Commission presented a Communication "A Sustainable Europe for a Better World: A European Union Strategy for Sustainable Development" to the European Council in Göteborg. The Commission emphasised that sustainable development offers the European Union a positive long-term vision of a society that is more prosperous and more just, and which promises cleaner, safer, healthier environment – a society which delivers a better quality of life for present and future generations.

In the Communication the Commission stated that decoupling environmental degradation and resource consumption from economic and social development requires a major reorientation of public and private investment towards new, environmentally-friendly technologies. Clear, stable, long-term objectives will shape expectations and create the conditions in which business have the confidence to invest in innovative solutions, and to create new, high quality jobs. The Commission proposed a strategy focused on a few priority areas, including investment in science and technology for the future.

- By promoting innovation, new technologies may be developed that use fewer natural resources, reduce pollution or risks to health and safety, and are cheaper than their predecessors.
- The EU and Member States should ensure that legislation does not hamper innovation or erect excessive non-market barriers to the dissemination and use of new technology.
- Public funding to support technological changes for sustainable development should focus on basic and applied research into safe and environmentally-benign technologies, and on benchmarking and demonstration projects to stimulate faster uptake of new, safer, cleaner technologies.
- Public procurement policies are an additional means to accelerate the spread of new technology.
- A "green purchasing initiative" from the private sector could similarly increase the use of environmentally-benign products and services.

On the basis of the Commission Communication the European Council agreed a strategy for sustainable development, completing the Union's political commitment to economic and social renewal by adding a third, environmental dimension to the Lisbon strategy and establishing a new approach to policy making. The European Council stated that clear and stable objectives for sustainable development will present significant economic opportunities. This has the potential to unleash a new wave of technological innovation and investment, generating growth and employment. The European Council invited industry to take part in the development and wider use of new environmental technologies in sectors such as energy and transport and in this way decouple economic growth from pressure on natural resources.

The Commission committed itself to present to the Spring European Council 2002 a report assessing how environment technology can promote growth and employment. The Göteborg Centre for Environment and Sustainability was invited by Commissioner Wallström to contribute to that report. A first version of this paper was presented to the Commissioner on 11 January as a background to the Commission report.

Chapter 2. The role of technology for investment, growth and employment.

The necessity to decouple economic growth from pressure on natural resources is now well understood. According to the OECD, the volume of world GDP is projected to expand by 75 per cent in the 1995-2020 period, with two thirds of this increase in the OECD countries. Over the same period world energy demand could increase by 57 per cent and motor vehicle kilometres travelled by around 80 per cent. On the demographic side, the global population, having tripled in the past 50 years, is expected to increase over the next 50 years by another 20-75 per cent, according to different UN assumptions on fertility and mortality rates – with much of this increase occurring in metropolitan areas of less-developed countries. Consumption patterns prevailing in the developed countries are already imposing a large burden on the global environment, through demand for food and other natural resources. The prospect of increased competition for scarce resources, and of greater pressures on the environment that would follow from the extension of these consumption patterns to the world population, underscores the importance of achieving more sustainable patterns of production and consumption world-wide.

- Human interference with the climate system is one area where de-coupling is particularly important.
- Similar concerns are justified by the rate at which water resources are being used and degraded. About one-third of the worlds population is estimated to be living in countries suffering medium-high to high water stress, and the proportion is projected to double by 2025.
- Degradation of fertile soil is a third area of deep concern; 40 per cent of the world's fertile soils are seriously degraded.

Negative environmental trends are imposing a large burden on the well being of today's generation because of their impact on human health. Environmental damage may already be responsible for 2 to 6 per cent of the total burden of disease in OECD countries and for 8 to 13 per cent in non-OECD countries. Furthermore, these trends are compromising the ability of nature to support future well-being. The emerging understanding of the economic, environmental and social consequences of these trends has led to a search for a major reorientation of public and private investment towards new, environmentally-friendly technologies.

2.1. The concept of technology for sustainable development

The starting point for this report is the broad definition of technology of Agenda 21. Technologies are embedded in investment and every investment decision includes a choice between more or less sustainable technologies, regardless of whether these technologies are labelled environment technologies (technologies, whose main drivers are environmental regulation) or mainstream technologies.

The integration of environment policy into a strategy for sustainable development and the broadening of the measures from regulations to more of market based instruments, as agreed by the European Council in Göteborg, leads by necessity to a situation where more and more of the technologies will be regarded as mainstream technologies. Therefore, this report takes the emerging integration of economic and environmental objectives as a starting point, and

analyse technology from the point of view of sustainable development. The purpose is to identify "the potential to unleash a new wave of technological innovation and investment, generating growth and employment". In macroeconomic terms all investment, about 20 per cent of GDP, represents a potential in a strategy for sustainable development, a potential far greater than the 1,6 per cent of GDP, represented by the eco-industries. Furthermore, a great deal of private and public consumption, amounting to 80 per cent of GDP, includes technological elements and choices of great importance for a sustainable development. Technological change is not only a question of investment choices. It is of equal importance to understand consumption patterns as a vehicle for change; this is clearly evident in the residential and transportation sectors. As a consequence of this choice of a broad definition of technology the report has the title "Technology and Policy for Sustainable Development".

2.2. Question number 1: What is the role of technology for investment, economic growth and employment?

A first question, arising from the mandate from the Göteborg European Council, is about the role of technology for investment, growth and employment. Investment plays a crucial role both on the demand side and the supply side of the economy. Gross fixed capital formation only accounts for about 20 per cent of GDP. It is, however, together with inventories, the most volatile component of domestic demand and therefore a key element of business cycle fluctuations. In a more medium to long-term perspective, gross fixed capital formation is a main determinant of the economy's supply potential. There are basically three channels through which investment affects the economy's supply side: firstly, it determines the size and the composition of the capital stock; secondly, it improves the diffusion of technological progress; and thirdly, it facilitates employment growth.

There is both a need and a scope to improve the investment environment in the EU to achieve an economic performance in line with economic and social strategy, agreed in Lisbon and confirmed and expanded in Göteborg to a strategy for sustainable development. To attain a growth rate of 3 per cent a rate of investment growth of about 4 to 6 per cent per year over several years seems necessary, which represents a significant acceleration from the 2 per cent average over the 1990s, as stated in the EU Economy Review 2001 (Chapter 3: Determinants and benefits of investment in the Euro area). The share of investment in GDP progressed steadily between 1997 and 2000 but, in the latter year, the investment-to-GDP ratio was still below its peak in the late 1980s.

In the standard neo-classical growth model, the main driver of growth is technical progress. Changes in GDP are related to changes in labour, the capital stock and a residual, called total factor productivity (TFP), measuring technological progress. Despite a deceleration in the 1990s technological progress remains the single largest contributor to GDP growth in the euro area. More recent models (vintage models) rest on the assumption that technical progress is partly embodied in physical capital. In this context, investment affects GDP not only through its direct impact on capital stock, but also through the indirect impact of the capital stock on total factor productivity (TFP). A younger capital stock is associated with faster change in technology. Hence, investment makes a more substantial contribution to the growth process, according to these models compared with the neo-classical models. There are also a significant amount of empirical evidence on the link between investment and employment; an increase of the capital stock increases the demand for labour, allowing for higher wages and higher employment levels. A recent empirical study, carried out for the EU Commission,

identifies a causal link from investment to employment and concludes that "a policy that encourages investment is good for both wages and employment"

2.3. Question number 2: How to decouple economic growth from pressure on natural resources?

However, economic growth has been strongly related to growing environmental problems. This is the consequence of the technological choices and investment made in the past, for example the heavy dependency of fossil fuel for the energy and transport or the extensive use of pesticides in agriculture.

This leads to the second question in the mandate from Göteborg, how to decouple economic growth from pressure on natural resources, a central element of the EU strategy for sustainable development. The concept of decoupling, as used by the OECD, refers to relative growth rates of an environmentally relevant variable and an economically relevant variable to which it is causally linked. Decoupling of environmental degradation from economic growth occurs when the growth rate of the environmentally relevant variable is less than the growth rate of GDP, over a given period.

If the GDP displays positive growth, "strong decoupling" is said to occur when the growth rate of environmentally relevant variable is zero or negative. "Weak decoupling" is said to occur when the growth rate of the environmentally relevant variable is positive, but less than the growth rate of GDP. According to the OECD, the member countries have seen a strong decoupling of the emissions of several local air pollutants, ozone-depleting CFSs and lead emission from petrol from economic growth. Emission of the latter two substances were almost eliminated despite continuing increase in the production and use of the products, refrigerators and petrol, which traditionally resulted in such emission. Weak decoupling is more common, with most OECD countries realising some level of weak decoupling for energy, water and resource use in recent decades. Although total energy use in OECD countries grew by 17 per cent between 1980 and 1998 the energy intensity of economic activity went down by 16 per cent of the same period. For some other factors not even a weak decoupling is yet evident.

Decoupling may result from one or a combination of different factors, including changes in consumption and production patterns as a result of environmental policy, including by forcing the pace of technological change. For instance, the decoupling of the emission of certain pollutants from GDP often results from decoupling these pollutants from production, consumption and disposal of goods and services in total output. Sometimes such decoupling may be the result of spontaneous changes in the economy of technical changes. Typically, however, it is necessary to use fairly strong policy instruments to achieve decoupling.

The Commission has in its communication on the integration of environmental issues with economic policy (COM (2000) 576) argued that there is no inherent contradiction between economic growth and the maintenance of an acceptable level of environmental quality. Indeed, economic growth typically enables societies to provide their members with a cleaner, healthier environment. Accordingly, the issue should not be seen as one of economic growth versus the environment, but rather of how improvements in living standards can be accompanied by the safeguarding and improvement of the quality of the environment. Moreover, improving integration should be beneficial for both environment and economic

policy. “Greening” fiscal policy, by removing subsidies to environmental harmful activities for example, should enhance economic efficiency.

There are several ways of moving our economies onto a sustainable path and these may be used, separately or in combination:

- **dematerialisation**, which means less material/energy flow to achieve a certain service (reducing the flow) or increased recycling of materials (closing the flow).
- **transmaterialisation,** which means substituting less harmful and/or scarce materials for scarcer and/or more hazardous materials or by substituting light materials for heavier ones, which is especially important in moving applications, as it saves energy, or end of pipe solutions, e.g, catalytic converters, scrubbers or CO_2 sequestration.
- **changing consumption patters,** where other services/activities with a much lower resource intensity are demanded

These ways are needed and they imply changes, in technology, in price relations, in public policies and in consumer behaviour. These changes are an essential part of achieving the EU goal of making the Community the world’s most competitive and dynamic knowledge based economy – and the most responsible society.

2.4. The “bottom line”: every investment decision is a choice between more or less sustainable technology

The Agenda 21 approach to environment technology, which has been chosen as a starting point for this report, is based on the understanding that every investment decision is a choice between more or less sustainable technologies, even a decision to postpone investment includes such a choice; a strategy for sustainable development is a way to gradually establish a new balance between old physical capital, the investment of the past, and natural resources. Thus, a successful strategy for sustainable development has to be an investment strategy, where the continuous turnover of the existing capital stock should be seen as an opportunity to phase out old technologies and phase in new environmental friendly technologies.

Every consumer, producer and investor has a responsibility for making choices, which contribute to more, rather than less environmental sustainable technologies, not least actors in the financial markets have to take a more long term perspective on investment and sustainability. However, the main responsibility rests upon governments and public policy makers to create the framework conditions needed for a change of technology to more sustainable patterns of production and consumption.

Because markets for many environmental goods and services are either missing or incomplete, producers and consumers receive misleading price signals. “Getting the prices right”- i.e. action to improve the working of such markets, where they exists, or to create markets when they do not – will be an important part of a strategy to integrate economic, social and environmental objectives and to stimulate the introduction of new technology. That includes the reduction and abolishing of state subsidies to environmental disturbing production, a rebalancing of taxes between labour and natural resources etc. By placing a price on pollution through the imposition of pollution taxes or charges, governments can reduce or eliminate the gap between the private costs of the activity, which generates the pollution and the degradation of natural resources. In contrast to pollution charges, which fix

a price for pollution but leave the quantity uncertain, tradable permits determine the quantity of pollution and allow market forces to set its price.

Although not strictly an economic instrument, clear and reliable information can substantially improve the effectiveness of economic instruments as a means of integrating environmental concerns with economic policy. The EU strategy need to use information on new technologies and on the long-term orientation of public policies to give consumers, producers and investors of today a better understanding of the price relations of tomorrow and the long-term profitability of investment for sustainability. Indicators to measure decoupling of environmental pressure from economic growth is one necessary element of strategic information. The establishment of an integrated system for business account, for example The Global Reporting Initiative ("the triple bottom line") is another way of using information to bring about change in the patterns of production and consumption.

2.5. A Global Deal: transfer of technology for sustainable development

One of the crucial questions in the run up to the World Summit for Sustainable Development in 2002 is the fight against poverty, bridging of the widening economic and social gap between rich and poor countries. This is a question on economic and social sustainability. A successful strategy for such a bridging requires both the generation of jobs for an additional half a billion people in working age in the next 10-15 years, of which 97 per cent are living in developing countries, and the improvement of income for another half a billion people, now living in extreme poverty, "the working poor".

One challenge in bridging the gap between rich and poor is to enable developing countries to have a strong growth, which requires a strong growth in investment and the implementation of productivity generating technologies. The other challenge is to enable developing countries to "leap frog" from traditional, polluting production to a more technologically advanced production, and into environmentally viable economic growth.

In a UN report on the implementation of Agenda 21 the organisation concludes that the transfer of cleaner technologies is largely a business-to-business operation, and technologies are constantly being transferred through foreign direct investment (FDI), trade and other business transactions. The main sources of FDI are large transnational corporations from developed countries with strong research and development efforts. The work of the United Nations Conference on Trade and Development in this area has contributed to integrating sustainable development into FDI and the activities of transnational corporations.

The transfer of cleaner technologies to developing countries has been most effective, according to the UN report, when it has been driven by demand from enterprises in those countries. The demand depends to a large extent on national policies for sustainable development. In general, countries with strong environmental policies have benefited from more technology transfer and more rapid economic growth than countries with weak environmental policies.

2.6. Conclusions: a strategy for sustainable development offers a strong growth dividend

To attain a GDP growth rate of 3 per cent a year in the EU – in line with the Lisbon strategy - a rate of investment growth of about 4 to 6 per cent over several years seems necessary, which

represents a significant acceleration from the 2 per cent average over the 1990s in the euro area. The replacement of old technologies with new more sustainable forms of technology offers a strong growth dividend, through the investment in which new technologies are embedded. A higher rate of investment will create room for a faster replacement of old technologies. In addition a strategy for sustainable development – including a forceful policy to get prices right – will make the introduction of new technologies more profitable and contribute to stimulate investment and economic growth.

Thus, the EU strategy for sustainable development can both build on the macroeconomic efforts to stimulate investment and give a strong contribution to such an investment strategy. In Chapter 3 the potential of new technologies are presented and in chapter 4 EU policies of importance for technological development are discussed.

3. The potential of new technology for sustainable development

Technology is a double-edged sword. It is both a cause of many environmental problems and a key to solving them. It is a matter of fact that the technologies of the past, still dominating in transport, energy, industry and agriculture, are undermining our basic life supporting systems – clean water, fresh air and fertile soil.

However, in each of these sectors there are new technologies available or emerging, that may not only slightly reduce the environmental impacts. They may, if widely used, essentially solve the environmental problems we are confronting. Thus, new technologies have the potential to contribute to a decoupling of economic growth from pressure on natural resources. The fact is that we face a choice between technological change at historically unprecedented rates or a change in atmospheric composition unlike any experienced since the dawn of humanity.

One example can better than anything else illustrate the importance of technological choices. The solar influx to Earth is roughly 10.000 times larger than the total global energy use. In spite of the availability of such an abundant renewable energy resource the dominant resource for electricity, heating and mobility is fossil, non-renewable and heavy polluting fuels. While fossil fuels provide 80 per cent of the global commercial energy supply, solar energy only provides a fraction of a per cent. The reason for this heavy dependency on a non-sustainable energy resource is that much more investment has been made over many years in research and development and in the implementation and maintenance of fossil technology systems than in solar technology systems. The cost of electricity from solar energy, for example via photovoltaic cells (PV) is still too high to compete with more conventional electricity sources.

This chapter presents for each of the four sectors mentioned above – energy, transport, agriculture and industry - the environmental state of play and a number of promising technologies to cope with the existing problems. To get a breakthrough for such technologies for sustainable development there is an urgent need for public policies to improve economic incentives ("getting prices right"), legal frameworks and infrastructures. How EU and national policies can contribute to a new technological paradigm will be discussed in Chapter 4.

3.1. New technologies for sustainable energy conversion, conservation and use

The energy sector constitutes a fundamental element of industrial economies and supports all economic activities. Economic growth is strongly linked to increased energy consumption. However, there has been a consistent decline in energy intensity, i.e. energy use divided by GDP, over the past fifty years in many countries, but this decline was much faster following the oil crises in 1973 and 1979. Since the middle of the 1980s, when energy prices fell, energy intensity has continued to fall, albeit at a slower rate. However, the link between growth in GDP and increased energy use has not been broken.

Global energy use has risen nearly 70 per cent since 1971 and is poised to continue its steady increase over the next several decades. The main problem is not the use of energy but the fact that the main source of energy is fossil fuels with serious effects on the air, the atmosphere and the climate. Such fuels supply roughly 80 per cent of the world's commercial energy and energy related emissions account for more than 80 per cent of the carbon dioxide released into the atmosphere each year. According to the IEA, by 2010 global energy consumption - and

annual CO_2 emissions – will have risen by almost 50 per cent from 1993. Policies to promote greater energy efficiency, including new technologies with an effect on supply as well as on demand for energy, could curb this rate of growth significantly.

One of the main roads to sustainable development is a reduction of demand for energy through implementation of better technologies in the residential and tertiary sectors (3.1.1), in transport (3.2) and in industry (3.3). The other main road is a decisive shift from fossil fuel to renewable fuels (3.1.2 – 3.1.5). A third option is decarbonisation of fossil fuel (3.1.6).

3.1.1. Energy conservation technologies

With 40,7 per cent of total energy demand in the EU the residential and tertiary sectors are the largest overall end users, mainly for heating, lightning, appliances and equipment. As regards energy in buildings a savings potential of around 22 per cent of present consumption is estimated to exist and can be realised by the year 2010. This figure has been based on the assumption of a normal rate of retrofitting and rehabilitation for existing buildings, a net increase in the buildings stock of around 1,5 per cent a year and a successively increasing share in the use of best available technologies in buildings. Given the low turn-over rate of buildings (lifetime of 50 to more than 100 years) it is clear that the largest potential for improving energy performance in the short and medium term is in the existing stock of buildings, notably in the 150 million residential dwellings in the 15 EU Member States. Thermal insulation and glazing technology still offer a potential for improvement in many Member States, as well as water heating systems. Furthermore, it is estimated that taking full account of existing bioclimatical or ecological dimension when designing and locating buildings can reduce energy requirements significantly over the lifetime of a building. In certain cases, buildings which already meet high thermal insultation standards can reduce energy demand by up to 60 per cent by using existing best technology.

These general observations are confirmed by practical examples from the construction of dwellings and offices. According to an international construction firm working in several EU Member States, a reduction of the use of energy of around 20 per cent is possible in existing office buildings and of almost 50 per cent in new buildings. Based on these experiences emission of greenhouse gases from buildings could be reduced by 20-25 per cent in the next 10-20 years. Another example of new energy management system is houses without heating systems; the traditional system has been replaced by heat exchanger, through which supply air is heated by the exhaust air, and by solar collectors for the heating of water. Building costs are estimated to be normal and the extra measures in the form of greater air tightness and insulation, solar collectors and heat recovery in the ventilation are paid for by the much lower costs of heating system and the saving in energy costs.

It is obvious that the rebuilding of existing houses and the building of new houses with the most recent technologies offer a great potential for low energy housing and for good energy economy. At the same time, such an activity on a broad front will play an important role for economic growth and employment.

3.1.2. Renewable energy: biomass (11 per cent of global energy supply)

In most global energy scenarios, which meet stringent CO_2-constraints, bio energy is assumed to be the dominating new energy source, displacing fossil fuels and associated CO_2 emissions.

In the EU total bio energy capacity was approximately 520 TWh, a capacity, which is expected to grow by almost 9 per cent a year.

Biomass sources include agriculture residues (bagasse, straw, etc.) forestry residues and energy crops, i.e. crops harvested primarily for their energy content (eucalyptus, willow). However, combustion of biomass does release CO_2, but if the forests are replanted then biomass is a CO2 neutral energy source since the same amount of CO_2 that was released is eventually captured. For this reason bioenergy is generally a CO_2 neutral energy source.

Biomass is increasingly being used in combined heat and power production and more advanced technical solutions based on gasification are being developed and tested for this purpose. For households a whole new system based on a set of complementary technologies is currently evolving. Biomass plays a significant role in the transport sector in some countries, notably in Brazil. Among EU Member States Sweden, Austria and Finland have leading positions; in Sweden the use of biomass has increased substantially in Sweden following the introduction of a carbon tax in the early 1990s.

For biomass to play a major role in the future energy system a more systematic use of residues and in particular the expansion of short rotating energy crops are needed. Land availability is a major limiting factor when estimating bio energy supply potential. Some analysts are concerned that there will be an increasing competition for land between food and energy crops. An improved understanding of how bio energy crops cultivation will interact with food production is warranted.

The wood raw material used in the pulp and paper industry is a sustainable biomass resource provided proper forest management is implemented. The biomass is processed to pulp, paper and chemical by-products, as well as biofuel for energy conversion.

More than 90% of the energy requirement in a typical pulp mill can be supplied by incineration of internally produced biofuel. Next generation pulp mills will be net producers of energy using only biofuel and today's best available technology. In Sweden, the net production potential is estimated to 12-15 TWh electricity annually. By-products from harvesting the forest can also be used as biofuel directly or converted into other forms of biofuel like e.g. ethanol.

The biofuel produces only negligible emission of sulphur compared to fossil fuel and the carbon dioxide released in the combustion forms an integral part of the natural carbon cycle. Proper forest management provides a potential for the industry to be a net sink of carbon dioxide. In Sweden, the growing forest binds more carbon dioxide than the total quantity emitted by the Swedish forest industry, transportation included.

The final paper product can be recycled or used as a renewable energy source, reducing the amount of municipal waste. In Western Europe, the use of recycled paper as a percentage of total paper production was 43% in 1997. Paper can be used directly for energy conversion or further processed to e.g. ethanol. The municipal waste incineration process typically requires a sufficient amount of paper in order to work properly.

Regulatory control has reduced the emissions from the pulp and paper industry significantly over the last 30 years. Reductions of more than 90% have been reported for emissions to air and water. Implementation of closed-circuit water systems reduces the water consumption and

the environmental impact of the process. The closed section of the process has been gradually extended over the years. This allows for up to 90% of the wash water to return to the recovery cycle for evaporation and incineration. In the recovery process about 97% of the cooking chemicals can be recovered and used again. In combination with a high degree of energy self-sufficiency, this provides for an industry with a high degree of eco-efficiency.

3.1.3. Renewable energy: hydropower (2 per cent of global energy supply)

The potential for hydropower depends on economic, technical, social and environmental considerations. The technical potential for hydroelectricity has been estimated to be 7-8 times the present one, and the long term economic potential my be in the order of 2-3 times the present one. Most of this potential is in Russia and in developing countries.

3.1.4. Renewable energy: solar energy

There is a huge physical potential for solar energy. The influx of solar energy to typical sunny places such as Sahara or southern USA can be as much as 2500 kWh per square meter per year. Even in northern European regions, such as Scandinavia, the average influx is 1000 kWh per square meter per year.

Solar thermal technologies using collector arrays for heat purposes have been growing fast during the 1990s in Europe, USA and Japan. It is regarded as a fairly mature technology but some developments are taking place with respect to material technology and design. The main bottlenecks for a massive diffusion are a lack of standards, absence of scale economies, inadequate attention given to design for manufacturability etc. However, projects are under way, through which customers collaborate to overcome these obstacles.

Solar photovoltaic technology, PV, is still a marginal source of energy with a world production of PV modules of about 270 MW in the year 2000. The cost of electricity from photovoltaic cells is still too high to compete with more conventional electricity sources. There are nevertheless niche markets, mainly off-grid applications, where PV technologies thrive. During the 1990s annual sales of PV cells have increased by 30 per cent per year. Current market growth is mainly driven by public initiatives to support building integrated PV, in Japan, Germany and in the US. The market growth has also enabled substantial learning and technology developments in the PV industry, which in turn has led to a reduction in the cost of PV cells. The progress ratio, i.e. the decline in cost for each doubling of accumulative production, has been estimated at roughly 20 per cent. Further cost reduction will open up new markets, i.e. grid support, and this may enable additional cost reductions. In addition, and important for world wide sustainability, PV gives a unique opportunity for rural electrification in many developing countries.

3.1.5. Renewable energy: wind energy

Wind is by now in many places the cheapest electricity generation technology, next to natural gas, when new capacity is to be added to the grid. This explains the high growth rates in installed wind electricity generating capacity, plus 21 per cent per year, and a total capacity of roughly 14.000 MW. This is an order of magnitude larger than of PV and probably the fastest growing renewable energy source in the world. Among the EU Member States both Germany and Denmark have had a significant growth in the use of wind power. The wind turbine industry has since its inception been dominated by Danish firms, which currently supply

about 44 per cent of the world sales. German firms take the biggest share of the rest of the market. The cost of electricity from wind power is much lower than that of PV. Today wind power is often subsidised but it is approaching a cost level that makes it economically attractive compared to established energy production methods, assuming good wind conditions. If the growth in wind generating capacity is maintained, wind will approach 2000 TWh of electricity per year by 2020 and become as important as nuclear energy today, about 7 per cent. At this adoption rate, intermittency considerations must be made, and it is unlikely that wind could penetrate even more without storage systems, such as hydrogen production via electrolysis.

3.1.6. Cleaning technology: decarbonisation of fossil fuels and biomass

The technologies mentioned above are different alternatives to combustion of fossil fuels. From time to time, the prospect of separating the carbon dioxide from the flue gases, and thereby creating a more environmentally sustainable energy production, has been discussed. This way of reducing the emissions of carbon dioxide, has hitherto not been considered as realistic, partly due to the lack of storage possibilities for the captured carbon dioxide. However, lately this has been reconsidered. During the last five years, one million tons of carbon dioxide per year has been stored in the Sleipner gas fields, in the North Sea, coming from the cleaning procedure of natural gas. The carbon dioxide is stored one thousand meters below the ocean bottom in a so called aquifer. This is considered as a safe storage, and thereby environmentally sound. Looking at the potential , it has been estimated that, in the Utsira aquifer below the North Sea, it would be possible to store an amount of carbon dioxide corresponding to the emissions from all power plants in Europe during several hundred years. In addition, there are several more storage possibilities in Europe besides the Sleipner field. In an ongoing research project, supported by the Commission, suitable storage places in Denmark, Germany, Belgium, Netherlands, France, Great Britain, Greece and Norway are investigated.

Another alternative could be to store the carbon dioxide in the ocean at a depth of at least 3000 meters, at which even pure carbon dioxide is heavier than water and will thus stay close to the bottom. To use empty oil and gas fields, as well as deep coal layers are other possibilities. More research is needed in order to fully understand the environmental implications, before these methods of carbon dioxide storage could be applied on a broader scale. All mentioned ways of storage are relatively cheap. The cost is estimated to a few euros per ton carbon dioxide. In conclusion, there are sufficient storage possibilities and the costs are quite reasonable.

On the other hand, the cost for removal of carbon dioxide from flue gases is around 30-50 euros per ton carbon dioxide, leading to an extra 0.015 – 0.025 euros per kWh electricity. This means that the cost to produce electricity by combustion of fossil fuels with carbon dioxide removal is of the same order as for combustion of biomass or wind-power, and substantially lower than for solar energy. The vast amounts of fossil fuels available on earth is an advantage compared to the biomass and wind-power alternatives that is often limited by the shortage of land.

The potential of storing carbon dioxide seems to be very large, at least for Europe. Carbon dioxide removal technologies could therefore, at least during a transition stage, be an important complement to other measures for reducing carbon dioxide emissions.

Finally it should also be noted that carbon sequestration may also be employed on biomass. If biomass is used to produce hydrogen, heat or electricity, all the carbon in the biomass could be captured as carbon dioxide and permanently stored under ground. If methanol, ethanol or DME is produced, parts of the carbon dioxide could be captured in the conversion process, since roughly only half the carbon stays in the produced fuel. Combustion of biomass would, under these conditions, not only be carbon dioxide neutral, but it would also result in a continuous removal of carbon dioxide from the atmosphere, and at the same time providing society with a fairly clean energy source.

3.2. New technologies for sustainable transport

Providing people and enterprises with good transport services is a prerequisite for continued economic prosperity. Today's transport systems allow more people than ever to move around with relative ease at affordable prices. However, current patterns of transportation are, according to the UN Division for Sustainable Development, not sustainable and may compound both environmental and health problems. Transportation of all types already accounts for more than one quarter of the world's commercial energy use; in the EU Member States the share is higher, 31 per cent. Motor vehicles account for nearly 80 per cent of all transport related energy. Vehicles are major source of urban air pollution and green house emissions. Currently, the transport sector is practically 100 per cent dependent on oil and consumes about half of the world's oil production, the bulk of it as motor fuel.

That makes the rapid increase in the global transport sector, particularly the world's vehicle fleet a real concern. Energy and carbon dioxide efficiency (i.e. energy use per passenger and per freight transport unit) has shown little or no improvement since the early 1970s. The increasing use of heavier and more powerful vehicles — together with decreasing occupancy rates and load factors — has outweighed increases in vehicle energy efficiency due to technological advances. As a result, growing transport volumes led to about a 14 % increase in energy consumption and a 12 % increase in carbon dioxide emissions between 1990 and 1996. According to the European Environment Agency (EEA), transport is expected to be the largest single contributor to EU greenhouse gas emissions. EEA recommends that policies should now focus on demand-management measures to curb growing transport volumes together with technical efficiency improvements.

The alarming greenhouse gas perspective has led the industry to seek new more sustainable ways of meeting the need of good transport service. A report from the World Business Council for Sustainable Development, representing the big majority of automobile industries, delivers a strong recommendation to the industry to change technology to *"drastically reduce carbon emissions from the transportation sector, which may require phasing carbon out of transportation fuels by transition from petroleum based fuels to a portfolio of other energy sources"* (WBCSD: Mobility 2001).

Three different technologies to promote sustainable development in the transport sector will be addressed in this report. The first one is Alternative Fuel Vehicles (AFV), the second one is Advanced Technology Vehicles (ATV), and the third is Intelligent Transport Systems (ITS).

3.2.1. Alternative fuel vehicles (AFV)

Alternative fuels are being used today in place of gasoline and diesel fuel made from petroleum e.g. biodiesel, electricity, ethanol, hydrogen, methanol, natural gas, propane. Penetration of any new transport technology is fundamentally dependent on broad availability of the fuel.

Establishing an area, covering fuel supply systems, might be expensive and only justified if there is a sufficiently high demand. As the Commission concluded in its Communication on alternative fuels for road transportation, COM(2001)547, this "chicken and egg situation" makes any take-off difficult.

In this report three transport fuel technologies will be discussed, namely biofuels, natural gas and hydrogen, that could each be developed up to the level of 5 per cent or more of the total automotive fuel market by 2020.

Biofuels. Ever since the first oil crises in 1973 particular attention has been given to the potential of using biomass as the basis for production of alternative motor vehicle fuel (diesel or gasoline). In principle biofuels offer an ideal alternative since they are practically 100 per cent CO_2 neutral and might be domestically grown (see 3.1.2) . On the other hand, biofuels are expensive. It would take an oil price around 70 euros/barrel, against the present level of about 20 euros/barrel, to make biofuels break even with conventional diesel and gasoline. Present consumption of biofuels is still below 0,5 per cent of overall diesel and gasoline consumption, mainly in captive fleets that operate on pure biofuels, and supported through different tax exemption schemes. In the short and medium biofuels have a good potential, as they can be used in the existing vehicles and distribution systems without expensive infrastructure investment. On the other hand, it has been argued that biomass, being a scarce resource, might be more cost- and eco-effectively used in other sectors, e.g. for heat and process heat.

Natural gas consists primarily of methane (CH_4), a lighter-than-air gas, used in compressed or liquefied form, as an alternative to gasoline for fuelling in a conventional gasoline engine. It requires special storage and injection equipment and large-scale use of natural gas as a motor fuel would have to be based on cars specially built for natural gas rather than on retrofitting existing gasoline vehicles. The technology is fully developed and proven. In Italy 300 000 vehicles run on natural gas provided through a network of 300 refuelling points. In addition 50 000 more vehicles throughout Europe operate on natural gas, normally in a limited geographical area and refuel at one or a few dedicated points. Natural gas has great potential as a motor fuel. It is cheap, has a high octane number, is clean and has no problem in meeting existing and future emission standards. However, methane is a powerful greenhouse gas. The CO_2 advantage over gasoline would disappear with just a few percentage point losses of methane during distribution, storage and refuelling. Experience from existing fleets indicates that the real CO_2 advantage is 15-20 per cent rather than the theoretical 20-25 per cent. Establishing a sufficient infrastructure for areas covering natural gas supply for motor vehicles will be moderately costly, benefiting from the existing natural gas distribution system throughout the EU. A recent study proposes an additional 1450 refuelling stations in order to create a proper EU refuelling network at a total investment of around 800 million euros.

Hydrogen has been the subject of intensive research as a potential fuel for motor vehicles during recent years. Hydrogen used in fuel cells has one emission, water, and it is therefore very attractive. However, it is important to remember that hydrogen is not an energy source but an energy carrier. Any generation of hydrogen requires sources of energy in the same way as any other major energy carrier, for instance electricity.

The advantage of using hydrogen as a fuel depends on how hydrogen is produced. If produced with coal it gives rise to CO_2 emissions. If produced by non fossil fuel it reduces CO_2 emissions, to zero or very low levels. Furthermore, hydrogen has the advantage of allowing generation from any imaginable source of energy and of allowing storage over time.

Large-scale production of hydrogen from natural gas or from electricity via electrolysis are fully developed industrial processes. World production of hydrogen is substantial, about 40 million tons a year. The technology presently used for production of hydrogen causes big emissions of CO_2. However, it is possible to produce hydrogen from fossil fuels in a process, through which CO_2 is separated from hydrogen and stored.

As regards distribution, pipeline distribution of hydrogen is a well-proven technology. The establishment of a broad distribution network is only dependent on a sufficiently large customer base. Until such point in time distribution via tanks to filling stations seems a more likely alternative. Storage of sufficient quantities of fuel in the car is another problem. Because hydrogen has only 30 per cent of the energy content of natural gas on a volumetric basis and hydrogen requires larger storage volumes.

Further progress in hydrogen and fuel cell related technologies could emerge from the heavy RTD investment by the car industry and the EU. For the time being a large scale demonstration project with 30 hydrogen-powered buses is run in 10 cities throughout Europe to gain practical experience in this new technology. Hydrogen is the most challenging alternative to the conventional gasoline or diesel powered car and it is widely assumed that hydrogen as a motor fuel will still take a number of years to take off on a full commercial scale.

3.2.2. Advanced technology vehicles (ATV)

Electric cars have been commercially available for a number of years but have not managed to attract much consumer interest. The size and cost of the batteries relative to traditional cars, seem prohibitive for producing a car of sufficient size, power and range between recharging at a price that the buyer would be willing to pay. Electric cars may still have a niche market for short-distance transport purposes.

More attention is given to the hybrid car, or hybrid electric vehicle (HEV). Such vehicles are based on “a flexible platform”, taking advantage of the best elements of the gasoline engine and of the electric car, while at the same time avoiding their disadvantages. A hybrid car has two engines, a combustion engine and an electric motor. The electric power is supplied to the electric motor from an energy storage device, a battery. Hybrid cars can make use of regenerative braking, in which the electric motor captures energy that would normally be lost as heat during braking and acts as a generator to convert the energy to electricity, which is stored in the battery for future use. Depending on the driving circumstances the car automatically switches to the most efficient mode. All the major automobile manufacturers

are developing gasoline-electric hybrid vehicles for a small but growing market. Until now the hybrid cars on the market have been heavily subsidised.

Fuel savings depends on the circumstances under which the car is used. A 30 per cent reduction in fuel consumption is achievable in urban traffic with frequent breaking and acceleration. However, a hybrid car, constant driven at high speed, does not seem to offer any major fuel efficiency gains compared to a traditional car.

Even further advances in technology includes the use of fuel cells, where zero emissions might be achieved in combination with substantially higher energy efficiency rates.

3.2.3. Intelligent Transport Systems (ITS)

More sustainable transport can be achieved through the use of information technology for the management of transports, so called Intelligent Transport Systems (ITS). A basic element in a future European transport system is GALILEO, the civil satellite positioning and navigation system, including 30 satellites, placed in orbit at an altitude of around 2000 kilometres and monitored by a network of ground control stations to ensure world wide coverage. It will contribute to the development of a wide range of applications across all transport modes through its highly precise positioning capability and improve the balance between different transport modes.

The introduction of the European Railway Traffic Management System (ERTMS) will enable locomotives to cross Europe using a single control and command system, instead of the 11 different systems existing today in Europe. This will contribute to make the railway system more competitive, which is necessary to improve the modal split between road and rail. Compared to the US the EU has a huge potential in such a move; road freight transport in the EU now accounts for 43 per cent of total tonne-kilometres and 80 per cent of total tonnes transported, a much higher rate than in the US, where rail plays a more important role.

The development of short-sea shipping will be fostered by the deployment of tracking and tracing systems, particularly regarding simplification of customs and immigration procedures in the context of the single market. In air transport priority is given to the creation of a single European sky to ensure efficient traffic management and more optimal and fuel saving flight paths. ITS for road traffic management are already in operation in many places throughout Europe. The next step is to further develop these systems on a pan-European basis.

3.3. Technology for sustainable industrial production

The manufacturing industry covers a broad spectrum of manufacturing and processing activities whose products range from raw materials to consumer goods. The many pollutant emissions from industry have traditionally been subject to regulatory control. Existing policies have succeeded in reducing emissions of the main pollutants. Based on energy consumption and selected air emission data, industrial eco-efficiency in the EU appears to have improved slightly during the last decade, according to the European Environment Agency. Although statistics suggests a positive trend in eco-efficiency, they mask diverging trends between individual Member States. In addition, the pollutants are particularly characteristic of heavy industries such as iron and steel, petroleum refining, pulp and paper, and organic chemicals. In spite of these improvements, manufacturing industry accounted for

around 30 per cent of total energy consumption and 20 per cent of carbon dioxide and sulphur dioxin emissions (in 1996).

The total resources flow from production of goods and services is a severe problem. According to the European Environment Agency over 250 million tons of municipal waste and more than 850 million tons of industrial waste are produced in Europe. The annual average rate of increase is estimated at around 3 per cent, a higher rate than the economic growth rate. Thus, the waste intensity of growth is increasing. In addition to requiring valuable land space, the management of waste releases numerous pollutants. Waste also often represents a loss of valuable resources, many of which are scarce and could be recovered and recycled. Present disposal and processing capacity is probably not sufficient to deal with the expected growth.

The development in the chemicals sector offers particular problems. Europe's chemical industry is world leading, accounting for 38 per cent of global turnover. Until 1993 chemical production in the EU increased in line with GDP, after which it began to grow faster. This rapid pace of development has been accompanied by uncertainty, as the exact number of chemicals currently on the market is unknown and toxicity data is lacking for most of them; estimates of the number varies from 20.000 to 70.000. The volume is expected to grow fast and both the volume and the variety of substances released and accumulating in the environment increases the risk of damage to human health or ecosystems.

3.3.1. Industrial biotechnology

Recent decades have seen enormous strides in the understanding of the biology, molecular structures and mechanisms, genetic basis and ecology of all living things. This new knowledge base has enabled a number of technical innovations, collectively know as biotechnology. These forms of technology are regarded as the basis for the next wave of knowledge based investment with huge potential for economic growth and employment and as tools for the protection of the environment.

Commercial applications of biotechnology occur in activities related to human, animal and plant life: principally healthcare, agriculture and environmental protection. By and large, commercial biotechnology differs from conventional technologies by using biological action in place of chemical reactions; thus it can also be used in some industrial processes. In the EU the main area of commercial biotechnology research is healthcare. The commercial applications of biotechnology are diverse; the common factor is the technological expertise in life sciences that is needed for upstream innovation.

In industrial production biotechnology offers the prospect of reductions in raw material and energy consumption, as well as less pollution and recyclable and biodegradable waste, for the same level of production. Biotechnology is considered to be a powerful enabling technology for developing clean industrial products and processes such as bio catalysis. Benefits have been shown for traditional industries like textile, leather and paper. Bioremediation also has the potential to clean-up polluted air, soil and water: bacteria have been used for a number of years to clean up oil spills and purify water waste.

OECD studies suggest that many manufacturing companies could reduce their environmental impact while improving their profitability through adopting biotechnology-based processes.

On the other hand, the potential long-term risks to the environment, particularly to biodiversity, of some applications of biotechnology should be taken into account.

Biotechnology is a key driver of progress in the pharmaceutical sector, whose end-user benefits are easy to identify. Biotechnology makes possible the development of new cures. It also permits yields and quality to be improved and enables existing pharmaceutical products to be manufactured with a lesser impact on the environment. A revolution in health-care is anticipated through a move towards prevention rather than cure and personalised medical treatments by means of genetic medicines, genetic testing etc. This may effect the prevalence of chronic illnesses and the ability of people to cope better with chronic illness and thereby impact on the future health status and quality of life of older Europeans and on the cost implications of population ageing. The EU Member States spend about 1.2 per cent of their annual GDP on pharmaceuticals. As preventive treatment continues to replace hospital care we can expect these figures to increase over the coming years.

Europe is a world leader in harnessing genetically modified micro-organisms (GMO) to produce pharmaceutical compounds and industrial enzymes. The main pharmaceutical uses are production of therapeutic protein products such as insulin and growth hormones, while the industrial uses are mainly within the food and detergent industries and bioremediation. The EU has more dedicated biotechnology firms (DBFs) than the US, but they tend to be much smaller with lower employment and research expenditure per firm, Germany has the most in the EU, followed by the UK, France and Sweden.

3.3.2 IT-technologies for resource management

During the last 5 years, many companies, SME's as well as large industries, have initiated a pro-active and systematic way of dealing with sustainability issues. Pro-active, in the sense that the companies often go beyond environmental legislation. Systematic, by the introduction of an environmental management system, e.g. the so called EMAS (EcoManagement and Audit Scheme) or the closely related ISO14001, and/or by applying life-cycle assessment methods (LCA). The EMAS/ISO14001 systems help the company to systematically analyse the environmental performance of both the company and its products, while the LCA-analysis are focused on the impact of the products, "from the cradle to the grave".

What good will come out of such efforts? First of all, the environmental management systems imply that the company has to strive for a continuous improvement of its environmental performance, which e.g. means that the environmentally superior technologies will more often be chosen. The companies gain a thorough knowledge about its environmental impact and the consumption of natural resources. This knowledge often helps the company to find ways of reducing costs, e.g. by improving the waste management, or by decreasing the consumption of natural resources as energy, water and materials. The preparedness to adapt to changes often increases. Furthermore, many companies witness, that the process also could have a good influence on the quality management. All these efforts improve the ability to meet the demands from the customers. In addition, contacts with environmental authorities often become easier.

In the environmental management systems, it is explicitly requested that the company investigate the environmental impact of its products or services in a life cycle perspective. If the impact is considered to be significant, action ought to be taken to improve the

environmental performance of the product or services. This could definitely hurry up the development of more environmentally friendly products and services, which is very important for a decoupling of economic growth from environmental impact.

A very useful tool in product development is the LCA-analyses. If the analyses is carried out properly, it can provide detailed information on e.g. which material that has the smallest environmental impact.

Both the environmental management systems and the LCA-analyses uses as well as creates considerable amounts of information. Fortunately, there are several IT-based environmental information management tools available. Some examples are: the data model and database format SPINE (Sustainable Product Information Network for the Environment) jointly developed by Swedish industry and academy, the data communication format for the European rail industry developed within the EC Brite Euram project RAVEL (Rail VehicLe eco-efficient design), and the car manufacturers' material data system IMDS (International Material Data System). These tools are intended to support and facilitate environmental management systems, such as EMAS and ISO 14001, and Design for Environment (DfE) methodologies, by supplying relevant and structured information into different analytical methods, such as Life Cycle Assessment (LCA) and Environmental Risk Assessment (ERA).

3.3.3. Cleaner technologies for waste management

The use of new waste technologies will be the most important action for reducing the environmental impacts from the waste management system during the next 20 years. The implementation of the Packaging, Land filling and Incineration Directives (Council of the European Union, 1994, 1999 and 2000) together with other national regulations is now radically changing the treatment of waste in the Member States. These changes will continue during the next decade until the directives are fully implemented. The most important change is the shift from land filling, which is the most common treatment method in Europe today, to other more beneficial methods where materials and/or energy are recovered. We will also see several new technologies for waste treatment introduced in the market during this period. This includes both improved traditional waste treatment technologies such as incineration and land filling and new technologies that will be given a chance to compete with the traditional technologies, due to higher handling and treatment costs. These costs are dramatically increasing due to the regulations mentioned above, but also due to new economic policy instruments such as fees and taxes (e.g. landfill taxes). Examples of new technologies are pre-treatment facilities for combustible waste or organic waste, new large-scale technologies for treating organic waste (e.g. anaerobic digestion), source separation systems and central separation facilities. However, the most important technological improvements for reducing the overall emissions are those introduced for incineration and land filling since these technologies are the main technologies used. These technologies are not only becoming more sophisticated but also larger and more centralised due to the synergies caused by the scale effect.

It is clear that there will not be one dominating method for waste treatment in the future. Instead, there will probably be broad spectra of locally adjusted combination of technologies. There are a couple of materials that it is energetically very favourable to separate from the waste stream and recycle, e.g. aluminium and steel. Another reason for an enhanced recycling

of materials could be that fewer chemicals are used and less emissions is often the case when materials are recycled compared to using virgin natural resources. If the organic fractions could be separated from the household waste, there are very promising new technologies for generating biogas. Organic material for these processes could also be collected from other activities like the food industry. Another interesting perspective is that many new fractions for energy utilisation are starting to emerge; it could be different kinds of sludge, different waste fractions from industry, waste tyres and so forth. In combination with new effective flue gas cleaning systems, this could lead to a considerable energy production, which could be a contribution to the ambition of decreasing the dependence on fossil fuel. These new fractions are to a large extent carbon dioxide neutral. It is, of course, necessary to be able to use the heat and electricity that is produced. There is a certainly a potential for an enhanced use of different forms of district heating within the European community. Also, the industry have a large heat demand that may be supplied with heat from incineration. One example of a new efficient waste incineration plant is the Dåva-plant in Umeå (located in the north of Sweden) where, due to an advanced flue gas condenser system, 99.5 % of the energy content in the waste is utilised as district heating (85%) and power production (14.5 %).

Although all these new and improved technologies are important for the environment, especially in the short run, they are still treatment methods and not measures for reducing the actual problem of waste generation. In order to make significant improvement on a long-term, waste generation must be tackled. If the amount of waste continues to increase with approximately 2-3% per year the amount of waste generated will be twice as much as today within 30 years. This is a problem of a different magnitude demanding other actions than the above mentioned treatment technologies. Statistics show that the battery of different policies and measures that has been introduced in the Member States has had hardly any effect on reducing the amount of waste generated but large impact for improving the treatment of waste.

3.4. Technology for sustainable agriculture

A key challenge for agricultural policies is the provision of sufficient and safe food and other agricultural products to meet the needs of a growing world population, while ensuring environmental sustainability. At the beginning of the 21st century almost 800 million people still go hungry in the developing countries and some 30 million in other countries. 1,5 billion additional people will be on the planet by 2020, almost all in poorer developing countries.

In parallel to the growing world population, the natural fertility of agriculture soil is generally declining; nearly 40 per cent of the world's agriculture land is seriously degraded, according to the International Food Policy Research Institute. Agriculture is still a major source of pollution to air, soil and water, and of biodiversity loss.

In the EU overall eco-efficiency in agriculture has improved only slightly since 1990, according to European Environment Agency (eco-efficiency is measured by comparing methane emissions and selected inputs with development in the gross value added). Use of nitrogen and phosphorus fertilisers has decreased overall, but this trend has been reversed since 1992. Agriculture is a major consumer of water and the area of irrigated land has expanded, particularly in southern Europe. Despite greater awareness of the harm pesticides cause to the environment and human health, dependence on pesticides has not diminished.

The sustainability of food and agriculture production has become a critical issue. Science and technology can, according to FAO, provide the knowledge and tools to meet the challenge of more and better food and agriculture products. Organic farming and biotechnology are new methods for sustainable agriculture.

3.4.3. Organic farming

Organic farming can be defined as an approach to agriculture where the aim is to create integrated, environmentally sustainable agricultural production systems. Maximum reliance is placed on self-regulating agro-ecosystems, locally or farm-derived renewable resources and the management of ecological and biological processes and interactions. Dependence on external inputs, whether chemical or organic, is reduced as far as possible.

Since the 1992 reform of the CAP, the number of organic farms has increased in all Member States, but is still very much a minority activity. About 2 per cent of all agriculture area is devoted to organic farming, too small to have had a significant effect yet on the total environmental burden from agriculture. 70 per cent of all organic farms in the EU are in six of the Member States: Greece, Spain, Italy, Austria, Finland and Sweden. Production of fodder is by far the most important use of organic land, though horticulture is important in southern Europe. World wide production and consumption of certified organic products continue to grow at about 20 per cent a year.

Organic farming should not be considered the ultimate solution to agriculture's environmental problems. Individual organic farms often vary widely, and the environmental benefits of organic farming are dissimilar and diverse. Other forms of farming systems such as Integrated Crop Management also contribute to reducing the environmental burden from agriculture. Nevertheless, the area under organic farming is a useful indicator of progress towards more environment-friendly agriculture.

3.4.4. Life sciences and biotechnology

Progress in the life sciences and biotechnology has continuously improved the quality of life for European citizens during the last century. Europeans can expect to live longer and healthier lives than earlier generations.

Two recent expert reports shed light on the potential of these technologies for agriculture. OECD has made a study "Modern biotechnology and agricultural markets" and the organisation states that it is too early to draw conclusions about the economic and environmental benefits of the current generation of genetically modified food crops. In developed countries, consumers are demanding ever-higher standards of food safety throughout the food chain as well as improving nutrition. The challenge here is to address evolving consumer demands, while ensuring that primary production and processing methods are competitive and yet safe and compatible with sustainable agriculture practices with reduced environmental impact.

The other report is made by the UN Food and Agriculture Organisation (FAO) about biotechnology in food production in developing countries. FAO estimates that 80 per cent of the increase in world food production required by population growth in the developing world will come from intensification of agriculture while 20 per cent will come from expansion of

arable land. Agronomically improved crops produced through biotechnology are likely to be important tools, although not a panacea, in solving these problems.

3.5. Sustainable consumption

To produce and diffuse technology for successful sustainable development requires an understanding of the consumers and their situation. An understanding of the complexities involved in consumption is necessary in order to develop technologically successful solutions. Consumers' motivation (e.g. a positive attitude) can not merely explain behaviour. The consumers' ability (habit, task knowledge) and opportunity (overall and situational conditions) should also be taken into consideration. It is also important to understand the context and the situation in which information is perceived and how consumers make decisions. Habits and actual behaviour in households such as food and waste management should be recognised. Information about environmental problems may not always lead to changed behaviour. Social norms, habits, and different situations may prevent the consumer from behaving in an environmentally friendly way. This makes it important to understand the cultural factors in-depth.

3.6. Conclusions on technologies for sustainable development

The technological potential for more sustainable patterns of production and consumption is great.

We have seen a rapid and important transmaterialisation away from harmful or scarce materials in many sectors. The transmaterialisation away from CFC's in white goods and away from chlorine in the pulp and paper industry are only two examples. We have also seen a fast dematerialisation in many sectors. This has partly been driven by the development of new high performance materials and by a progressive dematerialisation of electronic products. We have also witness technologies that have implied structural changes of the economy, it is now for instance possible to travel in cyber space with very little consumption of natural resources. And there are still very large potentials for new technologies which will imply further transmaterialisation, dematerialisation or structural changes for sustainable development.

During the 1990s we have seen a substantial diffusion of renewable energy and transport technologies and further progress in industry technology, not least biotechnology. The most promising is energy saving technologies in housing and the tertiary sector. A systematic introduction of best available technology could reduce the use of energy with 20-50 per cent. New technologies for waste management offers a great potential; the most recent investment in this sector shows a utilisation of 99.5 per cent of the energy content of waste. Even more fundamental are new technologies for resource management in industry, offering strong synergies for productivity in production, quality in goods and services and efficiency in the use of natural resources. In this way a dematerialisation can be brought about in a larger scale. In agriculture organic farming is increasing with 20 per cent a year, in spite of subsidies to traditional, non-sustainable farming methods. Yet, in other cases the growth is not self-sustained. There are still significant obstacles to be overcome to reach the stage where the diffusion of renewable energy technologies is independent of government interventions and where these technologies have made a major inroad into the energy market. The extent to which more efficient technologies will be adopted by the market depends largely on the

relative future price relations between different sources of energy and other natural resources, government support to emerging technologies, government policies to benchmark or to set standards for eco efficiency and voluntary commitments by industries. It is also of vital importance to consider consumers' preferences for eco efficient products as well as consumer protection. A long term vision and strong political commitments to a decoupling of economic growth from pressure on natural resources is a fundamental element, on which successful policies can be developed. These questions will be discussed in Chapter 4.

4. EU policies to unleash a new wave of technological innovation and investment

The European Council in Göteborg stated that clear and stable objectives for sustainable development will present significant economic opportunities. Such a strategy has the potential to unleash a new wave of technological innovation and investment, generating growth and employment. Economic growth is strongly desirable and needed to meet social goals, but might be a threat to the environment, unless some strong measures are undertaken to assure a decoupling of economic growth and environmental degradation. Chapter 3 of this report has shown the potential of existing and emerging technologies to be more environmentally friendly. This chapter will show how public policies, EU policies as well as national policies, can contribute to the promotion of sustainable development and to the introduction and implementation of these necessary technologies.

4.1. Macroeconomic policies

The Broad Economic Policy Guidelines 2001, the main instrument for policy coordination, are based on the objectives of sustainable development. The immediate task ahead for economic policy is to maintain a strong economic performance in a context of less supportive global economic conditions. The euro area will have to rely increasingly on its own strengths. The growth potential is still considered to be insufficient to sustain growth rates around 3 per cent over an extended period of time. In the medium term economic policies should concentrate on creating the right conditions for the efficient use of productive and natural resources and for their enhancement over time. In particular they should contribute to improved market functioning by addressing market imperfections or failure due to the existence of externalities, market power, imperfect information or the regulatory environment. To ensure a responsible use of scarce natural resources and an economic development, which is environmentally and socially sustainable in the long run there is a need for an active environmental policy. However, government action to protect environment is often delayed by concerns about possible short-term consequences on economic growth, employment and on the competitiveness of individual firms, sectors and Member States. In this context Member States should make increased use of market based systems in pursuit of environmental objectives, as they provide flexibility to industry to reduce pollution in a cost effective way, as well as encourage technological innovation. Furthermore, they are often the most efficient means to curb pollution since they lead to the internalisation of external costs and prices. They are therefore a way to implement more consistently the polluter-pays-principle. In this respect, better information and cost-benefit analysis are important. Investment in new, environmentally friendly technology can also be an important source of progress.

The European Council in Göteborg recommended Member States to set clear targets and timetables for environmental policies so that business and consumers can adjust smoothly. The Broad Economic Policy Guidelines emphasises the need for a gradual but steady and credible change in the level and structure of tax rates until external costs are fully reflected in prices. Such policies would minimize structural adjustment problems and support adaptation and innovative solutions by firms.

4.2. Environment policies

Environmental policy is the driver for much of the investment in technology for sustainable development, and so has a significant influence. The 6th Environmental Action Programme

"*Environment 2010: Our Future, Our Choice"* establishes the environmental priorities, covering a ten year time period to allow sufficient time for identification of new measures, implementation and evaluation of their efforts. The objectives, priorities and actions will apply to an enlarged Community. Legislation remains central to meeting environmental challenges. Full and correct implementation of the existing legislation is a priority. Integration of environmental concerns into other policies is essential to tackle the driving forces behind the pressures on environment. The programme incorporates new ways of working with the market, empowering citizens and encouraging better land use planning and management decisions to induce the necessary changes in production and consumption patterns. The objectives of the programme is (1) to tackle climate change, (2) to protect nature and bio-diversity, (3) to achieve a quality of the environment where the levels of man-made contaminants do not give rise to significant impacts on or risk to human health, and (4) to ensure that consumption of renewable and non-renewable resources does not exceed the carrying capacity of the environment, which includes a decoupling of resource use from economic growth through significant improved resources efficiency, dematerialisation of the economy and waste prevention. The implementation of the European Climate Change Programme (ECCP) and the establishing by directive of an EU-wide market for emissions will act as a strong driving force towards new, more sustainable price relations in energy and in favour of more echo-efficient technologies.

4.3. Research policy

The European Research Area initiative provides co-ordination at the Community level and allows research capacities dispersed across the Member States to be complementary and mutually supporting. Its principal instrument is the 6th Framework Programme for research. Sustainable development and global change is one of the selected priority areas. The purpose is to strengthen the scientific and technological capacities needed for Europe to be able to implement sustainable development and make a significant contribution to the international efforts to understand and control global change and preserve the equilibrium of ecosystems. Achieving the objective of the Kyoto Protocol requires a major large-scale effort to deploy eco-efficient energy technologies currently under development. The efforts will be concentrated on a limited number of actions: renewable energy sources, energy savings and energy efficiency, as well as clean transport. Above and beyond the objective of the Kyoto Protocol the objective to ensure the availability of the most appropriate energy resources and carriers will require a sustained long-term research effort. In the field of transport systems medium and long term research efforts will be necessary, especially in the form of technologies making possible a rebalancing of different transport modes. On the study of climate change, the EU has a duty to make a substantial and coherent contribution to the efforts made through the major international research programmes

4.4. Single Market

The creation of a Single Market with 370 million consumers in combination with the establishment of common environmental standards and best practices give strong impetus to the development of new environmental technologies. The latest Internal Market Report notes increasing industry awareness of environmental issues. For example, the number of ISO certificates of sound environmental management and enterprise performance granted to European firms in 2000 was four times higher than the 1996-98 average. The report concludes that the Internal Market can make an active contribution to sustainable development, through for example market instruments for the trading of emission allowances, the further application

of the "polluter pays" principle and more systematic assessment of the environmental impact of public policy proposals.

4.5. Employment policy

The objective of sustainable development implies that employment, economic reforms, social and environmental policies be addressed in a mutually supportive way. The European Council, in inviting the Member States to draw up sustainable development strategies, urged them to include the promotion of employment in the environment field in these strategies. In the Guidelines for Member States' employment policies for the year 2002 the Commission states that all possible sources of jobs and new technologies must be exploited effectively. Innovative enterprises must find a supportive environment because they can make an essential contribution to mobilising the job creation potential of the knowledge-based society.

4.6. Energy policy

In the Green Paper "Towards a European Strategy for Energy Supply" the Commission emphasised that climate change is a challenge to which the EU has committed itself by signing the Kyoto Protocol; energy policy plays a key role in meeting this commitment. The Green paper outlines a strategy to bring together the concepts of security of supply, economic growth, the liberalisation of markets and environmental protection: (1) the EU must rebalance its supply policy by clear action in favour of demand policy. The margins for manoeuvre for any increase in Community supply are weak in view of its requirement, while the scope for action to address demand appears more promising, (2) with regard to demand, the Green Paper is calling for a real change in consumer behaviour. It highlights the value of taxation measures to steer demand towards better-controlled consumption which is more respectful of the environment. Taxation or parafiscal levies are advocated with a view to penalising the harmful environmental impact of energies. The transport and construction industries will have to apply an active energy savings policy and diversification in favour of non-polluting energy, and (3) with regards to supply, priority must be given to the fight against global warming; the development of new and renewable energies (including biofuels) is the key to change. Doubling their share in the energy supply quota from 6 to 12 per cent and raising their part in electricity production from 14 to 22 per cent is an objective to be attained between now and 2010. Only financial measures would be able to buttress such an ambitious aim. One way which could be explored is that profitable energies such as oil, gas and nuclear energy could finance the development of renewable energies which, unlike traditional energy sources, have not benefited from substantial support. Research on waste management technologies and their implementation in the best possible safety conditions must be actively pursued. Every form of technological progress will help to reinforce the impact of the strategy. The public response to the Green Paper has, overall, been very positive. In March 2002 the Commission will present conclusions from the debate and orientations for the future direction of European energy policies.

In the Green Paper the Commission concluded that more emphasis should now be placed on concrete measures to promote new technologies, such as the establishment of a clear legislative framework to promote energy conservation in buildings in Member States, an important element in the European Climate Change Programme. A directive has now been proposed with four elements: (1) a general framework for calculating the integrated energy performance of buildings, (2) application of minimum standards on the energy performance to new buildings and to certain existing buildings, when they are renovated, (3) certification

schemes for new and existing buildings and (4) specific inspection assessment of boilers and heating/cooling installations.

4.7. Transport policy

The Göteborg European Council placed shifting the balance between modes of transport at the heart of the sustainability strategy. Reducing dependence on oil from the current level of 98 per cent by using alternative fuels and improving the energy efficiency of modes of transport is both an ecological necessity and a technological challenge. The Commissions program for reform of EU transport policy consists of a series of measures ranging from pricing to revitalising alternative modes of transport to road and targeted investment in the trans-European network. This integrated approach would allow the market shares of the other modes to return to their 1998 levels and thus make for a shift of balance from 2010 onwards. By implementing the 60-odd measures set out in the White Paper there will be a marked break in the link between transport growth and economic growth, although without there being any need to restrict the mobility of people and goods. There would also be much slower growth in road haulage thanks to better use of other means of transport. This trend would be even more marked in passenger transport by car. To speed up the decision making process and to assess progress the Commission has decided to draw up a timetable with dates for achieving specific objectives and to make an overall assessment of the implementation of the policies by 2005.

The Commission has also launched an action plan to foster the use of alternative fuels for transport, starting with the regulatory and fiscal promotion of biofuels. Use of fuels derived from agricultural sources, i.e. biofuels, is the technology with the greatest potential in the short to medium term. The action plan outlines a strategy to achieve 20 per cent substitution of diesel and gasoline fuels by alternative fuels in the road transport sector by 2020 by promoting three options: biofuels, natural gas in the medium term and hydrogen and fuel cells in the long term. The Commission will establish a minimum level of biofuels, starting with 2 per cent in 2005 and reaching 5.75 per cent in 2010. A second directive would give the member States the option of applying a reduced rate of excise duty to pure or blended biofuels, when used either as heating or motor fuel.

4.8. Enterprise policy

The sustainable development objectives are integrated in the EU enterprise policies in a way, which ensures that the definition and implementation of policy instruments for achieving environmental goals foster entrepreneurship and encourages innovation, thus contributing to competitiveness. Four principles are guiding the EU enterprise policy as regards sustainable development: (1) a stable and predictable regulatory framework should be guaranteed so that enterprises know the criteria against which to make their investment decision, (2) policies should focus on the results to be achieved and regulatory measures should only be considered when the objectives cannot be reached by more flexible means, such as voluntary agreements, codes of conduct or co-regulation, (3) all decisions should be taken on sound scientific bases, in which targeted risk assessments and sustainability impact assessments are essential elements and (4) cost benefit analysis and impact assessments should be used to weigh up the environmental objectives and economic repercussions, ensuring that these are both proportional and cost-effective.

The Commission's Green Paper on Integrated Product Policy (IPP) provides an example where enterprises are being encouraged to make the concept of sustainability an integral part

of their decision making process. IPP is concerned with how to cost-effectively reduce individual products' impacts throughout their life-cycle. It does this by choosing the instrument (correcting price signals, eco-labelling or a generic technology measures) best suited to the particular circumstances. Frequently, this will involve creating the conditions needed for efficient development and use of environmental technology. For example, IPP will enable stakeholders to contribute through product panels so that business can help identify technology needs and solutions. This philosophy of combining economic and environmental concerns can also be seen in recent proposals on electric and electronic equipment, which aim to make their production, use and ultimate disposal as ecologically friendly as possible.

4.9. Agriculture policy

Environment considerations have become a major concern of the common agriculture policy (CAP). The agri-environment programmes of the 1990s asked farmers to undertake environmental activities. The new CAP reform, as presented under Agenda 2000, goes further and is designed to achieve necessary structural adjustments in principle market regimes and a strong rural development policy. Environmental considerations aiming to assure farming practices, necessary to safeguard the environment and preserve the countryside form an important element of the Commission policy for sustainable agriculture. The general orientation is that farmers should observe a minimum level of environmental practice as part-and-parcel of the support regimes, but that any additional environmental service, beyond the basic level of good agricultural practice and respecting environmental law, should be paid for through the agri-environment programmes. When Agenda 2000 was agreed the Commission undertook to make a midterm review of the Common Agriculture policy to check whether the measures that were then decided are consistent with the objectives, of which the integration of environmental goals into the CAP is one. This policy review will be carried out in 2002 based on the agreement of the Göteborg European Council that the Common Agriculture policy should "contribute to achieving sustainable developments by increasing its emphasis on encouraging healthy, high quality products, environmentally sustainable production methods, including organic production, renewable raw materials and the protection of biodiversity".

4.10. Consumer policy

While producers will have the responsibility for the products put on the market, consumers have the power to make choices between different products. Public policies, particularly consumer policy, have the role to empower consumers to make rational choices, and to make choices that are rational in the perspective of sustainable development. The most important policies are differentiated taxes, safe minimum standards and other standard regulations. To help ensure that consumers are better informed about the processes and products in terms of their environment impact the Commission's Sixth environment action programme made three commitments: (1) encouraging the uptake of eco-labels that allow consumers to compare environmental performance between products of the same type, (2) encourage the use of reliable self-declared environmental claims and preventing misleading claims, and (3) promoting green procurement, while respecting Community competition rules and the internal market, with guidelines on best practice and starting with a review of green procurement in Community Institutions. This will encourage business to respond with innovations and enable consumers to adopt to greener lifestyles as informed choices. Consumer policy is of particular importance for the application of biotechnology to food and feed. The Commission has emphasised that a high level of protection, consumer choice and transparent, uniform and efficient authorisation procedures are key elements in fostering social acceptance and trust in

the application of biotechnology. The Commission has proposed two legislative instruments. The first concerns GM food and feed, the second establishes requirement for traceability of GMOs as well as for GM food and feed. The overarching principle of the new proposals is that GM food and feed must not present a risk for human health, animal health or the environment. Therefore, GM food and feed have to undergo mandatory pre-market authorisation involving a scientific assessment of potential risks. Only if concluded to be safe should such products be allowed to be placed on the market. The proposal establishes for the first time the same, clear and stringent rules at Community level for feed derived from GMOs. These initiatives are part of a Commission strategy to increase public acceptance of the use of biotechnology.

4.11. Conclusions on EU policies

The EU policies in the ten areas above will – when implemented by the Member States – have a strong effect on the demand for new technology in general and will give a strong push for investment. Of fundamental importance is the recommendation in the Broad Economic Policy Guidelines on gradual but steady and credible changes in the level and structure of tax rates until external costs are fully reflected in prices. There is a substantial scope for a rebalancing of prices, particularly on energy markets in favour of renewable energy sources and energy efficient technologies by using both taxes and other market instruments. The implementation of the European Climate Change Programme (ECCP) and the establishing by a directive of an EU-wide market for emissions will act as a strong driving force towards such new, more sustainable price relations. Care should be taken so that market instruments promote a variety of technologies and create fertile ground for longer term options that currently are less competitive. The setting of good environment standards to prevent the worst cases and measures to stimulate best practice (IPP) for the whole EU area will have a similar stimulating effect for investment in new technology. The European Single Market is the biggest market in the world for technology, and will become even more important through enlargement. The practices developed in this market will become global standards for all enterprises that wish to compete on this market. Thus, the integration of sustainable development in all policies, not least in research and development, will make the EU the leading global actor in the renewal of products and processes, unleashing a new wave of technological innovation and investment, generating growth and employment. This makes the Member States' sustainable development strategies, and a decisive implementation of these strategies, a matter of fundamental importance for growth and employment in the whole Community.

5. Enlargement and technology for sustainable development

The objectives, priorities and actions of the decision on the Community Environment Action Programme 2001-2010 will apply to an enlarged Community. The same goes for the strategy for sustainable development, agreed by the Göteborg European Council.

In the report "Making success of enlargement" of 2001 the Commission stated that most candidate countries had made significant progress in the adoption of legislation for alignment with the acquis for most areas. Some countries still have difficulties in transposing parts of the acquis. Nevertheless, the major need now consists of building up adequate administrative structures and strengthening administrative capacity to implement the acquis. For most or all of the candidate countries the Commission has emphasised such needs in following areas of particular importance for this report on technology for sustainable development:

- in environment to further strengthen administrative, monitoring and enforcement capacity, in particular in the field of waste, water and chemicals

- in transport and energy to strengthen or set up appropriate regulatory structures and inspection arrangements, in particular to ensure road and maritime safety

- in agriculture to upgrade inspection arrangements according to veterinary and phyto-sanitary legislation, in particular to ensure food and safety and the capacity to implement and enforce the management mechanisms of the CAP.

The Commission Joint Research Centre (Institute for Prospective Technological Studies) has made a review of technology and investment in key areas for sustainable development in the accession countries. The report can be summarised in the following way:

5.1. Energy

The energy infrastructure of the candidate countries will undergo drastic changes. The existing installations/power plants are generally outdated and do not comply with the environmental standards of the European Union. The fact that the existing power plants are mostly coal-fired and thus increases CO_2 emissions aggravate the problem. Gas and oil reserves in the region are small. However, the trend in the energy sector towards higher efficiency and lower prices for gas power plants in combination with environmental concerns may lead to a change from coal to gas in compliance with the EU standards. The potential for combined heat and power is at present not exploited, but should be considered a promising opinion. Opportunities also exist in exploiting wind energy and biomass. To satisfy the predicted demand in 2010 an increase of installed capacity of approximately 50 per cent is necessary. This in itself already means a substantial investment. To this should be added the investment in replacing older plants, not least the aging nuclear facilities.

5.2. Transport

The development in transport during the last 10 years show that the most progressive countries follow the Western blueprint in terms of the problems. This concerns the modal split with decreasing rail and bus transport and increasing utilisation of private cars. Local and

regional transport will require substantial investment to increase accessibility to markets and movements of people.

5.3. Industry

Environmental regulation for industry in candidate countries has until now been less strict than in the EU, which has attracted polluting activities. The IPPC directive and other environmental legislation will increase costs for such activities and force a restructuring. Most of the candidate countries have specific 'hot spot' areas, due to the concentration of heavily polluting industries and energy production. Many industrial plants in these areas are being restructured into modern and viable plants.

In the waste sector much remains to be done in all the candidate countries. The management and incineration of municipal and industrial waste is a challenge from both the financial and environmental point of view.

5.4. Agriculture

There is already an on-going process of structural adjustment in the agricultural sector, from a traditional labour intensive/low productive mode of cultivation towards a more capital-intensive mode of production. However, production is less intensive in the candidate countries than in the EU. This includes less use of inputs such as fertilizers and thus generally less pollution from agriculture. A potentially larger market for biofuels can be an opportunity for the candidate countries. On average, these countries have more agricultural land and a lower diesel and gasoline consumption per capita than current EU Member States.

5.5. Water

Major investment programs to improve drinking water quality, in some cases also to increase drinking water production and finally improve the management of wastewater are underway and planned in most of candidate countries. A particular challenge will be the establishment and implementation of an integrated river basin management approach by the riparian states of international rivers, such as the Danube and Oder.

5.6. Conclusions

The review of the situation in the candidate countries highlights the role of investment as key to the EU strategy for sustainable development. Enlargement of the EU will create strong incentives for the candidate countries to speed up the modernisation process, phasing out old investment and technologies from the command and control period and phasing in the most recent technologies. The energy sector is the most prominent example, where the candidate countries need to increase their capacity substantially and, at the same time, replace old outdated plants with new eco-efficient technologies.

6. Policy conclusions

The integration of environment in the Lisbon strategy and the emphasis on new technology for sustainable development, agreed by the Göteborg European Council, will make the policies of each of the three pillars of the strategy mutually supportive:

- To attain a GDP growth rate of 3 per cent a year and to bring about a decoupling of economic growth from pressure on natural resources, a rate of investment growth of about 4 to 6 per cent seems necessary, increasing the investment share of GDP from around 20 per cent to 24-25.
- A higher rate of investment should be utilised to phase out old technology and phase in new technology, contributing to productivity, quality and eco-efficiency for health, prosperity and environment; to achieve this a forceful implementation of a strategy to "get prices right" is necessary to make the value of natural resources and eco-systems visible to the agents in the economy
- Economic growth and investment should be utilised to create more and better jobs and be made sustainable by policies, that facilitate participation in working life (see Guidelines for Member States Employment Policy 2002); in this way the EU could reach the employment rate of 70 per cent, agreed in the Lisbon strategy, thereby making Member States' social protection systems, in particular the pension systems, more sustainable.