Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

Environment and Innovation

ECOLOGICAL INDUSTRIAL POLICY

Memorandum for a "New Deal" for the economy, environment and employment

IMPRINT

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FOREWORD

A new quality of life: a "New Deal" for economy, environment, and employment

You do not have to be a staunch supporter of the environmental movement to recognise that we in Germany, Europe and worldwide urgently have to change our traditional political and economic strategies. Just a look at medium- and long-term economic success alone is sufficient:

- There will soon be 9 billion instead of 6.5 billion people living on our planet;
- More and more people are using our limited reserves of resources and energy;
- As a result, prices for these limited resources and energy resources are constantly rising.

Countries such as Germany that are both resource-poor and export-orientated are facing extreme economic threats. At the same time, the hunger for energy and resources is leading to increasingly reckless methods of extracting or growing resources. The consequences of this escalating destruction of the environment and its resulting economic costs have long since hit even the rich industrialised countries, in the form of climate change, for example.

Anyone who does not have the means to keep up in this competition will simply be left behind. Already a continent such as Africa is forced to use the development aid made available from worldwide sources to cope with rising prices for oil and gas. The threat of conflicts escalating into war and civil war over limited resources cannot be ignored.

Thus it is a matter of real challenges to humankind. Prof. Klaus Töpfer, former head of the United Nations Environment Programme and former German Environment Minister described the situation as follows: "It has become an unmistakeable fact that it is not financial capital, nor human capital, but environmental capital that is increasingly becoming the factor blocking further economic development. Water, soil, biodiversity, climate, air pollution – throughout the world the ecosystems connected with these areas are increasingly showing symptoms of exhaustion."

It is thus as much a question of economic sense as ecological responsibility to find answers to deal with these challenges. And the answers and alternatives already exist:

- Greater efficiency in use of energy and resources, and
- Greater use of natural, renewable resources instead of growing dependency on finite resources that are become scarcer all the time.

Nature has provided us with a gigantic database and an inexhaustible source of resources, which we urgently need to maintain our high-tech systems and modern industrialized societies.

The areas of application are virtually unlimited:

- At the research airport in Braunschweig, DLR–German Aerospace Center, for example, is carrying out research into replacing metal and plastic in aircraft construction with materials made from renewable resources;
- White biotechnology uses microorganisms and enzymes to replace processes containing pollutants, in the chemicals industry for example. It makes it possible to use genetic engineering completely unproblematically, because it is used exclusively in closed-loop processes;
- And, nanotechnology can bring about a significant reduction in use of energy and raw materials.

This will not only reduce our economic dependence on resources that are both scarce and expensive; it will also mean that we can increasingly eliminate risks to health and the environment – starting with a new approach to use of raw materials and product design.

However, more efficient use of raw materials and sustainable use of natural resources hinge on one central condition: that we rediscover the idea of technical progress. What is meant by that is not a return to the blind faith in technology prevalent in the 1950s and 60s, but an understanding of technical progress

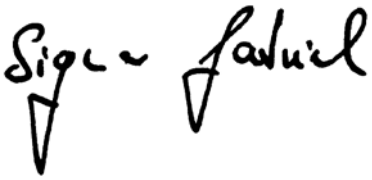
as a proactive instrument for mobilising the power within society that we urgently need to resolve the challenges described. After all, the politically defensive response - “limitations to growth” - is for most countries and regions of the world not a real alternative to their current response. And, if we are honest, most people here also feel that their “piece of the cake” is too small rather than too big.

But it is particularly the developing countries and newly emerging economies that have a right to expect countries like Germany and regions like Europe to mobilize the innovative strength within their societies. After all, what they need more than anything is technology transfer, because they will otherwise be forced to choose between continuing to over-exploit nature and the planet’s reserves of raw materials or leaving their population in poverty.
The problems of industrial societies can only be solved with the instruments of industrial societies, not those of agricultural societies. To cite a practical example: anyone who wants to reduce both the dependency on oil of an industrialized society that has millions of motor vehicles and the greenhouse gases associated with them cannot be satisfied with biofuels produced in oils mills but must instead develop synthetic fuels based on renewable sources that can only be produced in sufficient quality and quantity using modern refineries, engineering knowledge and skilled workers.

Thus we will not be able to achieve ecological progress without economic success nor sustainable economic growth without solutions to the dramatically escalating environmental problems. What we need is a “New Deal” for economy, environment and employment. At its core is innovation, a “third industrial revolution.”

Germany and Europe, more than most other regions of the world, are in a position to take on a pioneering role here. For over 200 years, Germany’s actual core competence has been its skills in innovation and integration: we are able to invent new products and processes better and faster than many other countries and to integrate them into our existing industry and services structure. This re-creates our economic, social and ecological success on a daily basis. And it is precisely this capacity for innovation and integration that is crucial to the development of an ecological modernisation concept for our industrial society. Particularly for a high-tech country such as Germany, this “New Deal” holds great opportunities for economic growth and jobs and also for safeguarding the natural resources upon which the life of our generation and that of future generations depends.

Innovation and technical progress hinge on skills and therefore on people. Investment in education and training are thus the crucial elements needed for successful innovation, research and technology.



Sigmar Gabriel
Federal Ministry for the
Environment, Nature Conservation
and Nuclear Safety

I. RADICAL CHANGES IN THE GLOBAL ECONOMY AND ECOLOGY

The world is changing radically. We are experiencing a major new stimulus of growth and industrialisation in the global economy. But it still remains to be seen whether the 21st century will be associated with the hope of prosperity and development for everyone, or whether this growth spurt will catapult the planet to, or even beyond, the limits of what its ecology can cope with, and the century will be remembered for global distribution conflicts and wars over resources. To be able to live, work and manage our economy well and indeed better - both now and in the future - we need more than normal growth rates; we need a vigorous growth spurt as the basis for a new ecological industrial revolution.

The modern world experienced the first powerful growth spurt between 1870 and 1913. The average annual growth rate doubled in just a few years. With Great Britain in the forefront and under the aegis of the British Empire, industrialisation became the hallmark of this age. The vastly improved efficiency of the steam engine and the corresponding improvements in the railway and steam ships, along with the advent of telegraph technology, brought the regions of the world closer together. Old markets were shaken up; new markets mushroomed.

The second growth spurt in the global economy can be dated to the period between 1950 and 1975, which saw a positive explosion in growth. Within just a few years, industrial production increased fourfold, world trade in industrial products rose tenfold. These "golden years" (Hobsbawm) were accompanied by the economic and political rise of the USA. They led to the universal application of a development model that was based on excessive consumption of fossil energy sources and featured a rapid increase in mobility. The ecological costs of this recent impulse of industrialisation were soon seen in the significant pollution of soil, air and water.

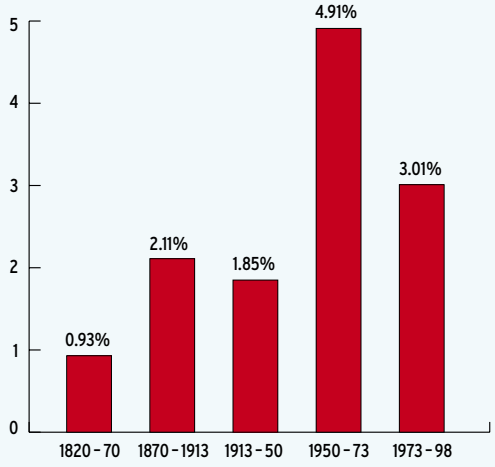
Now, we are once again experiencing a powerful growth spurt in the world economy. According to current knowledge, globalisation will continue to accelerate over the next two decades. Technical progress and the liberalisation of world trade will contribute to the continued integration of the regions and markets of the world. The output of the global economy will see an average annual growth of 3% up to the year 2030 and within the next 25 years the gross world product will almost double to over 60 billion dollars.[1] This global view hides the fact that growth rates in the different regions of the world will be extremely unequal. The transatlantic economy will remain the most important economic axis, but the majority of additional growth will no longer, as was the case in the nineties, be divided up within the triad formed by the USA, Japan and the EU, but will be

1 Fundamental scenarios were developed in publications such as: NIC, Mapping the Global Future. Report of the National Intelligence Council's 2020 Project, December 2004; Shell Global Scenarios to 2025. Executive Summary and Excerpts; International Energy Agency, Energy Technology Perspectives 2006. Scenarios & Strategies to 2050; Paris 2006; United Nation (Department of Economic and Social Affairs), World Population to 2300, New York 2004; cf. also: Atlas der Globalisierung. Die neuen Daten und Fakten zur Lage der Welt, Berlin 2006.

COUNTRY/YEAR	1820-70	1870-1913	1913-50	1950-73	1973-98
Western Europe	**1.65**	**2.10**	**1.19**	**4.81**	**2.11**
• Germany	2.01	2.83	0.30	5.68	1.76
• France	1.27	1.63	1.15	5.05	2.10
• UK	2.05	1.90	1.19	2.93	2.00
Eastern Europe	**1.36**	**2.31**	**1.14**	**4.86**	**0.73**
Former USSR	**1.61**	**2.40**	**2.15**	**4.84**	**-1.15**
USA	**4.20**	**3.94**	**2.84**	**3.93**	**2.99**
Japan	**0.41**	**2.44**	**2.21**	**9.29**	**2.97**
Asien (excl. Japan)	**0.03**	**0.94**	**0.90**	**5.18**	**5.46**
• China	-0.37	0.56	-0.02	5.02	6.84
• India	0.38	0.97	0.23	3.54	5.07
World	**0.93**	**2.11**	**1.85**	**4.91**	**3.01**

Source: OECD, The World Economy: A Millennial Perspective, 2001.

Rates of Growth of World GDP
Annual average compound growth rates in selected countries and regions



Source: OECD, The World Economy: A Millennial Perspective, 2001.

Annual average compound growth rate of World GDP

absorbed by the up-and-coming markets in Asia and the so-called emerging economies: China, India and also Indonesia will become the growth engines driving the global economy.

Source: OECD, The World Economy: A Millennial Perspective, 2001, composition.

Growth in World GDP and share taken by selected regions

China in particular will experience a full-blown wave of industrialisation. By 2020, the "global workbench" will have caught up with its international competitors, particularly in the manufacturing industry, and will have trebled its economic power. The region's second growth centre, the Indian economy, will create its economic dynamics in the field of skilled services, high-tech research and the production of high-value goods. Whether, on an analogy with the historical growth spurts, the "British century" and the "American century" will now be followed by an "Asian century" remains to be seen. In view of the considerable transformation processes still taking place within society and the massive social and political problems, this question remains open. Nevertheless, one thing can be stressed: the global economy is realigning itself and the Asian region will be the engine driving this development. Three overarching global trends are closely connected with this challenge and highlight important elements dictating the shape of the new global economy:

— Population growth and urbanisation will accelerate. The United Nations assumes that in 2025 almost 8 billion and in 2050 around 9.2 billion people will live on the planet, over half of them in Asia. The majority of the population increase will live in those regions that are least able to cope with it – economically, ecologically and socially. In most of the developed countries, particularly Germany, population figures will run counter to global trends and will drop. In 2030, a quarter of the population in Western Europe will be over 65 years old. The demographic changes and economic and social disparities that accompany them will cause major migration, both between and within countries and regions. In this way the urbanisation process will be spurred on further. Today, for the first time in the history of humankind, over 50% of the world's population live in towns and cities; in 2020 that figure will have risen to over 60%.

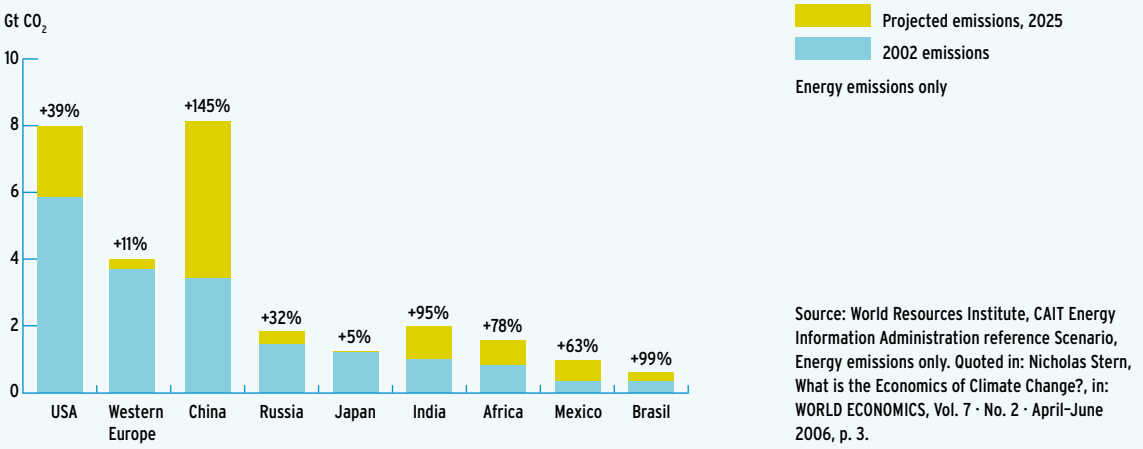
— Mobility will continue to grow significantly. In the wake of the new international division of labour, the volume of traffic between regions will intensify. Air traffic alone will more than double by 2020 compared to 2003. The volume of traffic in today's emerging economies will rise rapidly. Today there are 600 million motor vehicles in the world. One billion people currently live in India, owning eight million vehicles. If only half of the 200 million Indians who belong to the middle-class sector of society with purchasing power acquire motor vehicles in the next few years and the 1.3 billion Chinese also stake their claim to a level of motorisation similar to that which we in Europe take for granted, the worldwide stock of motor vehicles will double as a result of these two countries alone. Already, no other country in the world is building more motorways than China; each year 5000 kilometres are added and by 2010 the network of major highways there will have expanded to 70,000 kilometres.

— Energy demand is rising steadily. Prognoses assume that by 2020 energy demand will already have risen by 50 percent. Within 15 years, global demand for oil will rise from around 75 million barrels to over 100 million barrels. By 2015, only one-third of the oil from the Middle East will go to Western markets; three-quarters will be destined for Asia. The greenhouse gas emissions associated with the rising energy demand are a threat to the global climate.

More and more people live on the planet and economic and social needs are growing – but the available resources are for the most part scarce. The global competition for water, energy and resources has featured on the economic pages of the daily papers and magazines already as the "battle for prosperity." Changes in the global economy instantly trigger changes in the global ecology. The megatrends present major challenges to environmental policy.

The International Energy Agency estimates that the worldwide growth in energy demand will cause the emission of the greenhouse gases that are harmful to the climate to double by 2050 to almost 60 gigatonnes per year unless we take action to combat the trend. Already the worldwide increase in extreme weather, along with the increased incidence of flooding in Germany, highlights the urgency to take action in the field of climate policy. Furthermore, rising oil prices are already beginning to have social consequences: there is a direct correlation between international development aid's loss of significance and rising oil prices. In industrialised countries, households with small and medium-sized incomes use a disproportionate share of their disposable income to pay their heating bills and fill-up their cars. Colossal environmental harm, the rapid loss of biodiversity and the pollution of air, soil and water, in particular in the emerging economies, are already causing the costs in real terms of our current development model to escalate to unimagined heights.

In the globalised world, these problems are closely interwoven: environmental policy cannot be separated from economic, energy, demographic, social or development issues. Environmental policy in the 21st century is not merely concerned with the environment. Environmental policy is also economic policy, energy policy, security policy.



Source: World Resources Institute, CAIT Energy Information Administration reference Scenario, Energy emissions only. Quoted in: Nicholas Stern, What is the Economics of Climate Change?, in: WORLD ECONOMICS, Vol. 7 · No. 2 · April–June 2006, p. 3.

Current and projected emissions by country

The ecological question has become a social and economic question. And by the same token: there can be no economic development in the long term without ecology. That is why we need a sustainable model for industrial development. Ecology and the economy are interdependent. Human and environmental capital have become decisive production factors for economic development. Former World Bank chief economist Sir Nicolas Stern has put it in a nutshell: the sooner effective measures are taken to curb climate change, the lower the costs to the economy will be. If the increase in greenhouse gases continues until 2050 at today's level, enormous growth losses are to be expected.[2] What is true for climate change is true for ecological threats overall: that is an insight that has been reflected for a long time now in the company ratings of important financial intermediaries and in the rising premiums for reinsurers' policies.

It is essential that the model for sustainable development revolves around a "third industrial revolution" with energy and resource efficiency at its centre. Instead of playing economy and ecology off against each other, we need to finally understand the economic potential inherent in the necessary ecological structural change: new growth, new value creation, new products and processes and new jobs are all possible. To make it happen we need an ecological industrial policy that will adapt our industrial structures to the ecological and economic challenges.

— Ecological industrial policy must contribute to Germany and Europe achieving a better position in the global economy. As an economic specialisation strategy, it could reposition us in the changed global division of labour – as a producer of efficiency, exporter of infinite energy, guarantor of global environmentally sound mobility, a competence centre for public services provision and waste and wastewater disposal, in general as a global provider of environmental technology and services for the 21st century. Ecological industrial policy will thus contribute to new growth, new markets and new jobs.

— Ecological industrial policy is an instrument for sustainable development. By changing and adapting the material basis of our industry to renewable raw materials, offsetting the economic principle of scarcity with energy from infinite sources and efficient treatment of our natural resources, it not only makes an effective contribution to a more environmentally sound economic system here at home, but also contributes to the evolution of a development model that is globally applicable.

If China becomes the "workbench of the world," India blossoms into a "global service provider," Russia develops into the "petrol pump of the world" and Brazil becomes a "raw materials warehouse" and "global farmer" supplying the industrial and service provider societies of Asia with iron ore, copper, nickel and soya beans, then Germany should assert and consolidate its place in the global division of labour as a responsible "energy-efficiency and environmental engineer."

2 Nicholas Stern, Stern Review on the Economics of Climate Change, http://www.sternreview.org.uk.

II. THE MARKETS OF THE FUTURE ARE GREEN

Twenty years after the founding of the Federal Environment Ministry, Prince Hassan of Jordan, President of the Club of Rome stated: "The markets of the future are green."[3] With that statement he is not predicting a flourishing market for some ecological niche markets or other, but expressing the belief that the major markets of the future will have a strong ecological dimension, and that, in view of the megatrends described, there will be no option. Thus the careful treatment of energy and resources will become a matter of the very future of humankind. How we live and what our quality of life will be, will depend on whether we manage to make the markets of the future environmentally sound and whether we invest in the "third industrial revolution."

Those countries and regions that achieve technological leadership in the green markets will gain decisive advantages in the global competition, creating the right conditions for growth and job creation. Based on current knowledge, a number of central areas and markets can be identified, which will be characterised in the future by particularly dynamic growth. These markets combine economic and ecological challenges in a very particular way and will have a shaping influence on the face of this wave of industrialisation. Anyone who invests here is creating permanent jobs and safeguarding the future – economically, socially and ecologically.

In Germany and Europe there are many potential starting points for an ecological industrial policy focussing the markets of the future.

Energy generation and power station technologies

The growing demand for energy can only be satisfied if we achieve a massive expansion of renewable energies, combined with a major advance in power station technology. Power stations will have to turn fossil fuels into electricity with far greater efficiency than in the past and with significantly lower emissions of CO_2. In the medium term, coal-, oil- and gas-fired power stations must become completely CO_2-free. From 2020 at the latest, CCS technology to ensure safe capture and storage of CO_2 must become standard at all new fossil power stations. At the same time, a secure and adequate energy supply will depend on significant progress being made in the area of fuel-cell technology and energy storage.

Energy efficiency technologies

The global hunger for energy can only be satisfied if energy is produced and consumed in a more economical and energy-efficient way. The Japanese top-runner programme is already dictating the direction. The battle for markets will become an international efficiency contest within the consumer goods industry. But industrial production itself will also become the object of energy efficient modernisation. Heat insulation for homes is another business with a promising future. Germany's ambitious assistance programme for the refurbishment of existing buildings is an exemplary illustration of how environmental protection and job creation go hand in hand.

Recycling and waste management technologies

The high price of oil and scarcity of many raw materials also has an effect on waste management, which is already turning over 50 billion euros a year in Germany. Between 2000 and 2005, world market prices for raw materials imported into Europe rose by 81 percent. A study carried out by the "Institut der deutschen Wirtschaft" (Institute for Business Research), puts the value of raw-material and energy savings from secondary raw materials produced from recycling at 3.7 billion euros per year.[4] Not only will the market for secondary raw materials continue to grow but also the market for recycling technology, seeking more efficiently to exploit today's waste as "the mines of the future."

Mobility and transport technologies

Globalisation and demographic changes are intensifying transport volume. In China alone estimates predict a demand for a billion additional cars. This is an enormous opportunity for the automobile industry – provided the emissions problems can be tackled satisfactorily. At the same time, demographic changes, along with urbanisation and migration from the countryside, are also intensifying the need for innovative integrated transport concepts. New fuels, new drive systems such as the fuel cell, and intermodal transport are the buzzwords for a global market of the future which must reconcile the need to reduce emissions that are harmful to the climate with growing mobility requirements.

Water and wastewater technologies

The world community has set itself the ambitious goal of halving the proportion of the world's population without access to clean drinking water and

3 Prince El Hassan bin Talal, Die Märkte der Zukunft sind "grün," in: Die Umweltmacher. 20 Jahre BMU – Geschichte und Zukunft der Umweltpolitik, Hamburg 2006, pp. 180-190.

4 Hubertus Bardt, Die gesamtwirtschaftliche Bedeutung von Sekundärrohstoffen, in: IW-Trends – quarterly journal on empirical economic research published by the Institut der deutschen Wirtschaft Cologne, 3/2006.

hygienic wastewater disposal by 2015. In developing countries, flexible water infrastructure concepts are needed to meet the specific challenges. In addition industrialised countries face an enormous need for re-investment in their supply networks. The global market in water and wastewater disposal is currently estimated to be worth 250 billion euros.[5] Significant increases in turnover are expected. The EU believes it will have a value of around 400 billion euros by 2010.[6]

Environmental engineering/systems engineering

Important as it is to design products and production processes in future to be energy- and resource-efficient, the environmental sins of the past in many countries will ensure that environmental aftercare and environmental technology "at the end of the pipe" also remain a profitable business. In view of current industrialisation processes in emerging economies, these areas could actually become more significant. The range of environmental systems solutions and integrated environmental technology will also gain economic importance.

Further basic innovations and overarching economic growth areas also include:

Life sciences

Hardly any other area is the subject of such controversial discussion in society as biotechnology. However, it is relatively undisputed that both white biotechnology and "green chemistry" offer the opportunity to make chemical and industrial production environmentally sound. But it is also true that especially the use of genetically engineered organisms represents a particular challenge, especially from the environmental point of view. It is undisputed that the life sciences are one of the dynamically developing areas of knowledge with great economic potential. But justified reservations must not be pushed aside simply by pointing out their economic potential. The important thing is to take a differentiated and careful approach to life sciences in order to develop their potential for the environment and industry.

Nanotechnology

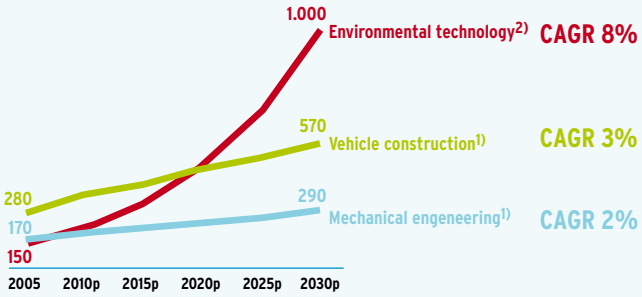
Nanotechnology will gain economic significance as a basic innovation and will become a dynamic business. From the environmental point of view, genuine opportunities are inherent in it: materials with new properties will result in significant reductions in the level of resources used in production and in operations, by dispensing with hazardous substances in the processing stage (varnishes for example), by energy saving in chemical processes or by higher energy yield (solar cells for example). Particularly from the environmental point of view, the exploration of previously unknown impacts in the life cycle of nanoproducts is an important challenge.

5 Roland Berger Strategy Consultants.

6 Fraunhofer Institut für Systemtechnik und Innovationsforschung (publisher), AKWA 2100 – Alternativen der kommunalen Wasserversorgung und Abwasserentsorgung, Stuttgart 2005.

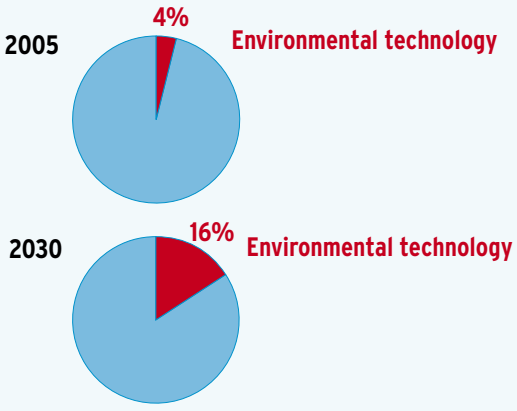
Predicted turnover for Germany (Euro billion)

1) Turnover (excl. goods for resale), real, baseline year 2000
2) Moderate estimation of growth rate and basic value 2005



Source: Prognos 2006, expert survey, Roland Berger 2006.

Share in the turnover of all sectors of trade and industry



The compound annual growth rate (CAGR) represents average annual growth and is a key indicator for observing market trends

Environmental technology markets will vastly outstrip classical sectors of industry

Eco-design

The products of the future will have to be produced and used not only with more low-energy technology, but also with greater economy of resources. Using bionics, natural processes that are economical in terms of energy and use of resources are exploited for technical applications. Material-saving construction methods, the incorporation of recycled material, energy-saving technology, longer service life, design that is independent of fashion, low-emission use, and low-pollutant disposal will become important reference parameters in the field of product design, around which know-how and economic potential will centre.

Bioplastic/biorefinery

Oil is the resource underpinning our prosperity not only in terms of energy but also chemically. Plastic made from renewable raw materials is the exception. But in the research labs of science and industry there is awareness that this is the material of which our future will be built. The more oil prices rise, the more financially attractive biopolymers from rapeseed, sugar beet or corn become. The US Environmental Protection Agency estimates that compostable bioplastic could reduce 94 percent of the plastic products that end consumers throw away today.[7]

The Federal Environment Ministry wants to implement an innovation-based environmental policy that will help to achieve a double dividend for the environment and trade and industry. By backing and disseminating eco-innovations and eco-high-tech we are assuming responsibility for our threatened ecosystem and making our contribution towards Europe achieving its ambitious goal: to become the most resource-efficient economic region in the world. But that it is why it will also be necessary to have better knowledge of the most important markets and trends. And it is important that we explore the environmental protection potential of technologies and technological developments and know more about and take into account the risks associated with them, which includes looking at the possible social consequences of their use. The Federal Environment Ministry has commissioned a research project that is currently studying selected fields of action, followed by an exploration of Germany's position in terms of competitiveness and technological developments. We are also looking intensively at enabling technologies such as nano- and biotechnology, to which great environmental and economic significance is attached, but about which there is still controversial public debate. In our innovation conference we have focused on four "key markets of the future," in order to intensify the discussion about their economic and ecological potential and to facilitate a joint discussion with industry and the scientific community on what concrete challenges we have to tackle today in the fields of energy, mobility, efficiency technology and life sciences, if we are to optimally exploit the potential of these markets for the future.

7 Handelsblatt, 2 October 2006, p. 3.

III. EXCURSUS: MARKETS OF THE FUTURE – POTENTIALS AND FACTS[8]

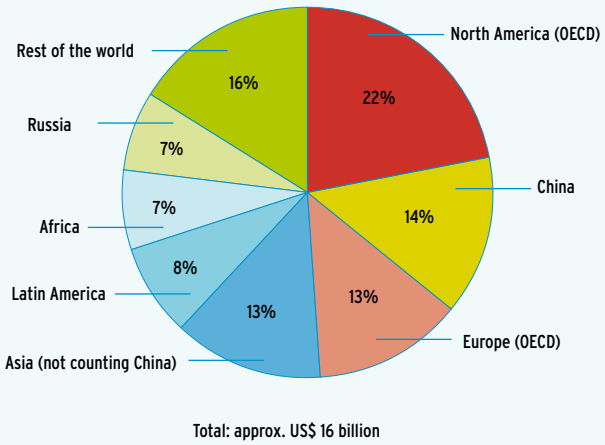
In a global economy that is caught in a process of change, key markets of the future are those markets where central and strategic future needs are linked with technological innovations in a special way. The ability to be present in these markets with innovative technology is a decisive factor in whether a country can compete internationally. It requires more than research alone. It requires a modern innovation system: interaction between all the institutions that produce, accumulate and convey knowledge, that provide training for the workforce, develop technologies, launch and disseminate innovative products and processes, including the appropriate regulative regime and state investment in the necessary infrastructure.

Key markets of the future that are not determined purely by economic concerns but include society's ideas on the quality of life, which new technological solutions and innovative technologies play an important part in achieving.

8 The following statements are in the main based on the interim results of a research project commissioned by the Federal Environment Ministry, carried out by DIW, Fraunhofer ISI and Roland Berger Strategy Consultants and coordinated by the Federal Environmental Agency. In order to be able to assess economic, ecological and scientific trends and identify market potentials, the research project links an examination of important quantitative macroeconomic parameters to an analysis of available technology and foresight studies. It combines this approach with a comprehensive survey of medium-sized and large businesses that are already amongst the innovation drivers and market leaders in selected fields of action. Top-down and bottom-up analyses will be combined in order to facilitate a more comprehensive view of the potentials of the selected fields of action.

ENERGY TECHNOLOGIES

Global energy consumption will rise by about 60% by 2030, from 10 to 16 billion tonnes of oil equivalent per year.[9] A large part of the growth in worldwide energy generation will still be accounted for by electricity generation from fossil sources.[10] In terms of climate policy it would be irresponsible to allow energy-related emissions to rise on the same scale. Germany has demonstrated that it is possible to break the positive correlation between economic growth and CO_2 output.[11] Energy from renewable sources and lower-emission, higher-efficiency conventional power station technology are the building blocks of the global markets of the future. In 2030 almost half of global energy consumption will be accounted for by today's developing countries, 43% by industrialised countries and 9% by the Central and Eastern European transition economies.



Source: World Energy Investment Outlook 2003.

Investment in energy infrastructure 2001 – 2030

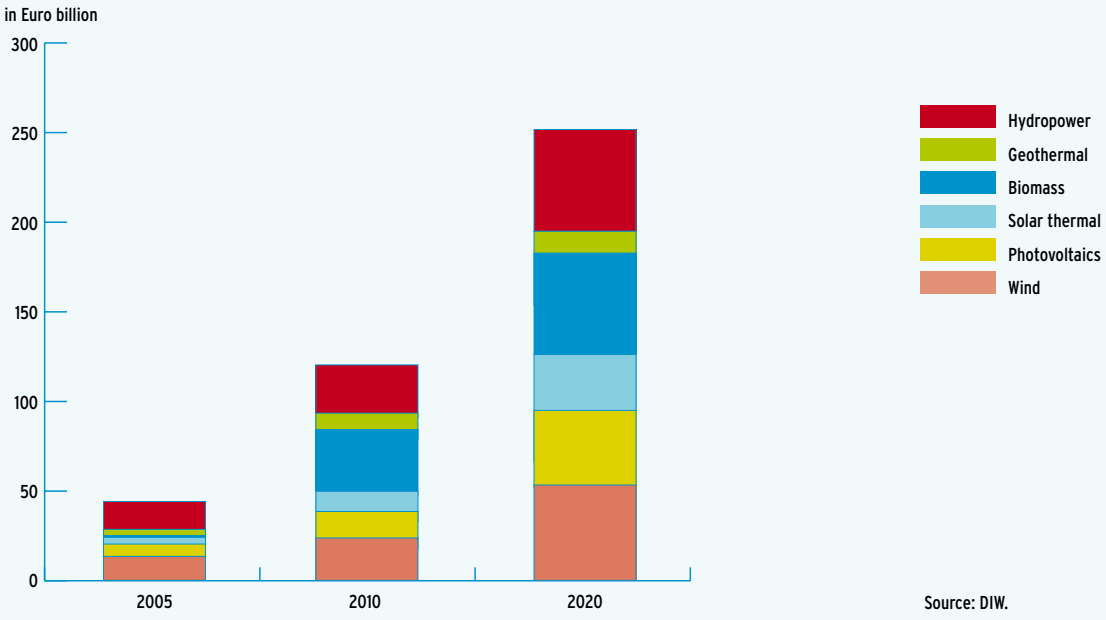
The largest of the conventional power stations that will be built by 2030 will have 800 to 900 GW capacity each and be located in Europe, North America and China. In the developed countries most of the power stations built use alternative energy sources. Coal-fired power stations, in particular, are due for an almost total change of generation. In China and other emerging economies, capacity expansion will play a major role (India +270 GW, Brazil +115 GW).[12]

9 Bundesministerium für Wirtschaft und Arbeit (publisher), EWI/Prognos – Studie, Die Entwicklung der Energiemärkte. Energiewirtschaftliche Referenzprognose. Energiereport IV – Kurzfassung, BMWA- Dokumentation No. 545), Berlin 2005.

10 International Energy Agency, Energy Technology Perspectives 2006. Scenarios & Strategies to 2050; Paris 2006.

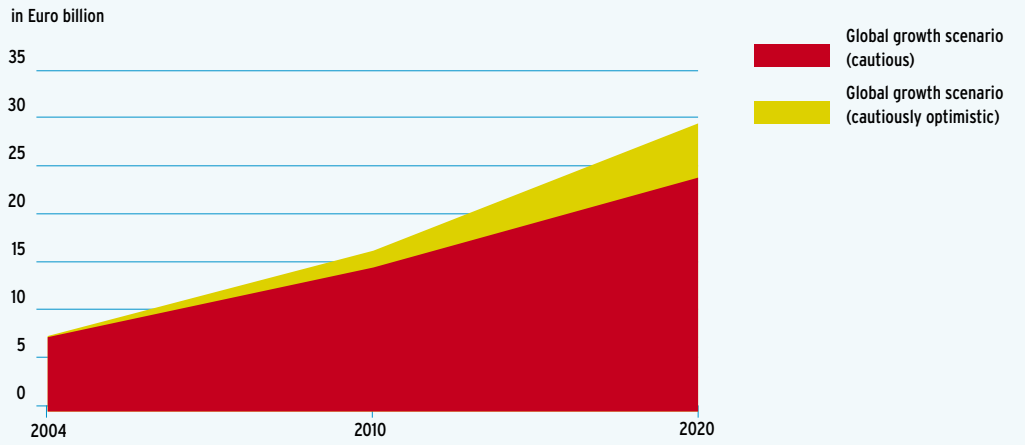
11 In 2005, the use of renewable energies led to a 16% reduction in CO_2 output compared with 1990 (DIW).

12 EIA: World energy outlook 2004.



Source: DIW.

World market trend for renewable energies up to 2020, by type (global growth scenario)



Source: DIW.

Production of systems for using renewable energies in Germany in EUR billion

In the energy mix in 2020 fossil resources will still contribute over 50% to energy generation. That will give rise to an annual market growth of 5-10% in power station technology; the worldwide market volume for power station technology is about 70 billion euros.

The predominant element of the innovation dynamics will be efficiency increases: the use of combined cycle power stations using gas and steam, raising the process parameters pressure and temperature in steam power stations and optimised power station components (turbines, compressors, engines). An important line of development focuses on preventing CO_2 emissions by capture and sequestration of the CO_2 (e.g. IGCC power stations).

In percentage terms, renewable energies' share in overall electricity generation will increase slightly by 2030, rising to 19%. However, in absolute terms that represents an increase over the current share of about 60%. In 2005 the global market for investment in new facilities (including large-scale hydropower) was put at around 45 billion euros per year, a rise of 25% within a year. Conservative estimates assume a world market volume for renewable energy facilities of 115 billion euros in 2020; moderately optimistic estimates put that figure at 250 billion euros. A three- to six-fold increase in global market volume is expected over the next 15 years. The largest market volumes are expected for biomass, wind power, hydropower and photovoltaics. The innovation dynamics will be characterised by:

— New output categories and offshore technology for wind power,
— Technological breakthroughs (that may lead to fundamentally new lines of technology) in photovoltaics (thin-film technologies using different materials),
— New technical lines of development in solar thermal power stations.

German companies have a technological edge over the competition in conventional power station technology, especially in the field of steam and gas turbines and high-temperature gas turbines. In the development of biogas engines (for gas-fired power stations) the USA leads the field, with Japan also a major player. In the area of renewable energies, Germany has an excellent position in photovoltaics and wind power. Due to economic growth in the rapidly developing newly booming economies (China, India and others) the world market share occupied by German companies will decrease in the long term, but in absolute terms turnover will rise. An estimated world market share of just under 10 percent in 2020 would, at around 24 billion euros, be tantamount to a trebling of 2005's turnover. However, with regard to technologies for storing energy and fuel cell research Germany also lags behind somewhat.

SUSTAINABLE MOBILITY TECHNOLOGIES

The world market volume for transport technologies is currently estimated to be 300 billion euros. Combustion engines account for approximately half of that. Other significant shares are held by the areas of rail vehicle engineering and track building, jet engines and shipbuilding. At the moment, the market for alternative drive systems and biofuels is still smaller, but the automobile industry nevertheless continues to assume stable overall development. Strong growth is expected, in particular with hybrid drive systems, albeit from a currently low level.

In terms of growing markets within the field of combustion engines, the next generation of diesel engines deserves special mention (market volume in

Energy technologies: SWOT analysis of Germany's position

STRENGTHS	OPPORTUNITIES
• Strong market growth in Germany in the early phase of development gives domestic companies a competitive edge (e.g. learning curve effects). • Good knowledge base and technological potential in important fields of technology in the renewable energy sector. • Ambitious environmental policy with strong international visibility.	• Global challenges that favour renewable energies will continue to exist in the long term. • Strong world market growth is highly probable. • The high world market shares held by domestic companies are a good starting point for further growth in sales. • Establishing Germany as a lead market for technologies in the field of renewable energies.
WEAKNESSES	**THREATS**
• Germany has a number of weaknesses in high-tech technology in terms of technological capability. • Social and political consensus on sustainable energy supply is still fragile. • Corporate structure (high proportion of small and medium-sized enterprises in certain fields of technology) is a possible obstacle to internationalisation.	• Use the expansion of the internal market in other fields of technology (e.g. photovoltaics) to improve international competitiveness. • Support companies focusing on innovation (today production is often the main area concentrated on). • Maintain a strong competitive position in dynamic markets despite shrinking world market shares • Raise companies' export focus and export capabilities.

Source: DIW/Fraunhofer ISI/Roland Berger Strategy Consultants.

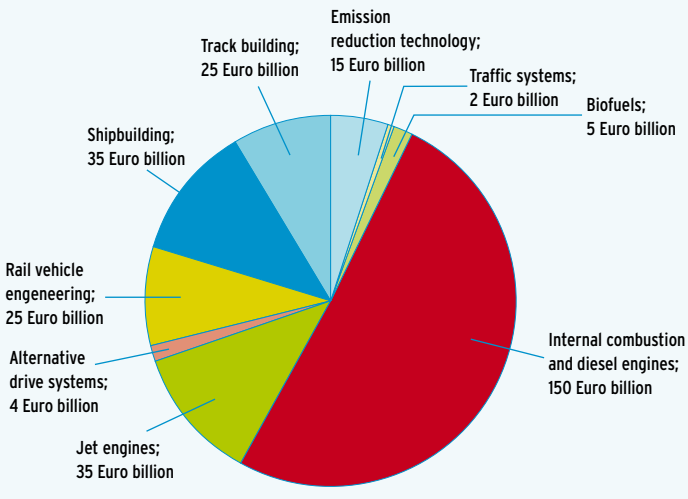
Europe of 6 billion euros with a rising trend), as do advanced high-pressure fuel injection systems (market volume in Europe of 4.5 billion. euros, also with a rising trend).

In the field of traffic control, the market for electronic toll collection systems in Western Europe was estimated at almost 700 million euros in 2006, based on a volume of more than 60 million euros. Including systems introduced in Germany, Austria and the City of London that were unknown at the time of the forecast gives a market volume of between 800,000 and 1,000 million euros and the trend will continue to rise sharply. The size of the transport management systems market will reach 595 million euros with the trend rising and the transport information systems market will be 300 million euros, similarly with a strongly rising trend.

The European market for rail vehicles and rail infrastructure is undergoing a very dynamic development. The overall market of almost 30 billion euros is divided into just under two-thirds in rolling stock and one-third in tracks. Urban infrastructure takes roughly a 30% share here, which, seen against the backdrop of rapidly growing metropolises throughout the world indicates considerable potential for development. Triggered by endeavours to create a single European railway region and by the rise in safety requirements worldwide, the market for control, security and safety technology is, at 4.6 billion euros, the largest sector of this market and has strong growth potential.

In the area of automobiles, the USA at 33 % and Western Europe at 28 % are still the largest markets in terms of demand for cars. Whereas sales markets for vehicles in Europe, North America and Japan are increasingly displaying saturation tendencies and sales figures for 2005 in the new EU Member States dropped by 10% over the previous year for the first time, India, China, Southeast Asia and South America will continue to develop very dynamically in all transport modes.

With its high-speed programme China will be an important market for the railway sector from 2006-2010. The railway market in Asia is estimated as being worth up to 10 billion euros per annum. In 2005, Brazil also witnessed record levels of investment. In the period between 2007 and 2013, the EU is expecting 350 billion euros to be invested in the trans-European transport networks. With its Safetea-Lu programme, the US government has also laid the foundation stone for extensive investment in infrastructure.



Source: Fraunhofer-ISI.

World market volume for sustainable mobility

Sustainable mobility technologies: SWOT analysis of Germany's position:

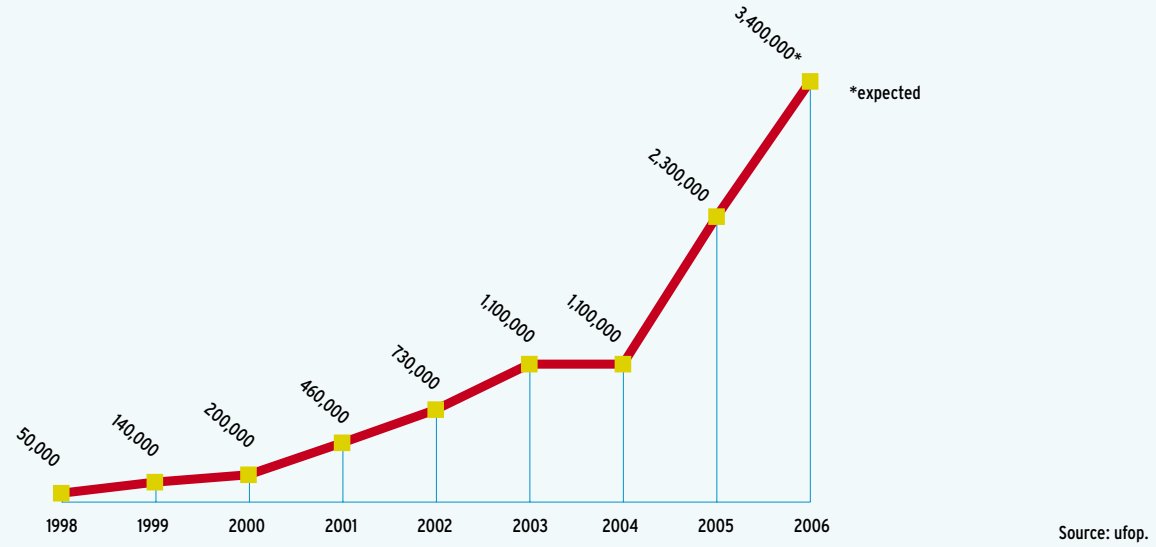
STRENGTHS	OPPORTUNITIES
• Outstanding competitiveness in central sectors (engines/automobile, rail vehicles and infrastructure). • Innovation and diffusion are backed by environmental policy.	• Massively expanding world market. • Discussion of new policy instruments (emissions trading, road pricing) to generate demand and take advantage of the focus on decentralized technological innovations. • Bring about prompt convergence of different areas of technology.
WEAKNESSES	**THREATS**
• Lagging behind technologically in individual areas (hybrid drive technology). • No constant demand for highly efficient vehicles. • Lack of coordination between actors on issues of intermodality and interoperability. • Political signals lack continuity and consistency.	• Increasing competition from newly booming economies, even in high-end technological products. • The rail regulation regime's orientation towards openness to new solutions.

Source: DIW/Fraunhofer ISI/Roland Berger Strategy Consultants

In the field of aircraft, the Asia-Pacific region is already the largest market with a market share of 36 % of sales, ahead of the USA (28 %) and Europe (24 %). The region's economic and demographic development makes it likely that this lead will continue to widen.

Today's mobility is based in all areas on fossil oil. Experts estimate that peak oil, which is the point at which maximum production is reached, will occur in the next ten to fifteen years. The world will have to adapt to a new basis for mobility. Contributory factors to that include: higher efficiency (cars with petrol consumption of three litres, or even one-litre, per 100 kilometres), alternative drive systems such as hydrogen technology as well as fuels from biomass. Initial assessments indicate that in the production of second-generation biofuels there is a high energy yield per unit of land and a potential for high volume. This produces a significantly improved CO_2 balance than was possible with first-generation biofuels. Estimates produced by the Fachagentur Nachwachsende Rohstoffe (Renewable Resources Agency - FNR) assume - in an optimistic scenario - around 4,000 litres of vehicle fuel per hectare.[13] This means that mathematically speaking at least 20 to 25% of Germany's entire vehicle fuel demand could be replaced, without the need for imports. A medium-term goal is therefore a 25-percent quota of biofuels to supply the mobility sector. Large-scale industrial production can probably not be expected until 2010. However, even now the biofuel market is expanding strongly, partly due to the Biofuel Quotas

13 Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz/ FNR, Biokraftstoffe – eine vergleichende Analyse, 2006.



Source: ufop.

Biodiesel production capacity in Germany (in tonnes)

Act. A comparison of biodiesel production capacities in Europe shows that Germany is ahead of other EU countries.

EFFICIENCY TECHNOLOGIES

Global consumption of energy and materials has risen astronomically in the last 30 years. Between 1970 and 2005, global energy consumption doubled (China and India: six-fold increase),[14] consumption of important industrial raw materials such as crude oil, coal, steel, aluminium or copper rose by a factor of 1.6 to 4.2.[15] Consumption dynamics have accelerated sharply in recent years. A further rise is expected for the future – for important industrial raw materials such as steel by 50% by 2015,[16] for oil by 40% by 2030, counting only its use as fuel.[17]

Sustainable management of resources can only be achieved if we manage to further improve energy and resource efficiency. This topic is increasingly becoming a central focus internationally and already plays a major role in programmes at EU level. The USA is currently rolling out a major research programme on the "green chemistry" complex. Because of its weak resource base, Japan has always been a country that has used resources as efficiently as possible. Large Japanese companies have perfected the life cycle assessment concept; the principle of dematerialisation underpins this, including in political programmes and decisions.

Efficiency technologies have great market potential. In the field of energy efficiency technologies, world market volume is already in the region of 400 billion euros. The majority of that is accounted for by the following sectors: measuring and control technology, household goods (white goods) and building services, heating and air conditioning technology. Steady worldwide market growth of about 5% is expected in these areas. By 2030, the additional market volume not counting the transport sector that can be directly attributed to increasing energy efficiency will amount to around 1,000 billion US dollars, just less than a third of which will be generated in non-OECD countries and two-thirds in OECD-countries. Industry represents 40%, whereas the area of buildings, including non-industrial electro-technologies, represent about 60%. Market potential in the field of recycling alone amounts to about 55 billion euros worldwide.

The potential for employment is also considerable. Calculations from scenarios commissioned by the Aachen Foundation Kathy Beys show that an improvement in energy and material productivity of 20% at the end of the calculation period of 15 years will lead to a net rise in the number of jobs totalling 1,000,000.[18] At this point, companies would be able to record 20% higher net trading profits.

The demographic growth regions in the emerging economies (China, India) are seen as having particular market potential. For example, in India, primary energy demand per unit of GDP, a measure of a country's energy efficiency, is still higher than in Germany by at least a factor of three; in China it is higher by at least a factor of four.[19] The potential for efficiency increases in the area of energy generation alone is thus estimated to be 30-50% in China.[20] China also lags behind in other fields, such as waste technologies. Between 1999-2003, the volume of industrial waste generated in China rose by 20%; currently only 20% of waste is disposed of in an environmentally sound way.[21]

Some industrialized countries are also dragging their feet in terms of energy efficiency. For example, the average primary energy consumption per inhabitant in the USA is still almost twice as high as in Europe.[22] Similarly, at 20 tonnes per inhabitant per year, the USA's CO_2 output is twice as high as Germany's (approx. 10 tonnes).[23]

There is also great potential in the area of reuse of materials. For example, metal recycling is already highly developed throughout the world, although the emerging economies still lag behind here somewhat. In plastics recycling the picture is still patchy across the industrialized countries. For example, in Greece the quota of packaging recycled is only 33%, whereas in Germany it is already 75%.[24] As a comparison: in China 50-60% of packaging waste is not even collected or landfilled properly.[25]

14 BP Statistical Review of World Energy 2006.
15 Abare Australian Commodities 2006, US Geological Survey Mineral Commodity Summaries 2006.
16 Mittal Steel: statement by its CEO for Europe, 2006.
17 EIA, International Energy Outlook, Washington 2006.
18 Aachener Stiftung Kathy Beys (publisher), Ressourcenproduktivität als Chance - Ein langfristiges Konjunkturprogramm für Deutschland, Aachen 2005.
19 EIA, International Energy Outlook, Washington 2006; International Monetary Fund, World Economic Outlook Database, April 2006; projection by Roland Berger Strategy Consultants.
20 EIA, International Energy Outlook 2006, projection by Roland Berger Strategy Consultants.
21 China Statistical Yearbook 2004.
22 BP, Statistical Review of World Energy 2006.
23 United Nations Millennium Goal Indicators Collaborative Research on the Economics of Environment and Development 2006.
24 European Environment Agency: Effectiveness of packaging waste management systems in selected countries: an EEA pilot study 2005.
25 United Nations Millennium Goal Indicators, Collaborative Research on the Economics of Environment and Development 2006.

The greatest opportunity in the field of increasing energy efficiency is in new technologies in building services engineering (in particular heat insulation and heating and air conditioning technology, low-energy/passive house), energy-saving electrical appliances ("white goods") and low-energy lighting. In addition to that, enabling technologies such as measuring and control systems, automation systems and more efficient electromotors also contribute to energy efficiency. New services such as contracting or energy consultancy are making an additional contribution.

In the field of resource and material efficiency, the most important areas for innovation are in material efficient construction ("green design") and optimisation of resource use in production. Miniaturisation of products and the use of nanotechnology processes also reduce material consumption rates.

Efficiency technologies: SWOT analyses of Germany's position: Energy efficiency

STRENGTHS	OPPORTUNITIES
• Good knowledge base and technological potential in important fields of technology. • Significant international competitive successes of technology manufacturers; high world market shares of companies as a good starting position for further growth in sales in a number of lines of technology. • Innovation and diffusion driven by energy and climate policy.	• Strongly expanding world market. • Need for reinvestment in the area of power stations, which makes it possible to realign energy demand and supply. • Discussion of new policy instruments (emissions trading, energy efficiency directive) to generate demand and take advantage of the focus on innovations in efficient technology. • Use price increase in energy resources to advance innovations.
WEAKNESSES	**THREATS**
• Despite a broad consensus in society on the role of energy efficiency, activities are unevenly distributed across different lines of technology (few incentives for industrial enabling technologies). • Companies are still not as organised as in the area of renewable energies. • Lack of "visibility" of the role of efficiency technologies amongst the public.	• Make use of political developments such as the energy efficiency directive to further strengthens lines of technology. • Take competition from technologically strong developing countries into account as early as possible. • "Export" incentive policies to other countries in order to create larger markets for products. • More systematic incorporation of "new fields of technology" such as nano-/biotechnologies into the development of efficient processes and products.

Source: DIW/Fraunhofer ISI/Roland Berger Strategy Consultants.

Resource efficiency

STRENGTHS	OPPORTUNITIES
• German companies are extremely well placed in the field of recycling technology, the key technology for improving resource efficiency. • Germany is perceived throughout the world to be a pioneer in recycling and efficient production and manufacturing processes.	• The demand for resources, and thus the demand for technologies that improve the efficiency of their use, will increase exponentially throughout the world with the development of emerging economies and developing countries. • Improvements in resource efficiency give industry the noticeable cost reduction it is looking for to secure its global competitive position. • Use price increase for non-energy resources to advance innovations.
WEAKNESSES	**THREATS**
• Research into the efficiency potential of resource use is still rudimentary, both in Germany and worldwide.	• The knowledge base on the politics of designing conditions that are conducive to sustainable management of resources must be expanded. • The change in paradigm towards intensifying resource research will meet with opposition from sections of the scientific community and industry.

Source: DIW/Fraunhofer ISI/Roland Berger Strategy Consultants.

LIFE SCIENCE TECHNOLOGIES

Life sciences will have a decisive influence on the 21st century. Biotechnology processes, modern biology and chemistry that look directly at the life of human beings, animals and plants have the potential to contribute to the resolution of central issues of the future. The life sciences are a dynamic research field with vast economic and ecological opportunities. However, biotechnology processes contain not only potentials but also risks to humans and nature that cannot at present be fully assessed – in the field of green genetic engineering and the release of genetically engineered organisms to name specific examples.[26]

From the environmental point of view, the greatest potentials the life sciences hold are probably in the areas of white biotechnology and nanobiotechnology. Because industrial biotechnology uses genetically engineered organisms in closed systems it is more widely accepted in society than green genetic engineering. If the use of microorganisms or enzymes makes it possible for industrial processes on a broad basis to use less energy or emit fewer pollutants and fossil resources can be replaced by renewable resources, it will be possible to achieve an outstanding reconciliation of ecological, economic and social benefits. In environmental aftercare, biotechnology processes are seen as an opportunity to eliminate pollutants, collect raw materials and recoverables and replace finite resources by renewable resources (fuels and polymers).
At the same time, white biotechnology makes an important contribution to the competitiveness of the chemicals industry. Only by establishing new value added chains using new, intelligent products that are incorporated in complete system solutions for the customer, will it possible to safeguard the future of the chemicals industry in Germany and the industries it supplies.[27]

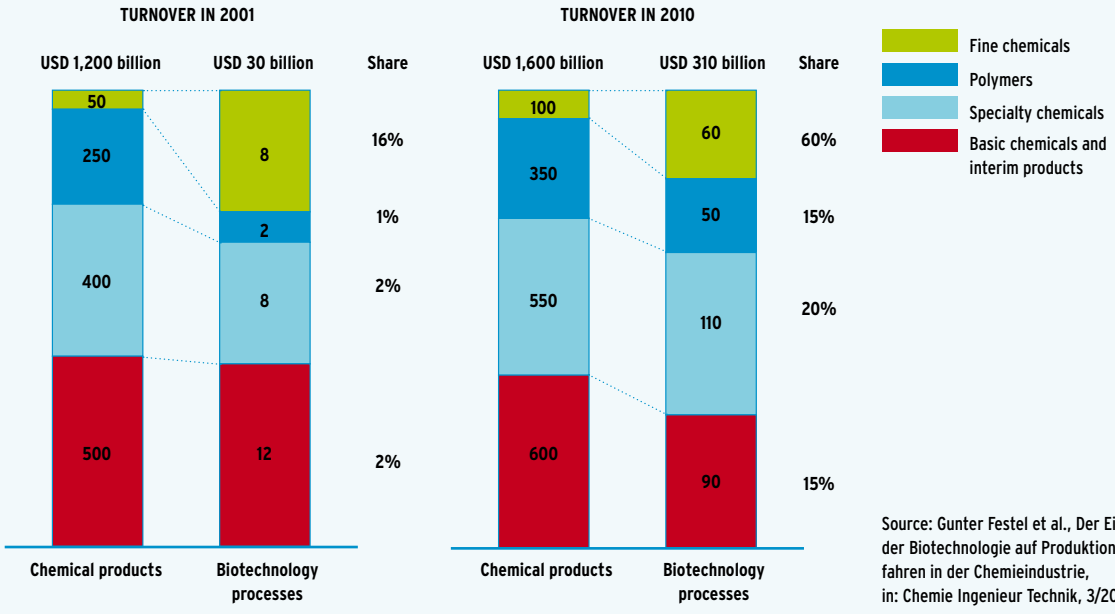
According to current estimates, the turnover for biotechnology processes will increase tenfold by 2010 compared with 2001 and in the field of fine chemicals the share occupied by biotechnology processes will rise to around 60 percent.

No studies are currently known that systematically estimate the economic potential of white biotechnology in applications that have environmental relevance. However, a number of pointers make it possible to imagine the economic opportunities:

— Diverse studies estimate the share of biotechnology processes in the production of various chemical products to be currently at around 5%; they suggest that that figure will rise to 20% by 2010. The added value of biotechnological production is currently estimated to be 11-22 billion euros per annum.[28]
— The world market volume for outstanding product groups such as amino acids, antibiotics and

26 Cf. also: Umweltbundesamt, Umweltpolitik und Life Sciences (unpublished report), Dessau, September 2006.

27 Dechema, Weiße Biotechnologie: Chancen für Deutschland. Position paper, November 2004.
28 Ibid.



Source: Gunter Festel et al., Der Einfluss der Biotechnologie auf Produktionsverfahren in der Chemieindustrie, in: Chemie Ingenieur Technik, 3/2004.

In 2010 approx. 20% of chemical products, with a value of about USD 300 billion, will be produced using biotechnology methods

enzymes is estimated to be about 55 billion euros.[29] The market volume for enzymes alone has grown by 50% in the last 10 years.

— Another profitable field of application is considered to be production of polymers from renewable resources. Since 1998, the automobile company Toyota has been using components made of bioplastic in selected models of vehicle. By 2020, the company plans to cover 66% of world market demand for bioplastic by expanding its own polyactide production. The company is assuming that bioplastic's share in global plastic production will by then have reached approximately 20% and expects to achieve a turnover of 38 billion US dollars in 2020 by going into bioplastic production.[30]

— Even now the chemicals industry meets 8 % of its raw material needs through renewables. In the USA the total switch from petrochemicals to a chemicals industry based on renewable raw materials is already under discussion. Biotechnology processes will contribute to changing the oil-based infrastructure of our industrial production to a technology based on renewables. McKinsey and the Oeko-Institut estimate that the available by-products and waste from agriculture would be sufficient to produce about 40 % of the world's bulk chemicals.[31] The management consultants put the overall reduction potential for CO^2 emissions through the use of biotechnology processes at 65 to 180 million tonnes per year worldwide.

— A study carried out by the Business Communications Company (BCC) puts the world market volume in products that can be classed as nanobiotechnology at 269 million US dollars in 2002. Analytical biophysics with a turnover of 181 million US dollars represents the most important area, followed by nanotechnology products for medical analysis and diagnostics. BCC is forecasting strong growth for 2007, with turnover rising to almost 1.2 billion US dollars.[32]

Figures on turnover relating to industrial biotechnology production in German companies are not available. DECHEMA puts the current figure in the tens of billions euros range. Biotechnology also has a significant impact on employment. According to estimates produced by the Fraunhofer Institut, the impact on employment in Germany in 2000 – taking preliminary work into account – was in the range of 614,000 jobs.[33] About 69,500 were directly dependent on biotechnology. The Fraunhofer Institut also analysed the impact of using biotechnology on the competitiveness of the industries in question and came to the conclusion that biotechnology in the pharmaceuticals industry and the chemicals industry has predo-

29 Ibid.

30 Ibid.

31 EuropaBio, White Biotechnology: Gateway to a more Sustainable Future, Lyon 2003.

32 BCC (2003) Biomedical applications of nanoscale devices: commercial opportunities, Conference proceedings, Nanotech and Biotech Convergence, quoted in: Umweltbundesamt, Umweltpolitik und Life Sciences, op. cit.

33 Fraunhofer Institut, Beschäftigungspotenziale in der Biotechnologie, Stuttgart 2003, quoted in Umweltbundesamt, Umweltpolitik und Life Sciences, op. cit.

Biotechnology: SWOT analysis of Germany's position:

STRENGTHS	OPPORTUNITIES
• Broad knowledge base: excellent basic research in many areas. • R&D personnel: highly qualified and motivated researchers. • Well-developed infrastructure: modern research landscape and numerous facilities for technology transfer and company start-ups. • Broad-based corporate landscape: start-ups, medium-sized enterprises and multinational companies present; all relevant application industries represented.	• White biotechnology: the chemicals industry is a strong sector of application, with corresponding impact on agriculture; accepted by the public as an appropriate use. • Maturing biotechnology companies: market launches of products (medication), new processes and services as a result of increasing consolidation.
WEAKNESSES	**THREATS**
• Pharmaceutical and chemicals industry: innovation drivers today in the USA, UK and Switzerland; too few vertical development cooperation ventures in Germany; hesitant uptake of biotechnological processes in medium-sized enterprises. • Inexperienced company founders: founder teams often lack business experience, lack of "serial entrepreneurs." • Low personnel mobility: transfers between science, industry and VCs not often enough. • Venture capital: private offer of early-phase financing thin on the ground, specific industrial expertise present in only a few VCs. • Licensing takes to long: slow licensing procedures. • Very few demonstration facilities: lack of evidence of "technical feasibility," lack of process data.	• Green genetic engineering: low consumer acceptance in the area of food and creation of innovation-friendly framework conditions. • Competition for high potentials: tough international competition for the best personnel. • Danger of key industries emigrating: loss of large companies in the pharmaceutical and food industry and therefore of potential customers for suppliers of biotechnology. • Economic use abroad: successful German biotech companies are being bought up by foreign competition and then transferred abroad with pharmaceutical patents being out-licensed, chiefly to other countries. • Competition from the Far East, particularly in simple and medium-difficulty technologies such as fermentation, biogenerics and antibiotics production. • Clear consumer benefits: develop products with convincing benefits and inform the public about them.

Source: Bundesministerium für Bildung und Forschung, Hightech-Strategie für Deutschland, Berlin 2006, p. 85.

minantly led to new products and that there tends to be little evidence of substitution effects. In environmental biotechnology – in the view of the Fraunhofer Institut – the competitiveness of over two-thirds of jobs (particularly in wastewater treatment) depends to a high degree on the use of methods and processes of modern biotechnology.
German companies as potential users of white biotechnology are amongst the key international actors in their field.

IV. GUIDING PRINCIPLES OF ECOLOGICAL INDUSTRIAL POLICY

In order to capitalize on the double dividends of green markets for both the environment and industry, policymakers must take a proactive approach. The window of opportunity will not remain open forever and we must take advantage of it if we want to maintain and consolidate our market position and prevent nature being irreparably damaged. The scientific community is largely in agreement: if we are to even limit the consequences of climate change, an unequivocal course of action must be set in the next 10-15 years. The industrialisation process in the emerging economies confronts us clearly with the tight time horizon. In China alone, 140 new power stations will be built in the near future, most of them fossil-fuel fired. According to the prognoses, three-quarters of the oil produced in the Gulf region will be shipped to Asia within the next ten years. And: even now China consumes a quarter of global steel production, 16 of the 20 metropolises with the worst air quality in the world are in China and four-fifths of all the country's waste are not disposed of in an environmentally sound way.

Germany has to rediscover the idea of technical progress, not in the sense of blind faith in progress but as a means to help solve the immense tasks that lie ahead of us. In view of the pressing need for action, "revolutionary" technological advances in core industrial areas such as energy generation and usage and use of materials are vital. The market cannot tackle this challenge alone. As long as it is possible to earn money so splendidly with scarce resources, or as long as markets continue to have an oligopolitical structure, we cannot rely on them. As important as it is that prices finally express the "ecological truth," and as correct as it is theoretically that those resources be efficiently and optimally allocated by the market, it is nevertheless also true that these requirements have not yet been met. The regulatory framework of the free market must be optimised.

What is needed is a strategic ecological industrial policy that serves the interests of our environment and our own economic interests. Ecological industrial policy therefore has to do several things simultaneously:

— It has to strengthen strategic industries of the future and make our industry fit for the markets of the future.
— It has to promote innovation, initiate advances in technology and help ensure that these technologies are used and reach the market more quickly.
— It has to adapt the industrial structure of our economy to ever-scarcer resources.
— It has to help switch the material base of our industry in important fields to renewable resources.

This can bring about new growth, new value creation, new products and new jobs.

Ecological industrial policy is an issue that must be tackled by society as a whole. It needs a government that ventures forth as a pioneer, but it does not rely on the idea of government's omnipotence in industrial policy. The political arena, industry and society have to tackle this task together. Innovation needs a dialogue between the main actors in order to identify mutual interests and look for win-win strategies. Only if, against a backdrop of different analyses of the situation, we manage to develop common perspectives about goals will we have the concentration and strength we need to solve the problems of the future. This dialogue between the actors must become a "New Deal" for economy, environment and employment.

In this it is essential that conflicts are not ignored or made into taboo subjects.

— Many questions relating to new enabling technologies such as bio- and nanotechnology are still unclarified and possible risks cannot be ruled out. Blocking attitudes that any of the parties might adopt can only be overcome through dialogue. Only through dialogue a differentiated approach to technological possibilities could become established to ensure that the environment benefits.
— Innovation ultimately always involves "creative destruction" (Schumpeter), win-win situations with regard to the environment and industry do

not automatically preclude conflicts of distribution within industry. New technologies replace old technologies; there are always growing markets on the one hand and shrinking markets on the other, which means there are always winners and losers.
— Environmental protection is not free of conflicting goals. Renewable resources need land, for example, and the competition over whether to use those resources as materials or to provide energy will continue to grow.

The following guidelines must contribute to the success of ecological industrial policy and thus to the establishment of a true global efficiency revolution within the broader context of the "third industrial revolution."

The state has to play a pioneering role

The state and its environmental policy are important innovation drivers. With state demand, the design of a regulatory framework and ambitious limit values that are announced in good time and with planning security, policymakers can instigate carefully targeted innovation incentives. But a proactive policy and the case for an ecological industrial policy go far beyond that: it is vital that Germany focuses its research on lead markets and concentrates on core strategic areas. The state must use intelligent market-launch programmes to take new technologies out of the laboratory and into the market and to kick-start their use and dissemination. And a proactive policy also means that the "pioneer markets" we need to ensure we have an optimum position on tomorrow's global markets have to be created today in Germany.

Set benchmarks as the basis for ecological industrial policy and action

Instead of cultivating alarmist tendencies, the state, industry and society must develop a political paradigm to counter ecological threats and global needs, which can be used to guide innovation policies. Joint objectives create acceptance for innovation – particularly if they make it clear that not everything that is technically feasible will actually be implemented. The power station that emits no pollutants, the low-energy house, decentralized energy supply and the "clean car" are visions, around which innovation, social acceptance and modernisation strategies can be organised. Concrete benchmarks help to structure the political agenda – for example, when the Federal Government commits to doubling energy and resource productivity by 2020 and increase renewable energies' share in electricity generation by then to at least 20%.

Develop an intelligent regulatory framework for ecological industrial policy

If, in a globalised shareholder economy, expectations of quick returns overshadow long-term profit thinking and become the decisive yardstick for business decisions, it is both detrimental to economic potential and bad for the environment. In the past, the "German model" drew its strength from an innovation strategy based on long-term investment cycles, particularly of small and medium-sized companies. Today they are often helpless in the face of global market dynamics. Despite the structural difficulties they face in the international context, something must be done to help long-term perspectives achieve a breakthrough. The regulatory hand of the state and the strategic view of policymaking must contribute to this. We need an intelligent ecological-industrial regulatory framework.

Exploit export potentials more effectively

The export initiative for renewable energies has contributed to the success of this industry. We should use the experience gained here to promote the export of other environmental technologies in a more focused way. The range of environmental technologies must be expanded if they are to be disseminated more widely. But boosting international demand is equally important. Exporting successful policies plays an important role in this. The German Renewable Energy Sources Act is an example of how a successful instrument has become established internationally and how climate change policies have decisively contributed to the success of an entire industry.

Accelerate the market launch of innovative technologies

State procurement policy and intelligent market introduction programmes can help disseminate innovations. But companies must also shoulder responsibility and ensure that their product policies reflect state of the art developments. The top-runner approach has contributed to the strength of the Japanese consumer electronics industry. An European top-runner programme would be to help create a revolving innovation system in Europe and ensure that both the design and production of consumer goods become increasingly economical and resource efficient.

Improve innovation financing for companies

Again and again the high costs associated with innovation projects and the lack of appropriate sources of financing prove to be central problems: small and medium-sized companies in particular can easily come up against their limitations. Lenders often impose restrictions due to uncertainties about the technological feasibility and market acceptance of ideas for innovations. If obstacles to financing could be overcome and financing for innovations improved, significant innovation potentials could be tapped.

In recent years initial steps were taken in the form of individual government programmes to expand direct project funding and reach more SMEs or young companies. What is required is a mix of financing instruments that can respond adequately to companies' specific financing situations.

Create lead markets and develop "man to the moon" projects

Technological development cannot be decreed "from above." But technological development does not take place in a vacuum. It is vital that the framework conditions centre on innovation. In addition, funding of research and development that is strategic and focuses on lead markets can also make an important contribution. "Beacons" can provide orientation and set markers for development routes. They help to create acceptance in society and contribute to a society's process of consensus building.

Build new institutional structures for innovation

Innovation needs dialogue. But dialogue needs structure – also in order to permanently establish innovation as an issue to be tackled jointly by industry, society and the political arena. One of the problems innovation strategies suffer is that they are fragmented in terms of financing, instruments used, and content. Most research in Germany is what is known as Ressortforschung (commissioned by specific government departments). But crosscutting issues need crosscutting research and innovation strategies. An "industry cabinet" would force the major government departments to coordinate their policies at ministerial level. That would strengthen political impetus and is the prerequisite for a concerted strategy.

V. THE FUTURE NEEDS COURAGE

In the next few months and years an agenda for an ecological industrial policy will have to be developed along these lines. The ecological and economic challenge cannot be met with the strategy of one single ministry but only with a comprehensive and crosscutting modernisation strategy on the part of Europe and Germany. Government departments must make their contribution to its success, along with industry associations, companies, the scientific community and key actors within civilian society.
Technological issues and developments will play an important role here. But technological innovations must be embedded in social and economic innovations and in cultural and social reflections. Anyone seeking a new kind of progress can organise it only on consensual lines. New progress needs a "New Deal," a social contract for the environment, economy and employment. This contract can only be drawn up by all parties acting together. But there will costs involved for all of us. Nevertheless, it will create new synergies and build on new alliances that are the outcome of radically different framework conditions. Ecology and the economy will increasingly become less of a contradiction; economic and ecological rationales will start to converge – inevitably and at an ever-increasing pace. Putting this into action and advancing the discussion of the consequences – that is the role the Federal Environment Ministry is committed to.

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