Federal Environmental Agency
Federal Republic of Germany

Sustainable Germany

- towards an environmentally sound development -

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PREFACE

The conference on environment and development held in Rio de Janeiro in June 1992 has led to the establishment of a new paradigm which has in the meantime brought about a new ideology within environmental and development politics: namely, sustainable development.

It appears simple to agree on a world-wide basis as pertaining to the paradigm to be striven for, but to the same degree, difficult when concerning the definition of concrete requirements and the fulfilment thereof. The requirement of sustainable development is not just adjusting all economies according to and within the limits of our natural resources, but at the same time planning with and considering the ecological and social dimensions. Ecology, economy and social structures should not anymore be separately dealt with or worse, be managed as rival sectors. The protection and conservation of the natural resources as the basis of life, economic productivity and social responsibility belongs together as one entity - as well as and for reason of the welfare of future generations.

The fact that the sustainability as a social objective has also found wide approval in Germany, gives some insight regarding individual ways through which sustainable development can be achieved. One thing is sure: we do have to revise our behavioural patterns, since this is the only way with which we can adapt ourselves, on a step by step basis, to the narrower margins which nature itself sets us. Presently in Germany, there are broad discussions on the goals and range of actions connected with the sustainability paradigm. Further, the Minister of Environment has established a range of working groups to make assessment of the existing consensus potential within our society towards sustainability, as well as to define next steps in implementing a sustainable, environmentally sound development.

This study contributes to the discussion on sustainability in Germany. Our main concern in the chosen fields of

energy use
mobility
food production
material flow management
consumption patterns

is less that of a totally new detailed information system as that of the convergence of the various problem areas, so far individually managed, into the comprehensive perspective of sustainable development.

In order to analyse the fields in question as pertaining to sustainability, we applied different scenarios and not prognosis. This comprises the postulation of possible future situations, from which necessary-action possibilities and suggestions were derived. These scenarios direct the attention towards future background conditions and the various possible paths of development.

In view of the year 2010, we have developed 3 scenarios:

1. ‘‘business as usual’’ scenario - continuation of the present trends

2. efficiency scenario - improvement of technical effectiveness

3. structural transformation and awareness raising scenario - assuming changes in behavioural patterns beyond the improvement of technical efficiency.

The instruments suitable for sustainable development will be debated on an interrelative level within the study fields.

The more sustainable development is considered by all the parties concerned as a joint responsibility, the more successful it will be. The contribution from the Federal Environmental Agency should help deepen the discussions between the parties involved which are aimed at achieving results.

Dr. Andreas Troge
President Federal Environmental Agency

I Introduction

I 1. Sustainable development - the emergence of a new paradigm

Global environmental changes are threatening the future of humankind. Unless effective counteractive measures are taken, these changes will assume even more dramatic proportions over the next few decades. It is also increasingly evident that environmental problems are closely linked to development concerns. The key symptoms of this alarming trend are:

- the increase in mean global air temperatures by 0.3 to 0.6°C since the end of the 19th century
- sea level rise of between 10 and 25 centimetres over the last 100 years
- the depletion of the stratospheric ozone layer
- accelerating species extinction
- continued erosion and rapid loss of fertile soils
- pollution and overfishing of the seas
- gradual over-taxation of the Earth System through anthropogenic loads.

In quantitative terms, the total estimated damage caused to the natural environment in one day is as follows:

- the destruction of 55,000 hectares of tropical forest
- the reduction of arable land by 20,000 hectares
- the extinction of 100 to 200 species
- emission of 60 million tonnes of CO_2 into the atmosphere.

I 1.1 From concept to programme

It would be wrong to say that the majority of nations are failing to perceive these trends and the risks implied, or that they refuse en bloc to acknowledge what is now patently obvious. The reactions of many countries, initially at the first United Nations Conference on the Human Environment in Stockholm in 1972 and later at the United Nations Conference for Environment and Development (UNCED) in Rio de Janeiro in 1992, show the extent to which awareness of these problems has meanwhile grown. Whereas the majority of the less developed countries were still convinced in 1972 that environmental demands on the part of the industrialised world were merely another attempt to block the countries of the South in their development, the nations represented at the Earth Summit in Rio de Janeiro

were very well aware that protecting the natural resource base requires major efforts and an unprecedented level of international cooperation.

UNCED has become a symbol of this new awareness of shared responsibility for our planet. A total of 178 countries emphasised the urgent need for action, and issued a number of declarations calling for the promotion of sustainable development and a global partnership in the fields of environmental and development. By adopting the Framework Convention on Climate Change, the Biodiversity Convention, the "Forest Declaration", the Rio Declaration and "Agenda 21", the Programme of Action for the 21st century, and by deciding to establish a United Nations Commission for Sustainable Development (CSD), the Conference laid the conceptual foundations for a qualitatively new form of cooperation in environmental and development policy.

In the beginning was the word

The debates at the Rio Conference revolved around the term "sustainable development", by which is meant a form of global development that can be maintained across generations in an environmentally and socially acceptable way. The term, which dominated the environmental debate throughout the first half of the 1990s, made its first appearance in the early 1980s in the global strategy for the conservation of nature adopted by the International Union for the Conservation of Nature (IUCN) and the World Wide Fund for Nature (WWF). Sustainability then referred to the utilisation of a natural system in such a way that its main characteristics are preserved over the long term.

The principle or paradigm of sustainable development achieved world-wide renown in 1987 when the Brundtland Commission for Environment and Development presented its report entitled "Our Common Future" (WCED 1987). The Brundtland Report defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The concept of sustainable development became the linchpin of an integrated approach in the formulation of strategic global policy responses.

According to the Brundtland Commission, sustainable development, must eradicate poverty in the developing world , on the one hand, and create a new balance between the material affluence of the industrialised world and the preservation of nature as the basis for life, on the other. It must be assumed in future that the consumption patterns and lifestyles of the Western industrialised countries cannot be transposed to the entire world population either today or in the future.

Although very differing positions and interests can coexist under the banner of sustainable development, this in no way implies that the term is void of real meaning. Sustainable development does not require that all future generations enjoy the same standards as we do today. The process involved in attaining sustainable development will demand enormous efforts and the abandonment of familiar habits on the part of all generations, both present-day and future; the global trends that are becoming increasingly evident necessitate corrective action relating, for example, to the consumption of resources and the growth of the world population. The Brundtland definition should not be interpreted as implying a continuation of current levels of consumption, but as a call to act in such a way that we do not limit the capacity of future generations to determine their own lives.

In contrast to prevailing environment policy, the concept of sustainable development emphasises: firstly, the interdependency of ecological, economic, social and cultural development; secondly, the prioritisation of the precautionary principle, and the larger-scale environmental objectives and strategies that

must now be specified at national, regional and local level. Referring to the precautionary principle as the basis for sustainability policies, Principle 15 of the Rio Declaration states that: "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

"Towards Sustainability", the 1992 EU Fifth Environmental Action Programme, states that: "It is becoming increasingly evident that many of the major environmental struggles will be won or lost in the course of this decade and that the next century may already be too late. .... We can no longer afford to wait and see, …. only to discover that we have made a mistake." (CEC, 1992)

And the German Federal Government wrote in its February 1997 report "Towards sustainable development in Germany" that: "Humankind, through its lifestyles and productive activities, has reached a point where it runs the risk of depriving itself of its own natural basis." The German Bundestag has set up an Enquete Commission for the 13th legislative period that will address the goals and conditional framework for achieving a form of sustainable development that accords with the needs of future generations.

Sustainable development requires fundamental changes in the economic system and in society generally. However, it cannot be ordained "from above". Sustainable development must be achieved by applying the principle of self-organisation, i.e. through targeted use of the system dynamics inherent in the ecosphere, society and economy. Sustainability cannot be achieved by designing and implementing a set programme, but can only be initiated and attained as a *process*. Within this context, the task of politics is not only to shape specific areas through direct action, but also to coordinate this process of self-organisation. In a liberal and pluralist society such as Germany, what is needed is an unprecedented level of cooperation between political decision-makers and the individual initiative of those directly involved (BUND and Misereor, 1996).

An ecological framework for the economy

This concept of sustainable development appears in the official documentation of the UNCED Conference in Rio de Janeiro as a guiding principle. Whereas the Brundtland Commission did not specify whether priority should be given to economic growth or to sustainable development, the final documents of Rio take a clear position: the fact that environment and development are interdependent, indivisible and equal in rank means that priority can no longer be attached to short-term economic interests. In response to the question whether the environment must always be accorded priority, regardless of the issue under dispute, the Earth Summit in Rio came to a new insight, namely that all human activities and even social welfare in the classical sense should be subsumed under the principle of environmental sustainability. Development and hence social welfare can only be achieved to the extent that the natural resource basis is not endangered. This principle establishes a clear and forceful environmental framework for economic activities.

If politics is to actively shape a sustainable future, it must recognise the carrying capacity of the environment as a final and absolute constraint on all human activities. The issue that remains is how humankind can best utilise the available options. The economic and social dimensions of the problem render the situation particularly volatile. Humankind as a whole can only survive within the greatly confined action space it now avails of if the socio-economic framework governing the use and exploitation

of nature is subjected to radical restructuring. An economic system necessitating bigger and bigger material flows in order to remain viable would be just as incompatible with sustainable development as would a centrally planned economy that fails to meet people's basic needs.

Although development is always implicit in the concept of sustainability, the goal is no longer progress in the sense of more, further and higher, but a new and qualitatively different set of aims. Depending on the initial situation, development towards this goal can involve quantitative increase (as will be the case for most of the world's less developed nations) - or drastic cutbacks in material flows and resource consumption. In terms of sustainable development, countries in both the North and the South are still "developing".

It should be emphasised at this point that policies geared to sustainability are a form of preventive adaptation that can only be in Germany's best interests, and not - as expected by some and feared by others - some "heroic go-it-alone attempt by Germany to save the planet". Germany's self-interest is served not only through environmental protection at national and global level, but also through the economic and social benefits that derive from this process in those countries that are able to gain a competitive lead in the development of appropriate technologies and patterns of behaviour. Thus, policies based on sustainability are motivated less by some form of universal altruism than by enlightened self-interest. Those who introduce today the necessary steps towards sustainable development will reap not only environmental but also economic benefits.

Archetypes of unsustainable and sustainable development

Sustainable development is more than a narrowly conceived method or technique, but stands for a certain range or "bandwidth" of human activity. This extends from using renewable resources at a rate equal to or less than their regeneration rate, to environmental investments from which the investor derives no gain during his or her own lifetime (e.g. afforestation measures). Thus, the sustainable development paradigm always stresses the priority of the long term over the short term, of the global commons over individual utility, of solidarity as opposed to egoism.

Some drastic examples of non-sustainable resource management include:

- the deforestation of the Mediterranean forests by the Romans and the destruction of the tropical rainforests today,
- the overfishing of the world oceans using ever more refined fishing techniques , and
- the desertification of extensive areas of land in Russia that used to be covered by the Aral Sea, following the large-scale diversion of the lake's feeders for agricultural irrigation.

Examples of sustainable management are more difficult to find, especially when we desist from labelling as sustainable all those forms of resource management that are based purely on former low-tech methods. However, the following practices can be perceived as sustainable:

- the centuries-old rice terraces in China and Indonesia,
- various forms of agroforestry in Africa and Latin America, and

- management of Alpine pastureland from the 17th century to the end of the Second World War.

I 1.2 The interdependency of environment, economy and society

The fragmentation of environmental discourse

One of the most important advances in the sustainable development debate is the recognition that economic, environmental and social factors can no longer be viewed in isolation from or played off against each other. The need to consider not only scientific and technological but also sociocultural aspects necessitates close links between scientific and technological discourse, on the one hand, and social discourse, on the other.

Unfortunately, there are no signs of these close links materialising. On the contrary: global environmental concerns have fragmented environmental discourse in the current crisis right down to the deeper cognitive and emotional levels. On the one hand, we have discourse on the finite nature of the world's resources, on the limits to growth or the carrying capacity of ecosystems, i.e. processes involving material and energy flows which are described using quantifiable parameters such as population size, energy consumption or emissions. On the other, there is the discourse on lifestyles and cultural patterns, on different conceptions of nature and values - i.e. on cultural and symbolic relationships. The former discourse is conducted using the language and methods of the natural sciences and technology, and operates with quantifiable facts, whereas the latter is dominated by the social sciences and the humanities, which work more with images and visions. The twin poles of this discourse are mirrored in the respective diagnoses and therapies put forward by each side: models for regulating energy and material flows are recommended, calls are made for technological innovation, management systems and for a new code of ethics, i.e. changes in our ways of thinking, our value systems and our symbolic orientations.

This mode of operation ignores a severe socio-ecological problem. It goes without saying that economic and social processes must accord with the laws of nature. No society, however well organised it may be, can circumvent the laws of thermodynamics. Goals must also be physically attainable on a permanent basis in order to be generally desirable. Social processes always involve a material and energy-related dimension; they unfold in time and space within a context governed by natural laws. This context is coming to depend more and more on boundary and initial conditions, and technology now interferes with its natural dynamics. Conversely, interactive relations involving materials and energy are also bound up in a web of interpretations that cannot be detached from the underlying causes and effects. Analysis can distinguish between the two sides of this material and symbolic complex, but cannot separate them from each other in reality. Production and consumption, economic life and lifestyles are all linked through markets and money at the regional and global level, and cannot be modified in isolation from each other. An economy needs a matching set of thought patterns, values and behaviours in order to function efficiently.

Social debates on how to modify our ways of thinking, our values and our lifestyles is at least as important as the various scientific and technological discourses on material flows and energy processes. The issue no longer centres on physical parameters, but on the identification and explanation of specific goals and on the time horizon within which we are able or wish to achieve these goals. The concept of sustainability must be overlaid with a time frame that is resource-specific and which also takes into account the assimilation capacity of the environment. Is resource utilisation sustainable when the resource in question will last at least another 200 years at current intensity of use? Social discourse on this issue has to clarify whether the paradigm of sustainable development is compatible with the legally prescribed neutrality in the balancing of economic interests - which mostly entails preservation of the status quo - or whether priority must be attached to environmental concerns wherever conflicts of interest arise.

Sustainability and the equity issue

The fragmentation of discourse on the global environmental crisis, and the strategic separation between prioritising efficiency improvements (the "efficiency revolution") and changing environmental awareness and behavioural patterns (the "sufficiency revolution"), could widen the gap between the North and the South even further. We tend to support an efficiency revolution that provides for continued affluence, while leaving the sufficiency revolution to the countries of the South where poverty is endemic.

A division of labour along these lines is by no means compatible with a genuinely sustainable development of the North and South. If human development is to be assured in the long term, then economic, environmental and social components must be forged into a new unity. Never before has there been such awareness that preserving the support systems for life on Planet Earth is directly dependent on the solutions generated by humankind to the problem of inequality. The transition to intergenerational equity - the idea that future generations must not be deprived of the options available today - is only feasible if there are major improvements in intragenerational equity, if the enormous disparities in wealth between the North and the South are dismantled. Concerning climate change, this means that the industrialised nations must drastically reduce their CO_2 emissions so that developing countries have the chance to catch up in their own development. Only when countries like Germany hold their promise to reduce their CO_2 emissions (by 25% by the year 2005 against the 1990 baseline), and see this as but the first step in the right direction, will they provide countries like India, Malaysia or Argentina with the opportunity to emit substantially more CO_2 when developing their own economic base, without this causing an increase in global CO_2 emissions. If it is certain that sustainable development in respect of global climate protection is only possible by halving present CO_2 emissions by the year 2050, this implies reduction rates for industrialised countries of around 75 to 80% by that date (see Section II 2 below).

Greater equity does not mean quantitatively equal needs and consumption levels all over the globe, but it does imply a fundamental parity of choice between the options essential for long-term survival. The North must abandon forms of production and consumption that cannot be universally generalised. In all spheres of life, be it the consumption of paper, cars, meat or air miles, the middle classes of the Western world have established a level of consumption for themselves that can only be maintained for as long as it is a minority preserve. The development potential of many countries is effectively blocked by 15% of the human population, who use half the world as a hinterland for their productivity growth and their exorbitant levels of consumption. They use the most fertile land, clear forests to cultivate cash

crops or as grazing land for cattle, and extract the natural resources of entire hemispheres. In the process, they have generated a level of wealth that is impossible to reproduce across the whole world. If we are to create equitable relations in the world as the precondition for preventing mass migration of the poor to the affluent nations of the world, with all the problems this would entail, we must use our creativity to reduce our share of global consumption and to narrow the gap between rich and poor countries.

I 1.3 Four basic requirements for sustainable development

Crucial factors for sustainable development are that the key environmental functions for humans

- source of renewable and non-renewable resources,
- sink for emissions and
- the very basis for life

are no longer endangered by unsustainable patterns of production and consumption.

This means not only conserving natural capital and biodiversity, but also that the stress-bearing capacity of humans themselves and of the various environmental media be taken into consideration. Four basic imperatives can be derived from the foregoing, similar to those by the *"Protection of Humanity and the Environment*" Enquete Commission set up by the German Parliament:

- Consumption of a resource may not exceed its regeneration rate or the rate at which all its functions can be substituted.
- The release of substances into the environment may not exceed the carrying capacity or the assimilation capacity of the environmental media.
- Anthropogenic dangers and unacceptable risks to humans or the environment must be avoided.
- The time scale of anthropogenic interference with the environment must be in a balanced relation to the response time needed by the environment in order to stabilise itself.

These basic principles require a new understanding of progress and development, especially in industrialised societies. Whereas the first principle primarily refers to a new understanding of economics, the second and fourth require fullest consideration of the response and carrying capacity of environmental systems.

I 2 Sustainable development in Germany

I 2.1 Germany's commitment to sustainability

In the field of environmental protection Germany has achieved considerable progress, not only in absolute terms but also in comparison to other countries.

The early 1970s saw the enactment of important laws which provided the essential basis for environmental protection as an independent policy field. The first Environment Programme established by the Federal Government in 1971, the ambitious goals of which are relevant even today, was preceded by a dialogue within society of such intensity that environmental problems rapidly became public issues. In 1972, the Council of Experts on Environmental Issues (*Sachverständigenrat für Umweltfragen*) was set up as a scientific advisory council to the Federal Government. Steps of decisive significance for effective environmental protection were taken in West Germany during the 1980s especially, e.g. in the form of the Large Furnaces Ordinance, the re-enactment of the Technical Regulations on Air Purification, the introduction of the catalytic converter in road vehicles, or the comprehensive concept for identifying and recycling materials.

Activities on the part of industry and the various levels of government, which were supported by a high level of environmental awareness among the population, enabled major advances in the improvement of environmental quality and the deployment of emission-reducing processes and technologies, making Germany one of the leading nations in this field. Very few countries have created such enormous capacities for reducing SO_2 and $N0_2$ emissions, or have such a high percentage of low-emission cars. Germany is also leading in the field of wastewater treatment.

However progressive German environmental policy may be, there are no grounds for resting on one's laurels. The environmental improvements achieved to date, some of them very impressive, have been mainly sectoral in nature. Both in Germany and in the world as a whole, we are still far away from sustainability. Long before we were confronted with the economic and social impacts of globalisation, the environmental repercussions - climate change, pollution and overfishing of the world ocean, depletion of the ozone layer and loss of biodiversity - had already made themselves felt. Epitomising a rich Northern country, Germany is not only a victim of these trends, but above all a culprit. It consumes a disproportionate share of the world's resources and causes a proportionate degree of environmental stress to the global commons in the form of emissions and waste. If Germany wishes to comply with the imperative of intragenerational equity, it must display a vital interest in multilateral treaties to mitigate such threats to the global environment.

Germany indicated such interest at the Earth Summit in Rio. Not only has it committed itself as one of the signatories to the final documents of the Rio conference to implement the conference resolutions, especially Agenda 21, in national and international policies. Over and beyond that commitment, Germany has also been playing a pacesetting role within the international community wherever sustainability issues are raised. By committing itself to reducing CO_2 emissions by 25 to 30% by the year 2000, Germany became the first industrialised nation to specify such a target, thus setting an example for other industrialised countries to follow. Moreover, Germany's willingness to implement Agenda 21 in the form of concrete policies has been underscored on many occasions: "Agenda 21 is the bill of specifications for global partnership in the fields of environment and development" (Töpfer, 1993).

Germany must honour its promises in this respect. If the country does not wish to see its credibility wane within the international community, it must progressively shape its policies in line with the Agenda 21 recommendations. Germany, of course, is not the only country intending to base mid- and long-term policies on the principle of sustainability. In its 5th Action Plan "Towards Sustainability" adopted in 1992, the EU clearly states that the 340 million inhabitants of the Community at that time consume a disproportionate share of the world's resources. "A child born in the Community will consume over 20

times as much natural resources over its lifetime as a child born in the majority of developing countries" (CEC, 1992). Various western European countries, such as the Netherlands, Austria, Sweden and Switzerland, have already developed national environmental plans for implementation over the coming years and decades. Their prime focus is on the high throughputs of materials in their national economies. Germany, too, has been gathering momentum on various levels of political planning over the last few years.

International cooperation and national role-model function

The more that Germany makes serious endeavours to adapt its national economic and environmental policies to the increasing environmental constraints imposed by nature, the more it must rely on intensive cooperation with the international community and its institutions. Sustainable development cannot be achieved by any one nation through unilateral action, and Germany is no exception here. Even if Germany aims to play a pacesetting role, and particularly so in this case, it has no option but to integrate its activities into those not only of the EU and the OECD, but also of the other multilateral organisations operating in the field of environment and development.

A purely national strategy would soon meet its economic and environmental limits. Firstly, economic interdependencies within the "global super-market" leads to the importation of environmental stress from countries with low environmental standards and regulations, and to transboundary environmental pollution. Secondly, there are legal constraints on any go-it-alone approach, such as those laid down in the General Agreements on Tariffs and Trade (GATT) and by the World Trade Organization (WTO).

Nevertheless, there is considerable scope for a national pacesetting role, scope that can be utilised if sufficient flexibility and caution are exercised. This scope is all the greater, the higher the environmental standards that are jointly attained. In this way, a dynamic strategy for the environment can be launched which leads from relatively narrow scope at national level, through an enhanced active environmental foreign policy on the part of allied states, to improved minimum standards for Europe, thereby expanding the scope for sustainable development at the national level.

What is needed is a joint approach at international level, particularly in view of global economic interdependencies and global competition. Any action taken by Germany to protect the environment must first be evaluated in terms of its environmental impact. Little is gained for sustainable development if, for example, environmentally sound production processes at national level are offset by buyers switching to imported products or by companies relocating their production to other countries. However, although a single state can definitely improve the chances of a joint approach by acting as a forerunner, this in itself does not suffice. In the long term, the globalisation of markets must be countered by greater globalisation of environmental strategy responses.

Globalisation - the new catchword

At first sight, the globalisation (of economy, environment and culture) is nothing more than the removal of borders, territorial barriers and national obstacles. One commonly recognised aspect within the sustainability debates, the disappearance of national boundaries to the network of cause-effect relations, now applies in equal measure to the international flows of capital and goods, to communications (now virtually unconstrained) and finally to the cultural domain.

Globalisation involves a tendency to decouple certain processes from their geographical, normative and social contexts, whereby power relations between the internationally mobile and locally tied players are shifting. Dependencies operate increasingly over enormous distances.

The root causes of economic globalisation include:

- progressive liberalisation of world trade
- the enormous expansion of global communication networks
- the removal of all barriers to and controls on the transfer of capital
- the very low cost of overcoming geographical distances.

These causal factors operate mainly in one and the same direction - they remove existing geographical, sociocultural and political boundaries and make the world a stage on which global players can operate. This increases competition among companies and locations. From the environmental perspective, the following negative consequences are possible:

- declining social and environmental standards as a result of growing competition
- an increasing tendency on the part of corporations to switch operations to countries with low environmental standards
- increased growth of the global economy , particularly in the transport sector
- accelerated development of remoter areas, especially through new transport infrastructures.

However, globalisation can also bring about benefits for the environment, such as:

- a harmonisation of environmental standards
- improved resource efficiency
- greater competition between products (e.g. product standards and eco-labels)
- the removal of subsidies with detrimental impacts on the environment.

At the level of production and production processes, there are clear affinities between globalisation and sustainability. Both processes centre on efficient resource use and a form of competition in which inefficient producers and locations are disqualified and/or lose importance. Competition in this sense can also function as a stimulus for sustainability - not automatically, but through political influences.

At this point we need to consider another dimension of globalisation. Key economic players are increasingly able to escape any form of political control. A purely national environmental framework will invariably fail if the players assess the costs and risks as too high and take advantage of their “exit” options instead. Preventing this scenario would be the task of an international negotiations system committed to global sustainability, but attempts to institute such a global environmental regime remain very tentative as yet.

Intensified competition between locations must not dilute the imperative of environmental protection, particularly since the costs for the latter rarely operate as real locational factors. The increased resource efficiency generated by more competition between industrial locations can have positive environmental impacts and can create synergy potentials. Sooner or later, lags in standards will generally lead to enhanced demand, driven by environmental considerations, for environmental technologies and product licences, particularly in those countries that are now overexploiting their natural resources.

In that sense, environmental impacts of globalisation are ambivalent and can only be assessed to an approximate degree. It is neither possible nor productive to weigh up positive and negative effects against each other. Future developments will show the direction we must take and the opportunities for counteracting the negative consequences of globalisation through the establishment of an ecological framework at national and especially at international level.

Environmental protection - a positive locational factor

Two opposing positions can be identified in the debate over the effects of environmental regulations and standards on the competitiveness of industry and on the quality of locations. Whereas the conventional position asserts that such regulations lead to high costs and declining rates of productivity, and hence to a loss of national competitiveness, the more progressive viewpoint is that environmental regulations and standards are a crucial factor for enhancing the competitiveness of industry and of the economy as a whole.

Although higher investments in environmental protection impair a location's attractiveness in the short term, it improves in the subsequent period. An enhancement of local environmental quality and the deployment of environmental technologies in a region can induce companies to locate there in order to gain from acquired know-how. These aspects may be reinforced by government efforts in the field of environmental protection that have a positive effect on locational quality. Individual companies must only contribute indirectly, by paying taxes.

In general, the costs for environmental protection are of subordinate importance within the overall cost structure, although many are glad to focus the location debate on just this aspect. Expenditure on environmental protection accounted for only 1.4 percent of Germany's GNP in 1994. The figure in other industrialised countries is of a similar order, varying between one and two percent. This is a clear illustration that differences in environmental standards do not induce any major distortions of competition between industrialised countries. Nor is there any evidence to support the widespread assumption that companies would relocate their production to developing countries with low environmental standards in order to save costs. Despite globalisation, the industrialised countries are still the biggest producers and exporters of environmentally intensive commodities such as fertilisers, steel and paper. The fact that growth industries in Germany include some environmentally intensive sectors with concomitantly higher costs for environmental protection, such as the chemical industry or the cellulose, paper and cardboard processing sector, points in the same direction.

In addition, there are numerous cases showing that corporate environmental protection activities are not only a cost factor, but also a means for increasing efficiency. Substantial savings can be achieved by reducing energy consumption and wastewater output, by improving waste disposal or by operating specific procurement policies. According to estimates by consultancies, the total costs incurred by companies can be cut by a sectoral average of two percent if environmental protection is integrated into the

production process. This is equivalent to 50 percent of the total energy costs of Germany industry. Given the intensified international competition brought about by the globalisation of markets, greater use of integrated environmental protection techniques can turn out to be a wise strategy for responding to new challenges on the world market.

A recent study by leading economic research institutes in Germany shows that, in 1994, almost a million people were employed in the field of environmental protection - about the same number as in the automobile sector. This means that environmental protection as a cross-cutting sector has helped enormously to stabilise employment in Germany. The economic importance of environmental protection is expected to increase still further. According to OECD estimates, the world market for environmental protection services is expected to grow by a further 50 percent in the 1990s, reaching a volume of US$ 300 billion by the year 2000.

German suppliers are well equipped for global competition on this key future markets. Their leading position in many areas is due primarily to the stringency of legal requirements imposed at an early stage, which led to a high level of domestic demand for environmental services and products. Ambitious goals in the field of environmental policy can certainly operate as locational factors with important and positive impacts.

Germany's environmental policy and sustainability

Although some areas have been successful in decoupling economic growth and environmental stress, the overall balance of German environmental policy remains unsatisfactory as far as the goal of sustainability is concerned. The pollutant reductions achieved in one area through technologies or recycling are balanced out in another by shortcomings in the sustainable management of national material and energy flows. Although the consumption of natural resources and the level of emissions per unit of production have generally declined, the quantity of products and services has grown to such an extent that efforts to achieve savings and reductions have been effectively cancelled out in many cases. Effective management of material flows, a crucial requirement in meeting sustainability criteria, is still in its infancy.

Although there is widespread consensus in Germany on the rationale behind the concept of sustainability, the transition to sustainable production and consumption patterns is a obstacle yet to be overcome. Differing viewpoints and interests are able to merge in the guiding notion of sustainable development, because it enables the following facts to be acknowledged, regardless of how open they may be to different interpretations:

Development is approved by all, whereby the term is no longer understood to mean greater material growth, but instead a qualitative change in wealth. The concerns that are uppermost in people's minds are not "more of this and more of that", but a different way of doing things. The persistent process through which the developed and the less developed countries are drifting further and further apart must be stopped, and conservation of the natural basis of life must be safeguarded world-wide for future generations. Nobody can seriously question the assessment that "Current economic and social trends run contrary to the criteria of sustainability" (Brundtland Report, 1987).

Social consensus and changes in perception

Establishing the conditions for a technologically driven efficiency revolution is impossible without changes in our ways of thinking, our values and our symbolic orientations. Both individuals and key social groups must develop a sense of responsibility for nature and society on a global scale , and must act on that basis in their everyday actions. In order to gear technological progress towards sustainability a new consensus within society is essential.

In the industrialised world, efficiency improvements through technology will not be sufficient in themselves to ensure a transition to sustainability. International documents arrive at the same assessment. The Rio Declaration, Agenda 21 and the EU's 5th Action Programme all take an unequivocal stance on this issue. For example, Chapter 4 of Agenda 21 ("Changing Patterns of Consumption") states that

"Although consumption patterns are very high in certain parts of the world, the basic consumer needs of a large section of humanity are not being met. (…) All countries should strive to promote sustainable consumption patterns; developed countries should take the lead in achieving sustainable consumption patterns" (BMU, 1992a). This cannot be achieved without changes in values.

I 2.2 Individual contributions

Germany's contribution to sustainability is closely linked to the contribution made by its people. One of the most important tasks in the future will be to foster awareness of the need for change in consumption patterns and needs. The - convenient - distinction between the private and political spheres (the powerless and the powerful, respectively) detracts from responsibility and is therefore inadequate, indeed extremely obstructive when it comes to solving the problems we face. What is needed, instead, is a common awareness that every individual must act autonomously to reduce resource consumption to a reasonable level.

The debate about such a new lifestyle should not focus on asceticism and renunciation, however, but on a new quality of life through different, sustainable forms of consumption and by changes in the way we satisfy our needs. People must, for instance, discover the pleasures of fulfilling immaterial needs. Those who are not held in perpetual check by what appear to be essential needs acquire a greater range of freedom, one that is necessary in order to live out a different and more authentic lifestyle. The richest societies of the world have created not only very hard and inhuman forms of material poverty, but also spiritual and emotional poverty, an absence of meaning in life.

An environmentally conscious approach to goods and commodities can also lead to a new quality of life. The growth of knowledge and the process of scientification brought about through the development of society towards "reflexive modernisation" (Beck, 1986) is characterised by the fact, *inter alia*, that industrial society is confronted indirectly if not directly with its own impacts - uncontrolled growth of waste, accelerating species extinction, global warming, etc. The reflection this compels relates not only to the collective but also to the individual level, which is characterised by increasing individualisation and the concomitant compulsion to shape one's own biography and one's own life pattern. The consequences must be borne by all, irrespective of the degree of conscious involvement in decisions.

The obligation of the individual

Social groups and individuals are responsible for the foreseeable consequences of their actions. Even when we assume that "society" does not exist as a discrete subject that speaks in the name of general reason and which can restore order to societal subsystems that have gone astray - industry, transport, tourism, etc. - the question as to individual and societal morality is by no means dispensed with. Although the majority of people living today, in their occupational roles at least, are integrated into society not on a *social* basis and hence through a free choice of objectives and ends, but *systemically*, i.e. they are bound to organisational goals that are not subject to freedom of individual choice, this does not imply that ethical issues have become superfluous. No-one can claim to be a mere element in a system or institution; everyone is at all times a person who acts as an individual and who is thus a bearer of different roles. Responsibility for one's actions or lack of same does not disappear in modern society, however much the latter may be characterised by the diverse compulsions and driving forces emanating from roles and social systems; such responsibility is merely redefined on a different basis. A person who acts according to ethical principles cannot presume that a simple distinction may be made between good and evil, but must acknowledge that a substantial body of knowledge is necessary to draw this very distinction in the first place. Secondly, if one's actions are based on ethical principles, one must acknowledge that what is good and evil cannot be seen and decided upon within the immediate context, but has become an integral constituent of highly complex processes operating over great distances and time spans. The extent of our responsibility must correspond to the extent to which we indulge in large-scale interference in the Earth System as a whole.

The same principle - that all countries and all human beings bear responsibility for protection of the environment and conservation of the natural resources - lies at the core of Agenda 21. By demanding intergenerational and intragenerational equity, Agenda 21 not only requires that ethical considerations be taken into account in the course of implementation - the very rationale on which the document is based is primarily ethical in nature. Indeed, without a feeling of global responsibility for the state of the Earth and the welfare of humankind, this document would never have come into being in the first place.

Lifestyle and consumption

Every ethically based strategy for changing consumption patterns must take account of the non-homogeneity of modern industrialised societies. Everyday reference to the lifestyle of industrialised countries - a useful distinction in relation to lifestyles in the less developed countries - can all too easily submerge an awareness for the fact that the industrialised world that is characterised by functional differentiation, individualisation and (lifestyle-specific) pluralisation. The relatively simple models of social stratification prevalent until the 1970s have now been succeeded by the assumption of increasing diversity of lifestyles and consumption patterns.

Lifestyles and consumption patterns have thus become much more complex (see Section VI 1). Although we can generally confirm an enhanced level of environmental awareness (as awareness of the existent crisis), this awareness only leads to correct (normatively desired) behaviour when the relevant environmental activities do not generate perceptible disadvantages for those directly involved. The social dimension therefore has an enormous impact on environmental problems.

While the mounting threat to the environment is attributable to a new culture of mass consumption within society, the options open to individuals to make a personal contribution towards protecting the

environment are distributed very unevenly, an aspect which is increasingly seen as unjust. People who feel unfairly treated will invariably develop a non-cooperative or hostile attitude - which means that any policy of sustainable development is doomed to failure if it does not take into consideration the principle of equal treatment, or fails to communicate this aspect with clarity.

I 2.3 Consensus-building within society

Sustainability policy is aimed at adapting society to the growth of natural constraints in a timely and orderly manner. The only way to accomplish this task with any prospect of success is through concerted action on the part of all users of environmental resources. Large, open societies are polycentric systems in which people adhere to abstract behavioural rules and in which nobody has the knowledge necessary to bring the entire system to specific results. Thus, any strategy that attempts to achieve the adaptations in society that are accepted as necessary merely through state management of resources will fail from the outset. Neither bureaucracies nor parliaments have a chance of exercising the all-important fine degree of control over resource use, for example by implementing a cross-sectoral sustainability plan.

It is all the more important, therefore, to arrive at a social consensus in key areas of environmental policy. This consensus should be the basis not only for national environmental and energy policies, but also for international agreements, especially within the EU. National and international sustainability policies must give adequate consideration to the precarious equilibrium between developmental needs, on the one hand, and the imperatives of environmental and resource protection, on the other. In particular, it is essential to produce a far-sighted analysis of the conflicts between environmental, social and economic compatibility and to take appropriate action to resolve them.

The capacity to shape trends within an open, pluralistic society crucially depends on a far-reaching consensus on behavioural rules. What society therefore needs in order to effect a radical change in course is a basic underlying consensus on the behavioural rules for a more sustainable form of development. These rules include various instruments for controlling behaviour by direct and indirect means. People living in prosperity will respond to the pressure to adapt only when they accept that prosperity - albeit of a different kind - can only be reached in the long term through structural changes and a transformation of awareness. First and foremost, this involves adapting the legal, economic and social framework as well as changing values within society, factors which currently obstruct sustainable development in many respects (see the section below on the structural transformation and awareness raising scenario).

I 3 Structure and methodology of this study

I 3.1 Why the focus on Germany?

Our analysis focuses on the specific steps and strategies for attaining sustainability in Germany. The authors are fully aware that this is intimately linked to the attainment of sustainability in the rest of the world, indeed that the former is impossible without the latter. As a rich industrialised country, Germany bears a specific responsibility for the transition to sustainable development. All the more so, given that

Germany is a system of open borders. We import and export material flows from and to many countries on a major scale. Global threats, such as the greenhouse effect, the pollution of the world's oceans or the depletion of the stratospheric ozone layer, cannot be alleviated by Germany alone. But it is high time to commence with sustainable production methods, particularly since Germany has the capacity, on the basis of its economic, scientific and technological potential, to be a role model for the international community.

The need for action dictated by global environmental changes is all the greater, the measures required all the more complex and their implementation all the more difficult than is the case with environmental impacts on a single nation-state. In many cases, when a country produces without giving adequate consideration to the environment, the population of the state can weigh up directly the benefits they obtain from the production and consumption of goods against the environmental impacts that ensue, since they are affected by both. The situation is different with global environmental changes, however, in that those causing the damage typically live in countries and regions that are removed from those who suffer the consequences. This is why it is much more difficult to bring about effective global environmental policies. Being the main perpetrators of environmental stresses, states like Germany are challenged far more than others to coordinate their activities with other nations and international organisations in order to assume their share of responsibility for the fate of the planet.

What is required here are not voluntary activities to reduce environmental stresses caused primarily by other states, but a fair contribution towards solving problems of international or in some fields global scale, in order to help overcome the attitude of non-cooperation strategically adopted by many states. The uneven regional distribution of costs and benefits of measures to improve the environment puts the international community in a dilemma. While every country stands to profit from measures implemented by other nations, the benefit to be derived from national efforts are minimal for the country concerned. This dilemma creates major problems for the formulation and implementation of common global strategies to protect the environment, as well as conflicts over the allocation of costs. When individual states take the lead and engage in unilateral activities, they help to overcome the international dilemma just referred to, and make an important contribution towards solving global environmental problems. The consequences of such activities go far beyond the actual improvements to the national environment.

I 3.2 Activities for sustainable development

As has already been emphasised, sustainable development must embrace the social, economic and environmental dimensions in their entirety, leaving no sub-domain of society untouched. This was also the viewpoint taken by the 178 nations at UNCED. The most important document produced by the conference, Agenda 21, comprises 40 separate chapters covering seven cross-sectoral issues (e.g. poverty eradication and changing consumption patterns) and 14 sectoral issues (e.g. promoting sustainable agriculture, combating deforestation); the other chapters cover the major social groups and the options for implementing Agenda 21 at national and international level.

Integrating environmental concerns into other policies

Operationalising the sustainability paradigm requires that environmental protection be taken out of the all too narrowly defined contexts in which it has long been constrained. The tendency to manage isolated environmental problems on the basis of policies drawn up by a specialist policy domain must be

stopped. Widening the scope of environmental policymaking by removing the specialist straitjacket means that policies in other fields must show an increasing concern for and commitment to environmental protection. What is needed is "integrated environmental policymaking", i.e. a greater focus on environmental aspects throughout the policy spectrum, from social welfare policy, economic and financial policy to the fields administered by transport, agricultural and energy departments. In order to avoid precisely those short-term frictions generated in the field of trade and industry as a result of counteractive policies, it is essential that the implications of sustainable development be integrated as parallel requirements in other policies. Conversely, environmental policymakers must foster the capacity for economic development and safeguard it over the long term.

Sustainability cannot be said to exist in Germany until the transition to sustainable development has been accomplished in key areas at national level and substantial contributions have been made to the achievement of sustainability at global level. Central elements include:

- energy use and CO_2 reductions,
- transport and human settlement development,
- food production, especially agriculture,
- material flow management of the most important substances,
- environmentally sound waste management,
- changing consumption patterns and
- national contributions to protect the world's natural and environmental resources (the Earth's atmosphere, biodiversity, soils, etc.).

Sustainable development requires major adaptations in all social, political and economic fields and structures.

Selecting relevant activity fields

The sheer complexity and scope of the various areas which need to be integrated within a national strategy for sustainable development necessitates confinement to a select group of issues. The requisite knowledge base is not available for all problems, added to which there is a simple lack of time in many cases; this explains why some crucial issues are dealt with only marginally or not at all. In selecting the specific areas to be focused on in this Report, we have tried to elucidate the full range of problems associated with the transition to sustainability, in basic detail at least. To do this, we have based our selection on fundamental needs of people in a modern society such as Germany.

The principal material needs include food, clothing, housing and mobility, all of which involve the use of energy resources. The problematic areas for which the model of sustainable development is specified and for which steps to achieve that goal are outlined all relate to these basic needs. As befits the multi-layered nature of sustainability problems, and in order to deal adequately with the specific aspects of the respective issues, each chapter focuses on different perspectives and approaches, since no purpose would be served by imposing the same structure on differing issues.

Chapter II deals with energy use, one reason being that the problems of climate and resource protection associated with it were more or less the starting point for the international and global debate on sustainability. Consequently, the chapter devotes equal attention to the world situation and to trends at national level.

The need for mobility, which is closely related to the need for energy and similar in both its fundamental nature and its importance for individuals and industry, is dealt with in Chapter III. Unlike the discussion on energy use, and despite the obvious international dimension of the mobility issue, the latter chapter focuses on national environmental targets and activities. This is also compliant with the way in which transport policy initiatives are perceived, in that the individual citizen can feel the impacts of such policies in a much more direct way. The greater focus on concrete activities in Chapter III is an expression of the directly perceptible effects induced by measures to promote sustainable mobility.

Chapter IV examines the basic need for food, the importance of which has not been fully appreciated until now simply because it has been taken for granted. An attempt is made to show the environmental dimension underlying our nutritional habits as it relates to food production, processing, transportation and consumption. Our analysis of sustainable food production is centred on the requirements that agriculture must meet in order to qualify as environmentally sound and sustainable, and is then extended to the food industry and transportation aspects.

The perspective is shifted in Chapter V from the side-effects of industrial activities to the utilisation of materials and resources, which needs to be adapted to the demands of sustainable development by means of material flow management. Due to the sheer number of substances used by industry and their disparate environmental impacts, the relatively abstract level of general material flow analysis is made more concrete by focusing on the specific flows that are characteristic for textile production. The latter was chosen not so much because textiles are so important for environmental policymaking, but rather on account of the fact that clothing, like food, constitutes a basic need.

Chapter VI analyses the role of consumption in relation to sustainable development. Consumption is a factor of key importance for sustainable development, in that the supply of material goods and services for use and consumption is the underlying objective for economic activity, while resulting at the same time in the utilisation of nature as a source and sink. This chapter provides a link to the instruments for sustainable development, by examining the ecological importance of consumption and outlining perspectives for sustainable consumption.

Other fields of activity

By no means do the selected activity fields provide exhaustive coverage of those areas that are significant for sustainable development. They are merely examples, albeit important ones, that would have to be supplemented by numerous others, such as production, industry, tourism or trade. Although the latter are unquestionably important for sustainable development, they are treated only marginally, if at all, due to limitations of space.

In the future, special attention should be given to the field of “housing and settlements” - another basic need closely linked to the ecological, economic, social and cultural dimensions of sustainability. Moreover, settlement development is a key determinant for energy and material flows, landscape consumption, land use, traffic flows and the geographical distribution of responsibilities and labour within a society.

Although there are obvious links to sustainable development, there is still a lack of detailed knowledge about the precise extent and nature of such links. The Federal Environment Agency has commissioned an intensive study on settlement development as part of a research project on sustainable development indicators (see Chap. VII.5). The aim of the study was to identify the level of sustainability in this domain using a set of special indicators. A "Local Agenda 21" initiative of the *Deutscher Städtetag* (Association of German Municipalities) is also examining in detail the relevance of settlement development for sustainable development, and is producing some interesting results. Steps towards sustainable settlement development are therefore important advances towards a sustainable Germany, even if they cannot be specified as yet in this Report.

I 3.3 Instruments for sustainable development

Various instruments are available for implementing the targets and goals adopted in the various activity fields, which are primarily environmental *quality* targets and the more quantitative environmental *action* targets. The principal instruments are

- legal regulations and planning instruments (e.g. rules and bans, plans and programmes),
- economic instruments (e.g. taxes, charges, levies, covenants),
- instruments for fostering environmental awareness (awareness-raising campaigns, information, initial and continuing training).

A broad consensus within society can be identified whenever the general need for a transition to sustainable development is insisted upon. However, this consensus disappears when discussion turns to the instruments for initiating and accomplishing changes. The ensuing disputes are often a reflection of the fact that the concept of sustainable development has optimised the capacity to engineer consent, but that latent conflicts can erupt again in response to any attempt at operationalisation.

Using a diversity of instruments

There have been many cases in which exclusive use is made of a certain instrument whose one-dimensionality runs counter to the multi-layered nature and complexity of the preceding analysis. Some people expect the solution to the problems to lie in regulatory frameworks that impose detailed and standardised rules for the specific issue in the most rigid possible way. Others place all their hopes in flexible economic instruments which they see as the only appropriate and efficient means of solving the problem. Others again rely on "soft" instruments such as information campaigns and awareness-raising activities, as these are effective ways to promote consensus and voluntary participation.

Economic instruments, especially environmental tax reforms, have tended to dominate the debate, at least in recent years. However, these have played a subordinate role where actual implementation is involved. We have no wish to play down the importance of economic instruments for environmental protection during the transition to sustainability. Price mechanisms can regulate a great deal in a complex industrialised society, but not everything. Even if a green tax reform is essential for successful climate protection, this does not imply that we can dispense with other instruments and combinations of same; for example, market imperfections imply that higher energy prices will not always have the desired effect. Regulatory measures, such as higher buildings insulation standards, are just as important as

improving the legal and administrative framework, the dissemination of information, advisory services and training schemes. Finally, broad-based media campaigns are indispensable as a means for raising public awareness of climate problems and their impacts. The scientific community and environmental organisations are very important agents in this context.

The transition to sustainable Germany on the part of industry and society cannot be achieved with only one type of instrument. Different problems require a diversity of solutions, which means specific strategies and instruments for each situation. Any policy based on the guiding principle of sustainable development must utilise the entire range of instruments; the success or failure of such a policy will ultimately depend on designing an appropriate strategy with the appropriate mix of instruments.

Shaping the regulatory framework as against limited interventionist approaches

In Chapter VII we focus on the activities and instruments we consider essential for attaining sustainable development in Germany. Attention is centred on ways to shape the legal, economic and social framework, since any interventionist approach is necessarily limited in scope and cannot give adequate consideration to the complexity and internal dynamics of social trends. Our attention was focused first of all on how to refine instruments in the field of environmental law. Potential for promoting sustainable development is provided, in particular, by planning law, by the various instruments for directly and indirectly influencing behaviour and by environmental impact assessments. The legal framework, especially at European level, must also be reworked in order to give greater consideration to sustainability concerns.

Sustainable development also requires changes in the economic and social framework, e.g. by correcting relative prices in accordance with environmental criteria, or promoting environmental awareness among the population. One important contribution towards sustainable Germany can be achieved in our view by "green reforms" of the national finance system. We deliberately avoid any confinement to green tax reform, which is often reduced in policy debates to a single "eco-tax" on energy. Reallocation and dismantling of subsidies according to ecological criteria, on the one hand, and the restructuring of existing charges (i.e. taxes, special levies, fees and contributions), on the other, must be accorded at least the same amount of consideration as mere taxation reforms.

Such highly ambitious goals, and the social and economic changes they imply, will be extremely difficult to attain if they fail to enjoy broad acceptance within society - which in turn requires a new awareness among the population. For this reason, we also discuss the opportunities for raising environmental awareness, and the limits to such a process. Acceptance of the recommended goals and activities necessary for any progress towards sustainable development is not something to be taken for granted; instead, it needs to be generated in the first place in a comprehensive debate involving the whole of society.

Continuous monitoring is essential to determine whether or not society is approaching the goal of sustainability, either as a whole or at least in the specific areas described here. The Report therefore ends by identifying a set of indicators for assessing progress towards sustainable development. Assessment based on such indicators can highlight, or at least point to, the need for action generated by current trends. Our efforts are also a contribution to the current debate on the development of sustainability indicators. The latter are an essential means for checking progress towards a sustainable Germany.

The instruments and activities referred to in this Report are a mere selection of steps necessary for sustainable development; they must be supplemented, of course, by numerous other initiatives and instruments. We are convinced that, in addition to the instruments and activities discussed in this Report, other important forms of cooperation between those involved in society and the state (voluntary commitments, Round Tables, etc.) will prove as indispensable as changes to the framework for international trade. The effectiveness and success of the activities described are likely to be weakened if we fail to motivate other states to undertake similar efforts and activities. However, the uncertainty that exists in this respect should not be used as a rationale for making national activities dependent on similar efforts by other states. A return to the dilemma mentioned above would cement non-sustainable patterns of thinking and behaviour, and would significantly increase future environmental pressures. The measures taken under such conditions would probably lead to social and economic frictions much more severe than might result from the policy action recommended in this Report. The assessments on which the recommended instruments are based may be alarming at first glance, but the alternatives are even worse. However strenuous the pathway to sustainable development may be, the failure to advance along it will probably cause much greater difficulty and hardship in the long run.

I 3.4 Methodological structure of the chapters

The importance of environmental targets

The attempt to transpose the model of sustainable development to the realities of present-day German society is bound to fail unless there are precise ideas about how to protect resources and the environment. It requires clear objectives, especially *environmental quality targets* and specific goals for policy action ("*environmental action targets*"). Environmental quality targets refer to a particular state of the environment towards which efforts are geared. They comprise elements derived from both the natural sciences and the domain of social ethics, and combine scientific knowledge with social valuation of the environmental assets to be protected and the level of protection to be afforded. Environmental quality targets are defined for the anthroposphere and/or the ecosphere in respect of objects or environmental media, and are oriented to the regeneration rate of key resources or to the ecological carrying capacity, to the safeguarding of human health and to the needs of present and future generations. A typical example for an impact-related and precautionary environmental quality target is the abatement of global warming in order to achieve long-term stabilisation of the climate.

The action targets of environmental policy delineate the specific steps that are necessary in order to achieve the state of the environment described by the environmental quality targets. They formulate objectives that can be quantified and measured (or capable in some other way of being monitored), objectives which address the various stress factors involved and which stipulate the necessary reductions in environmental stress. The environmental quality target referred to as "climate stabilisation" is specified for Germany by means of the policy action target to reduce CO_2 emissions by 25% relative to the 1990 baseline by the year 2005 (see Chapter II).

Environmental quality targets and environmental action targets are of crucial relevance for sustainable development to function as a guiding principle. Environmental action targets are important, operationally speaking, during actual implementation of environmental programmes in that they deliver the rationale for specific activities. They are based on the limits that the scarcity of environmental assets places on production. Responsible environmental policy must accept that these limits can rarely be determined to

any degree of precision (operations under uncertain conditions). Environmental policymakers in Germany have borne this in mind and have developed from the very outset, in addition to the "polluter pays principle", the precautionary principle and its two elements, namely the minimisation precept and emission limits, as the key pillars of environmental policy. When applied to material flows, environmental action targets take the form of quantitative reduction targets, specifying the extent to which total loads must be reduced in order to achieve a sustainable and environmentally sound level. Both types, environmental action targets and environmental quality targets, are indispensable for any policy based on the principle of sustainability.

Environmental action targets may refer to the quantity and quality of material throughput within an economic system and be formulated as volume reduction targets. Volume reduction targets for mass flows forge a link between the twin targets of reduced environmental stress and protection of resources. Such targets are aimed at quantitative reductions in the consumption or throughput of material and energy resources. Volume reduction targets are therefore a crucial element of sustainability strategies. They focus on innovative production methods and products, on a transformation of consumption patterns and lifestyles, and are directed first and foremost at increasing material and energy efficiency.

If our goal is a sustainable Germany, we need to take a more long-term approach based on key long-range environmental quality targets and environmental action targets of a precautionary nature. Substantive targets such as these can enhance environmental operations, also in the international context, and create a stronger foundation at both national and international level for decisions on the specific instruments to be deployed.

I 3.5 Scenarios - the range of potential trends

Given the major uncertainties underlying any projections of complex, dynamic processes, it is generally accepted nowadays that predictive models should not work on the assumption of only one possible future. The common approach today is to describe potential trajectories in terms of "scenarios". This makes it possible to generate "if-then" models of the future, by subjecting the initial assumptions (e.g. on economic and political development, population growth, etc.) to systematic variation. Scenarios, in contrast to predictions, do not imply that future trends are a foregone conclusion, but direct attention to the underlying conditions instead, thus highlighting the scope for action that exists.

The many assumptions on which scenarios are based can be extensively varied with a certain amount of plausibility, so the number of possible scenarios is very large. It therefore makes sense to concentrate on a small number of typical trajectories, each expressing a "pure" form of potential development. Although actual trends might not be congruent with these pure forms, the technique enables the range of potential developments to be portrayed in a particularly vivid way. In this Report, we distinguish between three ideal-typical scenarios, namely

- a "business as usual" scenario,
- an "efficiency" scenario and
- a scenario based on structural transformation and awareness raising.

The "business as usual" scenario

The "business as usual" scenario assumes a continuation of current trends and developments. The economic, legal and political frameworks are the same as those currently in operation and those already foreseeable, including measures already adopted or about to be adopted. These activities are congruent with targets that already enjoy public acceptance. The conditional frameworks and value systems now prevalent function as key assumptions in all important fields of activity, areas of society and sectors of the economy, such as the energy industry, the transportation sector and agriculture. Shifts in relative costs and prices, e.g. on account of technological innovations or changing needs and preferences in society, are not considered. Accordingly, the scenario does not assume any significant improvements in efficiency either in production or in connection with consumption patterns. Sustainability criteria do not play a role.

The "efficiency" scenario

The "efficiency" scenario assumes substantive improvements in the technical efficiency of production processes. This leads to reduced materials and resource intensity within the economy, accompanied by clear reductions in the specific material flows and level of environmental stress per unit of goods produced or service performed. However, the scenario proceeds on the basis of economic, legal and institutional frameworks and value systems as they exist today, which are not subjected to any (deliberately targeted) change. Prevailing patterns of production and consumption are largely retained, but involve much lower levels of resource use and environmental stress. The "efficiency" scenario therefore assumes that the pressure to bring about social and economic changes is reduced purely through increases in technical efficiency. In other words, there will be many improvements in the technical field, but no changes otherwise.

The "structural transformation and awareness raising" scenario

In contrast to the two preceding scenarios, the structural transformation and awareness raising scenario assumes a trend towards sustainable development that embraces all areas of society. The scenario includes all activities that go beyond those in the efficiency scenario, particularly those which are aimed at changing or refining existing frameworks and social value systems. Traditional economic, legal and administrative structures that do not comply with the sustainability principle are modified accordingly, a process involving radical changes in production and consumption patterns , including the attitudes and behavioural patterns on which these changes depend. Whereas the "efficiency" scenario specifies the possible range of technical adjustments to comply with the guiding principle of sustainable development, without aiming at deliberate changes in the conditional framework provided by society, the structural transformation and awareness raising scenario focuses primarily on the latter framework so that the range of options referred to is not only exploited to the full, but expanded at the same time. The structural transformation and awareness raising scenario also describes a set of measures that lead towards sustainability without having to deploy cutting-edge technology; examples include shifting consumption from environmentally intensive products or services to environmentally sound ways of satisfying needs.

It can be seen from precisely this aspect that the latter two scenarios are not as distant from each other as their ideal-typical classification might suggest. The reorientation and renunciation associated with the structural transformation and awareness raising scenario - e.g. restricting private car use or

dispensing with household chemicals that harm the environment - will generate new types of scarcity, such as public transport or environmentally friendly cleaning agents, and will therefore operate as incentives for developing technical innovations. Awareness raising and technological development are intimately linked; a society will only develop those technologies that can be coupled to existing values and behavioural patterns.

The time scale of the scenarios

The time frame for the three scenarios is generally the year 2010. This date makes sense for a variety of reasons: firstly, it is possible to estimate the level of scientific and technological advancement, or at least the application of innovations in real life, over a time span of 15 years. Secondly, sustainable development cannot be realistically started within a shorter time span. The advantage of a 15-year time span is that the majority of people and organisations actively involved in shaping this process will be able to monitor, analyse and evaluate the results themselves.

The choice of the year 2010 should not be misunderstood as an expectation on our part that the bulk of problems associated with Germany's transition to sustainable development could be solved or even tackled by the year 2010. We are well aware that sustainable development is a process that will take very many years indeed, and that the most one can hope for is that the first -albeit crucially important - steps can be taken by the year 2010. However, we are convinced that this process must be commenced with as soon as possible. If, on the basis of central and consensual environmental quality targets, the forces in a liberal society are to be mobilised and a basis created for stability of expectations, it is necessary to envisage much longer time spans for attaining these targets. Longer-term targets enable the people involved to realise their own responsibility and to establish appropriate forms of self-control. This improves the opportunities to integrate sustainability targets and the concomitant management rules as cross-sectoral elements in other fields of activity and sectoral policymaking, such as energy, transport, agriculture and finance policy.

II Sustainable Energy Use

II 1. Current energy use and sustainable development

World energy consumption has more than quadrupled since 1950. Economic growth and increasing world population will lead, in the foreseeable future, to higher energy demand, especially in newly-industrialising and less developed countries.

There can be no disputing, from the guiding sustainability principles, that the current intensity and form of energy use throughout the world - including Germany - are incompatible with sustainable development.

- Energy-related CO_2 emissions are responsible for about half of today's anthropogenic greenhouse effect.
- Resources of key fossil fuels will be depleted within a few generations if current trends continue (climate change permitting, which is very doubtful).
- The fossil fuels for which there are the least reserves in terms of years are those for which demand is growing at the fastest rate.
- Combustion of fossil carbon resources to provide energy means that these are no longer available as raw materials for other purposes.
- The production, transportation and combustion of fossil energy carriers bear substantial responsibility for many severe forms of environmental stress and degradation, as well as of various environmentally related illnesses.
- The use of nuclear energy burdens future generations with the problem of radioactive waste. In many parts of the world, the safety standards operating in nuclear power stations and for the disposal of waste are cause for grave concern.

A system of energy use compatible with the criteria of sustainable development can only be guessed at in rough outline at this point in time. Any monocausal approach focusing solely on the threat to climate is no basis on which to generate sustainable energy use, although this kind of monocausal thinking, often in the form of tacit assumptions, is commonly found in the current debate over future patterns of energy supply and demand.

Calamitous though the predictable implications of climate change may be, the guiding principle of sustainable energy use must be derived from a multi-causal analysis that takes into consideration all threats to nature as well as the objective of sustainable and environmentally sound development of society and industry.

The specifics of energy use are closely linked to trends and relations within the economy and society, such as the role played by energy-intensive sectors, the interdependence of national economies, or the prevailing patterns of consumption (see Chap. VI). This is the case both for present-day and future forms of energy use. No model is capable of simulating these interactions in their totality and complexity, so it is hardly surprising to see such intense controversy over the impacts liable to result from re-

designing the energy sector in accordance with the principle of sustainability. Too little attention tends to be given to the economic and social impacts that have already materialised through the destruction of our natural resource base. This situation will be further exacerbated if current patterns of production and consumption are maintained.

Technological issues are of secondary importance in this context. It is generally accepted nowadays that future energy supplies will be largely dependent on renewable energy sources, that this is technologically feasible and that a "quantum leap" in the efficiency of energy use is both possible and necessary. The question as to which pace and in what framework society and industry are able to implement these changes is highly controversial. This dispute is blocking the urgently needed policy decisions and hence the operational decisions urgently required if the energy sector is to be restructured in a sustainable way. We are currently wasting large amounts of two particularly scarce resources - time and energy.

II 1.1 Current energy use in Germany

Trends and changes in energy consumption

Germany has seen a downward trend in the consumption of primary energy since 1987. This trend is mainly attributable to the upheavals in the east German economy since the political unification of the Federal Republic of Germany and the former German Democratic Republic in 1989. It is also due to the recession of recent years. It is therefore unlikely to continue at the same rate in the years to come. Primary energy consumption in Germany fell by about 8% between 1987 and 1994, a major proportion of this reduction being achieved in the east German states, where primary energy consumption declined by around 46%. In the west German states, primary energy consumption increased over the same period by a full 5%. However, the figure for 1994 was only slightly less than the year before.

The rapid decline in primary energy consumption in east Germany occurred primarily in the industrial sector between 1989 and 1991. However, it would be wrong to conclude that the decline in consumption was caused exclusively by the collapse of the east German industrial base under market economy conditions. The east German states experienced significant economic growth after 1991, but primary energy consumption continued to fall. Despite the serious decrease in gross domestic product in 1990 and 1991, the 1990-1995 period as a whole saw a 7.2% increase in GDP, accompanied by a 36% reduction in primary energy consumption. The major factors responsible for this overall trend are not only economic collapse, but also the reconstruction of the east German economy, combined with structural transformation and substantial increases in energy efficiency.

A close look at the composition of energy consumption in Germany by energy carrier shows a predominance of fossil fuels, which account for 87.4% of primary energy consumption.

Table II 1: Primary energy consumption (PEC) in Germany in 1995 by energy source, in petajoule (PJ) (provisional figures as at May 1996)

Energy source	PEC in PJ	Percentage share
Oil	5,700	40.3
Coal	2,057	14.5

Lignite	1,732	12.3
Natural gas	2,837	20.0
Nuclear energy	1,436	10.1
Hydropower	243	1.7
Other	158	1.2
Total	14,165	100.0

Source: BMWi, 1996

The distribution of energy consumption by energy carrier has changed in recent years. Characteristic features of this change are the decrease in the percentage share of primary energy consumption accounted for by solid fuels (coal and lignite) and the increase in the percentage share of oil and natural gas. Although there continue to be major differences in fuel mix between west and east Germany, there is a visible tendency towards convergence; however, coal and nuclear energy will not play a significant role in east Germany for some time to come.

In 1994, final energy consumption was 9,000 PJ, or 64.3% of total primary energy consumption (14,006 PJ). The difference between the two figures is mainly due to energy consumption and the energy losses incurred in the energy conversion sector when supplying the various forms of final energy. Table II 2 shows how final energy consumption is distributed among the various energy carriers.

Table II 2: Distribution of final energy consumption (FEC) in Germany in 1995 among the various energy carriers, in petajoule (PJ) (provisional figures as at May 1996)

Energy carrier	FEC in PJ	Percentage
Coal	431	4.7
Lignite	185	2.0
Vehicle fuel	2,685	29.2
Heating oil - heavy grade	152	1.6
Heating oil - light grade	1,433	15.6
Gases	2,295	25.0
Electricity	1,574	17.1
District heating	363	3.9
Other	79	0.9
Total	9,197	100.0

Source: BMWi, 1996

The percentage of final energy consumption accounted for by coal, lignite and (heavy grade) heating oil has clearly decreased in recent years, while vehicle fuels and gases have been on the increase for many years. The proportion of final energy consumption accounted for by electricity has been roughly constant since the late 1980s.

In 1994, about 40% of final energy consumption in Germany was for mechanical energy, principally in transport, about a third for space heating, mainly in private households, about a quarter for process

heating, mainly in industry, and only about 2% for lighting. Table II 3 shows the shares of the various sectors in final energy consumption (FED).

Table II 3: Sectoral distribution of final energy consumption (FEC) in Germany in 1995, in petajoule (PJ) (provisional figures as at May 1996)

Sector of consumption	FEC in PJ	Percentage
Industry	2,477	26.9
Transport	2,585	28.1
Households	2,702	29.4
Small consumers	1,389	15.1
Military	44	0.5
Total	9,197	100.0

Source: BMWi, 1996

Transport's share of final energy consumption in Germany has increased continuously in recent years. While still only 16.6% (1,579 PJ) in 1973, it had risen to 28.1% (2,585 PJ) by 1995. In contrast, industry's share in final energy consumption fell from 40.2% (3,815 PJ) in 1973 to 26.9% (2,477 PJ) in 1995.

Energy consumption and pollutant emissions

As shown in Table II 4, by far the greatest proportion of all air pollutants and greenhouse gases emitted in Germany result from energy consumption, primarily through the combustion of fossil fuels.

Table II 4: Energy-related emissions in Germany, 1991

	Energy-related emissions in kilotonnes p.a. (incl. transport)	Percentage of total emissions	Energy-related emissions in kilotonnes p.a. (exc. transport)	Percentage of total emissions
Nitrogen oxides	3,136	99.9	975	31.0
Sulphur dioxide	4,470	98.2	4,240	93.2
Carbon monoxide	9,400	94.0	3,100	31.0
Dust	1,395	77.5	1,275	70.8
Methane	1,745	48.6	1,650	46.5
Carbon dioxide	968,000	98.5	765,000	79.0

Source: UBA, 1994

II 1.2 Global energy consumption

Consumption and distribution of energy

Annual global consumption of primary energy in 1992 was around 341.5 exajoules (=341,500 PJ), with Germany accounting for a share of about 4%. The global distribution of primary energy consumption is very uneven, with about 70% of total consumption occurring in the industrialised countries. Europe accounts for 20% of global primary energy consumption, the CIS 16%, North America 29% and Japan 5%.

Table II 5 shows how global primary energy consumption is distributed among the various energy carriers.

Table II 5: Global primary energy consumption (PEC) by energy carrier, in petajoule (PT)

Energy carrier	PEC in PJ	Proportion in %
Solid fuels	94,154	27.6
Liquid fuels	116,707	34.2
Gases	78,085	22.9
Primary electricity	31,905	9.3
Other	20,630	6.0
Total	341,481	100.0

Source: UN, 1992

In UN statistics, primary electricity refers to energy production from geothermal energy, hydropower, nuclear energy, solar energy, tidal, wind and wave energy, whereas other sources include "traditional fuels" such as fuelwood, charcoal, waste, dung and plant biomass.

Limited energy reserves

Both global and national energy supply relies heavily and predominantly on the consumption of finite, i.e. non-renewable energy sources. Energy flows, unlike material flows, are impossible to "recycle", so the question of reserves, resources and duration of finite energy sources is of crucial importance (Table II 6).

Table II 6 Reserves, resources and duration of finite energy sources (as at 1992, global)

Energy carrier	Reserves in billion t TCE	Resources in billion t TCE	Consumption in billion t TCE, per annum	Reserves at current consumption levels - duration in years	Resources at current current consumption levels - duration in years	Resources, provided an increase in consumption of 2% annually - duration in years
Conventional mineral oil	200	500	4,55	44	110	60
Non - conventional	350	1.170		77	260	90
Natural gas	175	310	2,59	68	120	60
Coal	480	7300	3,15	150	2.300	200
Lignite	200			63		
Uranium			0,77			
Light water reactor	40	270		52	350	100
„Fast Breeder" reactor		14.600			19.000	300

Source: Steubing, 1995

The figures in Table II 6 illustrate that current reserves of finite energy resources (i.e. those which can be feasibly recovered with today's technologies and prices) will be fully depleted within a few generations if consumption continues at present levels. If we look at resources (i.e. the total estimated occurrences, regardless of technologies and prices), then depletion is equally foreseeable for oil and natural gas at least - the two most important sources of energy. Particularly significant is the fact that a real energy demand growth rate of 2% would drastically reduce the duration of available resources.

The role of nuclear energy

Uranium is a finite energy source that, if used exclusively as nuclear fuel in light-water reactors, will be used up even more quickly than coal. Light-water reactors use only the U-235 uranium isotope, which comprises a mere 0.7% of natural uranium; this particular isotope is fissile when bombarded with "slow" neutrons (neutron braking with water). Nuclear fuels can be made to last longer by using plutonium-uranium mixed oxide (MOX) elements and "fast breeder" technology in particular, which Germany has decided against deploying. "Fast breeder" reactors use all the uranium to produce energy in a process where uranium nuclei are brought to fission using "fast" neutrons, combined with simultaneous "breeding" of fissile plutonium. Both methods require a nuclear fuel cycle in order to extract the extremely toxic plutonium from highly radioactive materials.

Overexploitation of natural resources

By using fossil fuels at current rates, we are frittering away the accumulated product of hundreds of millions of years of photosynthesis, namely the carbon compounds now existing as fossil energy sources. In other words, these resources are being consumed at a rate *millions* of times higher than the rate at which they are formed in nature - a disparity that defies our comprehension. H.-P. Dürr, a famous German physician, compares modern industrial societies and the way in which they treat their energy resources with a bank robber who offsets the minuscule expenses for his welding apparatus against the much greater "profits" that he generates by cracking more and more safes each more richly endowed with "natural treasures" than the one before. This drastic comparison illustrates how irresponsibly we manage the world's energy resources. We cannot carry on like this indefinitely, robbing future generations of every opportunity to use these resources in a wiser manner.

II 2. Objectives of sustainable energy use

We may conclude from the principle of sustainable development and the criteria specified in Section I 1.3 for achieving it that current energy trends are non-sustainable, but it is not possible to derive automatically the specific details that sustainable energy use could or must evidence. To operationalise the principle of sustainable development with respect to energy use, i.e. to translate the principle into practical terms, it is first necessary to derive specific goals and targets in the energy field. By referring to the latter, it is then possible to postulate and evaluate certain scenarios (potential futures) in terms of their contribution towards attaining the defined goals.

The starting point for deriving targets and goals are the action principles for sustainable development already mentioned. How must future energy use be engineered in order that emissions do not exceed the environment's absorptive capacity? How can the consumption of non-renewable resources be kept low enough to be compatible with the regeneration rate of renewable resources.

It is obvious that the two questions are closely linked in the case of energy use, since it is the consumption of non-renewable resources that generates emissions in excess of the environment's absorptive capacity. If we consider the time frame in which this occurs, then we are compelled to realise the following - that the limited absorptive capacity of the environment imposes much tighter (temporal and ecological) constraints on energy use that the foreseeable depletion of fossil resources.

The atmosphere as a limiting factor

The main problem is less the depletion of non-renewable energy sources, but first and foremost the limited capacity of the environment (the atmosphere) to absorb the CO_2 emitted during the combustion of fossil carbon. Humankind has far more fossil carbon resources than the necessity of climate protection will permit it to use in the foreseeable future, if the greenhouse effect is to be combated effectively. Only about one third of proven reserves of fossil energy sources may be burned in the next century (Enquete Commission, 1994, p. 1091) if the anthropogenic greenhouse effect is to be confined to an ecologically acceptable level.

If one accepts the "dangers" of global climate change as the environmental problem with the severest and most far-reaching repercussions, then the goals of sustainable energy use must be derived primarily from climate protection goals (whereby other environmental stresses at all levels of energy use involve secondary goals of a similar nature).

Sustainable energy use must be congruent with the objectives of climate protection - stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (Framework Convention on Climate Change, Article 2). What actually constitutes "dangerous interference" is very difficult to quantify, and depends on values that cannot be determined by scientific methods. However, current scientific understanding of the greenhouse effect and resultant climate changes, as summarised in the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 1996), provides some key elements of a sustainable form of energy use in keeping with the goal of climate protection.

Unless corrective action is taken, mean global surface air temperature will increase by two degrees Centigrade by 2100 according to "best estimate" data (across a range between 1 and 3.5° C). The average sea level would rise by 50 cm from the present to 2100 as a result of such higher temperatures, according to best estimates; the figure ranges from 15 to 95 cm, depending on scenario.

There is still considerable uncertainty regarding the precise timing and potential regional impacts of such changes; there are neither parallels in climate history, nor computer models capable of delivering sufficiently reliable data. The enormous complexity of the climate system means that surprises are possible at both regional and global level. Regional climate may deviate from mean climate trends, while changes in the frequency and intensity of extreme weather events is of greater significance than alterations in mean climate conditions.

Such climate changes pose a particular threat to our civilisation due to the short time horizons in which they occur, compared to previous climate changes in the history of the planet. In addition to higher temperatures, scientists also expect changes in the distribution of precipitation, shifts in climate and vegetation zones, soil degradation, sea level rise and further exacerbation of the world food situation. Research studies in which the economic repercussions of the anthropogenic greenhouse effect are identified reach alarming conclusions that threaten to overshadow all environmental problems previously known. The very fact that the scale of impacts, temporal sequence and regional consequences of climate change cannot be assessed to any degree of precision means that every precautionary measure must be taken to avert such catastrophic scenarios. Precaution is called for also because climate-forcing gases have atmospheric lifetimes amounting to decades, which results in their accumulation and mounting concentration in the atmosphere, where they interfere with climate for a very long time.

Stabilisation of energy-related CO_2 emissions, which are responsible for about 50% of the anthropogenic greenhouse effect, *at current levels* is not enough to protect the climate, because this would lead to a constant increase in CO_2 emissions for at least another 200 years and to a doubling of CO_2 concentration up to about 2100 compared to the pre-industrial value of 280 parts per million volume (ppmv). In 1994, the concentration of CO_2 in the atmosphere had already reached 358 ppmv - a *stabilisation of the CO_2 concentration* can only be achieved, therefore, if global CO_2 emissions decline over a transitional period to a level below that of the 1990 base year, after which they must be subjected to further substantial reductions.

The crucial contribution of the industrialised countries

Reversing CO_2 emission trends will demand great efforts. Because of their historical responsibility for energy-related CO_2 emissions and their technological capacities, industrialised countries are expected to contribute much more to the reductions, and rightly so. The Enquete Commission on "Protection of the Earth's Atmosphere" set up by the German Parliament has shown by means of model computations what trends in the industrialised and the less developed countries would accord with the goal of protecting the climate (Table II 7). As far as energy-related CO_2 emissions are concerned, this would mean that after a transitional period lasting at least 60 years, i.e. after the year 2050, emissions would have to be reduced to at most half the current level. This must occur at a time when the world population will roughly double. Annual per capita CO_2 emissions would then be about 75% less than the current global average of around 4 tonnes.

Table II 7: Profile of global CO_2 emissions necessary to protect the climate - required reduction and conceivable distribution among various groups of countries

	Population		CO_2 emissions			
	millions	%	Mtonnes	%	t per capita	'90 = 100
1990						
Industrial world	1,213	22.1	15,900	72.2	13.1	100
Developing world	4,271	77.9	6,100	27.8	1.6	100
World total	5,484		22,000		4.0	100

2050						
Industrial world	1,500	15.0	3,500	31.8	2.3	18
Developing world	8,500	85.0	7,500	68.2	0.9	56
World total	10,000		11,000		1,1	27

Source: Enquete Commission, 1994

This model computation takes into consideration the high initial level of CO_2 emissions in the industrialised countries (including the countries of central and eastern Europe (CEEC) and the CIS), as well as the low initial level in less developed countries (including China). For this reason it assigns higher CO_2 reduction targets to the industrialised countries. Although responsibility for the bulk of emissions shifts from the industrialised countries to the less developed countries, the per capita emissions in the industrialised countries remain much higher (almost three-fold) than those in the less developed countries. If we take cumulative CO_2 emissions, i.e. the amount of CO_2 emitted between 1990 and 2050, then despite the relatively low share of population, the industrialised countries predominate, which in turn results from the high starting level of emissions.

The projections of this model can be expressed as a specific target for sustainable energy use in the industrialised countries: if the industrialised countries wish to make an appropriate contribution towards stabilising the world climate, energy-related CO_2 emissions have to fall by 2050 in the order of 70 to 80%. The extent to which this goal is attained has a crucial influence on the extent to which future energy use complies with the criteria of sustainability. The less developed countries must also contribute towards protecting the climate, of course, but this contribution cannot be measured with the same standards as for the industrialised countries, and must take into consideration the scope for economic and social development much needed in these countries.

Any energy scenario must also be evaluated in terms of its contribution towards other sustainability goals, in that a monocausal approach focusing purely on the threats to climate will fail to provide an adequate response for sustainable energy use. The manifold threats to the natural base on which humankind depends, of which the threat to climate is certainly a dominant one, demand a multi-causal approach instead. Other important objectives include the reduction of air pollution and the degradation of land and water through acidification and nitrogen loads. These environmental problems are caused predominantly by the burning of fossil fuel.

What role can nuclear energy play in achieving sustainability goals?

In the debate on the "correct" path to achieving the CO_2 reduction target, much emphasis is placed on the "zero CO_2 emissions" produced by the nuclear energy system, with many protagonists claiming that nuclear energy is indispensable. However, there can be no equivocation about the fact that use of nuclear energy does not conform to the principles of sustainable development either (see Chap. II 1.2 and I 1.3):

- Uranium is a finite geological energy carrier that is basically incapable of regeneration. Although resources can be stretched by using plutonium-uranium mixed oxide fuel rods (MOX), and even more by breeder technology, reserves will last only a couple of hundred years if current energy consumption levels continue (see Table II 6).

- All stages of the nuclear fuel cycle involve emissions of radioactive substances that remain in the environment for a very long time.

- Nuclear accidents and reactor meltdowns would involve grave threats and risks for human health.

- Final disposal of radioactive waste requires a time frame of more than 10,000 years.

In the long run, Germany does not need nuclear energy to achieve its CO_2 reduction targets. Increasing the use of nuclear energy (and the same applies to large-scale coal-fired power stations) may stabilise the supply-side oriented structures of our energy supply system, which is a serious obstacle to the efficiency improvements necessary for effective climate protection.

Set the course today!

Looking at the recent developments in energy consumption, it becomes evident that a CO_2 reduction target of around 80% for the industrialised countries by the middle of the next century is hardly feasible. But it must also be emphasised that the idea of projecting these trends far into the next century is unrealistic. Continuation of current emission trends might be feasible for another 25 years or so, but climate changes would then necessitate such drastic reductions that the technologies capable of producing such radical reductions are not even remotely conceivable under the prevailing social and economic conditions (WBGU, 1995a). The sooner we start reducing CO_2 emissions, the more degrees of freedom we will have for actively shaping sustainable forms of energy use.

II 3. The "business as usual" scenario - current trends and developments

II 3.1 Forecasts for Germany

Energy forecasts produced in recent decades have had one thing in common: they were not confirmed by actual trends; estimates of future energy consumption were invariably too high. The uncertainty factor plays a critical role in the scenarios presented here, too. No status quo is immutable, and a continuity, "business as usual " scenario does not imply that nothing changes.

"Business as usual" scenarios are typically based on assumptions derived primarily from current conditions and trends, i.e. they mainly consist of projections of present trends into the future. Such status quo assumptions place fewer demands on our powers of imagination, but in many cases they do not bear up to closer analysis

Assumptions of the "business as usual" scenario

For the "business as usual" scenario of future energy demand in Germany, the following assumptions hold:

- Constant population level in Germany, or only marginal variations.

- No major changes of economic, legal, institutional and regulatory frameworks.
- Economic growth between 1.5 and 3% per annum.
- Inflation rate between 1.5 and 3% p.a.
- Energy prices either constant or with only moderate deviations.
- Continuation of energy-saving schemes, but without full exploitation of technically feasible potential.
- No escalation of tensions on the international energy market.
- Maintenance of German coal mining industry, with gradual decline in production.
- More or less constant contribution of nuclear energy to German energy supply, with no expansion and no phase-out.

"Business as usual" scenarios also take into consideration the wide range of efforts for climate protection in Germany since the late 1980s, the impacts of which will primarily or even entirely be felt in the future. Schemes already adopted or whose implementation is very probable are taken into account in such scenarios.

Results of the study

One example for a "business as usual" scenario is a detailed 1995 study carried out by 'prognos AG' entitled "The German energy markets within an Integrated Europe - prospects for 2020", some results of which are given below.

This typical "business as usual" scenario draws a picture of the German energy sector under the premise that the framework conditions for the energy industry undergo no fundamental changes. However, it is assumed that in the course of the foreseeable expansion of the Single Market into fields that are currently non-competitive, the organisation of energy demand and energy supply will be enhanced. As far as price mechanisms on the energy markets are concerned, it is assumed that the state does not interfere significantly with new energy or environmental taxes and levies.

Table II 8 shows the projection of primary energy consumption in this scenario. Tables II 7 and II 8 show the trajectory of final energy demand by sector and energy carrier. The figures for 1992 obtained in the prognos study deviate slightly from the official German energy statistics for methodological reasons. However, these deviations are irrelevant for our specific subject-matter.

Table II 8: Business as usual projection of primary energy consumption in Germany by energy carrier, in petajoule (PJ)

Primary energy consumption in PJ	1992	2000	2005	2010	2015 Outlook	2020 Outlook
Coal	2198.8	2153.9	2118.1	2076.0	2036.4	2020.2
Lignite	2176.2	1609.7	1563.0	1532.0	1524.5	1521.1

other solid fuels	132.5	160.2	187.8	214.6	223.5	232.7
Crude oil / oil derivatives.	5628.1	6054.8	5969.7	5806.9	5629.4	5463.9
Natural gas	2374.8	2891.0	3040.0	3160.5	3260.3	3378.3
Other gases	35.8	26.3	22.4	20.4	18.7	17.2
Electricity (balance of imports)	-52.6	19.7	94.6	156.8	195.8	190.2
Hydropower	163.3	171.8	173.6	174.8	173.8	170.4
Nuclear energy	1496.1	1429.8	1332.2	1298.6	1271.4	1237.0
Total	14149.9	14517.3	14501.3	14440.6	14334.2	14230.9

Source: prognos, 1995

Primary energy consumption displays relative stability. The substantial decrease in lignite consumption is due to changes in eastern Germany related to the transition from the former GDR centrally planned economy to market economy structures. The latter transition is thus a singular event that does not fit into any particular “trend”. The decline of lignite is largely compensated for by increases in other energy carriers, especially gases and oil derivatives. After 2010, a slight decrease in primary energy consumption is expected.

Table II 9: Business as usual projection of final energy consumption in Germany by sector, in petajoule (PJ)

Final energy consumption in PJ	1992	2000	2005	2010	2015 Outlook	2020 Outlook
Industry	2559.7	2458.6	2511.9	2587.5	2669.1	2777.5
Households	2389.3	2509.7	2463.4	2382.5	2311.7	2229.1
Small-scale consumers	1530.8	1614.6	1619.8	1640.2	1642.7	1651.8
Transport	2522.1	1968.8	3001.4	2985.5	2945.8	2908,4
Military	71.8	68.4	64.4	61.1	58.1	55.2
Total	9073.7	9619.6	9660.9	9656.7	9627.4	9622.1

Source: prognos, 1995

Table II 10: Business as usual projection of final energy consumption in Germany by energy carrier, in petajoule (PJ)

Final energy consumption in PJ	1992	2000	2005	2010	2015 Outlook	2020 Outlook
Electricity	1549.7	1688.1	1774.0	1862.8	1931.3	1999.4
Coal	483.3	384.3	335.5	303.2	276.2	259.2
Lignite	352.8	151.0	114.9	92.7	84.7	79.4
Other solid fuels	43.6	49.6	53.4	56.7	58.1	60.6
Oil derivatives	4376.2	4779.7	4716.3	4603.1	4461.4	4337.9
Gases	1912.6	2200.3	2295.9	2363.2	2429.4	2495.9
District heating	355.9	366.7	370.8	375.1	380.3	389.8

Total	9073.7	9619.6	9660.9	9656.7	9627.7	9622.1

Source: prognos, 1995

Trends in final energy demand can be characterised as stable in a similar way as well, increasing from 1992 to 2000 by 5.9% (3.5% if adjustments are made for temperature). This is made possible, despite stagnating primary energy use, through more efficient energy technologies. After 2000, the increase in consumption continues until about 2005, declining somewhat after 2010 (-0.4% between 2010 and 2020). The distribution among the various energy carriers shows a growing share of electricity and gas, with these two carriers increasing their share by almost 30% up to 2020. This contrasts with a considerable decrease in the significance of the two main solid fuels, coal and lignite.

A sectoral differentiation of final energy consumption reveals major increases in the transport sector (+18%) and in the small-scale consumer sector (+7%, caused by the services sector). Growth in industrial demand is low, at only +1.1% over the same period. In 2010, energy consumption by private households will be lower than the 1992 level. After 2010, there will be even greater reduction in household energy demand; small-scale consumers and transport will show stagnating energy demand, while industrial demand will rise once again.

Reference should be made here to the fact that the transport sector figures in the prognos AG scenario are not congruent with those in the "business as usual" scenario for mobility described in Section III 2.

The role of renewable energies

Renewable energies play a minor role in current energy statistics. It follows that their importance in the "business as usual" scenario is correspondingly low.

According to prognos (1995), renewables will account for a modest 3.3% of primary energy consumption in western Germany in 2010, assuming an increase in the primary energy equivalent of renewable energies from 318.4 PJ (in 1992) to 4472.1 PJ (in 2010). If the framework conditions that already exist are maintained, major increases in the use of renewables for heating and electricity can be expected, albeit at a low level in absolute terms. The proportion of electricity generated from renewable energy sources will increase by 67% between 1992 and 2010, whereby in terms of total electricity generated this corresponds to a rise in share from 4.5% to 6.8%. In the "business as usual" scenario, renewable energies will not provide a considerable contribution towards reducing CO_2 emissions, despite the increases mentioned.

Actual trends confirm this assessment: the amount of electricity generated in Germany from wind power increased in 1995 alone by 60% relative to 1994 (from 0.9 to 1.5 billion kWh); however, consumption of electricity increased the same year by 9 billion kWh, which is 15 times the absolute growth in wind energy generated. This example, and the results of the "business as usual" scenarios are a clear indication that renewable energies can only contribute in a substantial way towards protecting the climate and resources if serious efforts are made to implement rational energy use, and thus bring about a substantial reduction in primary energy consumption. This is not the case in the "business as usual" scenario.

Expected impacts on the environment

Every form of energy use has impacts on the environment, and the respective environmental stresses are highly diverse. Until the late 1980s, the environmental debate in Germany was centred primarily on emissions of air pollutants such as dust, sulphur dioxide and nitrogen oxides, and on the risks associated with nuclear energy (operation of nuclear power stations and the disposal of radioactive waste). A new awareness for the dangers of human-induced climate change has diverted attention to the emissions of greenhouse gases invariably produced through the production and use of energy.

However, other environmental impacts must not be neglected, examples of which include:

- large-scale destruction of landscapes through the production of coal, crude oil and other energy sources,
- marine and coastal pollution caused by off-shore production of oil and the transport of oil, especially from tanker accidents,
- disastrous environmental effects of large-scale water development projects.

Table II 11 shows the energy-related emissions in Germany as projected by the prognos "business as usual" scenario.

Table II 11: Energy-related emissions in Germany from 1990 to 2010, in kilotonnes p.a.

Emissions	1990	1992	2000	2005	2010
Carbon dioxide (CO_2)	990,000	918,000	917,000	909,000	897,000
Methane (CH_4)	1,330	1,172	784	672	571
Sulphur dioxide (SO_2)	6,825	3,646	950	730	614
Nitrogen oxides (NO_x)	3,183	2,786	2,079	1,824	1,728
Carbon monoxide (CO)	9,077	6,278	3,368	2,484	2,145
Dust	1,934	1,034	297	224	193

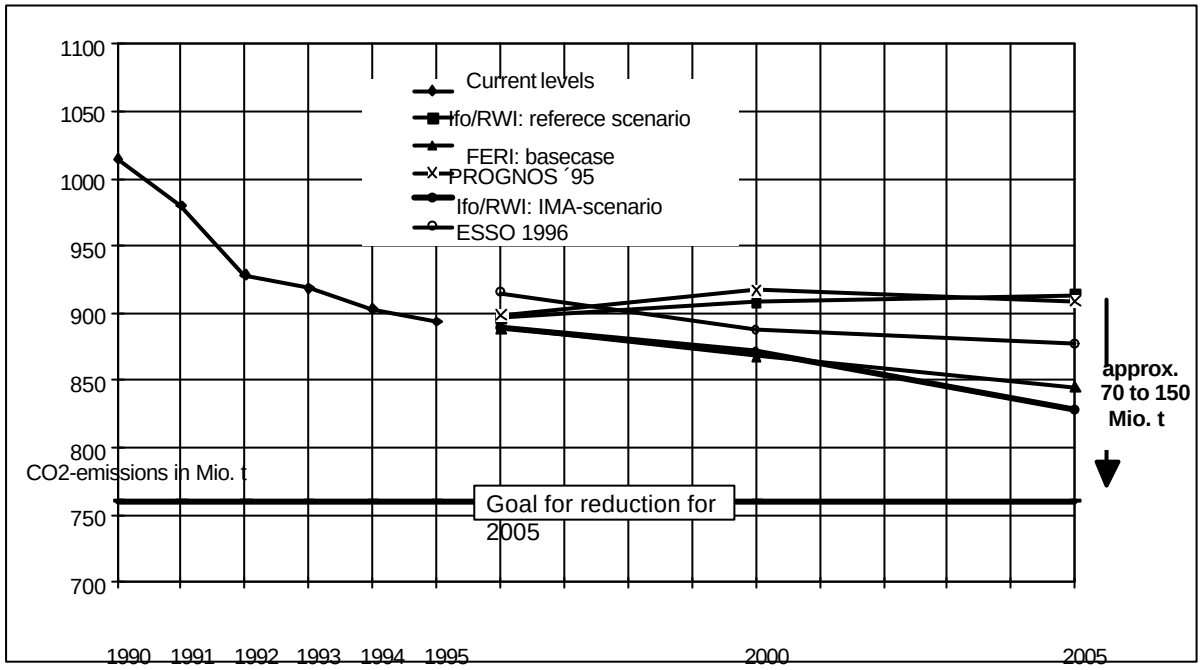
Source: prognos, 1995

The "business as usual" projection of energy-related emissions in Germany is characterised by two different trends: while emissions of the "classical" air pollutants (sulphur dioxide, nitrogen oxides, carbon monoxide and dust) are decreasing sharply, emissions of climate-forcing trace gases (carbon dioxide and methane) are decreasing to a minimal extent. This disparity is attributable to the fact that retention and disposal technologies for the classical air pollutants are available and are deployed on a major scale, but not for the climate-forcing trace gases.

Present forms of energy production and energy use, which the "business as usual" - scenarios predict will be maintained in future, are in violation of sustainable development principles. Non-renewable resources are being used up at a rate far higher than the regeneration rate of renewable resources, which means that such practices are non-sustainable. Substances are released to the environment in dimensions that exceed the Earth System's carrying capacity. Renewable resources are used at a rate beyond their regenerative capacity.

The results of "business as usual" scenarios depend heavily on the assumed conditions on which they are based, even when the assumptions of various "business as usual" scenarios differ relatively little. Figure II 1 illustrates this with reference to some "business as usual" scenarios and their projections of CO_2 emissions.

Fig. II 1: CO_2 emissions in Germany, 1990 - 1995, and projected emissions until 2005 according to selected forecasts/scenarios



The outcomes of different scenarios vary enormously, depending on the specific set of assumptions. This is not the place to discuss how these disparities originate. As far as sustainable energy use is concerned, i.e. the issue addressed in this Report, all "business as usual" scenarios deliver the same answer: there is nothing automatic about the CO_2 reductions achieved in the early 1990s, and they are not continued in the "business as usual" scenario. The German CO_2 reduction target - which in itself is only an interim stage on the road to sustainability - cannot be attained under "business as usual" conditions. Reaching this target requires additional and much greater efforts.

II 3.2 Global forecast

Future energy demand

A "business as usual" scenario, based as it is on permanent yet moderate economic growth, would involve stagnating or at worst slightly increasing primary energy consumption in Germany, where economic growth and rising energy demand are decoupled. In other world regions, by contrast, the situation would be totally different. A good example for an international business as usual or continuity scenario is the Case B ("Reference") scenario of the World Energy Council (WEC, 1993).

Table II 12: Primary energy consumption (PEC) by region in Mtoe (million tonnes oil equivalent), 1 Mtoe = 41.868 petajoule (PJ)

Region	1990	2020	annual growth rate of PEC (1990-2020) in %
North America	2,157	2,337	0.3
Latin America	577	1,397	3.0
Western Europe	1462	1,726	0.6
Central and Eastern Europe	292	319	0.3
CIS	1,447	1,529	0.2
Middle East and North Africa	317	864	3.4
Sub-Saharan Africa	266	690	3.2
Pacific Region (incl. China)	1,843	3,482	2.5
South Asia	446	1,015	2.5
World	8,807	13,359	1.4

Source: WEC, 1993

Table II 13: Global primary energy consumption by energy carrier in Mtoe (million tonnes oil equivalent), 1 Mtoe = 41.868 petajoule (PJ)

Energy source	1990	2020	Percentage change 1990-2020
Coal	2,319	3,035	+31
Oil	2,773	3,769	+36
Natural gas	1,718	2,977	+73
Nuclear energy	441	793	+80
Renewables			
Hydropower	464	920	+98
“traditional”	930	1,323	+92
“new”	166	542	+227
Total	8,811	13,359	+52

Source: WEC, 1993

At global level, the WEC continuity scenario involves strong growth in energy demand, whereby a moderate improvement in energy efficiency through the use of better technology is already taken into account.

Energy demand will increase sharply, particularly in regions that now have comparably difficult economic situations and low energy demand. For these regions, very high levels of population and economic growth are expected. These countries see a need to “catch up” with the industrialised world, and indeed they have every right to do so. Economic growth and rising energy demand are closely linked for countries in these regions. The same interrelationship existed in Germany from the onset of industrialisation until only a few years ago, and it is precisely this relationship that is responsible for the high level of energy consumption in Germany and other industrialised countries.

All energy sources contribute to the growth in primary energy demand predicted by the WEC Case B scenario. However, starting from the currently high percentage of fossil fuels in the energy mix, their absolute contribution to the growth of primary energy demand will be the highest of all.

Projections of energy-related emissions

Looking at the "business as usual" trends at international level (Tables II 12 and II 13), it comes as no surprise to see that the projected rise in energy-related emissions differs significantly from the figure for Germany. In the case of sulphur dioxide and nitrogen oxide emissions, the decline in North America, Europe and the CIS is over-compensated by major increases in other regions, with a net global increase in sulphur dioxide and nitrogen oxide emissions of 2% and 13% respectively in the 1990 - 2020 period. Because of the long-range transport of these air pollutants, and the impacts they have as acidification agents (respiratory diseases, "acid rain", acidification of soil and surface waterbodies), this will lead to severe environmental degradation in the regions affected, similar to experience in Europe and North America.

The global increase in carbon dioxide emissions is much higher than is the case with other "classical" air pollutants, since the former are directly linked to the amount of fossil fuel that is burned. Table II 12 shows the CO_2 emissions derived from the World Energy Council's Case B scenario (WEC, 1993).

Table II 13: Energy-related carbon dioxide emissions by region, in millions of tonnes (Mtonnes)

Region	1990	2020	Percentage change from 1990 to 2020
North America	5,682	5,462	- 4
Latin America	935	2,493	+162
Western Europe	3,666	3,886	+ 6
Central and Eastern Europe	916	843	- 8
CIS	3,959	3,776	- 5
Middle East and North Africa	648	2,163	+168
Sub-Saharan Africa	403	1,136	+182
Pacific Region (incl. China)	4,656	8,578	+ 91
South Asia	733	2,016	+117
World	21,6294	30,684	+ 42

Source: WEC, 1993

II 3.3 No sustainable energy use under "business as usual" conditions

It should be obvious by now that the trends projected by "business as usual" scenarios are non-sustainable. Even if one were to call into question the dangers that future anthropogenic climate changes imply - despite the overwhelming evidence provided by current scientific knowledge - "business as usual" remains non-sustainable on account of the rapid depletion of non-renewable resources that would otherwise be available to future generations, and due to the substantial impacts on human health and the environment that such development would imply.

"Business as usual" scenarios themselves provide some important findings in the search for possible alternatives:

The decoupling of economic growth and energy consumption now evident in Germany and other highly developed industrialised countries is not sufficient to even slow the growth of global energy-related emissions of greenhouse gases.

Efficiency improvements in the delivery and use of energy in the industrialised countries is largely offset by their own economic growth, leading to stagnation of primary energy consumption and a slight reduction in energy-related CO_2 emissions.

The reductions in primary energy consumption and energy-related CO_2 emissions achieved in Germany since 1990 are mainly a result of German unification, and particularly the subsequent radical transformation of the former GDR economy (where energy efficiency was very low). If "business as usual" trends are analysed from the present-day perspective - where the most important changes and adaptations have already been accomplished - it is unlikely given the expected rates of economic growth that primary energy consumption will fall any further, despite the improvements in energy efficiency. The reductions in CO_2 emissions achieved since 1990 will not continue in the same form under "business as usual" conditions.

The less developed regions of the world will see a strong growth in energy demand, with primary energy consumption increasing at annual rates of between 2.5 and 3.4%. Adding this to the lower growth rates in industrialised countries (0.2 to 0.6% p.a.) results in an annual global growth rate of 1.4%. According to the "business as usual" scenario, energy-related CO_2 emissions will thus increase by 42% between 1990 and 2020, whereby future growth in energy-related CO_2 emissions will occur in those countries where current emission levels are very low. This means that reductions in energy-related CO_2 emissions can and must be expected of those countries where current emission levels are high.

II 4. The efficiency scenario - technological improvements and sustainability

II 4.1 The potential for technologically induced reductions in Germany

The trends projected by the "business as usual" scenario are based on the assumption that no major technological improvements will be made. What trends are likely if development is grounded first and foremost on *technological activities* to refine processes and products with the aim of reducing material and resource intensities? Since energy cannot be consumed free of charge, industry has always implemented measures to reduce energy intensity using the current state of scientific knowledge, and with certain expectations regarding amortisation. Energy intensity, which is the proportion of energy used to gross value added at constant prices, has fallen in Germany by an average of about 1.5% annually over the last 20 years.

However, the technological potential for increasing energy efficiency is far from being exhausted. In contrast to "business as usual" scenarios, efficiency scenarios therefore assume that the barriers ob-

structing efficiency improvements will be reduced. Since these barriers are inherent in existing social structures and value systems - e.g. in legal regulations or in the prevailing patterns of production and consumption - there are no clear demarcation lines between efficiency scenarios and a structural transformation and awareness raising scenario (see Section II 5).

One thing is certain: significant efficiency improvements can only occur as a conscious and deliberate process in which many players in society assume an active role and for which politics creates an appropriate framework composed of a wide range of coordinated measures (instrument mix).

Results of previous studies

On the basis of the 1995 prognos scenario described above in Section 3.1, in which the adopted measures to reduce CO_2 emissions were already taken into account, the Federal Environmental Agency carried out an investigation to determine the additional measures necessary in order to attain the national CO_2 reduction target by 2005 and the further reductions in CO_2 emissions that would be needed between 2005 and 2020.

It made sense in this context to condense the multitude of potential activities to sets of measures and to activity fields where they can be put into operation. These areas of activity can then be assigned to the respective stakeholders (policymakers, manufacturing industry, the services sector, agriculture, consumers, local authorities, etc.), who can and must take the initiative to develop further CO_2 reduction potential.

The result of this process was the classification of twelve activity fields where CO_2 reductions could be achieved, with plausible assumptions and frameworks applied to each in order to arrive at estimates of the CO_2 reductions that each could contribute.

- CO_2 / energy tax
- power generation
- cogeneration
- industry / voluntary commitments
- saving electricity
- buildings (households and small-scale consumers)
- renewable energies
- waste management / life cycle management
- district heating / use of waste heat
- CO_2 reductions at the local community level
- transport
- small-scale potentials

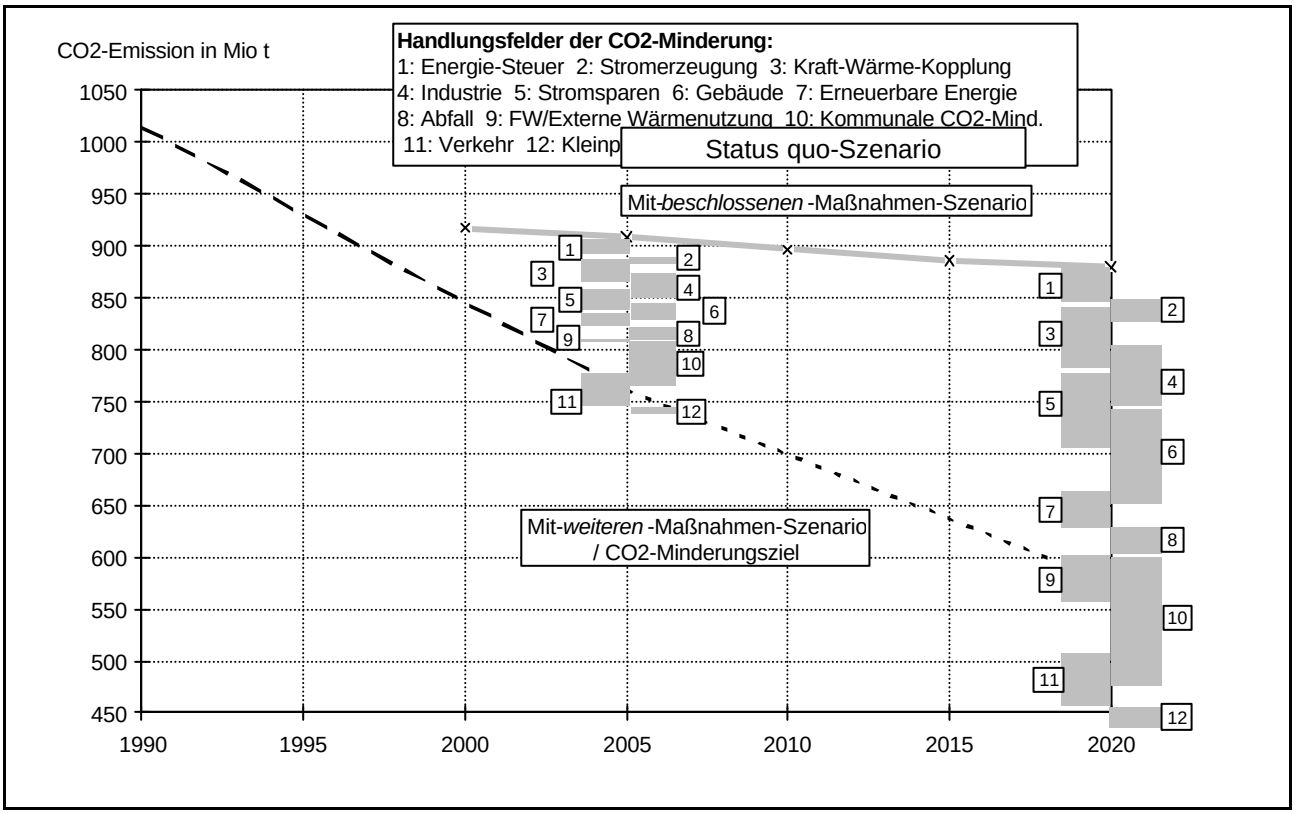
It is not possible at this juncture to present and discuss all the assumptions underlying the separate areas of activities. What is important in this context is that they are plausible and feasible.

For example, in the "CO_2 / energy tax" area, recourse was made to the 1992 proposal of the European Commission for a CO_2 / energy tax and the CO_2 reductions estimated according to the moderate taxation rates of that proposal. If one were to take the significantly higher taxation rates put forward in other proposals for a CO_2 / energy tax, the potential CO_2 reductions that could be achieved in this field would be much greater.

The reduction scenario applied to the "transport" activity field leads to much lower CO_2 reductions than the efficiency scenario discussed in Chapter 3.

Various overlaps may arise between the specific reduction potential in different areas. A CO_2 / energy tax, for example, would obviously have effects on many other activity fields. Overlaps also exist between cogeneration, power generation, district heating / use of waste heat and industry. It is not possible, therefore, to simply add up the respective CO_2 reductions in each statistical year. Figure II 2 shows the CO_2 reduction potential for each of the activity fields in the 2005 and 2020 reference years, as well as a rough indication of possible overlaps.

Figure II 2: The CO_2 reduction target can be achieved with the following additional activities



Activity fields for CO_2 reductions: 1: Energy tax 2: Power generation 3: Cogeneration 4: Industry 5: Saving electricity 6: Buildings 7: Renewable energies 8: Waste 9: District heating/use of waste heat 10: CO_2 reductions at local level 11: Transport 12: Small-scale potentials

Source: Federal Environmental Agency, 1996, unpublished

The contributions of specific efficiency improvement measures, indeed the contributions of separate activity fields to the reduction of CO_2 emissions may seem rather small compared to the major reductions that are necessary, but their accumulated impact is substantial. If a large number of reduction potentials are exploited to the full over a protracted period, it is possible to attain not only the German CO_2 reduction target by the year 2005, but also the CO_2 reductions that must be made after that date.

Other efficiency scenarios conclude that energy intensity in Germany could be reduced at annual rates of between 3 and 4% over a time scale of decades.

Taking the path to such an "efficiency revolution" would provide industry with a major boost for a broad spectrum of innovations and would be an appropriate response for a country, like Germany, where complaints are often heard about a lack of innovation. The heated debates over Germany's strengths and weaknesses as a location for industry should also lead to a recognition that the perspective of "more affluence with less energy" is more realistic than the prospect of "more affluence along the same old lines".

II 4.2 Global potential for improving energy efficiency

Our example of a global efficiency scenario is the World Energy Council's "Ecologically Driven" Case C. The latter uses the same population and economic growth assumptions as the continuity scenario (Case B "Reference"), but assumes an annual reduction in energy intensity of 2.4% (as opposed to 1.9% in the Reference scenario) as well as extended use of renewable energy sources. Primary energy demand in 2010 falls relative to the continuity scenario by around 16% from 13,359 Mtoe (million tonnes oil equivalent) to 11,273 Mtoe. Energy-related CO_2 emissions in the same year are about 24% less than in Case B, but still approximately 7% *higher* than in 1990.

Taking energy intensity, the primary energy consumption per US$ 1,000 Gross Domestic Product (GDP), as the parameter for energy efficiency highlights the trivial but often overlooked fact that improving efficiency can only lead to a reduction in primary energy consumption if the rate at which energy intensity declines is higher than the increase in GDP. Usually, however, this is *not* the case.

Table II 13: Comparison of the World Energy Council's Case B ("Reference") and Case C ("Ecologically Driven")

	1990	2020 Case B "Reference"	2020 Case C "Ecologically Driven"
World population	5,292.4 million	8,092 million	8,092 million
GDP growth in % per annum	3.1 (1980-1990)	3.3 (1990-2020)	3.3 (1990-2020)
Change in energy intensity in % per annum	-0.82 (1990-2020)	-1.9 (1990-2020)	-2.4 (1990-2020)
Energy intensity in toe / US$ 1,000 GDP	0.42	0.29	0.20
Primary energy requirement in Mtoe	8,807	13,359	11,273
Primary energy per capita in toe per capita	1.66	1.65	1.39
CO_2 emissions in Mtonnes	21,633	30,684	23,247

Source: WEC, 1993

It should be stressed once again that the WEC's Case B "Reference" scenario assumes an annual 1.9% reduction in energy intensity over the 1990 - 2020 period. If annual economic growth is assumed to be in the order of 3.3%, primary energy demand increases despite improvements in energy intensity from 8,807 Mtoe (in 1990) to 13,359 Mtoe, accompanied by an increase in energy-related CO_2 emissions of 42%. The "Ecologically Driven" Case C scenario leads to *no* reduction in primary energy demand or CO_2 emissions, but to an 28% increase in primary energy demand and a 7.5% increase in CO_2 emissions relative to the 1990 base year.

II 4.3 Sustainable development through improvements in energy efficiency?

As the preceding scenario shows, improving energy efficiency does lead to a more sustainable pattern of energy use. Such strategies are therefore indispensable on the path to sustainable Germany. They can be maintained over a time scale of decades, but their effectiveness dwindles over time due to the fact that efficiency potential declines and their exploitation becomes progressively more expensive.

Although global energy intensity could be more than halved by 2020, the anticipated level of economic growth will cancel out the CO_2 emission savings if fossil fuels remain the dominant source of energy.

Efficiency scenarios are very sensitive to changes in the underlying economic growth rates and hence to the assumed level of production and consumption. The lower rates of economic growth expected for the industrialised countries compared to the other regions of the world (2.4% per annum, according to WEC) lead to a real decline in primary energy consumption and energy-related CO_2 emissions for these countries in the projections of efficiency scenarios.

It is difficult to estimate the technological potential for rational energy use over a protracted period of time. Very little is known about the specific energy requirements of production facilities, machinery or vehicles in the middle of the next century, because in many fields the potential for technological advances are simply immense.

However, improvements in energy efficiency are absolutely essential if primary energy consumption is to be reduced and the energy-related impacts on the environment ameliorated. Of cardinal importance is the fact that substantial increases in energy efficiency can be implemented relatively quickly and within existing social and economic frameworks. Major potential can be tapped by eliminating existing barriers, by implementing environmental and energy policies based on the sustainability principle, and by means of energy price increases that are economically and socially tolerable and which mobilise the capital for essential investments. It is therefore imperative to exploit every opportunity for improving efficiency as a first step towards rational energy use.

However, efforts based solely on technological measures are not sufficient if sustainable energy use is to be achieved with a minimum of social friction. It is therefore necessary to take further steps that go beyond the mainly technological activities. This requires a willingness to change values and established frameworks that are not compatible with the goal of sustainable development.

II 5 The "structural transformation and awareness raising" scenario

The efficiency scenario described above identifies opportunities for technological adaptation to the principle of sustainable development. Reference has already been made to the fact that these technological adaptations, if they are to be more than the technological adaptations in a projected "business as usual" scenario, require changes in structures and in a certain sense a radical change in awareness. There is therefore a smooth transition to "structural transformation and awareness raising" scenarios which postulate a future situation in which energy use complies with sustainability objectives.

Such visions can be extrapolated from existing technologies. It is neither crucial nor imperative to rely on or hope for rapid advances in technological development. There is already a whole set of national and international scenarios that assume a transformation of values in the population. The "Protection of the Earth's Atmosphere" Enquete Commission set up by the 12th German Bundestag analysed the most important scenarios in its Final Report in 1994.

II 5.1 Is phasing out fossil fuels a feasible alternative?

Two examples of an international "structural transformation and awareness raising" scenario are presented here in brief. The two studies were commissioned by very different organisations - Greenpeace International and the energy industry - and both describe energy futures in which the goal of climate protection is achieved.

"Towards A Fossil Free Energy Future - The Next Energy Transition" was commissioned by Greenpeace International from the Stockholm Environment Institute - Boston Center in 1993 (SEI, 1993). According to this scenario, global demand for primary energy will increase only slightly from 338 exajoules (1 EJ = 10^{18} Joules) in 1988 to 384 EJ in 2030, followed by a rise to 987 EJ by the year 2100. This marginal increase in primary energy demand in the first 40 years is achieved through major im-

provements in energy efficiency. Energy intensity is reduced through intelligent energy use and structural changes in industry by an average of 2.5% per year until 2030, in other words to half present-day levels, after which it decreases by only 0.5% on average per year. A radical increase in the share of solar and wind energy in primary energy consumption occurs after 2030, thus enabling a complete switch from fossil fuels despite *increasing* primary energy demand until 2100.

Table II 14: Projection of primary energy demand and energy-related CO_2 emissions according to the Greenpeace scenario

	1988	2010	2030	2100
Primary energy demand in EJ	338	406	384	987
of which fossil fuels	80%	71%	38%	0%
coal and oil	61%	44%	22%	
gas	19%	26%	15%	
of which renewables	14%	29%	62%	100%
hydropower/geothermal energy	7%	7%	7%	3%
wind and solar energy	0%	9%	31%	79%
biomass	7%	13%	24%	18%
energy-related CO_2 emissions in billion tonnes	19.6	19.3	8.6	0

Source: SEI, 1993

In the Greenpeace scenario, nuclear power will be phased out by the year 2010. Fuel switching from coal and oil to natural gas increases the proportion of the latter among the fossil fuels, with elimination of all fossil fuel combustion by the end of the 21st century. The scenario assumes a continuous increase in the absolute volume of biomass-based energy supply, which increases four-fold by the year 2030 and 8-fold in total by 2100.

The assumptions underlying the Greenpeace scenario are somewhat conservative as far as demoscopic and economic trends are concerned: world population is projected to increase to 11.3 billion by the year 2100, while world economic output is assumed to rise by 1,400% over the same period. Consumption levels in developing and industrialised countries converge. A moderate projection of current economic trends is also assumed for the coming century, whereby the scenario constraints include a *change in the structure of added value creation* after 2030. Due to the presumed transition to new and more durable products, energy demand decreases in the industrialised countries as a result of modified behavioural patterns (e.g. use of more energy-efficient household appliances, or changes in mobility patterns), without exploding in the less developed countries. Per capita GDP in 2030 is defined as US$ 4,749 (in 1985 prices), or US$ 19,899 in the industrialised countries and only US$ 1,830 in the developing countries. At the end of the 21st century, per capita GDP is projected at US$ 18,777, the gap between industrialised and less developed countries narrowing to US$ 29,537 and US$ 17,245 respectively.

The International Institute for Applied Systems Analysis (IIASA) was commissioned by the World Energy Council (WEC), an international body representing the energy industry, to prepare a study entitled

"Global Energy Perspectives to 2050 and Beyond" (WEC, 1995), which was debated at the 16th World Energy Conference in Tokyo in October 1995. This study formulates and examines a total of six scenarios for three alternative trajectories of economic growth and energy demand.

Particularly interesting are the two ecologically driven scenarios (C1 and C2). These show transition pathways from the predominance of fossil fuels to the predominance of renewable energies. By the year 2050, renewable energy sources will have reached a share of almost 40% (C1) of world energy consumption, increasing to over 80% by 2100. This is achieved through widespread increases in energy efficiency, energy savings and the production of new, decentralised and more environmentally sound technologies. As a result, global primary energy demand increases to only 14 Gtoe (gigatonnes oil equivalent) by 2050, whereas the growth scenario projects an increase in primary energy demand to 25 Gtoe.

The basic assumptions behind the ecologically driven scenarios are that a new global control system for greenhouse gas emissions will establish itself and that efforts are made to reduce global CO_2 emissions to 2 billion tonnes of carbon by the year 2100 (7.3 billion tonnes CO_2).This leads to global emissions stabilising at today's level by 2050, followed by a one-third reduction by 2100. Towards the end of the next century, the atmospheric concentration of CO_2 will be around 420 ppmv, while the mean global temperature will increase over the same period by less than 1.5° C. Key climate protection targets are thus attained. In the ecologically driven scenario, C1, these targets are achieved under the assumption of a global phase-out of nuclear energy.

In the World Energy Council study, the requisite investments by the energy sector for the various development pathways described in the separate scenarios were calculated in relation to global GNP. Investment costs are lowest, at 0.9% of global GNP, in the ecologically driven scenario. In contrast, the scenarios based on largely unchecked growth in energy consumption require energy sector investments of between 1.2 and 1.7% of global GNP. This might seem surprising at first glance, in that an ecological orientation on the part of the energy industry is often thought to be far too costly. But it is plausible when one considers that the comparatively low energy intensity of the national economies and the rapidly deteriorating conditions for the production of conventional energy resources due to uncontrolled growth of energy consumption, as described in the growth scenarios, require massive investments in the energy sector. The comparatively low investment expenses in the climate protection scenario are due to the low level of energy consumption, although the investments needed to improve the efficiency of final energy use are not taken into consideration.

What is not included at all in these calculations are the follow-up costs of climate change and other environmental damage caused by the energy future described in the rising energy demand scenarios, or which are avoided in the ecologically driven scenario. The development pathway described in the ecologically driven scenario is not only a feasible option, but appears to minimise risks as well, which makes it all the more preferable.

II 5.2 Assessment of the structural transformation and awareness raising scenario

The Greenpeace and WEC scenarios describe energy futures that are compatible with the Earth's climate, and therefore fulfil the most important criterion for sustainable energy use. Phasing out the use of

fossil fuels leads “automatically” to the mitigation of other forms of environmental degradation linked to the use of these energy sources. In the energy growth scenarios based on the assumption of substantial increases in fossil fuel combustion, energy-related emissions of sulphur and nitrogen rise considerably, despite the assumption that modern emission-reduction technologies will be put to greater use. The transition from present-day energy use patterns to sustainable energy use appears, as far as technological implementation is concerned, to be a realistic option. However, the drastic increases in energy efficiency that are needed and the widespread use of renewable energy sources require appropriate frameworks to become reality, and these frameworks can only be created within an internationally coordinated strategy for climate and environmental protection. Another aspect that should not be neglected is that renewable energy sources are not without their own environmental impacts, which must be examined in each case with respect to sustainability.

Although dominant social frameworks and value systems have always been subject to change in all human societies, it is very difficult indeed to manoeuvre these processes towards a specific goal; attempts to do so have often ended in total failure.

The decisive issue in achieving sustainable energy use is not technological in nature, but how the necessary conditions and frameworks underlying the structural transformation and awareness raising scenario can actually be created. What we need are political instruments, ethical values and novel interpretations of what denotes “prosperity”, elements that must first be developed on a global scale and in relation to goals that seem far removed in time.

The issue revolves around transforming a system that is still seen by many as inherently stable, and which may remain stable for another 25 years or so if current trends continue. The unease about transforming such a seemingly stable system into a different one that functions in a similarly stable way is something that probably emanates from the perception that there are no guarantees for stability in the transition phase (Matthes, 1995).

All in all, however, the risks that must be accepted when reengineering the energy supply system are much less critical than the risks emanating from “business as usual”. This assessment should be kept in mind when deciding to take the first steps towards sustainable energy use right now. The considerable scope for action currently available will be reduced by every delay.

II 6 Main features of an energy strategy for Germany

So far, there has been much mention of the frameworks, conditions and political instruments for successfully advancing along the road to sustainable energy use. What measures are now appropriate, and what instruments can be made available in order to attain the objectives?

Before addressing this question, it is useful to consider some fundamental aspects at issue in order to circumvent the danger of unwise activities or wrong directions.

The global problems that ensue from the way in which we currently use energy resources and which are liable to escalate enormously in future cannot be solved at the purely national level. This undisputed

condition seems to be the source of the greatest psychological barrier to serious reflection on a new energy strategy for Germany. One gains this impression if one follows the current public debate on future energy supply. Many people in Germany display greater anxiety about projected CO_2 emissions in China and India than about their own. The function of such skewed perception is clear: it is easier to give advice to others that to take action oneself. The need for global environmental policy does not obviate the need for policies at national level. On the contrary: faster progress in the environmental policy field can be achieved when states or groups of states are willing to take action or assume a vanguard role with respect to certain solutions (WBGU, 1995 b).

The steps towards sustainable energy use must be evaluated in terms of their contribution towards achieving the goal - the prevention of dangerous anthropogenic interference with the climate system. What is involved is not only the oft-cited "steps in the right direction", but also the chance to reach the goal at the pace decided upon. What might appear at first glance as a step in the right direction may even prove, in the longer-term analysis, to be an obstacle on the way to sustainable energy use. If, for example, it becomes necessary to replace conventional power stations in Germany at the start of the next century, and if this occurs through new large-scale power stations using state-of-the-art technology, then the energy conversion efficiency in the generation of electricity will increase by several percentage points and CO_2 emissions will fall by millions of tonnes per annum. However, having such ultramodern power stations would, from the longer-term analysis, be counter-productive for achieving the CO_2 reduction target for Germany, since they would shape the structure of our power supply system up to the middle of the next century, continue to block the exploitation of cogeneration and renewable energy sources, undermine efforts to save electricity and render the reduction target for 2050 an illusory one. Therefore, the power stations of the future must not be evaluated purely in terms of energy conversion efficiency, but must be integrated within an overall concept for power generation that is benign to climate.

If one is aiming for a particular goal that is far removed in time, one must also provide for possible corrections to the adopted route whenever obstacles arise that are not foreseeable at present. It is therefore a risky endeavour in such a situation to place all one's bets on one option and in that way restrict our future scope and that of generations to come. The logical conclusion as far as an energy strategy for Germany is concerned is to turn down those options that lead in future to preserving or even worsening the lack of flexibility on the part of our energy industry.

An energy strategy for Germany must formulate steps towards sustainable energy use in the present and immediate future. It should include subsequent steps in the present and create the conditions for accomplishing these steps. In addition, it must ask itself with seriousness and moderation what contribution Germany can make in support of the global process towards sustainable energy use and to reinforce the inherent dynamics of said process.

As early as 1990, the Final Report issued by the first Enquete Commission on Climate (set up by the 11^{th} German Parliament) listed a whole series of measures and instruments for effective reduction of energy-related CO_2 emissions. These recommendations have been repeated, added to and commented on frequently since then (Enquete Commission, 1990; Enquete Commission, 1994;Altner, 1995). Some of the measures recommended have been or are now being implemented (BMU, 1994).

The problem, therefore, is not a lack of ideas - indeed, a simple list of all the measures and instruments proposed so far would take up far too much space in this context. What is needed in order to handle the multitude of measures and instruments is a broad-based policy approach. An energy strategy for Germany must cover all sectors, such as private households, small-scale consumers, industry, transport and the energy industry itself, and deliver the relevant and appropriate instruments and measures in each case, in order to tap the CO_2 reduction potential necessary for protecting the climate. The following sub-sections attempt to structure the large number of potential activities and instruments into a general overview.

Regulatory instruments

Regulatory instruments permit changes to be made to the framework within which the energy industry operates, in the interest of developing efficiency potential and enhanced use of renewable energy sources. The spectrum of regulatory instruments is wide. Especially important are the following:

- Amendment of the Energy Management Act (*Energiewirtschaftsgesetz*), which is now 60 years old and thus inadequate for protecting resources, the environment and the climate. In the interest of rational energy use, it would be necessary to take into consideration the demand side, to organise the production of electricity from renewable energies in a way that is profitable but which does not encourage profiteering.

- Amendment of the federal tariff rules for electricity and gas, in order to develop inexpensive options for saving energy (least-cost planning) in the interest of rational energy use outside the energy production sector, and to enable the retransfer the costs for energy-saving programmes and the incremental costs of electricity from renewable energy sources.

- Further development of the Electricity-Feed Law governing the sale of electricity to the grid (*Stromeinspeisungsgesetz*) (in force since 1st January 1991), with the aim of guaranteeing the acceptance of electricity generated from renewables and improving payments for such externally produced electricity.

- Ensuring a high level of voluntary commitment within industry to exploit the potential for thermal energy use, which should be flanked in the event of non-compliance by enforcing the Ordinance on Heat Use (*Wärmenutzungsverordnung*), which was drafted at one stage but set aside.

- Amendment of the Thermal Insulation Ordinance (*Wärmeschutzverordnung*) (previous re-enacted version has been in force since 1st January 1995), with the aim of reducing the need for space heating. The next re-enactment, aimed at further reductions in space heating requirements, is scheduled before the year 2000.

- There is also a need for regulation in a large number of fields, with the aim of reducing barriers to rational energy use and the utilisation of renewable energies, e.g. in tenancy law, building law, waste management law, public finance law, taxation law and many other areas.

Financial instruments

Financial instruments in the energy sector are designed to influence energy prices in order to promote rational energy use and greater utilisation of renewables. Such efforts are necessary, because the price

mechanisms do not take into consideration the external costs of energy use and because energy price trends in recent years have emanated signals that run counter to sustainable development. While rational energy use and greater use of renewable energies are what the situation now demands, the supply of energy on the world market is growing unrelentlessly, with the result that the prices for energy in real terms have been falling for a number of years.

The most important financial instrument is a CO_2 / energy tax. Taxing energy is a central element in all recommendations for a green reform of the public finance system (see Section VII 3). Recent years have seen a steady stream of proposals concerning the introduction and design of such a tax. In 1992, the European Commission drafted its first proposal for a Council Directive introducing a CO_2/energy tax, which envisages step-by-step increases in the rate of tax over a longer period of time, in order to give industry sufficient time and planning security for adaptive measures (see Section VII 3.5.2). Germany takes a clear position within the EU in favour of introducing an EU-wide CO_2/energy tax.

Financial instruments are not confined to energy taxes and other levies. Promoting the introduction of and using technologies for new or renewable energies can also prove an effective instrument. Such support can be given through direct grants for investment or operating expenses, inexpensive credits, tax benefits, assistance with product launches and other methods. Administratively stipulated minimum prices for electricity generated from renewable energy sources, in accordance with the law governing the sale of electricity to the grid (*Stromeinspeisungsgesetz*), are an instrument that has convincingly demonstrated its effectiveness in recent years. Although price-fixing is not compliant with a free market, it is acceptable here as a form of regulation given the lack of competition in the supply of electricity.

Many important successes in the rational use of energy resources and in the greater use of renewables in recent years are attributable to various support programmes. Although the overall evaluation of such programmes is positive, they show up a serious dilemma: given current energy prices and budgetary constraints in government spending, the requisite measures for rational energy use and for boosting the introduction of renewable energies cannot be financed with support funds alone. In order to take the necessary steps towards sustainability, there is no alternative to raising energy prices in the future, a step that would obviate the need for many support schemes.

Measures for eliminating gaps in information and lack of motivation

Although cost aspects play a key role in decisions concerning rational energy use and renewable energies, even steps that are clearly cost-efficient are not automatically taken. Gaps in information, uncertainty or lack of motivation due to ignorance of complex interrelationships are the decisive obstacles to any progress. Communicating information is therefore an important precondition for energy-conscious behaviour on the part of consumers (see Section VI 5.3). This communication of information, which given the accelerating rates of innovation in all areas of life can only occur through “lifelong learning”, is the responsibility of many different players. It begins, quite literally, in the children’s nursery, and must be continued in the planning frameworks for schools, in the syllabi of the universities and polytechnics, in vocational training, in continuing and further training. The responsibility for this process is shared by the Federal Government, the individual states in Germany, local authorities as well as industry and the craft trades and their respective federations, consumer organisations, environmental organisations, the solar energy lobby, energy suppliers and others.

Measures for promoting research and market launches

There is a considerable need for more research in the field of new energy technologies, which in turn requires research support in the field of fundamental and applied research. Energy research is not only in the interest of climate protection, but, if it addresses the right issues and supports new technologies until they can be marketed, is always an enlightened form of economic policy, because anyone who has engineered a lead in research and development and in market introduction has a stronger position on the markets of the future. When setting the priorities of research support in future, the energy technologies to be promoted should be assessed and selected to a greater extent on the basis of sustainability criteria. Technologies that do not comply with these criteria should not consume a major share of the research funds, scarce as they are. There is still a considerable need for research regarding the optimal ways in which to apply new energy technologies, both from the ecological and the economic perspective (e.g. in the fields of solar generated hydrogen, bioenergy sources or fuel cells). Research findings in the field of power engineering will not have any impact on climate protection until they spawn new products and new services with viable prospects on the market. In many cases, such implementations require special marketing assistance, which must form a more integral part of research support in future if expenditure on research is to have any positive impacts on the competitiveness of German industry.

Instruments and measures at international level

Against the background of European integration, the globalisation of markets and the international activities since the Rio conference, international instruments and activities are becoming more and more important, as well indispensable for a sustainable energy industry. Since Germany is in favour of these processes and has played a leading role in many fields, it should make further efforts. With reference to sustainable energy use, this means that Germany should assert its influence in international negotiations,

- so that, in the international negotiations following the 1995 Conference of the Parties in Berlin, specific and binding targets for reducing greenhouse gas emissions for the years 2005, 2010 and 2020 are agreed upon and definite implementation steps defined, for the industrialised countries at least,

- to formulate binding rules for equitable “joint implementation” of activities in the energy field aimed at protecting the climate,

- so that sustainability aspects are taken into account to a greater extent than previously in development aid relating to energy use,

- so that technology transfer in the field of rational energy use and renewable energy sources is strengthened and

- criteria for rational energy use are integrated appropriately into international norms and standards.

German industry, with its presence on the world’s markets, must also face up to its responsibility for climate protection and sustainability within the international context. This is particularly the case with regard to the pilot phase of “joint implementation” since the Conference of the Parties in Berlin, which

is conceived of as a basis for further development of this innovative international instrument for climate protection.

Another international instrument for climate protection that distinguishes itself through its flexibility in reducing greenhouse gas emissions is that of tradable emissions certificates. What is needed here is an internationally agreed target for emissions reduction. Within this basic framework, it would then be possible for the emissions certificates to be traded. Players who achieve higher reductions in greenhouse gas emissions may then sell any certificates they no longer require. However, simple and cost-efficient though this mechanism may be in theory, it must be tried out in practice at international level before it can be implemented on a larger scale.

This short and incomplete list of activities and instruments leading to sustainable development shows that:

- There are sufficient measures and instruments for taking the first definite steps towards sustainable energy use.

- The measures and instruments can be implemented within our current economic system without any basic problems; indeed, the successes already achieved show how possible this is.

- However great our uncertainty may be regarding the need for action in future, the sheer number of available options should prompt us to be optimistic about approaching the goal of sustainability once we have started out along that path, for all the course corrections that may have to be made.

The task which we have to accomplish in the immediate future is to create the conditions, with additional measures and the deployment of new instruments, for achieving Germany's CO_2 reduction target for the year 2005. This is the most important step on the way to sustainable energy use.

III Sustainable Mobility

III 1. Mobility and sustainable development

III 1.1 What is mobility ?

Mobility is often seen as a definitive element of modern industrial society, and the growth of individual and goods traffic as the precondition for economic growth, prosperity and quality of life. The perspective taken is often confined to auto-mobility, with other forms of mobility, especially walking, the most fundamental and original form of mobility, tending to fade into the background. At the same time, the environmental stress caused by road traffic is so high that it is no longer possible to maintain the close linkage between growing affluence and higher levels of motorised mobility without major changes being made. Mobility, too, must be assessed according to the criteria of sustainability.

Mobility means potential and actual changes of location. Having the capacity to change one's location enables one to choose between different destinations. Actual changes in location are manifested as traffic. However, mobility is not the same as traffic. Maintaining one and the same level of mobility can result in very different volumes of traffic. Mobility can be an end in itself, but in most cases is a means to an end, i.e. movement to a particular destination with the intention of carrying out a specific activity there. The closer the points of departure and the destinations, the less traffic arises for the same level of mobility.

Post-war growth in passenger transport was mainly expressed in the replacement of walking by motorised travel and as growth in the distances covered. Today, people do not perform more "acts of mobility" per day on average than they did 20 years ago (the mean value is around two), but they cover greater distances.

Freedom and the compulsion to be mobile

The attractions of mobility are mainly attributable to the options it provides. Anyone who is mobile has more choice, and is *not* dependent on what is literally "close", be it the place of work, the shop, the sports centre or the social contacts that are kept, even by those with solitary lifestyles. Growing mobility is a gain for the individual. The change in spatial behaviour is not without consequences for spatial structures, however. If facilities in the locality are no longer used, they tend to deteriorate. Individualised, motorised mobility furthers the establishment of monofunctional spatial structures. The concentration of services in the city centres and shopping facilities in large periurban centres, and the shift in housing patterns to detached homes on the urban periphery are all developments that would not have been possible without appropriate, i.e. inexpensive transport modes, cars especially. However, the short-term benefits of motorisation are partly eliminated in the longer term. The distances covered are greater than they were before - but out of necessity, not choice. Choice of transport mode is also restricted. It is difficult if not impossible to walk, cycle or indeed, where there is too little traffic, to take a bus or train instead of drive. The result is the differentiation of society into "the mobile" and "the immobile". Those who are compelled or who choose of their own free will not to have a car are more restricted in their mobility options than they would have been previously, due to changes in settlement structures and on account of the considerable space that road traffic commands.

III 1.2 External costs of transport - unpaid bills

A transport system that permits a socially unacceptable level of environmental stress without at least charging those causing such environmental damage with a fair proportion of the ensuing costs is unsustainable by definition. Seen in this way, the existence of external costs of mobility can be seen as an indicator of the non-sustainability of a transport system. As long as prices and cost structures ignore the substantial damage being caused, each incidence of transportation imposes costs on the general population and on future generations. Sustainable mobility must therefore involve appropriate measures for avoiding the external costs of transport, or at least ensure that external costs are charged to those who cause them (the internalisation of externalities).

What are the external costs of transport?

External costs are negative impacts on third persons for which the person carrying out such activities has no direct or indirect economic consequences to bear. Examples include the pollution and other forms of environmental stress caused by transport, costs of accidents that are not covered by vehicle insurance, and the costs for transport infrastructure where these are covered by fiscal revenue. In the view of the European Commission, there is "a significant mismatch between prices paid by individual transport users and the costs they cause" (EU Commission, 1996, p. 9). The fact that transport causes major external costs is undisputed, even by the motorists' lobby. Opinions differ with regard to the amount of costs involved. Estimates range from 2.6 to 36 pfennigs (0.05 - 0.71 ECU) per kilometre for passenger traffic, and 3.2 to 28.7 pfennigs (0.06 - 0.57 ECU) per tonne-kilometre for goods. These enormous differences are the result of highly divergent delineation of the external cost categories to be taken into account, as well as different reference data, assumptions and monetarisation methods. For example, infrastructural costs, damage to health, accidents or the impacts of the greenhouse effect are included to very different extents. If one were to apply standard monetarisation methods, cost categories, delineations and data, then the range of estimates would decrease considerably. Road transport causes specific values that are as much as ten times higher than those of rail transport. Despite the advances made in determining external costs, many types of cost defy complete identification and quantification. Some impacts of traffic are (still) impossible to evaluate in monetary terms, such as the role played in the extinction of species and biotopes, or the psychosocial effects of traffic, or other impairments of individual well-being. The external costs which can be determined therefore reflect only part of the total degradation and damage that are actually caused.

Level of external costs

Following analysis of existing publications and studies on the external costs of transport (e.g. PLANCO, 1990; Kageson et al., 1993; Infras/IWW, 1995; Bickel/Friedrich, 1995; DIW, 1992), and our own calculations at the Federal Environmental Agency, it can be assumed that the external costs of transport (including subsidies for local public transport) are currently in the order of DM 161 billion (Huckestein/Verron, 1996). Of that total, about 17% are for public transport. The assessable external costs of road transport of more than DM 133 billion per annum are offset by revenues from transport-related taxes of around DM 70 billion. However, more than DM 7 billion of these revenues must be deducted for tax rebates for travelling to work and for tax avoidance through private use of company cars. Only part of this revenue is earmarked for transport-related spending, and the income is not used to provide at least financial compensation for accident victims and/or to remedy damage to the envi-

ronment. Nevertheless, a comparison of external costs and transport-related tax revenue shows that less than half the total externalities are recovered from those causing them. Internalisation of external costs is of course no guarantee of sustainable mobility, but making transport services deliberately more expensive would indeed help to achieve the specified targets with respect to environmental quality and environmental policy action.

III 1.3 Mobility in a sustainable society

Alarming symptoms of transport-induced damage at global, regional and local level include climate change, forest damage, the destruction of biotopes and areas of unspoiled nature, health risks in urban agglomerations, and the loss of urbanity and quality of living in cities. Moreover, transport consumes huge amounts of material and energy and causes enormous quantities of waste. Threats to health and the environment as a result of transport activities can only be sufficiently reduced in the long term if technological measures are supported by steps to influence the volume of traffic and the choice of transport mode.

The principle of sustainable development requires a definition of minimum standards for environmental quality. By comparing actual and ideal figures for the transport sector, it is possible to set environmental objectives from which the required measures can be derived. Without such objectives, it would be difficult to avoid a situation in which the various sources of environmental damage are simply played off against each other (reduction of CO_2 emissions from heating as opposed to those from traffic), or to define the required action in the transport sector in a clear and unambiguous way. Such a procedure must be based on a clear decision on who has to reduce emissions by how much - i.e. on how the burden of adaptation for sustainable development is to be shared among the various emitter groups. An excellent example for how this is done are the sectoral environmental targets for transport drawn up in Sweden in a project for developing targets and measures for sustainable and environmentally sound transport for which there is a powerful national consensus (Swedish Environmental Protection Agency, 1996). These targets are supported not only by the Swedish Environment Ministry, but also by the Ministry of Transport (road, rail and air transport) and by the Swedish car manufacturers.

We cannot foresee today what mobility in a sustainable society will look like in practice. The purpose in defining the following environmental policy action targets is not to mark a final and absolute goal, but to initiate a process. The recommendations should be understood as the first steps towards sustainable mobility.

In the following, environmental policy action targets relating to transport are proposed for the problematic areas

- climate protection, CO_2 abatement,
- summer smog (ground level ozone),
- carcinogenic substances,
- nitrogen oxides (NO_x) and volatile organic compounds (VOC),
- noise,

- waste and waste disposal,
- conservation of nature and landscape protection and
- residential surroundings / urban compatibility.

Climate protection

The Enquete Commission on "Protecting the Earth's Atmosphere" set up by the 11th German Bundestag recommended an 80% reduction in the CO_2 emissions of industrialised countries relative to 1990 by the year 2050 in order to ensure that global warming is sufficiently limited to prevent dangerous changes in the climate.

The Federal Government decided on 13.6.90, 7.11.90, 11.12.91 and 29.9.1994 to reduce CO_2 emissions in Germany by a total of 25% to 30% between 1987 and 2005. In his address to the Conference of the Parties to the Framework Convention on Climate Change on 5 April 1995 in Berlin, the Chancellor of Germany, Helmut Kohl, corrected the reference year for the 25% policy action target to the base year specified in the Climate Convention, namely 1990. This is a first step towards a long-term climate protection strategy. Details on the proportion to be accomplished by the transport sector have not been derived as yet.

The proportion of CO_2 emissions accounted for by transport in Germany is currently around 20%. Were they to remain at this absolute level, all other sectors would have to reduce their CO_2 emissions to zero by the year 2050 in order to meet the emissions target specified by the Enquete Commission of the German Bundestag. The relentless growth in the volume of traffic means that, under business as usual conditions, CO_2 emissions are likely to increase rather than remain at current levels. It is patently obvious, therefore, that enormous efforts will have to be made in the transport sector as well if CO_2 emissions are to be reduced. For the economy as a whole, it is preferable to allocate the required CO_2 emission reductions to the various emitter groups (ideally to individual sources) in such a way that reductions are achieved at lowest total cost. In other words, those sources with the lowest CO_2 emission reduction costs would have to make the first reductions. However, since there are no specific criteria available as yet for allocating CO_2 emission reductions to emitter groups, we assume in the following that various measures for achieving the desired reduction in CO_2 emissions in the transport sector are introduced. Another assumption is the "equal distribution of emission reductions among emitter groups", which would mean that the transport sector effects an average 25% of the national emission reduction target. Since implementing a CO_2 reduction strategy is likely to be most difficult of all in the transport sector, a more realistic approach in this case would be to work with a longer adaptation phase.

The 35th Conference of Environment Ministers (at federal and *Länder* level) held in Berlin on 22 / 23 November 1990 adopted a comprehensive plan for reducing transport-related air pollution. According to the plan, transport-related CO_2 emissions are to be reduced by 5% and 10% by the years 1998 and 2005 respectively, relative to 1987 levels.

The Conference of Ministers of Transport (at federal and *Länder* level) agreed in October 1991 on a 10% reduction target for transport-related CO_2 emissions over the 1987 - 2005 period.

In November 1991, the Federal Minister for Environment, Nature Conservation and Reactor Safety presented a set of measures on "Environment and Transport", in which the target is similarly a 10% reduction in transport-related CO_2 emissions between 1987 and 2005.

In June 1990, the German Motor Industry Association (VDA) promised the Chancellor that they would "endeavour to reduce the fuel consumption and hence the CO_2 emissions of car traffic by the 25% national reduction target" (VDA, 1991). On 23.3.1995, the VDA agreed to reduce the specific fuel consumption of cars manufactured and sold in Germany by the German car industry by 25% by the year 2005, relative to the 1990 base year.

In its paper on "Key factors in reducing transport-related environmental stress", the Council of Experts on Environmental Issues (SRU) takes the same position as the Enquete Commission on reducing emissions of CO_2 and other climate-forcing gases (SRU, 1994).

Within the framework of a project for developing targets and measures for sustainable, environmentally sound transport in Sweden, it was recommended that CO_2 emissions from traffic be reduced by 5%, 15% and 60% relative to 1990 levels by the year 2005, 2020 and 2050 respectively (Swedish Environmental Protection Agency, 1996).

Ground level ozone, nitrogen oxides (NO_x) and volatile organic compounds (VOC)

To ensure that ground level ozone concentrations do not exceed the maximum levels stipulated in the air quality standards of the World Health Organisation (WHO), it is necessary, according to model computations, to reduce concentrations of the precursor substances, NO_x and VOC, by at least 70 to 80%. This is also necessary for climate protection reasons (ground level ozone is also a greenhouse gas). Sustained reductions in acid loads to soils in order to prevent forest damage according to the "critical loads" concept, and the reduction of nitrogen loads to the North Sea and the Baltic require a similar 80% reduction in NO_x emissions. Since transport accounts for two-thirds of all NO_x emissions and is responsible for about 40% of VOC emissions, we recommend, like the Council of Experts on Environmental Issues (SRU) before us, that transport-related NO_x and VOC emissions be reduced by 80% relative to 1987 by the year 2005.

Carcinogenic substances

According to studies carried out by the *Länder* Committee for Immission Protection (LAI, 1992), emissions of diesel particulates, polycyclic aromatic hydrocarbons (PAH) and benzole are a major contributory factor (more than 80%) of immission-related cancer risk. One estimate arrived at by the Committee was that the cancer risk in urban agglomerations attributable to immissions is more than five times greater than in rural areas. The long-term goal must be for urban areas to have the same air quality as rural areas now have (benzole: 1.3 µg/m^3, "black smoke" (diesel particulates): 0.8 µg/m^3, PAH: 0.6 ng/m^3), although this would still signify a residual cancer risk (approx. 1 : 5,000).

The first step in reaching the LAI criteria for carcinogens (1 : 2,500 risk; benzole: 2.5 µg/m^3, diesel particulates: 1.5 µg/m^3, PAH: 1.3 ng/m^3) is a 90% reduction in diesel particulates, PAH and benzole emissions between 1988 and 2005, while the second step (air pollution levels equivalent to current rural levels) would necessitate a 99% reduction in urban agglomeration levels. These are the same reduction targets as those recommended by the SRU in its 1994 Annual Report.

Noise

Noise pollution constitutes a threat to health (high blood pressure, cardiovascular diseases), and must be brought down to under 65 dB(A) during daytime hours (see Ising et al., 1996). Further reductions than these are necessary in order to prevent adverse effects (interference with communication and sleep disturbance) (see Klippel, 1993; Interdisziplinärer Arbeitskreis für Lärmwirkungsfragen beim Umweltbundesamt, 1990). A three-step approach for reducing noise pollution is recommended:

- reduction of health-impairing noise pollution by the year 2005, target level ≤ 65 dB(A),
- reduction of major noise-related stresses by the year 2010, target level in residential areas ≤ 59 dB(A) during the day and ≤ 49 dB(A) at night, and
- reduction of noise levels in residential areas by the year 2030 to ≤ 55 dB(A) during the day and ≤ 45 dB(A) at night.

The environmental quality targets for noise relate primarily to road and rail traffic, and can be understood directly as environmental policy action targets, i.e. nobody should have to endure noise levels above these recommended levels in his or her immediate residential surroundings.

Nature conservation and landscape protection

In the field of nature conservation, preservation of landscapes and improvement of residential areas, there are no unequivocal environmental quality targets from which environmental policy action targets could be derived. Nevertheless, the stresses to which nature and landscapes are exposed today through the continuous expansion of transport infrastructure, and the traffic-related changes in urban living conditions (accidents, loss of the street as part of the social environment, etc.) necessitate the formulation of targets for further action. The first specific targets were laid down in the "Nature conservation and transport" policy concept adopted by the 39th Conference of Environment Ministers in autumn 1992, which included, for example, the preservation of large contiguous areas, the preservation and development of protected and designated areas and the linkage of nature reserves with conservation corridors, protecting the ecological functions of near-natural ecosystems, reduction of transport-related land consumption and the development of settlement structures which minimise traffic.

In detail, the policy concept contains the following requirements:

- Exclusion of new transport facilities from protected and designated areas (nature conservation areas, biotopes pursuant to Section 20c BNatSchG (Nature Conservation Act), nature reserves linked by conservation corridors, etc.)
- Keeping all low-traffic contiguous areas free of through traffic infrastructures (transport links for local needs must also rely as far as possible on existing roads and tracks, even if this means less direct routes)
- Concentration of transport and utilities infrastructures in order to avoid additional fragmentation
- Preservation of semi-natural riverine systems and their ecological functions

- Gearing instruments for regional planning and local land use plans to the avoidance of "forced mobility"

- Increasing diversification and density of urban settlement structures,

- Location of new residential and industrial areas, as well as leisure facilities, only in conjunction with existing settlements along regional development axes,

- Conservation and development of adequate green and leisure areas in towns and cities and their immediate surroundings

- Prioritisation for expansion of existing transport routes over new construction, reduction of construction standards, and renaturation and recultivation of roads and road surfaces that are no longer required

- Prevention of landscape overdevelopment due to bypass roads and local motorways ("pull" effects).

In view of the dramatic decline in the number of contiguous low-traffic areas and the increasing impairment of protected and designated areas, the Federal Environmental Agency recommends the following policy targets for the transport sector in addition to those put forward by the Conference of Environment Ministers:

- In protected and designated areas, it is important to prevent not only the construction of new roads, but also the widening of existing roads. Other areas of special environmental interest besides protected and designated areas must be kept free of new roads, road development schemes, new rail links and waterways.

- Expansion of trunk roads in Germany should be stopped, at the latest in the next Federal Transport Network Plan.

Improving residential surroundings

Present-day auto-mobility is incompatible with sustainable urban living. Urban areas are finding it increasingly difficult to cope with the large and growing number of vehicles on the road, and too many trips are done by car. Important urban spaces are occupied by parked cars. Today's traffic conditions are seriously detrimental to urban living conditions: children can hardly play or otherwise spend their time on or near the streets, elderly people feel insecure and confined when walking on the streets, and inner-city streets have virtually lost their function as a place to spend time and communicate with others..

Formulating generalised standards or minimum requirements is more difficult in respect of residential surroundings than for other fields, because specific local conditions vary considerably depending on the location. The objective cannot be to eliminate differences that have arisen by historical process and which convey a specific urban character, since these characteristic features of the urban environment themselves provide a certain quality of life and identity. The objectives formulated should mainly act as a pointer from which specific activities and programmes can be developed for the respective conditions in each case.

An excellent example is the inner-city of Berlin, where a system for evaluating and assessing the urban compatibility of traffic was developed (*Senatsverwaltung für Stadtentwicklung und Umweltschutz Berlin*, 1993). Taking account of the limited transferability of this approach to other cities, we attempt in the following to outline some minimum requirements for improving the safety and quality of the urban environment.

The risk of being killed or seriously injured in inner-city traffic is considerable: the risk of being killed is 1:404, while the risk of being seriously injured is 1:19. The Federal Environmental Agency recommends that the exposure to traffic-related safety risks be evaluated in precisely the same way as the immission-related risk of cancer. Adapting the LAI objectives for limiting the cancer risk from air pollutants, the risk of being killed in a road accident in a built-up area should be reduced to 1:2500, while the risk of being seriously injured should be cut to 1:125. On this basis, it is possible to generate standards for permissible speeds and for aids for crossing main thoroughfares. The normal speed limit in built-up areas should be lowered to 30 kph. Pedestrians should not have to wait more than 30 seconds on straight stretches of road, and no more than 40 seconds at road junctions (see Apel, 1994).

The design of roads must be geared more to the needs of non-motorised traffic. Road surfaces and parking areas should not occupy more than 50% of the total road width. Pavements and cycle paths should be at least 3.80 m and 2.50 m wide, respectively. Pedestrian streets and shopping streets need an additional 2 to 4 m in pavement width.

Waste and waste disposal

As regards the use of non-renewable resources by the transport sector and its material flows, our recommendation is confined initially to a quantitative target for disposal. The dimensions of the material flows involved are highlighted by the following figures: approximately 2.4 million tonnes of iron/steel, approx. 300 kilotonnes of other metals, approx. 450 kilotonnes of synthetic materials, approx. 75 kilotonnes of glass and 500 kilotonnes of other materials are consumed in Germany alone in the production of new cars (Enquete Commission 1994; own calculations). Sustainable development requires a marked reduction in and closure of the material flows associated with the production, maintenance and disposal of motor vehicles. To protect resources and mitigate the enormous environmental stresses caused by the disposal of vehicles, it is recommended that the lifetime of vehicles and vehicle parts be increased, and that the recycling rate be increased to 85% and 95% of vehicle weight by the years 2000 and 2005 respectively.

Whether or not the specified targets are sufficient for sustainable development will be seen when we enter into implementation. For now, they are intended first of all as basic guidelines for the selection of measures.

The following scenario calculations provide a basis for investigating which particular combinations of measures are suitable for bringing about sustainable mobility, with specific reference to climate, noise and air pollution. Additional activities will be necessary to attain the set targets for other environmental media as well, although this has not yet been subject to sufficient investigation in all areas.

Reduction targets relate to forecasts for 2005 compared to the starting years mentioned in Section III 1.3 above: 1990 for CO_2, 1987 for NO_x and VOC, and 1988 for benzole and diesel particulates. The reason for the different base years is due to the different policy targets for reductions, all of which are not listed here.

III 2. The “business as usual” scenario - whither development?

III 2.1 Trends in car numbers, kilometres driven and fuel consumption

Substantial growth in the volume of traffic is expected in coming years if current trends continue. According to the predictions on which the Federal Transport Network Plan is based, the number of registered cars in Germany will increase from a current fleet of 40 million vehicles to 46.5 million vehicles in the year 2005. In 2010, the number of vehicles will have reached 48 million (see Table III 1). Predictions of fleet size have always underestimated future trends. The forecast figures should therefore be seen as a minimum estimates.

Table III 1: Car fleet growth

	No. of cars (in millions)	1990
1980	25.9	
1990	35.5	
1995	40.4	14%
2005 (Ifo 1994)	46.5	31%
2010 (Ifo 1994) [1)]	48.0	35%

[1)] Shell (1995) predicts, depending on the underlying population scenario, a fleet size of between 45 and 48.6 million cars in 2010.

Sources: DIW, 1991; Ifo, 1995; Ifo, 1994.

In the period between 1990 and 2005, the number of vehicle kilometres in motorised private traffic (MPT) will increase by 25%. By 2010, total growth is expected to reach 32% (see Table III 2). Leisure traffic accounts for the highest proportion of kilometres by motorised private traffic (approx. 45%).

Expected growth of goods vehicles and buses is even higher - 44% over the 1990 - 2005 period. An increase of 27% was already reached by 1995 (see Table III 2).

Table III 2: Growth in motorised private traffic (MPT) and commercial vehicles (CV)

	MPT		**CV**	
	billion km	1990	billion km	1990
1990	519.9		72.3	
1995	549.1	+6%	92.1	+27%
2005	649.4	+25%	104.2	+44%
2010	686.9	+32%	107.1	+48%

Source: Federal Environmental Agency, TREMOD, 1996

Fuel consumption, an indicator for the depletion of oil resources, is not increasing as fast as the number of vehicle kilometres (see Table III 3). This is attributable to the lower average energy consumption per vehicle. In 1990, the average for all vehicles in Germany was 9.4 litres per 100 km, according to figures published by the Federal Transport Ministry (DIW, 1995). Under business as usual conditions, the Ifeu institute assumes that the average energy consumption of new vehicles will decrease by 15% in the case of petrol-driven cars and by 20% in the case of diesel-engined cars. Fuel savings by lorries and buses will only be about 2%.

Table III 3: Fuel consumption by road traffic (Mtonnes)

	Petrol	Diesel	Total	D from 1990
1990	30.8	16.3	47,1	
1995	29.7	22.0	51.7	10%
2005 (ifeu 1992)	35.8	22.8	58.6	24%

Sources: BMWi, 1990; DIW, personal communication; ifeu, 1992

Air traffic is also increasing in significance. By 2005, the total number of passenger kilometres in air traffic is expected to increase by almost 175% relative to 1988 (ifeu, 1992). The growth of tourist travel plays a predominant role here. Air freight traffic is expected to increase by as much as 270%. The consumption of aviation fuel will rise from 4.6 million tonnes in 1990 (DIW, 1993) to 9.1 million tonnes in 2005. It should be noted here that air traffic volume is normally delimited in traffic statistics according to the territorial principle (i.e. within German air space), which systematically produces an under-estimation, since nobody counts the volume of air traffic over the world's seas and oceans in their own statistics. The data are obtained using the principle of location, i.e. international flights count to the first non-domestic airport.

III 2.2 Trends in transport-related environmental pressure

CO_2 emissions

According to the objectives stated in Section III 1.3 above, transport-related CO_2 emissions in 2005 must be 10% to 25% lower than the 1990 level. In contrast, all forecasts show an increase in emission levels. Compared to 1990, CO_2 emissions in the transport sector are expected to increase by 24% (see Table III 4).

Table III 4: CO_2 emissions in the transport sector: current figures and projections to 2010

	Mtonnes	D from 1990
1990	188.3	
1995	204.3	+9%
2005	233.1	+24%
2010	239.9	+27%

Sources: Federal Environmental Agency, TREMOD, 1996; ifeu, 1992.

The proportion of total transport-related CO_2 emissions accounted for by air traffic was about 7% in 1990. By the year 2005, this share will rise to 12%.

Emissions of air pollutants

Air pollution trends under business as usual conditions are calculated on the basis of the current EURO I and EURO II exhaust emission standards for cars and commercial vehicles. There are no plans to introduce tougher emissions standards for motorcycles and other transport modes (rail, shipping and air traffic) in the period under review.

In the "business as usual" scenario, transport-related emissions of nitrogen oxides and particulates will fall by only 31% or 26% by the year 2005, relative to the respective base years (1987 and 1988), thus failing by far to reach the set targets (see Table III 3 and Table III 4). The greater part of these emissions is accounted for in both cases by commercial vehicles and other transport modes (shipping, rail transport, agriculture and military transport). Nitrogen oxide emissions from goods vehicles and buses will decrease by 4% by 2005, relative to the base year. Particulate emissions from diesel-engined cars will increase by a fifth by the year 2005, due to the expected increase in mileage.

In contrast to the above, emissions of volatile organic compounds (VOC) are clear evidence that the measures already implemented (especially the introduction of closed-loop catalytic converters and charcoal filters for cars) will lead to the targets for all transport modes in 2005 being achieved or at least approached. This is largely due to the substantial reductions in emissions from cars. If the benzole concentration in petrol were to be reduced as well, something that is not taken into account in our calculations here, then the target for benzole emissions could almost be attained by the year 2005, provided that reductions are made in all types of petrol. However, it is doubtful that the 1.3 mg/m³ target for benzole emissions in 2020 will be reached.

Table III 5: Air pollutant emissions in the transport sector ("business as usual" projections and target conditions)

Pollutant in 1000 tonnes					Business as usual projection	Target
Source of emissions	1987	1988	1990	1995[1)]	2005	2005
VOC	1466	1461	1482	684	310	289
Road transport	1351	1352	1404	610		
Other transport	115	109	78	74		
NOx	1547	1521	1489	1311	1068	309
Road transport	1276	1252	1223	1015		
Other transport	271	269	266	296		
Diesel particulates	67.9	68.9	69.6	65.1	51.3	6.8
Road transport	37.8	38.5	40.5	43.2		
Other transport	30.1	30.4	29.1	21.9		
Benzole	67.0	66.9	70.5	29.3	11.5	6.7
Road transport	65.1	65.2	68.7	27.8		
Other transport	1.9	1.7	1.8	1.5		

1) Other transport 1994

Sources: for VOC and NOx, 1987 to 1990 : BMU (1996a), otherwise Federal Environmental Agency TREMOD, 1996.

Table III 6: Index of transport emissions relative to 1987 and 1988 base years (in %)

Pollutant					Business as usual projection	Target
Source of emissions	1987	1988	1990	1995[1)]	2005	2005
VOC	100%	100%	101%	47%	20%	20%
Road transport	100%	100%	104%	45%		
Other transport	100%	95%	68%	64%		
NOx	100%	98%	96%	85%	69%	20%
Road transport	100%	98%	96%	80%		
Other transport	100%	99%	98%	109%		
Diesel particulates	99%	100%	101%	94%	74%	10%
Road transport	98%	100%	105%	112%		
Other transport	99%	100%	96%	72%		
Benzole	100%	100%	105%	44%	17%	10%
Road transport	100%	100%	105%	43%		
Other transport	112%	100%	106%	88%		

1) Other transport 1994

Noise

Noise levels in excess of 65 dB(A) increase the risk of cardiovascular disease. Such levels should therefore be avoided in order to protect the health of the population. Computations using the Federal Environmental Agency's noise pollution model show, however, that in 1990, about 16% of the population were exposed to road traffic noise levels in excess of 65 dB(A) during the day. The number of those exposed to road traffic noise will decrease only a little to 12.5% by the year 2005, because the increase in traffic volume during this period will balance out most of the improvements achieved through the integration of noise reduction technologies in road vehicles.

About 3% of the population was exposed in 1990 to rail noise levels greater than 65 dB(A). The percentage of people exposed to severe noise pollution from railroad traffic increases under "business as usual" conditions (see Table III 7). This increase, albeit marginal, does not accord with the target to reduce extreme noise levels. Additional measures are necessary, since the technology-based measures already in place do not compensate for the higher noise levels expected as a result of higher speeds. All the more so, in that the proportion of rail transport in total traffic volume should increase significantly for environmental reasons.

Table III 7: Proportion of the population (in western Germany) exposed to high noise levels from road and rail transport (in %)

	Road		**Rail**	
	Day	**Night**	**Day**	**Night**

Model computation	**> 65 dB(A)**	**> 55 dB(A)**	**> 65 dB(A)**	**> 65 dB(A)**	**> 55 dB(A)**	**> 65 dB(A)**
1990	15.8	17.2	3.1	3.2	11.7	1.5
Business as usual projections to 2005	12.5	12.0	2.5	3.5	14.1	1.9

Land use by the transport sector

In no other European country have so many roads have been constructed since the end of World War Two as in Germany. In 1992, transport accounted for 4.6% of total land cover. In the states of western Germany, 5.1% of land is used for transport, compared to 3.3% in eastern Germany (BFLR, 1994). In assessing these figures, one must realise that the area of land classified statistically as used by transport bears little relation to the area actual used. Plant and facilities related to transport, such as petrol stations, car repair workshops, motorway maintenance centres, storage areas and the bulk of private parking space are not reflected in the statistics (see Apel et al., 1995). In western Germany, the area of land used for transport has increased by about 370,000 hectares from 900,000 hectares in 1950 to a total of 1.27 million hectares in 1992, of which 1.16 million are for roads, and 300,000 hectares of which were sealed road surfaces - the rest being embankments, shoulders, centre islands, parallel farm roads, cycle paths and pedestrian footpaths. The figures do not include adjoining areas that can be used only to a limited extent or not at all because they are degraded by traffic. This indirect land use by roads is taken to be 30 to 300 m on either side of the road section. Assuming a stress zone of 100 m along public roads, this would mean that 12% of the unsealed surface land area in western Germany is degraded or impaired by roads (SRU, 1994). The stress zone around airports is five to ten times higher than the actual runway area (ibid.).

Using land for transport has negative impacts on the environment not just because these areas can no longer be put to other uses. Transport infrastructures fragment ecological zones and reduce the value of the entire area for other uses. Contiguous, low-traffic areas of landscape measuring more than 100 km^2 in size account for only 22.6% of land cover in former west Germany. Between 1977 and 1987, the number of such areas fell by 15% and their total area by 18% (SRU, 1994).

Fragmentation of ecosystems means loss of habitat for fauna and flora populations and thus a threat to biodiversity. Smaller and smaller habitats and the separation of animal populations endanger the survival of intact stocks and prevents new colonisation (see Section IV 1). More and more landscape is being lost for human leisure as a result of fragmentation by roads and other transport infrastructures. Freedom of movement is impaired, as is the aesthetic well-being of those seeking rest and relaxation.

The forecasts of vehicle fleet size and traffic volume, as well as the currently known infrastructure plans for all transport modes provide no evidence of a forthcoming trend reversal. While efforts are being made to use the existing capacity of transport infrastructures more intensively (especially with telematics and road pricing systems) so that the growth of transport infrastructure is less than the growth of traffic volume, new surface sealing, encapsulation and fragmentation of nature and landscapes and the loss of valuable biotopes can be expected.

Traffic-induced changes to residential areas

Competition between transport and other uses of urban land is seriously detrimental to residential environments. In about half of all local communities in western Germany, the area of land used by transport

is greater than the remainder. Front gardens and houses have been sacrificed in the course of the last few decades in order to build roads and car parks. Besides the loss of such land, the aesthetic quality of housing areas has been degraded by excessively wide roads, large junctions and the ubiquitous presence of parked cars. For many centuries, streets and roads were not designed primarily for transport, but were areas where residents could spend time and communicate with each other. It was not until recent decades that the non-transport use of roads was increasingly suppressed. A reversal of this trend did not occur until local authorities began to adopt traffic calming measures, but this has been limited so far to only a few roads and residential areas. The long-term impacts on the quality of life resulting from the displacement of people from the streets are virtually unresearched. One manifestation of this change is the common practice whereby parents of younger children take or drive their children virtually everywhere. Because the latter are unable to use the streets on their own, never mind play on the street, they are taken (often driven) even short distances - to the kindergarten, to school, to the playground, etc.

Despite the forecast growth in traffic volume, it can be assumed in the "business as usual" scenario that there will be little growth in the area of land used for building new urban roads. However, it is unlikely that any roads will be re-appropriated for other uses, particularly in light of the anticipated growth of the vehicle fleet in the "business as usual" scenario. More parking space will be needed, and the dependence on cars is also likely to increase. Despite a substantial fall in exhaust levels, our urban environment will be dominated by cars, while fragmentation of landscapes will increase still further.

III 3. The efficiency scenario - how much can be achieved with technology?

III 3.1 Objectives in designing the scenario

The "business as usual" scenario is aimed at showing the trends likely to result if the basic framework remains unchanged. The scenario is thus a forecast under status-quo conditions. This "status-quo", "continuity" or "business as usual" forecast is contrasted in the following with two scenarios based on different criteria than probable outcomes. They serve to demonstrate possible development pathways and are not predictions of any kind. The "efficiency scenario" and the "structural transformation and awareness raising scenario" are used to work out where activities have to be focused in order to reach the goals specified in Section III 1.3.

The efficiency scenario assumes maximum utilisation of all technological means at our disposal. It assumes that steps will be taken, as far as technically feasible, to reduce fuel consumption, and hence CO_2 emissions, air pollution and noise. It is therefore an extreme-case scenario in that it takes no account of political feasibility. The conclusion drawn from the scenario, namely that improved technology is not sufficient in itself to achieve sustainable mobility, is arrived at on the basis of maximum deployment of technology. This conclusion is all the more relevant if one considers those technological solutions that fall short of the maximum.

III 3.2 Alternative engine types

Alternative energy sources for road vehicles currently being debated include electricity, natural gas, hydrogen, alcohols and plant-based oils. To assess these alternatives, it is necessary to evaluate future technologies for petrol and diesel vehicles. The improvements in fuel composition and emission reduction technologies that are already possible today tend to offset the apparent benefits of alternative energies. Moreover, it is possible to achieve further dramatic reductions in the fuel consumption and CO_2 emissions of Otto engines by means of engine efficiency and vehicle construction techniques. In the short term, the fuel consumption of today's vehicles could be halved.

A comparison of projected direct and indirect emissions of advanced electric and petrol-driven cars in 2005 shows that the only advantages of the electric car worthy of mention are lower nitrogen oxide emissions. However, this reduction on the part of electric cars is bought at considerable expense. Comparisons of the incremental costs of very low-emission Otto engines and electric vehicles show that the additional costs required for just one electric car could pay for the additional cost for exhaust gas after-treatment of as many as 40 Otto-engined vehicles with extremely low emissions.

Solar-powered vehicles obtain electricity from renewable energy sources. The use of renewables can bring about substantial environmental benefits, so renewable energy sources have to be used as efficiently as possible. This is not the case with solar-powered vehicles. Calculations shows that the substitution of fossil fuel power stations by renewable energy sources would be up to 110% more effective and even cheaper than the substitution of petrol-driven cars by solar-powered vehicles. Apart from marginal uses for specific circumstances, solar-powered cars make no contribution to environmental protection.

Compressed natural gas (CNG) and liquefied petroleum gas (LPG) provide clear benefits for commercial vehicle fleets, and result in much lower emissions than is the case with diesel fuel. Bus fleets and smaller commercial vehicles in inner-city areas could therefore contribute towards reducing air pollution in the form of nitrogen oxide emissions and particulates. If the entire product chain is taken into account, CNG and LPG do not lead to any noticeable increase in greenhouse gas emissions. One should note that LPG is still flared in large amounts in oil fields. If this gas were put to use, the result would be a significant reduction of CO_2 emissions. Unlike CNG, LPG is suitable for passenger cars due to its greater storage density. Emissions are about the same as cars equipped with closed-loop catalytic converters.

Using hydrogen (H_2) as a fuel implies significant losses during production and processing. Even in the solar generation of H_2, between 40 and 45% of the solar energy is lost. Preference should therefore be given to the direct use of solar energy as a substitute for fossil fuel power stations. Should solar-generated H_2 be available, it should be used preferentially in stationary installations, since the additional treatment for storage leads to energy losses.

Fuel cells have been little researched as an alternative energy source. An objective technology impact assessment still needs to be made in this field. Fuel cells are known to have benefits when used for stationary equipment.

The Federal Environmental Agency has compared the life cycles of rape-seed oil and rape methyl ester (RME) with diesel fuel (UBA 1993a). The results show that rape-seed oil and RME cannot be recommended in diesel engines for environmental reasons. If additives are used with RME, the resultant

fuel must be classified as endangering water resources. In terms of specific CO_2 reductions, RME is much less cost-efficient than improvements to vehicle design.

Alcohols such as methanol and ethanol can be used in internal combustion engines. The energy content of methanol is only half that of petrol, which means that storage and tank volumes would have to be doubled for the same level of energy consumption. Methanol is produced from natural gas, whereby about 33% is lost in the production process. Direct use of natural gas is more efficient and therefore generates less greenhouse gas emissions. The energy required to produce ethanol from wheat is higher than the energy content of ethanol itself. Ethanol can only be considered as an alternative to other fuels when it can be generated cheaply from wood using enzymes.

Compared to the alternative fuels mentioned above, petrol has major benefits when all technological feasibilities are exploited. A drastic reduction in consumption, combined with cost-efficient emission abatement, could safeguard the use of petrol in the long term. Natural gas should be used for commercial vehicle fleets in urban traffic. Electric vehicles only make sense in specific niches, if at all (e.g. enclosed spaces, areas where people go for rehabilitation). Use of additive-free rape oil methyl ester only has benefits where water resource protection standards are higher than usual. Liquefied gas should be used in both passenger cars and commercial vehicles on account of its availability and environmental benefits. The use of hydrogen as a fuel for transport is not a feasible alternative at present.

III 3.3 CO_2 reductions using more efficient technologies

Given the technological possibilities for drastic reductions in the fuel consumption of petrol-driven cars and hence in climate-forcing CO_2 emissions, the petrol engine will be the obvious choice. The various potentials for reducing consumption through improved engine technology range to as much as 36% with different techniques, such as exhaust recycling, turbocharging, cylinder cut-off, pressure-wave supercharging or direct injection. Further improvements can be achieved in car design, for example through weight reduction, downsizing and optimisation of air and roll resistance, as well as lower acceleration rates. Technology makes it practically feasible to cut the fuel consumption of today's cars by half. With the help of technological innovations already on the market or which will be available in a few years, the fuel consumption of cars can be reduced by 20 to 40%. Fuel consumption reductions in the order of 20% for commercial vehicles and 40% for aircraft could also be attained.

If all new cars registered from 2000 onwards were to fully exploit the technological potential for emission reductions as a result of policy measures, and in this way achieve an average of 30% less fuel consumption than in 1990, this reduction in consumption would be achieved throughout the vehicle fleet by the year 2010. In 2005, all cars would consume 20% less fuel on average than in 1990. Full implementation of savings in the commercial vehicle fleet would already be achieved by 2005, if all technologically feasible improvements were to be made from the year 2000 onwards.

Measures to reduce fuel consumption bring down the operating costs for transport. If these cost savings for motorised private traffic were not balanced out by policy measures in the transport field (e.g. higher vehicle and/or fuel taxes, road pricing), the overall effect will be an increase in traffic volume instead, thus defeating the purpose of technological improvements.

However, the model computation carried out on the basis of technological reduction potential illustrates that reducing average fuel consumption by improving vehicle design (e.g. by imposing CO_2 limits on new vehicles) is not sufficient in itself to stop higher CO_2 emissions from traffic, since lower consumption is offset by the growth in traffic. One side effect is an even greater rise in traffic volume, because lower consumption would mean lower costs per kilometre. Underlying the predictions for future traffic volume, however, lies the assumption that personal income increases by 2% annually, and that demand for transport services depends on both incomes and prices. If fuel price increases were to keep costs per kilometre constant, thus preventing an automatic increase in traffic volume, the rise in CO_2 emissions could be kept down to 7% by 2010, provided that technologies for lower fuel consumption are implemented throughout the vehicle fleet (as opposed to 28.5% in the business as usual scenario) (see Table III 8). Limiting fuel consumption reductions to cars, without compensating for lower costs, would generate an 18% increase in CO_2 emissions from the transport sector as a whole, since there would be unchecked growth in emissions from aircraft and commercial vehicles.

Table III 8: CO_2 emissions in the transport sector: projected trends under "business as usual" and "efficiency" conditions (in Mtonnes)

	MPT	**CV**	**Rail**	**Air**	**Other**	**Total**[1)]	**D from 1990**
1990	107.3	44.3	10.1	13.0	13.6	188.3	
1995	110.7	53.9	10.1	16.0	13.6	204.3	**+8.5%**
2005 Business as usual scenario	123.9	57.9	8.9	28.6	13.8	233.1	**+23.8%**
2005 Efficiency scenario	112.6	51.1	8.9	22.0	13.8	208.4	**+10.7%**
2005 Efficiency scenario + cost compensation	109.9	51.1	8.9	22.0	13.8	205.7	**+9.2%**
2010 Business as usual scenario	124.7	58.7	8.9	35.8	13.8	241.9	**+28.5%**
2010 Efficiency scenario	105.7	52.5	8.9	26.9	13.8	207.8	**+10.4%**
2010 Efficiency scenario + cost compensation	99.2	52.5	8.9	26.9	13.8	201.3	**+6.9%**

1) These figures are not congruent with those for CO_2 emissions from the transport sector stated in Chapter 2, due to different delineation criteria.
Air transport: all flights departing from Germany until first landing
Other: inland shipping and ocean shipping, underground railways, trams, but not including military traffic, agriculture and forestry and fuel-driven machinery
Motorised personal transport (MPT), commercial vehicles (CV), inland shipping and ocean shipping: direct emissions;
rail, underground rail and trams: total emissions

III 3.4 Technological potential for reducing air pollutant emissions

Reductions in air pollutants are achieved in this scenario primarily through improved catalytic converters for petrol-driven cars , particle filters and SCR catalytic converters for diesel vehicles and exhaust-reducing aero engines, the use of natural gas vehicles in local transport and the phasing out of cars without three-way catalytic converters.

With enhanced fuels and the possibility of substantial reductions in exhaust emissions (especially from petrol-driven vehicles), it is foreseeable for emissions to be reduced by a further 70 - 80% compared to

vehicles that now have three-way catalytic converters. Detailed estimates show that implementing the catalytic converter technology necessary for such reductions, as well as a wise combination of components and other emission-reduction measures can all be achieved at additional production costs well under DM 350. Compared to cars without catalytic converters, reductions in the order of 99% could even be made. The technological possibilities available in the short term for reducing exhaust emissions from diesel engines involve higher emissions compared to petrol-driven cars. The technological possibilities in this area involve improvements in combustion characteristics, exhaust recycling and oxidation catalysers, which can be achieved at additional production costs of approx. DM 150 per vehicle. In the long term, however, there will also be effective exhaust-treatment processes for diesel engines as well as particle filters and catalytic converters for reducing nitrogen oxide emissions to levels comparable to those of petrol vehicles, whereby the expected increase in production costs per vehicle will be about DM 600 - 900 per vehicle (UBA, 1995a).

Highly efficient clean exhaust systems for diesel-engined lorries and buses will soon be going into series production or have already undergone trials. Exhaust gas recirculation enables nitrogen oxide emissions to be reduced by between 20 and 60% compared to modern engines currently on the market, or by 70 to 90% if used with selective catalytic reduction (SCR). Oxidation catalysers can reduce volatile hydrocarbons by 50 - 70% compared to today's engines. In addition, particle filters have been successfully tested and enable a reduction in harmful particles of up to 90%. Engine design improvements for better combustion can generate further reductions in pollutant emissions. According to calculations carried out by the Federal Environmental Agency, the incremental production costs for integrating exhaust recycling in large lorries (based on high unit sales) amount to DM 500 - 1500, DM 6000 - 8000 if SCR technology is deployed, DM 450 - 600 in the case of oxidation catalysers, and between DM 6000 and 8000 for particle filters. Given procurement costs of DM 300,000 to DM 600,000 for a new long-distance lorry or urban bus, these additional costs are only a few percent of the purchase price (UBA, 1996).

Further emission reductions can be achieved by using natural gas in commercial vehicle fleets. Since natural gas engines produce much lower emissions of particulates, nitrogen oxides and noise compared to diesel engines, gas-driven bus fleets and small commercial vehicles for urban transport can make a substantial contribution towards reducing nitrogen oxide and particulate emissions. By using natural gas, emission reductions of 84% in the case of nitrogen oxides and more than 90% in the case of particulates can be attained. The level of emissions from natural gas-driven passenger cars is about the same as that from petrol-driven vehicles equipped with 3-way catalytic converters, whereas the level of emissions from natural gas-driven commercial vehicles is well below current and foreseeable legal limits for diesel engines.

The reduction target for volatile organic compounds (VOC), which was almost reached in the "business as usual" scenario, can even be improved upon under efficiency scenario conditions. Nitrogen oxide emissions, which fall by about 30% in the "business as usual" scenario, now drop by approx. 70%, and particulate emissions by approx. 80%. This means that the 80% reduction target for nitrogen oxides and 90% for diesel particles is not quite reached. The long-term reduction target for benzene and diesel particulates (99% reduction in urban areas) is nowhere near being reached in these figures, however.

III 3.5 Possible ways to reduce noise levels

The noise limits for cars and commercial vehicles have been progressively reduced over the last 20 years. This has resulted in substantial reductions in engine noise, but tyre/road noise has remained largely unchanged, even rising in some cases (Stenschke, Jäcker, 1996). There is still considerable technological potential for reducing noise with low-noise road surfaces and low-noise tyres.

Suitable methods for reducing road noise include porous asphalt surfacing (drainage asphalt) or similar porous surfaces. Pavement surfaces can be acoustically optimised through careful selection of surface material, brick size and intervals between blocks, and by the road surfacing method applied. Noise reductions of 4 dB(A) to 6 dB(A) can be achieved outside residential areas. However, no satisfactory solutions have been found so far for urban areas.

Studies have revealed that the noise emission level of car tyres increases by 2 to 3 dB(A) as tyre width increases (up to 195 mm). The noise emission level remains constant for even wider tyres. Much bigger differences - 7 to 8 dB(A) - are found if one compares different makes of tyre (Stenschke, Jäcker, 1996). There are also substantial differences in the noise emissions of heavy commercial vehicles. Noise emission levels of tyres of equal width vary by 4 to 6 dB(A). By all these means, road traffic noise emissions could be reduced by about 5 dB(A) in total if the current technological potential for noise reduction in road vehicles and road surfaces were fully exploited. However, a considerable percentage of the population would still be exposed to noise levels in excess of 65 dB(A).

There is also substantial potential for reducing railway noise. Use of disc-braked rolling stock has reduced noise emissions from freight trains by up to 9 dB(A). Reductions of up to 6 dB(A) were achieved by optimising the noise characteristics of wheels, and up to 8 dB(A) by fitting absorbers. If the current noise reduction potential in rail transport were to be fully exploited (low-noise trains with disc brakes, wheel absorbers, noise-reduction aprons and low noise-protection walls), the rail noise levels to which the population is exposed could be brought down to under 55 dB(A).

III 3.6 Conclusion: technological efficiency will not suffice

Exploiting current technological possibilities to the full could generate considerable emission reductions. A number of targets for air pollutant emissions defined in Section III 1.3 could be achieved. Reduction of transport-related CO_2 emissions cannot be achieved with technological measures alone. Given that the volume of traffic will continue to increase, CO_2 emissions will exceed those of 1990 in the years 2005 and 2010, despite substantial reductions in fuel consumption. The goal of preventing cancer risks from benzole and diesel particulates cannot be achieved with these measures alone. As far as rail noise is concerned, complete prevention of disturbing noise levels is possible through technological improvements. In the case of road traffic noise in urban areas, in contrast, little improvement is likely using current technological potential. A large proportion of the population will still be exposed to noise levels damaging to health. As the volume of traffic is not affected, technical solutions are unsuitable for attaining the targets for residential surroundings, nature conservation and landscape protection..

Besides activities for improving technological efficiency, policy action for sustainable mobility must therefore include measures for limiting the growth of traffic and for reducing the environmental stresses caused by traffic in urban areas.

III 4. Trends within a "structural transformation and awareness raising" scenario

Sustainable development in the transport sector requires an integrated strategy and measures based on regulatory, economic, regional planning and behavioural modification instruments.

Striving for structural transformation and awareness raising is an effective way to attain sustainable mobility if it results in changed individual behaviour:

- Further significant reductions in fuel consumption can be achieved, in addition to the technological reduction potential, by small, low-powered vehicles (downsizing). Giving preference to the best available noise and emission reduction technologies speeds up and strengthens the emission reduction process.

- Driving more slowly and smoothly reduces not only fuel consumption and emissions of air pollutants and noise, but also the frequency and severity of accidents.

- Public transit systems and the railways can be used more efficiently if there is greater flexibility in the choice of transport mode.

- Car sharing reduces the volume of motorised personal transport without reducing the number of passenger kilometres.

- Car sharing can reduce the need for parking space.

- Motorised traffic can be avoided by walking instead of driving short distances (up to 1 km) and by making greater use of bicycles for medium-range trips.

Economic and transport planning measures influence transport behaviour among the population. Such measures must therefore be designed so that progress towards the set goals is achieved, i.e. that they influence the choice of transport mode in favour of environmentally friendly modes, and the distances travelled in favour of destinations closer to home.

Changing aspects of behaviour that are not directly related to transport can also contribute to a reversal of transport trends. Such changes would include, for example, the choice of residential area. The design of attractive residential areas involving less land use and traffic volume, in which the separation of different functions is eliminated as far as possible, is likely to be a major future challenge for architecture.

Dispensing with further growth in traffic - first and foremost through a decline in motorised traffic volume - requires a fundamental transformation of values. Younger age groups in particular have displayed greater appreciation for nature and the environment as "post-materialist society" evolves (see Section VI 2.4). The high value attached to an intact environment that has been repeatedly identified in opinion surveys is the essential, but not the only condition for ultimate acceptance of uncomfortable measures.

A change in values pertaining to transport implies that the automatism with which the interests of road transport are asserted must be superseded by other priority interests. These include, for example, the value of life and physical integrity, which contrasts with a conspicuous acceptance of thousands of deaths and serious injuries each year on the roads. Other values which used to be taken for granted but which have seemingly lost any importance include the idea that pedestrians must have priority in urban traffic. It is not pedestrians who should make sure they do not obstruct road traffic - road traffic should flow where it does not disturb pedestrians. Although the German Highway Code keeps certain roads free of traffic, cars are still parked almost everywhere on the public roads, occupying valuable space and preventing other uses of such land (footpaths, play areas, benches, greenery, etc.). A change in values could lead above all to a definite reduction in motorised traffic, by placing greater value on public transport and non-motorised ways of moving around, especially in leisure time (cycling, excursions with public transport services).

Structural transformation and awareness raising must take place at all levels. The point at issue is not to limit mobility, but to develop different forms of mobility by changing those framework conditions that have an impact on mobility (settlement structures, the economic system, transport services). Change must be given a positive boost. Important in this context is the behaviour of social elites, who must demonstrate that environmentally friendly behaviour does not necessarily mean deprivation of one kind or another, but that it is a worthwhile goal to strive for (see Section VII 4.3). The reputation and the acceptance of public transport services or the bicycle could certainly be enhanced if prominent personalities used them more frequently.

III 4.1 Scenario calculation

A structural transformation and awareness raising scenario is calculated here only for CO_2 emissions. This is justified by the fact that the disparity between the actual situation and the ultimate goal is still very large, even in the efficiency scenario. The scenario involves full exploitation of the emission reduction potential (see Section III 3.2) and assumes that fuel consumption will be reduced even more through people buying smaller and less powerful cars. The growth in motorised private traffic and commercial traffic is slowed substantially, so that by the year 2005 the number of vehicle kilometres does not exceed the 1995 level to any significant extent (see Table III 9. The same applies for air traffic. In this "transformation of values" scenario, CO_2 emissions from the transport sector can be reduced by almost 10% and 20% relative to 1990 levels by 2005 and 2010 respectively.

Table III 9 Vehicle kilometres under business as usual and target conditions (in billion km)

	MPT	CV
1990	519.9	72.3
1995	549.1	92.1
Business as usual scenario to 2005	649.4	104.2
Business as usual scenario to 2010	686.9	107.1
Structural transformation and awareness raising scenario to 2005	573	93
Structural transformation and awareness raising scenario to 2010	573	93

Table III 10 Results of various CO_2 emissions scenarios in the transport sector (Mtonnes)

	MTP	CV	Rail	Air	Other	Total	D from 1990
1990	107.3	44.3	10.1	13.0	13.6	188.3	
1995	110.7	53.9	10.1	16.0	13.6	204.3	**+8.5%**
2005 Business as usual scenario	123.9	57.9	8.9	28.6	13.8	233.1	**+23.8%**
2005 Efficiency scenario	112.6	51.1	8.9	22.0	13.8	208.4	**+10.7%**
2005 Efficiency scenario + cost compensation	109.9	51.1	8.9	22.0	13.8	205.7	**+9.2%**
2005 Structural transformation and awareness raising scenario	82.6	45.6	12.3	16.2	14.4	171.1	**–9.1%**
2010 Business as usual scenario	124.7	58.7	8.9	35.8	13.8	241.9	**+28.5%**
2010 Efficiency scenario	105.7	52.5	8.9	26.9	13.8	207.8	**+10.4%**
2010. Efficiency scenario + cost compensation	99.2	52.5	8.9	26.9	13.8	201.3	**+6.9%**
2010 Structural transformation and awareness raising scenario	59.0	45.6	12.3	16.2	14.4	147.5	**–21.7%**

See Notes to Table III 8

Every single person contributes with his or her transport behaviour to the scenario conditions being met or not. To illustrate this more clearly, we calculated how many vehicle kilometres per capita in Germany would be possible in a structural transformation and awareness raising scenario. The results are heavily dependent on average fuel consumption and the occupancy rate of each vehicle.

Hypothetically, under the conditions of a "structural transformation and awareness raising" scenario, each person in society, from infants to the oldest citizens, could travel 6,222 km per year in a car that consumes five litres per 100 kilometres. This figure is reduced to only 5,547 km in the case of diesel-engined cars with the same fuel consumption. If two people always travel in the car, they could travel twice the distance. If the car's fuel consumption is only three litres of petrol per 100 km, each person could travel 10,370 km per year (9,244 km in the case of diesel-engined cars). If the car consumes 10 litres per 100 km, each person could travel only 3,111 km.

Table III 11: Kilometres per capita under the conditions of the structural transformation and awareness raising scenario [1)]

	Fuel consumption of cars		
	3 l /100 km	5 l / 100 km	10 l / 100 km
Occupancy: 1 person			
Petrol-driven cars	10,370 km	6,222 km	3,111 km
Diesel cars	9,244 km	5,547 km	2,774 km
Occupancy: 2 people			
Petrol-driven cars	20,740 km	10,170 km	5,085 km

Diesel cars	18,488 km	9,066 km	4,533 km

1) Under current conditions (average consumption of cars in 1994: 9.3 l / 100 km according to DIW, 1995), kilometres travelled in cars per capita of population is 6,216 km.

This sample calculation is a clear illustration that, even in the "structural transformation and awareness raising" scenario, today's (auto)mobility standards can be maintained if the relevant technologies are applied. However, they are not compatible with the projected growth rates of vehicle kilometres in the business as usual scenario.

III 4.2 Measures for attaining the reduction targets

The measures necessary to achieve the reduction targets can be classified under traffic avoidance, modal shifts and environmentally friendly transport management.

- The main way to avoid traffic is to keep trips shorter ("rediscovering the vicinity"). Traffic avoidance requires the most radical changes in spatial and economic conditions and in behaviour, but in the long term is the most important aspect, because it tackles the problem of traffic at the very roots and in this way can reduce the growth of traffic volume.

- Modal shifts involve switching to environmentally friendly transport modes such as cycling or walking, and to less environmentally harmful transport modes such as buses, rail or inland waterways.

- Essential traffic must be managed in the most environmentally friendly way possible by exhausting all technological opportunities and by achieving a radical modification of behaviour (especially driving style and choice of transport mode).

It is now quite obvious that sets of measures will fail their purpose if they are based purely on technological changes or traffic restrictions. What is needed instead is a combination of diverse strategies: economic instruments, technological improvements and redesigning through organisational and planning processes. At all events, any such concept must display endurance, whereby long-term goals and short-term activities need to complement each other. Exploiting technological potential to the full in order to lower fuel consumption and to reduce air pollutant and noise emissions is probably only feasible if binding limits are set.

Raising transport costs is one of the most effective short-term measures, in that it helps prevent traffic and engenders modal shifts, since the more environmentally friendly transport modes acquire competitive advantages. Also, it gives technological improvements better chances in the market. In a market economy, financial and fiscal instruments leave it to the individual to decide on the type and size of demand for, and supply of transport services. These instruments are therefore indispensable for precisely this reason. Such targeted price policies can link up with existing instruments (e.g. fuel tax, emissions-based road taxes, car park management), or strike out in new directions (e.g. tolls based on distances driven, higher parking fees).

Various studies have shown that pricing measures are particularly effective. For example, a study carried out by Prognos for the Federal Transport Ministry revealed that, of 22 different measures under investigation, increasing fuel tax has the greatest impact on transport-related CO_2 emissions (Prognos

1991). Another study commissioned by the Federal Ministry of Transport and carried out by the IFO Institute confirmed that price policies are highly efficient at reducing CO_2 emissions in the transport sector, and concluded that such policies have no detrimental effects on national economic performance (IFO 1995).

Regulatory and pricing instruments must be supported by activities to encourage alternatives to motorised private traffic and road freight traffic; these include infrastructural and organisational activities to expand and consolidate the railway system, multi-modal transport, local public transport services, footpaths and cycle path networks, and the sustained provision of sufficient funds for maintaining an attractive range of public transport services.

Expanding urban public transport should be primarily directed at eliminating time losses, thus boosting modal shifts. This will not be achieved if the road infrastructure is enlarged at the same time. What would then happen is that the modal split will be shifted in favour of rather than away from road transport, and that additional traffic volume will be induced by the construction of new or better roads (BMV, 1996). Construction of new roads contradicts the CO_2 reduction target. What is needed instead, besides bus prioritisation and other measures to speed up public transport, is a mixture of "push" and "pull" strategies, including the pedestrianisation of roads and car parks, avoiding the simultaneous expansion of all transport modes and encouraging low-traffic zones - thereby reinforcing the positive effects of expanding public transportation. The only way to achieve those goals relating to residential surroundings and the compatibility of traffic with sustainable urban living is through transport management policies that are geared to the needs of the weakest people in the transport system and which support attractive urban planning solutions. In the road freight sector, special efforts must be made to ensure compliance with existing regulations in the field of social policy, transport and safety (e.g. night-time lorry bans, speed limits, maximum loads, etc.).

Transport infrastructure and emissions from traffic have caused severe damage to nature and landscapes. Further damage as a result of new infrastructure (this applies for all transport modes) are not compatible with sustainable development. As far as goals are concerned, it is possible in the "structural transformation and awareness raising" scenario to reach the objectives of sustainable mobility as specified in Section III 1.3 above, since infrastructure needs to be expanded only in respect of public transport and the system of footpaths and cycle paths, while existing capacities should otherwise be utilised as far as possible. Additional environmental stress can be prevented by prioritising road improvements rather than new roads, by bundling transport infrastructures and by reclaiming roads for other purposes. The main focus when supporting inland waterway transport should be on greater use of existing infrastructure rather than developing natural waterways (damming stages, deepening of water courses, etc.) or in the construction of new canals. Alternatives exist above all in respect of technological improvements (vessels adapted to specific waterways) and logistics (optimised use of capacities).

A combination of traffic growth restrictions and the technological measures for improved air quality mentioned in the efficiency scenario (see Section III 3) enables the air pollution reduction targets to be achieved, but not the noise reduction targets. If noise pollution along trunk roads and the health risks that ensue are to be prevented, greater reductions in traffic and more and stricter speed limits are necessary. In addition to general activities aimed at reducing traffic levels, local restrictions on car traffic are needed in order to protect residents against excessive noise levels.

In the “structural transformation and awareness raising” scenario, accident statistics will also improve. The resulting speed limits and changes in driving style can have positive impacts on both the frequency and severity of accidents. Road safety campaigns and, for example, fewer motor sport activities can help to de-escalate the climate of aggression now seen on the roads. If further improvements are made in the field of automobile engineering and road design, the number of accidents involving personal injury could be reduced even more than the current downward trend might suggest. We assume here that technological improvements to road vehicles (e.g. airbags, ABS etc.) do not lead to a more aggressive driving style, as has sometimes been the case, but to enhanced safety for all participants in the traffic system.

In spite of the enormous efforts necessary to accomplish a genuine transformation of behaviour and awareness, these would only signify an initial - albeit crucial - step towards sustainable mobility. Further steps will certainly have to follow with regard to climate protection, while only time can tell whether these advances will suffice to achieve sustainability vis-à-vis other environmental domains.

In the long-term perspective, the key requirement for any progress towards sustainable mobility is to implement urban and regional planning policies targeted at low-traffic systems. Deploying the strategy of making traffic more expensive has already produced effects that could halt the tendency towards spatial structures with higher and higher traffic intensities. There is still a considerable amount of potential here for sustained traffic reduction. Price policies, land-use planning and regional economic development must operate hand in hand in order to ensure a long-term reduction in traffic.

IV Sustainable Food Production

IV 1. Is our food production sustainable?

Food supply in Germany today is more abundant than ever before, and the variety of food available, the high standard of food technology and acceptable food prices mean that adequate nutrition is secured. At the same time, however, there is increasing unease among consumers about the quality of food. The quality standards for food, mainly defined to accommodate the needs of the trade (weight, size, transport and storage capacity, processing properties), are being called into question more and more. In surveys on possible threats related to the environment, fear of contaminated foodstuffs (e.g. pesticides in drinking water and wine, hormones and antibiotics in meat, salmonellae and nicotine in eggs, and preservatives and additives in food generally) is frequently ranked first by consumers. Moreover, one cannot rule out a direct or indirect correlation between the increase in nutrition-related diseases (especially allergies and cardiovascular diseases) and malnutrition, pollutant residues, artificial additives and the high degree to which food is now processed. The Federal Government is now focusing attention on the problems associated with residues of veterinary drugs as they relate to consumer health protection, and is conducting an assessment of the health-related impact of these residues.

In contrast to many less developed countries, individual nutrition in Germany does not at present pose a serious problem constraining opportunities for future development, despite a number of unhealthy eating habits - particularly overeating and foods that contain either too much fat or sugar. Food security seems to be assured on a long-term basis. What is the picture if we expand our perspective, however? The issue, after all, is not merely what is put on the table, but also how food is produced and grown and under what conditions it is processed and marketed.

Before we can assess the extent to which our food production meets the requirements of sustainability, agricultural production and its effects on the environment have to be examined. Furthermore, it is necessary to take into account the effects of food processing, as well as the residual and waste substances resulting from production and processing. The conditions under which food is marketed and traded also play a major role - above all the rapid growth in transport due to the globalisation of markets and trade liberalisation within the European Single Market.

Just under 50% of the land area in Germany is used for agricultural purposes. Agriculture in Germany not only shapes landscapes, it is also of decisive importance for food security and regional policy, not to mention the conservation and development of cultivated areas. Of the 17.3 million hectares of agriculturally used land (1994 figures), 11.9 million hectares are areas under cultivation. Grain is grown on 55% of these areas, fodder crops on 15%, oleaginous fruit on 9% and root crops on 7%. Around 1.5 million persons, i.e. about 3% of the total labour force, are employed either full- or part-time on a total of 580,000 farms (1994). As a comparison, around 30% of the labour force was employed in agriculture during the immediate post-war period. The progressive decline in the economic significance of the agricultural sector is also reflected in the share of gross domestic product accounted for by agriculture, which is trailing towards 1%.

The key agricultural policy objectives in recent decades were to secure an adequate supply of high-quality food at reasonable (i.e. low) consumer prices, to increase agricultural productivity and raise in-

come in the agricultural sector(Art. 39 ECSC Treaty). The productivity of labour and soil in agricultural sector was considerably enhanced through technological advances. This was reinforced by national protective measures to guarantee prices and markets, as well as by high subsidies for land consolidation and modernisation of farm enterprises. The consequences of this policy are well known. "Milk lakes" and "butter mountains" have become synonyms for an agricultural policy that produced food surpluses far beyond the needs of the population, thus placing a mounting burden on taxpayers.

Although the 1992 reform of the Common Agricultural Policy (CAP) initiated a change, EU funding for the agricultural sector in Germany alone amounted to approximately DM 12.5 billion in 1995. A total DM 27.9 billion in public funds (BML, 1996) contrasts with DM 23.2 billion in net value added in German agriculture (i.e. the value of all food and other products produced in the agricultural sector, excluding forestry management and fishing). In 1995, agricultural land was subsidised with DM 1600 per hectare, i.e. every full-time job in agriculture was granted a subsidy of DM 40,000 (BML, 1996c). From an economic point of view, this policy can hardly be considered "sustainable". From the environmental perspective, the question of sustainable agricultural production is of eminent importance given the enormous need for subsidies.

IV 1.1 Environmental pressure caused by agriculture

Post-war agricultural policy in Germany (and Europe), which was aimed primarily at raising productivity, led to production methods with increasingly adverse environmental effects. Scientific and technological advances over the last 40 to 50 years have contributed further to profound structural changes in agriculture (SRU, 1985 and 1994). Technological progress resulted in energy- and capital-intensive production methods and a drastic reduction in labour force per hectare. The use of new, efficient means of production (improved seeds, mineral fertilisers and chemical/synthetic plant protection agents, more efficient machines and special equipment) was followed by an increasing degree of farming specialisation (within individual farms as well as regionally). The separation of crop production and livestock farming led to the latter becoming divorced from the land itself. Rationalisation and specialisation was accompanied by increases in farm size (i.e. larger areas of land or more livestock) and, at the same time, abandonment of farms. This "efficiency revolution" in agriculture has apparently not yet ended, indeed the use genetic engineering signals a further continuation of this trend.

The effects on the environment brought about by these structural changes and the associated consolidation of arable land included the "clearing of landscapes" (elimination of structural elements in the landscape as a result of consolidation), loss of biotopes, loss of biodiversity, contamination of water and air as well as increasing soil compaction and erosion. The problems caused by intensive animal production become particularly evident if one looks at surpluses of liquid manure, for example. In some regions of Germany, slurry is produced in such quantities that it can no longer be returned to the nutrient cycle in an appropriate way with the area of land available. Impacts include excessive amounts of nitrate in the groundwater of these regions, with subsequent effects on surface water resources.

It was only in recent years that attempts were made to reverse this trend through the so-called extensification support programmes and the 1992 reform, which involved decoupling income policy from price policy, land set-aside and the promotion of environmentally sound production methods that do not impair the natural habitat (EEC Regulation 2078/92). The lowering of regulated market prices (e.g. 15% for

beef, 30% for grain) and the simultaneous transition from a policy of quantity-based price support to one of compensation payments for income losses (and animal premiums) represent a first step in the right direction. Economic incentives were set up to reduce farming intensity. However, these measures are inadequate to bring about the necessary reduction in pollution levels caused by agriculture, especially since compensation payments have not been strictly linked to ecological criteria.

Nitrogen and phosphate loads

In Germany the nitrogen and phosphate loads to agricultural land, in the form of slurry and mineral fertilisers, are much higher on average than the level absorbed by crops. In the 1992/93 business year, the average nitrogen surplus on farming land in Germany was 118 kg/ha, the average phosphate surplus (as P_2O_5) around 18 kg/ha (with substantial regional variations in each case).

According to the report of the joint government/*Länder* "Nitrogen reduction programme" working group set up by the 40th Conference of Environment Ministers, agriculture accounts for 48% of total nitrogen emissions in Germany. Transport (22%), human nutrition and wastewater (17%), energy, heating and industrial processes (13%) all account for a much lower proportion of emissions than agriculture (Lower Saxony Ministry of the Environment, 1996).

In particular, ammonia (NH_3), nitrous oxide (N_2O) and nitrate (NO_3) are responsible for enhanced concentrations of nitrogen compounds in soils, water and air, with far-reaching impacts on fluxes in the overall nitrogen cycle. This is the major cause of eutrophication/hypertrophication in soils and water resources, as well as acidification of forest soils, and may severely disrupt previously intact ecosystems.

In 1994 agriculture was responsible for around 85% of total ammonia emissions in Germany (LAI, 1995), of which about half was released through the application of organic fertilisers (mainly cattle slurry). This means that agriculture contributes about 25% to the total acidification potential and more than 50 % of the nitrogen-related acidification potential (Isermann, 1994a).

In 1990 agriculture accounted for 36% total nitrous oxide emissions in Germany, i.e. around 75,000 tonnes. The largest proportion of this by far (approx. 80%) was caused by agricultural land use (deposition of fixed nitrogen in soils). Increasing fertiliser intensity generally leads to higher emissions of nitrous oxide to the atmosphere (Beese, 1993). Nitrous oxide emissions contribute to the depletion of the stratospheric ozone layer and to the anthropogenic greenhouse effect.

More than half of all nitrogen loads and over 40% of all phosphate loads to Germany's water resources originate from agricultural land. The nutrient content in German waterbodies has multiplied over the last 30 to 40 years (nutrient loads transported by the Rhine have increased sixfold since 1945). For decades now, a continuous rise has been observed in the nitrate content of groundwater and drinking water, especially in regions where agriculture is intensive. The quality of drinking water in such areas is severely at risk. Water production facilities have had to be closed down in virtually every region in Germany, especially in agricultural areas. Waterworks are being increasingly relocated to forest areas, a process that may exacerbate new forms of forest damage. A reversal of this trend is not yet in sight (LAWA, 1995).

Continued deposition of nitrogen compounds is increasingly overtaxing the nitrogen storage capacity of forest ecosystems. Deposition of airborne nitrogen promotes growth at first, thus inducing increased

uptake of nutrients that are already scarce. As a result, forests may get caught in a "nutritional physiology trap", leading to large-scale nutritional disruption. Transfers of nitrate from soil to groundwater is increasingly common in forest areas. The drinking water obtained through the generation of new groundwater by our forests is therefore threatened, too. Major groundwater resources in Germany exceed the current EU nitrate limit of 50 mg/l.

Another problem that should not be underestimated concerns the excessive growth of grasses and nitrogen-absorbing plants on forest soils that is caused by nitrogen loads in forests. This enhanced competition for water exacerbates the aridity stress to which forests are exposed, and impairs the formation of new groundwater. The natural renewal of forest stands is also placed under considerable strain as a result. Moreover, special sites low in nutrient resources, such as highland moors, lean turf and similar areas close to forests are exposed to the threat of eutrophication.

Agricultural nitrogen inputs (overfertilisation) are a major cause of nitrogen pollution in groundwater, surface waterbodies as well as the North and Baltic Seas. The proportion of nitrate (NO_3) groundwater pollution emanating from agriculture is around 90% (UBA, 1994 d).

Since the early 1980s, the high level of nutrient deposition in waterbodies has occasionally led to oxygen scarcity and enhanced growth of toxic and foam-producing algae, resulting in the dying off of fish and soil organisms as well as skin irritations among bathers in some cases. The consequences included declining tourism on the North and Baltic Sea coast and at a number of lakes. The worst example in the North Sea was an "algae pest" (mass development of *Chrysochromulina polylepis*), which caused considerable damage to flora and fauna in 1988. One of the express objectives of numerous international conventions, resolutions and recommendations (including OSPARCOM, HELCOM, INK, IKSR, IKSE*) is to reduce water pollution through nutrients and contaminants

Phosphate loads from agriculture also pose an environmental problem that cannot be ignored. Most of the phosphate imported to Germany is used by agriculture in the form of mineral fertiliser and fodder. Phosphate fertilisers are applied directly to the soil, while about 66% of the phosphate contained in fodder enters the soil in the form of animal excrement. More than half of the phosphate applied to cultivated plants is enriched because of inefficient utilisation in the soil (Leinweber et al., 1994).

Despite declining use in recent years, high phosphate loads in recent decades has led to substantial phosphate accumulation in the topsoil that diminishes at a very slow rate, even when no more phosphate is added. As a consequence, over half the cultivated land does not require any phosphate fertilisation at present to enhance crop production, while a third merely requires uptake fertilisation (fertilisation here corresponds to nutrient discharge from the field, but excludes the nutrients that remain on the field) and only 14% needs increased phosphate fertilisation (Scheffer/Schachtschabel, 1992).

A large proportion of phosphate loads to waterbodies stems from agriculture (> 40%). Phosphate enters waterbodies, causing water eutrophication, primarily through soil erosion, as well as through manure drainage and drainage water. In regions where soils and drainage ditches contain abundant water

* Oslo Paris Commission, Helsinki Commission, International North Sea Protection Conference, International Commission for the Protection of the Rhine, International Commission for the Protection of the Elbe

and a low level of oxygen, large amounts of phosphate (2-4 times higher than normal) are leached, also in dissolved form (Schubert, in print). This applies in particular to marshy areas near the sea, from which the wadden seas and the North Sea are polluted directly. Following the resolution adopted by the International Conference on the Protection of the North Sea to reduce nutrient inputs by 50%, considerable reductions in phosphate input have been achieved at point sources (discharges from sewage treatment plants) by implementing drastic measures (switching to phosphate-free detergents, construction of new treatment plants and expansion of existing ones).Agriculture therefore accounts for a growing share of the remaining phosphate pollution.

Pollution by plant protection agents

Around 30,000 tonnes of active plant protection agents are officially sold in Germany every year. There are no statistical records of the quantity actually used in agriculture and horticulture (in contrast to the USA, for example, where quantity is monitored). Imports (especially in border regions) probably mean that the total amount used is more than the aforementioned 30,000 tonnes. Slightly fewer than 1000 preparations (around 200 active substances) are available for application.

Following a decline in the volume of active substances officially sold in Germany in the early 1990s, domestic sales rose again by 18% from 1994 to 1995. The largest share of plant protection agents sold in Germany (in 1995) was accounted for by herbicides (13,751 tonnes), followed by fungicides (7,638 tonnes). (IVA, 1996).

Findings of plant protection agents in waterbodies as well as the effects of these agents on the balance of nature (e.g. reduction in species diversity through herbicides) are described in numerous studies. Aquatic biota are prone to a variety of acute and chronic effects if critical concentrations of plant protection agents enter waterbodies.

Plant protection agents are generally undesirable in drinking water. Legislation has been implemented to enforce this through the general precautionary limit value of 0.1 µg/l for individual substances and 0.5 µg/l for the sum of all active substances. However, the impact threshold for aquatic organisms is significantly lower (Irmer et al., 1994).

Survey results from the *Länder* show that about 10% of all measuring units in near-surface groundwater indicate concentrations of plant protection agents above the 0.1 µg/l limit value for drinking water (plant protection agent report of LAWA, in preparation). Atrazine, an active substance that has been banned since 1991, and its decomposition product, desethylatrazine, are still the main causes of such pollution (a large portion of which presumably stems from contaminated sites).

The additional costs incurred for the drinking water supply in western Germany alone due to substances such as nitrate, phosphate and plant protection agents amounted to over DM 920 million at the end of the 1980s (Winje et al., 1991). Model calculations using the “Regionalised Agricultural and Environmental Information System” (RAUMIS) developed by the University of Bonn on behalf of the Ministry of Agriculture showed that resource management requirements and compensation payments in water protection areas are more beneficial than dispensing with such measures and accepting higher costs for purifying drinking water (Weingarten, 1996). The Federal Environmental Agency has been an approval authority for plant protection agents since 1987. Permits are not granted if model calculations

and lysimeter investigations indicate that the drinking water limit (0.1 µg/l) has been exceeded (cut-off criteria).

Pollutant loads through fertilisers

Mineral fertilisers may be contaminated with pollutants due to their respective manufacturing process, or depending on the origin of their input substances. Phosphate fertilisers, especially, display high levels of pollutant elements, above all cadmium. Depending on land use and fertilisation methods, these pollutants enter agricultural and forestry soils through the application of fertilisers. Cadmium and chromium are the main contaminants, with lesser quantities of lead, nickel and arsenic being deposited.

Since 1986 German fertiliser manufacturers have committed themselves to keep the cadmium content of their products below certain limits. However, the obligation to comply with agreed cadmium limits does not apply to importers, which results, on account of the high proportion of imported phosphate fertilisers, in the growth of cadmium deposition from mineral fertilisers. Therefore, the stipulation of a standardised EU cadmium limit value for mineral fertilisers is urgently necessary.

Liquid manure, sewage sludge and compost are also contaminated with heavy metals, dioxins or polycyclic aromatic hydrocarbons (PAH), depending on origin and composition. The only national regulation in this area concerns the use of sewage sludge. The latter may not be applied as fertiliser if the limits laid down in the Sewage Sludge Regulations (AbfKlärV) are exceeded. A Federal Compost Regulation is in the preparation phase. Furthermore, the law governing fertilisers must be amended with respect to so-called secondary raw material fertilisers. Information sheet 10 of the *Länder* Working Group on Waste (Working Group on Biocompost: "Quality criteria and application recommendations for compost") contains recommended values for heavy metals in compost (LAGA, 1994). Liquid manure is subject to the fertiliser regulations, but these do not include rules governing pollutant loads.

Soil erosion and structural damage

Soil erosion in the strict sense refers to degradation processes exceeding natural dimensions. It is caused by water and wind and enhanced by certain forms of land use. To maintain soil fertility, soil degradation should not exceed the rate at which new soil is formed. Soil erosion due to non-sustainable land management leads not only to loss of soil fertility, but also to water pollution through phosphates, plant protection agents and nitrogen compounds deposited along with soil material.

As a result of increasing intensification of land management, soil erosion due to water and wind has assumed dangerously high proportions for soil functions and neighbouring ecosystems. For example, the maximum tolerable soil degradation in Bavaria proposed by Schwertmann (Schwertmann et al., 1987), namely 8 tonnes per hectare and year, is exceeded on 43% of the area under cultivation according to the soil erosion map (Auerswald/Schmidt, 1986). In Bavaria, 66% of the area under cultivation and in Lower Saxony 26% of the total area were classified as threatened. According to the soil erosion map, almost 18% of the area with soil degradation exceeding 5.1 tonnes per hectare per annum in Baden-Württemberg can be regarded as significantly threatened (Gündra et al., 1995). In east German states, 27% of the area under cultivation is threatened by water erosion and 28% by wind erosion, while 50% of sites display signs of degradation.

Farming methods in intensive agriculture, especially soil tillage and the use of heavy equipment, cause technogenic damage to the structure of both topsoil and subsoils, especially compaction, with subsequent negative impacts on the regulatory functions and fertility of the soil. This structural damage is designated as excessive soil compaction.

Estimations of the distribution and extent of soil compaction in Germany are available in varying detail for the states of western and eastern Germany. In the case of the west German states, various references are made to plough and tractor wheel pans (compaction under tracks made by plough blades or tractor wheels) of increasing depth and magnitude depending on land management methods and site conditions. Data for the states of eastern Germany indicates that about 40% of the area under cultivation can be classified as topsoil compacted. Loss of plant yield is calculated as 10 to 25% annually due to topsoil degradation by wheel pressure (Dürr et al., 1994).

Loss of biological diversity

Biodiversity, the characteristic of biological systems to be different from each other, is manifested at the level of genes, species and ecosystems (Solbrig, 1994). Agriculture, with all the landscape-altering activities it involves, such as consolidation of arable land, construction of all-purpose rural roads and melioration, is regarded as the main cause for species and biotope decline among plants in Germany (SRU, 1985). Historically, traditional farming played an important role in the formation and preservation of species diversity. This has changed, however, especially within the framework of the Common Agricultural Policy, due to mechanisation and intensification of agriculture. Another key factor in this process is the increasing size of land under cultivation. However, to some extent a rethinking process commenced in the late 1980s.

Intensive agriculture deprives numerous biota of their habitat, as compared to the relatively small spectrum of new biota created by agriculture. When insufficient areas exist to which species can withdraw, intensive agriculture endangers the preservation of species and species diversity. Approximately 50% of the land area in Germany is used, mostly intensively, by agriculture. The area covered by forests is slightly less than 30%, and only 4% are near-natural areas (nature reserves and national parks).

The new “Red List of Threatened Plants in Germany” (BfN, 1996) covers a total of 13,907 different species of plant studied in Germany, of which around 40% have been included in the Red List. This means that about 40% have been classified as threatened, seriously threatened, threatened with extinction or extinct. The percentage of threatened species fluctuates between 14% and 90%, depending on genus. Thirty-one percent of ferns and flowering plants are threatened, for example, as are 6% of lichens. The main sources of threat are destruction of habitats due to intensive, mechanical agriculture, land-use changes and abandonment of land (e.g. species of lean grass such as gentian and orchid varieties that have adapted to extensively managed locations) as well as pollutant emissions (especially in the case of lichens). No examples of large-scale respreading of threatened plant species have been found to date (BfN, 1996).

Fig. IV 1: Red List of threatened plants in Germany

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New niches for successor species can be created through adapted, extensive forms of land management, thus enhancing species diversity. Placing areas under protection within the framework of nature conservation treaties is an important but expensive instrument deployed by the *Länder* to preserve large areas as habitats and to protect the species that remain. Moreover, programmes exist at the federal and *Länder* level within the framework of EC Regulation 2078/92 (promotion of environmentally sound production methods that do not impair the natural habitat) which promote broader use of extensive farming methods. These measures currently relate to around 5 million hectares, but in varying ways. A detailed review of the environmental benefits has not been conducted as yet. Criticism has been levelled at the economic inefficiency of agricultural environment programmes (AGRA-EUROPE 41/96).

Contribution to the greenhouse effect

Taking into account all climate-forcing emissions, agriculture in Germany is responsible for about 10% of the national anthropogenic greenhouse potential, with the emission of trace gases causing global warming.

Emissions from the agricultural sector in 1994 were as follows:

- nitrous oxide (N_2O): approx. 66,000 tonnes, or 36% of total N_2O emissions,
- methane (CH_4): approx. 1.66 million tonnes, or 32% of total CH_4 emissions and
- carbon dioxide (CO_2): approx. 23 million tonnes, or about 3% of total CO_2 emissions

These emissions contribute to Germany's national anthropogenic greenhouse potential and are mainly attributable to intensive agriculture, above all livestock farming. A certain degree of importance is also attached to CO_2 and NO_x emissions from petrol- and diesel-engined vehicles in agriculture and forestry.

The main cause of nitrous oxide emissions is the deposition of fixed nitrogen in agricultural soils. Livestock farming, particularly cattle farming, is responsible for the bulk of methane emissions from agriculture. Large amounts of methane are released by cattle and other ruminants during digestion, and through the anaerobic storage of farmyard manure. About 75% of methane emissions from agriculture stem from animal digestion alone.

CO_2 emissions are attributable to energy consumption, in that working methods and agricultural services, especially the production of mineral nitrogen fertilisers, are very energy-intensive. Agricultural machinery and mineral fertilisers account for about 60% of fossil fuel consumption on crop farms.

However, calculations of the share of CO_2 emissions accounted for by agriculture do not take into account the energy input of imported means of production. One must include the fact that Germany's fodder imports in 1993/94 alone amounted to around 8.7 million tonnes of grain, and that fodder was responsible for around 60% of total grain consumption. The 8.7 million tonnes of grain from imported fodder contain approximately 2.2 million tonnes of digestible protein, which means that about 23% of the fodder protein used in Germany is imported (BML, 1995).

The energy efficiency of intensive animal production is particularly low. On average, ten times the amount of energy required for the production of food crops is needed to produce food of animal origin, for the same nutritional value (Heinloth, 1993) (see also Section IV1.3). The energy input for imported fodder is 58% higher than for domestic fodder, due to transport costs (Haas and Köpke, 1993). For a global strategy for sustainable agriculture, intensive animal production must be reduced considerably or be altogether eliminated.

According to the "Protection of the Earth's Atmosphere" Enquete Commission of the German Bundestag, at least 50% of all climate-forcing emissions from agriculture can be avoided by switching to a sustainable form of land management. Savings could be achieved primarily by greater extensification in farming, especially through reduced use of mineral fertilisers and of additionally purchased or imported fodder, introduction of a CO_2/energy tax, locally adapted tillage methods, as well as reintegrating food processing and cash crop production. A reduction in livestock in general as well as a shift in production away from meat and towards food crops would contribute to savings in climate-forcing emissions (Enquete Commission, 1994).

The decline in gaseous emissions from agriculture since 1990 (6^{th} Immission Control Report of the Federal Government) is basically attributable to the drastic reduction in livestock in the states of eastern Germany. Cattle stocks have been on the increase again since 1994, however.

Summary: Despite positive trends in recent years, agriculture in Germany still generates excessive environmental pressures, albeit with regional variations. Overall, agriculture does not meet the basic requirements for sustainability, based on the guiding principle of environmentally sound and sustainable development agreed on at the 1992 UNCED conference in Rio.

IV 1.2 Environmental impacts of food processing and transport

Much of our food is marketed in more or less processed form. To be able to assess the impacts of food production on the environment, the conditions under which food is processed and then marketed must be analysed in addition to agricultural production methods itself. Sales of DM 218 billion in 1994 and over 5200 enterprises make the food industry one of the largest economic sectors in Germany. The sector is characterised by a high level of technology, mass production, a specialised and qualified labour force, as well as long transport distances for delivery of input materials and distribution of the products due to the persistent trend towards concentration on a few central production sites.

Adverse environmental impacts caused by the food industry

The intensity of processing ranges from pure sorting (fruit and vegetables) to preparation of ready-to-eat products, such as frozen ready-to-serve meals. Further processing of food implies environmental stress, for example in the form of large quantities of wastewater and production residues, air pollutants and odorous emissions, as well as the use of problematic process materials such as solvents, cleaning agents and disinfectants. A study carried out by the Fraunhofer Institute for Food Technology and Packaging in 1990 on emissions from food production in the states of western Germany points to typical industrial problems that still exist today. The following is a summary of the main results:

Waste:

Solid wastes are usually disposed of by using them as animal feed and fertiliser. Some wastes, like filter materials and surplus sludge, are disposed of in landfills. Using waste products as animal feed is increasingly viewed as problematic for appropriate (species-oriented) livestock farming. Discharging some of the solid residues into wastewater results in substantial wastewater treatment costs.

Waste gas:

For the most part, waste gas emissions comprise intensively odorous substances that cause odour pollution. Problems arise in connection with smokehouses that produce emissions with a certain toxicological potential. There are no economically viable waste gas purification methods for small-scale smokehouses, which in most cases do not fall under the Technical Regulations on Air Quality. Dust emissions are significant in certain areas of the food processing industry. Each year, between 7,500 and 10,000 tonnes of the solvent hexane are released during the production and processing of cooking oil and related products. Hexane belongs to the class of volatile organic compounds (VOC), which are responsible, inter alia, for ground level ozone. In Germany 2.5 million tonnes of VOC are emitted annually.

Packaging:

In addition to the pollution caused by the production of foodstuffs, it is important to consider the environmental impacts of packaging. Expenditure on packaging amounts to a peak value of 38% of product value in the case of beverages, 16% for fruit and vegetables and 1% for eggs (Fraunhofer Institute, 1990).

Environmental stress caused by food transport

Transport connected with the production and marketing of food is of considerable environmental relevance. Expenditure on transport has risen dramatically in recent decades due to the concentration and specialisation of agricultural activities, productivity increases and growing centralisation in the food industry. The environmental pressures caused by the mounting volume of traffic (particularly the rise in emissions and resource consumption) is described in Chapter III. Consumer behaviour has also undergone fundamental changes due, among other things, to declining household size (more single households) and changes in gender roles and attitudes towards housework. Expectations regarding the quantity and quality of food products as well as on their constant availability have risen. There has been and continues to be a strong demand for both partially prepared and ready-to-eat meals, as well as for food that has to be transported across long distances (e.g. tropical products). This leads to refined production methods in the food industry, new products and, above all, growing imports.

Between 1970 and 1991 alone, the freight volume generated by food production and distribution rose from 97.1 million tonnes to 157.8 million tonnes, corresponding to a growth rate of 67.2%. Due to greater transport distances, transport performance in kilometre-tonnes increased to an even greater extent than freight volume. Radical changes occurred between 1970 and 1991in the modes of transport used. Whereas 41% of foodstuffs were transported by rail and only 38% by road in 1970, the figure for rail transport had dropped to 10% by 1991, while 76% of food shipments were by truck. Air freight traffic, particularly transport of foodstuffs and preliminary products, has grown in importance in recent

years. Imports and exports by plane were around 35,000 tonnes and over 12,500 tonnes respectively in 1994. Although the percentage of total agricultural freight volume accounted for by air freight is small, air freight is responsible for a much higher share of total emissions.

The modal shift to road transport from inland shipping and even more so from rail was much more pronounced in the case of food transports than for long-distance freight transport in general. Transport by truck significantly expanded its market share in all freight segments. The other transport modes, by contrast, not only lost a substantial proportion of their market shares, but also declined in absolute terms. All these developments are not merely a problem connected with agriculture or food production, but a result of a transport policy favouring road transport.

IV 1.3 Environmental impacts of consumer behaviour

Today (1996), the number of people in the world who need to be fed is around 6 billion; by the year 2010, this figure will probably reach 7.2 billion and by the year 2020 about 8 billion. This estimated growth of approximately 2 billion people is equivalent to twice the population of China, or 30 times that of Germany. The productivity growth rate for grain, the most important foodstuff world-wide, has dropped at the global level over the past 10 years from around 3% to 1.4% (v. Braun, 1996). The growth rates for total agricultural production have dropped to about 1% since 1984 and are currently less than half the population growth rate. However, the problem of food security is not only one of distribution, but will also become a capacity problem in future. In view of a rapidly growing world population and the simultaneous rise in soil degradation and decline in the growth rates of global food production, the question has to be asked whether the nutritional habits in affluent western societies, also in Germany, are compatible with sustainable development principles (see also Chap. VI).

Over the past 30 years, individual nutrition in Germany has been characterised by rising consumption of meat, eggs, dairy products as well as fruit and vegetables. Per capita meat consumption peaked in 1988 at around 70 kg per annum. Since the beginning of the 1990s, meat consumption has dropped - as a result of food scandals and animal diseases - to reach a level of approximately 62 kg per capita in 1995. Nevertheless, Germany numbers among the European countries with the highest meat consumption. The proportion of staples in the daily diet has fallen continuously. The share of food involving a high degree of processing (ready-to-eat and partially prepared foods) and of imported food products has risen significantly in relation to total consumption.

According to various forecasts, it will not be possible to achieve global food security for coming generations if the consumption patterns of the affluent in all countries, the wasteful use of water and soil resources and the high losses involved in processing and marketing continue at present levels. The present rate of global meat consumption - 160 million tonnes a year - is expected to rise to 280 million tonnes by the year 2020 if current trends continue. To meet this demand, world grain production alone would have to increase by around 50% to over 3 billion tonnes per annum.

According to the Worldwatch Institute (1996), 38% of the world grain harvest is fed to livestock for meat production. The production of meat is extremely inefficient in terms of energy. A kilogram of feedlot-produced beef requires seven to nine kilograms of grain, four kilograms of grain are necessary for a kilogram of pork meat and three kilograms of grain for a kilogram of chicken meat. These millions

of tonnes of grain fed to livestock every year are an extreme waste of energy. The most effective means of improving the food situation for the world's population would be to reduce global meat consumption and, instead, make greater use of plant foodstuffs, while ensuring distribution according to need.

Feeding a growing world population is only possible by switching to plant-based diets, which necessitates a major reduction in global meat consumption, above all in the industrialised states where consumption is highest (Brown, 1996). Apart from the positive environmental impacts of lower meat production, moving down the food chain would make substantial quantities of grain available for human consumption. Nutritional physiologists also call for lower average meat consumption in Germany for health reasons.

The statements contained in the preamble of the declaration of the 1974 World Food Conference still apply today. "Overconsumption (of food) by the affluent is not only detrimental to health, but also leads to reduced food availability for the less privileged; furthermore, enormous quantities of food resources are fed to animals". "The current patterns of consumption among the affluent cannot serve as a model".

Summary: Taking a broad perspective embracing not only agriculture, but also the food industry, the trade in and transport (including imports) of foodstuffs, as well as the consumers, it is now obvious that our food production and marketing system, including our consumption habits, does not conform with the principle of sustainable development due to the environmental pressures they induce.

IV 2. What is sustainable food production?

In ecological terms, sustainability requires that the economic system in operation is viable for the ecosystem on a long-term basis. Food production can only be sustainable if it can be continued for generations in an environmentally and socially acceptable way. For agricultural production and food processing in Germany, this means that maximum levels of resource consumption and pollution, which are technically and socially defined as a function of the population to be supplied, are not exceeded. One of the prerequisites for this (as already mentioned) is to achieve wise consumption patterns in relation to food. In the following two sections, an attempt is made to describe some guiding principles for sustainable food production and to define environmental goals pertaining to soil, water and air.

IV 2.1 Guiding principles and goals of sustainable agriculture

Description of such a principle requires a definition of the term "sustainable agriculture". The following definition is largely based on that of the Enquete Commission on "Protection of the Earth's Atmosphere":

Sustainable agriculture operates largely in cycles, conserving and preserving the natural resources on which life depends, i.e. soil, water, air, species diversity as well as scarce natural resources. Prerequisites in this regard include the integration and adaptation of farming practices into the natural balance.

The aim of agriculture must be to supply the population with healthy food products and raw materials, primarily on a regional basis. Agriculture also serves to preserve and/or restore a varied, diversely structured cultivated landscape abundant in species and biotopes, and to safeguard and develop rural areas. In the interest of achieving a circular flow economy, non-hazardous biogenic wastes and residual substances should, wherever possible, be recycled and reused within the agricultural sector. (Enquete Commission, 1994).

The definition of "sustainable agriculture" in Agenda 21 also includes eradicating poverty and ensuring public participation. The criteria to be applied when shaping a conditional framework in the food sector involve not only responsibility towards farmers, consumers and the environment, but also towards the less developed countries of the South. Sustainable development cannot be achieved unless there are changes in demands, consumption patterns, traditional patterns of behaviour and in the priorities pursued at the individual and social levels.

- Sustainable agriculture therefore embraces the following objectives:
- Securing a stable food supply on a long-term basis
- Preserving soil fertility as a basis for life and economic activity for future generations
- Efficient use of renewable resources without exceeding their regeneration capacity
- Protection of non-renewable resources
- Preservation and sustainable use of biodiversity
- Animal and species protection
- More concern for consumer interests
- Equitable relations in international trade.

However, sustainability must not be reduced to environmental soundness in the narrower sense, but needs instead a holistic view and the consideration of economic, social, cultural and ethical aspects. Sustainability is energy- and resource-extensive, but labour- and know-how-intensive. To this extent, sustainability requires a fundamental reorientation of entire sections of society and the economy.

Ecological farming, as practised in Germany in accordance with the framework guidelines of the Association for Ecological Farming (Arbeitsgemeinschaft Ökologischer Landbau - AGÖL), is the closest approximation to sustainable food production (se also Section IV 3.2). Farmers applying these guidelines have been implementing the principle of sustainability in agriculture for decades, also with theoretical foundations. Ecological farming is not only an ecological model for economic activity, but subjects the goals of economic efficiency and profit maximisation to ethical limits that ensure a balanced interaction with nature.

IV 2.2 Guiding principles and goals of sustainable food processing

Sustainability in the food industry means producing, processing and transporting food of sufficient quantity and quality in such a way that the impacts on soil, water, air and climate cause no significant damage to the balance of nature, even if continued for numerous generations. A major intermediate objective is to reduce CO_2 emissions in Germany (see Chap. II) by at least 25% by the year 2005 relative to 1990 as the base year (pledge made by the German Chancellor at the 1995 Climate Conference in Berlin).

Diversity of food supply can only be ensured through trade and the exchange of commodity flows. However, this trade must not be allowed to produce significant pressures on the environment or other external impacts. This means, inter alia, reducing the energy intensity of food production and processing. Food marketing based on sustainability avoids environmentally harmful transport by means of regional supply concepts, strengthens local markets and is based on transport prices in which external costs are internalised - which alone would reduce much transport. This guarantees that the remaining trade in foodstuffs and substances used in agriculture operates to enhance prosperity, rather than serving primarily to increase the profits of enterprises at the expense of the public at large and the environment. Sustainable food production also implies the lowest possible energy input when producing and packaging food.

The objectives of sustainable food processing and transport include:

- Reduction of CO_2 emissions during processing in order to achieve the overall reduction target of 25% by 2005
- Introduction of waste gas limits for agricultural machinery and minimisation of engine-related emissions
- Incorporation of external costs into transport prices
- Reduction of foodstuff transportation
- Enhancing regional supply concepts and markets
- Consideration of consumer interests

IV 2.3 First steps towards sustainable food production

Implementing the aforementioned principles and objectives of sustainable food production requires strategies that ensure protection of soil, water and air, and biodiversity. The targets and measures of environmental policy action described below should be considered as initial steps towards sustainable food production:

Climate protection

Agriculture must contribute towards stabilising the greenhouse gas concentrations in the atmosphere by reducing climate-forcing emissions to prevent dangerous anthropogenic interference with the climate system and to provide ecosystems with sufficient time to adapt naturally to climate changes. The mean global increase in temperature must therefore not exceed 0.1°C per decade, as called for in the reports

of the Enquete Commission (1994). For this reason, we recommend that the national nitrogen balance surplus in agriculture be limited to a maximum of 50 kg/ha (with regional variations), that methane emissions be avoided and that energy be saved (see also Chap. II on sustainable energy use). Agricultural subsidies and aid (e.g. gas oil aid) should be reduced step by step. Furthermore, a CO_2 tax or higher energy taxation on non-renewable energy sources should be imposed at EU level. Trace gas emissions must be lowered nation-wide, possibly within the framework of a general reassessment of the energy sector. In the medium to long term, agricultural subsidies and allowances should be reduced and redirected to support landscape management.

Protection of water resources

Water resources must be protected against pollutants and eutrophication. Nutrient loads must be halved, especially to protect the marine environment (Basis 1985), so that marine coastal waters can be designated as "non-problem areas". The quality of surface water must be improved so that biota typical of the natural area are given back their habitats. Here again, the national nitrogen balance surplus should be limited to 50 kg N/ha (with regional variations). In the event that this target is not reached with the fertiliser regulations, the response must be to introduce a nitrogen levy, i.e. a tax on fertilisers containing nitrogen, at EU level.

Soil protection and reduction of soil erosion and compaction

The natural soil functions must be secured on a sustainable basis by reducing pollutant loads to a minimum and by orienting nutrient input to plant requirements and to the filter and buffer capacity of the soil. Environmental requirements are to be met through compliance with standardised assessment principles and common, site-specific and tillage-based limits for all tillage-related depositions arising from the agricultural use of soils (e.g. for nitrogen loads in the form of liquid manure, sewage sludge and compost).

Long-term protection of natural soil functions, particularly the filter and storage function, must also be ensured through water resource protection. To safeguard the quality of groundwater resources (threshold value: 25 milligrams of nitrate per litre, limit value according to the regulations on drinking water: 50 milligrams per litre), an upper limit of 50 kg for the national nitrogen balance surplus - followed by stepwise reductions - must be complied with as a first step. To reduce pollutant loads due to mineral and organic fertilisers, it is necessary not only to restrict the contaminant content of fertilisers, but also to impose regulations on fertiliser application (specification of total permissible loads).

Soil erosion and compaction have to be reduced by switching to appropriate tillage methods, by changing crop rotation and field rotation practices, and in future by linking compensation payments to compliance with minimum ecological standards.

Lasting protection of soil resources against erosion means restricting the quantity of soil that may be removed to the amount that is created through weathering, i.e. approximately 1 tonne per hectare and year. The intermediate target is to preserve soil fertility for a period of 300 to 500 years. For deeper soils, a maximum tolerable value for the medium term of 8 tonnes per hectare and year is proposed, and lower values for shallow soils (Schwertmann et al., 1987). Strategy responses to prevent sheet erosion, the most common form of soil erosion in Germany, will limit other forms of erosion as well, at least to some extent. Most strategies for preventing and reducing soil erosion are technically feasible,

although they may impair the profitability of farms, at least in the short term, where long-term reduction of the soil substance has been tolerated for business reasons. Farmers must therefore be provided with temporary advisory and adjustment support.

To protect the soil against excessive contamination and compaction, an overall concept containing the following four components would make sense (Dürr, Petelkau & Sommer, 1994):

- Limit values have to be set for soil pollution. One conceivable option is to classify agriculturally used areas into "soil pressure categories" according to their sensitivity to mechanical stress, and to base the use of structure-protecting machinery and vehicles on this classification.

- The trend towards increasing pressure on soil surfaces is to be counteracted by implementing existing technical solutions (wide tyres, rubber-belt drives, adjustment of inner tyre pressure) in accordance with "good expert practice".

- Working methods for crop production are to be adapted to "good expert practice". This involves, for example, exploiting working width benefits, also in sugar cane production, optimising payloads of manure-spreaders, harvesters and transport vehicles to field length, as well as separating field and road transport.

- The vehicle load-bearing capacity of the soil should be improved through conservation tillage (minimising soil disturbance, leaving stubble from the previous crop in place).

Implementation of this overall concept will not only prevent excessive contamination and compaction, but will also reduce expenditure on mineral fertilisers and tillage, thus contributing to higher profits in agriculture.

Ecosystem protection

Preservation of threatened ecosystems and protection of animal and plant species must be adequately ensured through locally adapted forms of farming. To safeguard biodiversity in Germany, it is necessary to set up a network of integrated biotopes in the agricultural landscape. This system should consist of large ecological priority areas accounting for an average 8% of the total area in rural regions - excluding forest, settlement and traffic areas. These ecological priority areas must be linked to each other through an additional 2 to 3% of small-scale, punctiform and linear, extensively natural biotopes in such a way that wider biotic interrelationships can be restored (SRU, 1985, TZ 1194; SRU, 1994; SRU, 1996). This average area of 10% (with fluctuations between 5 and 20%) of the agricultural landscape under cultivation should represent the ecological subsistence level ("Noah's Ark") for numerous animal and plant species living in the wild (SRU, 1985).

The following list is a summary of the measures, in compliance with all currently valid laws and regulations, that are necessary as initial steps towards sustainable food production in the agricultural sector in Germany:

- Reintegration of plant and animal production on farm or at least on a regional level, with largely closed cycles;

- Transformation of slurry-intensive mass livestock farming and production methods through land-based and species-oriented livestock farming;

- Substantial reduction of fodder imports and substitution by locally produced fodder, resulting in changes in and extension of crop rotation;

- Reduction of the national nitrogen balance surplus to a maximum of 50 kg per hectare and year (with regional variations);

- Increase in the share of ecological farming in relation to total production and marketing through appropriate agricultural policy measures;

- Cutback in subsidies for environmentally harmful activities (e.g. "gas oil allowance" for diesel consumption), linking compensation payments to ecological criteria.

For the food processing, trade and transport sectors the following measures are to be implemented as initial steps:

- Development of concepts for reducing waste and energy consumption in the production and packaging of foodstuffs;

- Internalisation of the external costs of food production and processing;

- Limitation of emissions from agricultural machinery and vehicles by introducing limit values for exhaust gas;

- Reduction in food transport through comprehensive regional supply concepts and inclusion of external costs of transport sector in product prices;

- Support and promotion of nutrition based on health consciousness, by offering "holistic" nutritional concepts and an adequate selection of ecological farming products at numerous selling locations and at favourable prices.

Significant contributions on the part of consumers can be achieved by reconsidering and possibly changing their individual nutrition patterns, especially by reducing meat consumption and by supporting and promoting ecologically produced food through greater awareness when buying.

IV 3. Business as usual scenario: food production trends to the year 2000

In Section 1, an attempt was made to assess the current environmental impacts of agricultural production, further processing and transport, and consumer behaviour. To gain an insight into future trends in these areas, the following sections will describe possible futures in the form of scenarios. Scenarios are "if-then" pictures of the future that can be varied systematically depending on the underlying assump-

tions. Unlike forecasts, they do not convey inevitable future developments, but rather illustrate the existing scope for shaping the future.

In the following section a "business as usual scenario" will be outlined for the food production sector (see also Section I 3.4). Assuming that the existing economic, legal and political framework as well as values and activities remain unchanged, current trends and developments in food production are extrapolated in this "business as usual scenario" to the year 2010. The environmental impacts involved will then be assessed.

IV 3.1 Potential trends in agriculture

In contrast to the transport or energy use sectors, where future scenarios have been part of the established repertoire of political consulting for decades, future scenarios for German agriculture, especially as far as the qualitative aspects are concerned, pose special difficulties. Agriculture, in addition to the natural site-specific factors, is dependent to a high degree on government policy. This means the future of land use in Germany will depends to a critical extent on the frameworks provided by agricultural policymaking.

The business as usual scenario is based on the following assumptions (EU Commission, 1995; BML 1996 a and b):

- the reformed Common Agricultural Policy in the EU will be maintained and continued towards deregulation;
- current market regulations (price compensation payments, limited agricultural exports in accordance with the GATT/WTO agreements) define the economic framework;
- agriculture will continue to display high rates of technological progress;
- yields will continue to rise, although less rapidly than to date;
- the trend towards substitution of labour by capital will continue;
- the demand for agricultural products within the EU will stagnate;
- the growth in food supply within the EU will be higher than the rise in demand;
- the accession of central and eastern European countries to the European Union will take place step by step;
- world trade will be liberalised further.

Under these basic conditions, the following trends will most likely emerge at EU level:

- Internal support, i.e. the subsidisation of certain products within the agricultural sector, will be cut back further, market access for third countries will be further improved and export subsidies and export quantities will be further reduced. Liberalisation of the world agricultural markets will probably bring about an additional increase in grain and meat surpluses within the EU. (BML, 1996 c)

- After accession of the central and eastern European countries to the EU, the population of the EU could grow by 100 million consumers whose average purchasing power is only about a fourth of the figure for the present EU. Arable land in the EU would expand considerably. The area under cultivation would grow by 55%. The supply of grain and oleaginous seeds especially will presumably increase. The rise in production due to the expanded area and technological advances will most likely continue in a number of key sectors - despite continued set-aside - with the exception of milk and sugar, for which there are currently production quotas. Exceeding the quotas in this area would lead to less rapid development or even reduction of cattle stock. The opportunities for market relief through export subsidisation are restricted (provided that the world market price for grain remains below the intervention price). In some sectors demand may even decline. The consequence would be a significant imbalance between supply and demand. This imbalance would be aggravated by the planned extension to eastern Europe. Pressure on the EU's agricultural policy to restructure funding will mount (EU Commission, 1995; BML, 1996 b).

- Agricultural production will continue to face increasing competition in the EU Single Market. The pressure this exerts on structural adjustments in the production and processing sector will grow, in Germany particularly (BML, 1996 b).

- This will most likely imply even more concentration in agriculture, i.e. the number of farms and the number of full-time workers in the agricultural sector will decline further and the average area per farm will grow. In this respect, future scenarios for German agriculture - in contrast to those for other policy areas - are "reduction scenarios".

IV 3.2 Projection of environmental stresses caused by agriculture

Although there were signs of reduced intensity of agricultural production in the early 1990s, which were mainly attributable to German unification and the 1992 reform, it cannot be assumed that substance loads from agriculture to water, soil and air will continue to decline significantly. In general, the current process of differentiation will continue at a slightly reduced level of intensity, while efficiency will gradually improve.

Land-use trends

The area used by agriculture will decline further, as in previous decades, but will still comprise - at around 50% - the largest proportion of total land area in Germany. Extensive to complete cessation of farming in some regions of Germany cannot be ruled out (BML, 1996 b).

Assuming that productivity advances in European agriculture will continue at an annual growth rate yield per hectare of around 1 to 2% over the next few years, approximately 15 to 30% of the area currently used for agriculture in Germany may no longer be required for food and fodder production in the year 2010. However, this assumption does not take into account future trends in global food demand, which may have considerable influence on land requirements and possibly reverse the trend described above. This means the following options are available for land use:

- Continuation of intensive production on the largest proportion of land, preferably at favourable locations. The areas that become available are set aside, in some cases afforested, while renewable resources are grown on part of the land, provided they are marketable.

- Continuation of agriculture on current area at varying degrees of intensity. In other words, intensive farming is still carried out at favourable locations, while a transition to more extensive farming methods (e.g. grassland farming) takes place in less unfavourable areas. Less arable areas receive support for species and biotope protection, landscape management, groundwater recharging and restoration of floodplains (rewards for ecological services).

Whether or not large-scale agriculture will be carried out at low-yield sites over the long term will depend on how much support is provided to extensification in future and what land management requirements are planned for fallow land. In general, a successive differentiation of agricultural production into areas less favoured by nature with low levels of intensity, on the one hand, and areas favoured by nature with high levels of intensity, on the other, can be expected (BML, 1996 b).

On most agricultural land environment degradation will presumably continue, while a certain reduction in intensity and hence amelioration of the environment can be expected only on part of this area.

Development of organic farming

The number of farms that practise organic farming and which are organised in the organic farming associations in Germany grew steadily during the 1980s and has risen in leaps and bounds since the early 1990s, not least because of various support programmes. The area used at present for organic farming accounts for around 2% of the total agricultural area in Germany. In some *Länder* (e.g. Lower Saxony, North-Rhine Westphalia, Hesse), attempts are being made to strengthen support and expand the area used for organic farming to 10% of the total land area by the year 2000.

Fig. IV 2: Number of farms practising organic farming in Germany

Hier Graphik aus Buch S. 147

Assuming that organic farming in Germany expands at the (rather moderate) growth rates of the 1980s (15 to 20%), slightly more than 10% of agricultural land will be managed according to organic methods in the year 2010. 10% is a realistic estimate if the current support programmes and activities at *Länder* level are continued, and there is no change in consumer trends or in neighbouring countries (Austria, Denmark).

On the consumer side, there has been a visible tendency towards more health food in recent years. Health food products, whether in fact from organic farming or only dressed up as such, are now available in nearly every supermarket. One of the major reasons for this development is a new health consciousness among consumers. Definite trends have been identified by consumer research institutes. The trend labelled “health food on the rise” (Lünzer, 1993) will presumably continue, especially since higher product prices can be compensated for by a health-conscious lifestyle involving limited consumption of meet, sweets and alcohol. In general, greater prospects for selling organic products can be expected. The market potential for organically grown food is estimated to range from 10-20% by the year 2010.

Despite this forecast extension of organic farming to about 10% of the agriculture area, one can expect a high proportion of conventionally operated farms in the year 2010. Progress towards sustainable food production must therefore be achieved primarily through activities and improvements within conventional agriculture.

Future nutrient loads

Following a decline from the late 1980s onwards, domestic sales of commercial fertilisers (nitrogen, phosphorous, potassium) underwent a turnaround in 1993/94 (BML, Annual Statistics). In 1995, an increase of 11% on 1994 figures was recorded for nitrogen sales alone (IVA, 1996); this rise was due, among other things, to the declining land set-aside rate. National nitrogen balances (inter alia, Bach and Frede, 1994; Isermann, 1994) displayed the highest surpluses in the mid-1980s, after which there was a decline to the 1992 level where they have since stagnated.

Substance loads to waterbodies (nitrogen and phosphate) as a result of fertilisation reached a maximum in surface water at the end of the 1980s; since then, there has been a downward trend (UBA, 1994 d) which is expected to continue until the year 2000 (due, for example, to improved efficiency of fertiliser application) before nitrate pollution then levels off at around the 1985 figure. Nitrate concentration in groundwater is still rising, however, and there are no signs of a reversal of this trend (LAWA, 1995).

Reduction in the pollution of water by nutrients and/or contaminants is the professed objective of numerous international conventions, resolutions and recommendations (including OSPARCOM, HELCOM, INK, IKSR, IKSE). In 1987, for example, the ministers of the states bordering the North Sea decided to reduce nutrient loads by 50% (relative to the 1985 base year) by 1995. The activities specified for achieving this objective included measures for the agricultural sector. However, nitrogen loads were reduced by only 25% in total, and by only 17% in the case of agriculture. The reduction target for phosphorus was reached, primarily due to measures at specific point sources, while the contribution of activities in the agricultural sector remained relatively small (UBA, 1994 d).

In 1993, the German *Länder* Conference of Environment Ministers (UMK) established a working group for a "Nitrogen reduction programme". The working group submitted an interim report to the Conference in 1995, and a further report in 1996 which was prepared jointly with representatives of the *Länder* Conference of Agriculture Ministers (AMK). The UMK welcomed the fact that a joint basis for data collection and assessment was found and that joint measures were proposed for reducing nitrogen. The UMK is committed to reduction of nitrogen emissions. In addition to regulatory measures, voluntary agreements with the agricultural industry as well as economic instruments will be used to effect implementation. After five years, the federal government and the *Länder* will report to the *Land* chairing the UMK on the status of implementation.

Considering the current economic incentives and the regulatory framework, further reductions in fertilisation intensity of any significance cannot be expected in conventional agriculture. The Fertiliser Regulations (on the principles of good expert practice with regard to fertilisation), which entered force in full on 1.7.1996, are designed as an instrument for reducing fertilisation-induced nutrient pollution of soils, water and air. It defines good expert practice with regard to fertilisation and, in particular, requires farms to prepare annual nutrient balances. Whether the Fertiliser Regulations will, in fact, be effective in lowering balance surpluses is a disputed issue at present, and remains to be seen.

Future trends in pollution through plant protection agents

Following a sharp decline in domestic sales of plant protection agents (herbicides, fungicides, insecticides and others - measured in tonnes of active ingredient) in Germany in 1993 and 1994, 1995 saw a renewed rise of 18% (Agra-Europe 20/96, Country Report 17). The current trend is towards plant protection agents requiring lower applied quantities but higher ecotoxicological impact potential. Pollution caused by plant protection agents (PPA) could decrease overall as the area of agricultural land declines, application methods are improved, pollution thresholds are complied with and areas used for ecological farming are expanded, but the pollution per unit of land farmed is difficult to estimate.

Future contamination of soils

If present-day farming methods are kept up, some further accumulation of pollutants in soils can be expected. Average annual cadmium loads from conventional farming, at 4.1 grams per hectare (Boysen, 1992), is about 20 times higher than the withdrawal rate of roughly 200 mg per hectare (according to KTBL, 1995). Use of mineral fertilisers containing phosphate will lead by the year 2010 to a total of about 1,148 tonnes of cadmium entering soils, where it accumulates in the upper 30 cm layer of topsoil. Similar figures cannot be assessed for organic wastes and farmyard manure, since they are not applied on the same large-scale basis. Around 23 tonnes of cadmium are deposited via compost (based on 4 million tonnes of dry substance in the year 2010, a concentration of 1 mg/kg of dry substance and a utilisation rate of 40%), while a total 112.5 tonnes of cadmium could be applied in the form of sewage sludge if the values stipulated in the Sewage Sludge Regulations (10 mg Cd/kg) were taken full advantage of.

As far as soil degradation is concerned, it not foreseeable at present that the level of degradation due to erosion will be brought under control by the year 2010, despite the fact that measures and instruments for soil protection against erosion are available and have been tested. This is due in part to the lack of a legal framework, although an appropriate regulation is provided for in the draft of the Federal Soil Protection Act. Secondly, erosion protection measures only make economic sense at present if they are implemented on a long-term basis.

Biodiversity trends

Germany is one of the signatories of the "Convention on Biological Diversity". This convention, which was adopted at the 1992 UNCED Conference in Rio de Janeiro, requires that the signatory states commit themselves, inter alia, to protection of endangered plant and animal species and biotopes as well as to the principle of sustainability in the use of nature outside protected areas. For the agrarian landscape (covering half of all German territory), this requirement can only be met, given continued intensive use, if at least an adequately large and diverse integrated biotope system is available (segregation model) to preserve currently threatened species in a stable minimum population size and, if necessary, permit stable resettlement of displaced species. Assuming a decline in agricultural land of 15 to 30% by the year 2010 (which is by no means certain), there should be sufficient areas available for this purpose. If adequate financial support is provided by the *Länder*, these areas could be used selectively for the benefit of species protection within the framework of nature conservation treaties or other programmes.

More far-reaching proposals call for large-scale extensification (integration model) and hence the achievement of species and biotope protection on the entire agriculturally used area. If intensive agriculture is carried out at favourable locations and areas becoming available are afforested, cultivated to produce renewable raw materials or used for recreational, settlement or similar purposes, this might result in a threat to those species that are dependent on a relatively extensive form of agriculture. According to the Council of Experts for Environmental Issues (SRU, 1985), the abandonment of land used for agricultural purposes is one of the major causes of biodiversity loss. It must be taken into account, however, that the expected growth of organic farming may also have positive effects for the preservation of biodiversity (e.g. among birds).

The role of genetic engineering

From an environmental point of view, an assessment of future developments in the field of genetic engineering is a difficult undertaking because of the inadequate experience gained so far in the use of genetically modified organisms in food production and the limited data available. However, on the basis of the legal and economic framework as currently foreseeable, a rapidly growing proportion of genetically modified products can be expected on the food market.

It is possible that a level of resistance to insects (such as the European corn borer) can be attained through genetic manipulation of crop varieties, thus permitting a reduction in insecticide use. Manufacturers also promise substantial savings in agrochemicals through the cultivation of crop varieties that are resistant to herbicides, since pre-emergence spraying could be dispensed with. In certain cultivated areas, a reduction in the application of herbicides or replacement of an environmentally harmful agent by a less harmful one might be conceivable. This would have to be examined for each individual case, however.

On the other hand, it cannot be ruled out that multiresistance will lead in future to wild, difficult-to-combat herbs and vegetation when varieties resistant to different herbicides cross, especially if they are able to cross with wild plants.

It is still uncertain whether a reduction in mineral fertilisers and concomitant environmental pressures can be achieved through the application of genetically generated biofertilisers (non-mineral fertilisers). Adverse effects on the environment may result if the modified bacteria are capable of symbiosis with wild plants that did not possess this ability before. Possible consequences of this at low-nutrient locations, e.g. dry turf, range from significant shifts in species composition to loss of sensitive species.

With regard to ethical aspects, the use of genetic engineering to attain certain breeding targets with domestic animals must also be assessed very critically. From the environmental perspective as well, genetically modified fish have to be viewed with great caution, since fish (e.g. salmon) frequently escape from the breeding ponds or tanks and may have major impacts on natural populations, e.g. on their mating or eating behaviour.

IV 3.3 Forecast trends in food transport*

Trends in goods transport, including the food production and distribution sector, have been forecast to the year 2010 in a large-scale study carried out by the German Institute for Economic Research (DIW). In a trend scenario the DIW assumes that the present transport policy will be essentially maintained at all levels concerned. Emergent and visible changes in relevant factors were taken into account. In this trend scenario, the most radical changes in relation to the past result from German unification, the completion of the European Single Market and the opening of markets in eastern Europe.

According to the trend forecast, the volume of transport connected with food production and distribution in the west German states will grow by 33% to 186.8 million tonnes by the year 2010 (total for Germany: 225 million tonnes). Long-distance road freight transport is developing with a growth rate of 46% and a volume share of 74%. Rail and inland shipping, on the other hand, will probably show relatively little growth, with the result that their share of the total transport volume will fall to around 10 to 15%.

The trend analysis also foresees an overall increase up to the year 2010 in the environmental pressure caused by food transport. The main factors behind this development are the large quantities transported, the longer distances and the growing share of road transport.

Due to this development, energy-saving and emission-reducing measures will be more than offset in many cases. However, this does not apply equally to all substances. CO_2 emissions, for example, will rise by about 50% while NO_x emissions will increase at a negligible rate. Nevertheless, the transport sector will probably develop even more rapidly into a major source of pollution as a consequence of food production and distribution.

Summary: Under the conditions of the business as usual scenario, considerable structural changes will take place in the agricultural sector by the year 2010. Given a lower total agricultural area in Germany, the number of farms will decline and the average farm size will increase. From an environmental point of view, food production and processing (including trade and transport) will by no means be compatible with the principle of sustainable development in the year 2010.

IV 4. Efficiency scenario: reductions in environmental pressure through technological improvements

In the following, an "efficiency scenario" is developed for the food production sector in accordance with the approach pursued throughout the report (see Section I 3.4). This "efficiency scenario" assumes considerable improvements in the technological efficiency of production processes and products. This leads to reduced environmental stress per unit of material and service produced. The scenario is based on the existing economic, legal and institutional framework and present-day ethical values. The

*Transport of products arising from food production and distribution. This includes agricultural products, food and semi-luxury foodstuffs, fooder and fertilisers.

environmental impacts of food production are assessed while assuming a technology-related leap in efficiency.

The characteristic feature of scenarios - namely their conception of possible futures - has an influence on the way they are articulated. Once the assumptions are described, trends within the scenario are described as if they were taking place in the present. Nothing is said about the probability of such trends actually occurring.

IV 4.1 Amelioration potential in agriculture

For the agricultural sector the "efficiency scenario" assumes that, given no changes in existing agricultural policy, agribusiness, legal and institutional conditions, all opportunities for improving the technological efficiency of production processes and operations will be exploited.

Reduction in pollution from fertilisers

The current state of scientific knowledge regarding efficient strategies for reducing pollution from fertilisers is already very comprehensive, but there are still major shortcomings regarding the translation of these measures into practice.

Table IV 1 below shows the potential of technical, organisational and regulatory measures as well as economic instruments in agriculture using the example of nitrogen, with specific data provided on the respective source-related reduction (based on NH_3, NO_3 or N_2O emissions), the reduction in pure nitrogen as well as the contribution to overall reductions.

The technological potential for reduction is quite substantial, particularly as far as storage and application of manure are concerned. Merely by observing the optimal time for manure application and working it into the field or deploying improved application techniques, for example, nitrogen emissions into the air can be reduced by around 10% in each case.

Under the conditions of the efficiency scenario, an annual reduction of 900,000 tonnes of nitrogen is possible by applying manure efficiently. The remaining nitrogen surplus, amounting to about 600,000 tonnes, stems entirely from liquid manure and organic wastes. Heavy metal loads (primarily cadmium) can be reduced by cutting back on the use of mineral fertilisers (especially phosphate fertilisers), which is made possible (and necessary) by the above changes. Changing the fodder variants used for pigs (less copper and zinc) enables the heavy metal load in manure to be lowered to a tenth of the present level.

Table IV 1: Nitrogen reduction potential of agriculture, by source (data base 1992)

Measures	Source-based reduction [%]	Pure N [kt/a]	Pure N 100% = 2,356 kt
Application and storage of farmyard manure (UBA/LAI, 1994):			
Time of application, weather			
Immediately worked into grassland, at least	35.0	99.8	4.2%
Area under cultivation, at least	50.0	142.5	6.0%
Application technique close to ground			

Drag hose technique	80.0	228.0	9.7%
Drag shoe technique			
Injection and slitting equipment	35.0	99.8	4.2%
Storage of farmyard manure: from	65.0	185.3	7.9%
(UBA/LAI, 1994) to	90.0	256.5	10.9%
More efficient production, storage and application of farmyard manure (Isermann, 1994)	75.0	85.5	3.6%
	98.0	111.7	4.7%
		271.0	11.5%
Shed and barn construction and technology (UBA/LAI, 1994) up to	50.0	57.0	2.4%
Feeding according to need and output:			
at least (UBA/LAI. 1994)	10.0	57.0	2.4%
maximally (Isermann, 1994)		108.0	4.6%
for cattle, maximally (LAI, 1993)	24.0	95.8	4.1%
for pigs, maximally (LAI, 1993)	40.0	54.4	2.3%
Land required for livestock farming (1):		90.0	3.8%
Reduction in livestock in accordance with sustainable animal production to 0.6 DE/ha (2) (currently 0.91 DE/ha, Isermann, 1994):	34.1	344.1	14.6%
Fertiliser charge on mineral N fertilisers depending on amount, location and type of farm: (Weinschenk, 1990) from	8.0	7.2	0.3%
to	36.0	32.4	1.4%
Nutrient charge on organic and mineral fertilisers: (Becker, 1992) from	22.3	98.1	4.2%
to	30.5	134.2	5.7%
Substitution of residual organic substances for mineral fertilisers (Isermann, 1994)		33.0	1.4%
Needs-oriented and balanced (50/50) animal and plant protein supply of the population with simultaneous reduction in agricultural exports (Isermann, 1994)		295.5	12.5%

Source: Lower Saxony Ministry of Environment, "Nitrogen reduction programme" 1996

Reduction in ammonia emissions (NH_3)

In the "Nitrogen 2000" Action Programme, a working group at the Bavarian State Ministry for Food, Agriculture and Forestry has described the potential for reducing ammonia emissions by the year 2000 using Bavaria as an example. The results of the study can be summarised as follows:

- Reduction of animal stocks: decline in dairy cow stocks by 0.3 million animals due to imposition of quotas in the regulations governing guaranteed milk quantities as well as increased output; decline in other cattle stocks by 0.4 million; the remaining animal stocks will decline by about 10%. This means that statistically an ammonia emission reduction of *25,000* tonnes per year can be expected.

- Funds are provided by the Bavarian Agricultural Credit Programme in order to promote environmentally sound, ground level application of liquid manure. The aim of the programme is to enable farmers to switch and/or modernise their application methods. An emission reduction of *14,000* tonnes per year is expected.

- Nutrient balance assessments for farms are carried out within the framework of the "Fertiliser consulting system for nitrogen". This measure will make it possible for farmers to detect errors in the overall balance and initiate environmentally sound remedial action. The savings in emission through nutrient assessment are estimated at *10,000* tonnes per year.

- Through new focal points for consultancy services, particularly with regard to shed and barn construction, basic fodder analyses and phase feeding in pig farming, additional emission reductions of *10,000* tonnes per year can be achieved.

- By covering the storage sites for liquid manure, ammonia emissions can be reduced by *5,000* tonnes per year.

Overall, in Bavaria ammonia emissions from agriculture could be reduced by 64,000 tonnes per year by the year 2000 through the sum of the individual measures and could thus be lowered by approximately half within a few years. In general these measures are applicable to other *Länder* as well. The proposals of the UMK's "Nitrogen reduction programme" working group (see Table IV 1) point in the same direction.

Reductions in the use of plant protection agents

Substantial reductions in the use of plant protection agents can be brought about using certain technologies . The use of herbicides can be reduced by up to 50% alone through more targeted application of plant protection agents on only part of the area on which maize and turnips are grown (so-called in-row spraying) (FIP, 1993). Further technological reduction potentials can be derived from the application of optically- and computer-controlled application technology. Biological and integrated methods (pollution threshold principle) can be improved and are to be implemented to a greater degree in the field. The reductions attainable through such measures are difficult to determine at present. An important point is that other active agents can involve different ecotoxicological impacts.

Reduction in water pollution

An array of measures for better environmental and water resource protection has been adopted by leading scientific research organisations in the field of agriculture and water management (Federation of Agricultural Research, German Association for Water Management and Cultivation, German Limnological Society, Water Chemistry Group). Extensive water protection calls for the following action:

- nation-wide monitoring of groundwater quality,

- lowering the nitrogen surplus in agriculture,

- reducing nutrient emissions from animal and plant production,

- erosion protection, e.g. through the creation of protective strips along river banks
- reducing the use of plant protection agents.

Furthermore, surface waters can be protected against plant protection agents by cleaning spray equipment in the field instead of in the farmyard to prevent the deposition of plant protection agents into the sewage system. Soil has the capacity to degrade all approved plant protection agents.

Under the conditions of the efficiency scenario and given optimal implementation, the aforementioned combination of measures is an adequate instrument, at least as a start, for alleviating major water problems in agriculture, particularly as far as nutrients are concerned, and hence for taking a significant step towards sustainability.

Enhancing energy efficiency and climate protection

Efficient and thus less environmentally harmful use of energy can be achieved in a variety of ways, ranging from the individual to the political level. Major factors in this context include restraining energy use, efficient use of energy carriers, redesigning production methods and charging higher prices for energy. Chapter II contains a detailed discussion of the objectives and strategies of sustainable energy

On the basis of the efficiency scenario assumptions, energy consumption in agriculture will be radically cut back by switching to extensive production methods in agriculture. Ecological farming - with 10 to 30% lower yields - saves substantial amounts of energy per hectare as compared to conventional farming (based in each case on farms operated full-time as primary source of income). Crop production using ecological farming techniques leads to energy savings per hectare of 66% compared to full-time farms that use conventional methods (Enquete Commission, 1994).

Fig. IV 3: Comparison of average energy use in conventional and organic farming, on the basis of yields

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Further energy savings as well as modifications to production methods that have adverse effects on the environment can be achieved through cutbacks in subsidies, such as lower costs of gas oil (reimbursement of 0.41 DM per litre of diesel fuel consumed in agriculture), and exemption from motor vehicle tax for agricultural vehicles. However, this would necessitate an EU-wide reduction in such subsidies in order to avoid competitive distortions. Moreover, the minimum tax rate for diesel fuel (currently 0.245 ECU/l) must be raised.

Considerable potential for CO_2 reductions lies in expanded use of energy from renewable energy sources in the agricultural sector. Other climate-forcing emissions (NH_4, NO_x , CH_4) can be reduced with a variety of measures, including improved storage of liquid manure, better feeding methods, especially for cattle, and cutting back nitrogen fertilisation.

Impacts on land use and species diversity

Given exploitation of all technical options for reduction of pollution in agriculture (technology-based leap in efficiency) and assuming constant demand and increasing land productivity, around 30% of the land currently used for agricultural purposes will no longer be required for food production in the year 2010. These areas would then be available for increased cultivation of domestic fodder, for afforestation as

well as for agrarian environment or nature conservation programmes. The greatest uncertainty factor in such considerations, however, is the future development of the world-wide demand for food.

Provided that all technical potential for reducing environmental stress stemming from agriculture is exploited, one can assume the following conditions for species protection in the year 2010:

- sufficient areas are available for an integrated biotope system,
- areas are used for the purpose of nature conservation and environmental protection in a planned and efficient manner,
- the immissions of undesired nutrients and pollutants are decisively reduced through technological measures and
- agriculture also takes on the tasks of landscape and biotope management within an (also economically) acceptable framework.

If these conditions are met, it will be possible to engage in extensive, though not large-scale, protection of species and biotopes. Whether species diversity can be maintained or even restored in stable minimal populations in this way remains uncertain. The conditions for such a development, however, would be significantly enhanced in comparison to the situation today.

IV 4.2 Amelioration potential in the food industry

Assuming that all technological opportunities for emission reduction are utilised in the food industry, substantial amelioration of the environment can be achieved. Strategies for avoiding and reducing emissions focus primarily on solving the following key problems:

- decentralised, on-site collection of wastewater as well as recovery of recyclable substances from partial flows using new technologies (membrane technology, reverse osmosis, etc.),
- changes in cleaning and disinfection methods through the use of biologically degradable substances, minimisation of quantities used,
- improved waste gas purification through further development of biofilter technology,
- development of new filtration methods to avoid accumulation of used filter materials,
- energy-saving measures and
- reduction in transport expenditure.

Emission reductions

With respect to the emission situation in the food industry, potential for amelioration of the environment exists in the following areas:

Wastewater

The food industry sectors of relevance to wastewater (e.g. breweries, meat-processing industry) will probably increase their share of wastewater still further until the year 2010. Despite rises in production, annual nitrogen and phosphorus load will not undergo any significant change up to the year 2010 as a result of the expected tightening of wastewater purification requirements, given the high elimination rates already achieved.

Another improvement in wastewater purification is conceivable through wastewater filtration, especially in smaller production sites. In this way the phosphorus content in wastewater could be reduced to 1 to 3%. Financial aspects will induce food-processing enterprises to lower water needs using recycling methods. Since this technology is already taken for granted in new plants, the potential for savings will presumably be exhausted within the next five years. Further reduction in the use of freshwater cannot be expected for this reason and because of hygiene standards.

Energy

Final energy consumption by the food industry is not expected to increase in the long term. The opportunities for savings in heating in the food and semi-luxury foodstuff sector are estimated at 20% of total fuel consumption. This corresponds to the energy savings aimed at by several segments of the food industry (such as the sugar industry) on the basis of voluntary agreements. For the entire food industry it is assumed that approximately 40% of these savings can be achieved by the year 2005. The potential for electricity savings is estimated at around 10%.

Energy-saving potential in the food industry is assumed to be in the order of 25 to 30%. In bakeries, for example, the baking oven consumes the most energy, accounting for 70% of total energy consumption. Through consistent installation of flue-gas traps, 20 to 30% of the energy used can be saved on average (Schildhauer, 1993). These potential savings contrast with the forecast of rising energy needs as a result of further specialisation of production.

An analysis of emissions in terms of what is technically feasible leads to the conclusion that environmentally relevant potential exists in connection with energy, where a reduction of around 25% could be attained. The savings potential with respect to material and energy flows is estimated at 15% for the entire food production industry (Enquete Commission, 1995).

IV 4.3 Technological improvements do not suffice

Technology-based efficiency improvements in production and processing can bring about considerable environmental benefits and represent an important contribution towards sustainable food production. Technological improvements could lead in Germany to the following effects:

- Pollution of soils and water by agriculture could be reduced. This applies to only a limited extent for intensive livestock farming and the pollution it causes, since low-cost treatment processes are not yet available for liquid manure
- Mechanical soil stress can be diminished.

- Achieving equilibrium between soil degradation and formation of new soil is probably not feasible.
- The 25% reduction target for energy consumption could be achieved by the food industry in all likelihood. If the switch is made from conventional to ecological farming to the requisite extent, the same target can be reached by consistently saving energy and expanding the use of renewable energy.
- Assuming a decline in area of agricultural land due to further technological advances, improvements could be effected for species and biotope protection through appropriate planning and suitable use of the areas that become available. Ecological monitoring of success is necessary, however.

At the same time, however, it must be kept in mind that the use of modern technology on the part of farmers requires a certain willingness to invest that depends on political and economic trends as well as on their economic situation. Furthermore, it is difficult to predict the impacts that the expected increase in food demand on the part of the newly industrialising countries will have on production systems and prices in the industrialised countries, and on the world market in general.

Many of the environmental pressures emanating from food production will continue to exist in any case. Moreover, the technological measures described above are not sufficient to achieve a contribution towards the target proposed for the industrialised states, i.e. an 80% reduction in CO_2 by the year 2050 (Enquete Commission, 1995). Additional changes in the direction of sustainable development, beyond mere increases in efficiency, are therefore necessary.

Technology-based improvements in efficiency have limitations that cannot be overcome without modifications to the existing economic, legal and social framework. Further emission reductions, resource savings and conservation improvements going beyond the aforementioned technical shifts require above all the willingness of society to undertake changes in familiar structures and values.

IV 5. Environmental improvements through structural transformation and awareness raising

In this last section, a "structural transformation and awareness raising scenario" is outlined for the food production sector in line with the approach pursued throughout the report (see Section I 3.4). Whereas the "efficiency scenario" dealt primarily with opportunities for enhancing sustainable development through technological changes, the "structural transformation and awareness raising scenario" raises the question as to what the future might look like if food production fundamentally accords with the sustainability principle. The assumption here is that a dynamic process embracing all segments of society powers progress towards sustainable development.

Assumptions for the "structural transformation and awareness raising" scenario:

Measures are implemented that aim at changing and developing the political and economic framework and social values in a fundamental way. Traditional economic, legal and administrative structures are adapted to the needs of sustainable development. Production and consumption patterns as well as attitudes and behavioural patterns change.

IV 5.1 Modifying the political and economic framework in which food is produced

Changes in the conditional framework must be so designed as to achieve a conformity of aims and coherence between environmental, agricultural, economic, energy and development policies . Sustainable food production requires an agricultural policy oriented to long-term environmental goals. To this extent, it is necessary to implement an environmental and social reform of agricultural policy at European and national level.

Such a reform not only encompasses fundamental changes in the areas of market, price, income and structural policy, but also has an impact on the responsibilities of various government departments. This report does not present comprehensive proposals for reform, but touches on some elements of a reform that we feel are important in order to point out possible developments.

Greening of EU agriculture policy

The agricultural sector represents the largest item (over 50%) in the EU budget. Through reallocations in the Guarantee Section of the European Agricultural Guidance and Guarantee Fund (EAGGF), particularly by means of changes in market organisation (grain, dairy and beef products) and price policy, with a stronger weighting of economic instruments, a long-term contribution is made to sustainable food production. Debureaucratisation of the agrarian sector and elimination of planned economy instruments ensure that agricultural budget funds reach the farmers with a high degree of efficiency.

Direct income transfers are granted only to farms that operate according to sustainability criteria (see section VII 3.3). Compensation payments are linked to assessable ecological and social criteria and to the providing of ecological services. Compliance with the criteria is monitored. Related activities are significantly intensified (currently around 2-3%) and ecologised to an even greater extent. Existing land set-aside measures are carried out in line with the interests of environmental protection and nature conservation. At the same time there is a gradual departure from the focus on agrarian exports.

Greening of national agricultural policy

Nature conservation is added as a new field of activity under the "Common Task: Improvement of Agrarian Structure and Coastal Protection" (GAK). The consulting and voting rights of the Environment Department in the planning committee on "Agrarian Structure and Coastal Protection" (PLANAK) leads to the disbursement of funds according to an allocation scheme specifically geared to ecological needs. Eco-friendly production methods, especially organic farming, are given greater support both for production and marketing. A standardised label for organic farming products proves very effective here. Targeted advisory and information services for consumers contribute to healthy

nutrition. Special importance is attached to the promotion of regional food production and measures for strengthening rural regions.

Economic incentive systems

Agricultural policy committed to environmental protection and nature conservation gradually dismantles all incentives for intensive agriculture, as well as allowances and tax exemptions besides those necessary for social reasons. The gas oil allowance or a tax exemption for commercial vehicles fundamentally conflict with the requirements for sustainable food production. The additional funds that are freed up in this way are redirected in support of appropriate ecological activities, such as support for organic farming, or are invested in other resource-preserving activities with long term impacts (e.g. erosion protection measures). Ecological services actively provided by agriculture are rewarded (compensation for quality instead of quantity). Organic farming products are exempt from value added tax.

Assessment and monetarisation of the externalities of food production

Taxing the consumption of non-renewable energy and resources, in particular CO_2, as well as a charge on nitrogen (see Section VII 3.5) at European and national level reduces environmental pressures to a considerable extent. An energy tax and an oil tax, or the imposition of minimum EU CO_2/energy tax rates, has far-reaching structural impacts. Transport in general is reduced because of higher costs, fertiliser and fodder imports are less favourable in monetary terms, while domestic cultivation of fodder crops is promoted. Overall, these measures foster regional orientation and have a positive effect (as environmental amelioration) on regional production structures and types of farming.

Regionalisation of agriculture and markets for agricultural produce

The development of regional supply concepts is a major contributory factor enabling, for example, the avoidance of food transport, the consideration of regional nature protection requirements and the advancement of rural areas. Promotion of local and regional marketing concepts as well as the maintenance and re-establishment of processing and storage facilities (such as cooperatively used facilities for slaughtering, cooling and refrigeration) enable a high level of locally adapted management of the respective economic region and reduces, in combination with a higher fuel tax, the transport and flow of goods.

Elimination of trade barriers and export-centred production

The conditional framework governing the international food trade is restructured (‘Greening the GATT’, implementation of minimum environmental and social standards in world trade). Trade distortions due to subsidised exports will be eliminated through regionalisation, more expensive transport and fair trade agreements. Access to our markets will be provided for products from less developed countries (predominantly pre-processed products or foodstuffs rather than just fodder), although they represent unwelcome competition for domestic products. However, this is an important contribution to the self-development of less developed countries - in contrast to external aid. Consideration must be given in this context to whether the related flows of goods lead to environmental stress, e.g. to enormous external costs in freight transport.

Creation of a multilateral framework convention on global food security

Germany, as a country exporting agricultural produce, is actively involved in creating such a convention through the EU and is committed to a policy of dispensing with agricultural export subsidies and refraining from dumping practices. Germany makes a financial contribution to a world-wide system of decentralised food reserves. This type of worldwide cooperation is linked to effective mutual agreements to promote a policy of self-sufficiency in the less developed countries (food security strategy). Debt relief for these countries is imperative for such efforts.

IV 5.2 Changing the social framework

Changing the conditional framework for food production necessitates awareness raising in politics and the public. In view of the enormous influence of major interest groups and the still dominant demands on agricultural policy (mass production, low food prices, income security for farmers, etc.), the required awareness raising process will certainly take some time. The road to sustainable development, however, will make it easier for food production, as for other sectors, to mitigate the hardships associated with delayed adjustment and lead to increased acceptance of sustainable changes.

Changing nutritional patterns

Around 80% of crop production in Germany today is used as fodder for meat production and in the dairy industry. Animal products represent only about 15% of the nutrient and energy content contained in the plant fodder fed to the animals. This means that approximately 65% of the total crop production is consumed through the metabolism of livestock used for meat and dairy production. Reducing the national consumption of meat offers a very efficient way of cutting back on intensive agriculture, thus diminishing the nitrogen surplus (along with the consequences described above: high nitrate content in groundwater, excessive nutrient concentrations in waterbodies, forests and nature reserves, acidification) and water pollution due to plant protection agents. Intensive livestock farming, which in itself is a completely inappropriate way to keep these animals and which leads to concentrations of liquid manure that are far too high to be absorbed regionally, can also be restricted. One result is that that fodder imports and their adverse impacts on the environment are avoided.

In a scenario described by Bechmann (1992), appropriate changes are made not only by consumers but also by producers. Meat consumption falls by a third to about 40 kg as opposed to the average 60 kg per capita and year consumed nowadays. Milk consumption is reduced to around 315 litres, down from the present figure of 360 litres per capita and year, while per capita egg consumption falls from 11.5 kg per annum today to approx. 9 kg. This means that a complete switch to organic farming is possible in German agriculture. Since subsidies are restructured at the same time, prices can remain relatively constant (Bechmann, Meier-Schaidnagel & Rühling, 1992).

Adaptation in the food industry

In the “structural transformation and awareness raising” scenario, modern methods such as recovery of thermal energy and avoidance of diffuse heat loss through process refinement are applied throughout the food industry, and the processing intensity of agricultural resources is reduced. This results in energy savings of 30 to 40% in heat and power.

Furthermore, food production and processing are geared to supplying the regional population while minimising transport expenditure through a closer geographical links between agricultural production, further processing and consumption. This avoids excessive food transport from the farm to the slaughterhouse, from there to the factory and finally to supermarket shelves that may be located in larger consumer centres outside the cities (see also Chapter III).

Product developments are more in line with the (altered!) needs of the population (see also Chapter VI) and with the environmental relevance of production, for which moderately higher prices can be obtained on the market. Certain process materials which have serious effects on the environment are replaced by other materials (e.g. replacement of diatomite filtration by membrane filtration), environmentally harmful technologies are modified (e.g. drying of sugar beet pulp through steam drying), or new products are developed (e.g. foodstuffs requiring little preparation, thus saving energy).

Through minimal use of cleaning agents and disinfectants containing chlorine in production, wastewater treatment has a less negative impact on the environment for the same capacity level. This is achieved with modern methods for managing material flows, which in turn involves cooperation between the chemical and the food industry.

Further development of the legal framework

The legal framework is an expression of values in society. Structural transformation and awareness raising for sustainable food production necessitates extensive revision of the present legal framework (see also Section VII 1), because the currently valid regulations governing food production are based only in part on recycling. However, sustainable food production can hardly do without. The new Closed Substance Cycle and Waste Management Act can be regarded as a step in the right direction, and one that must be further developed.

The current system of environmental law does not pursue an integrated approach on the whole. The "structural transformation and awareness raising" scenario presupposes that an Environment Code will be established on the basis of a integrated, "trans-media" approach. Agriculture's privileges in the Federal Nature Conservation Act no longer apply. The scenario also envisages the following regulations being adopted:

a) Federal Water Act (WHG)

In order to provide those concerned and the law enforcement authorities with more manageable criteria for monitoring activities that pose a threat to water, the Federal Water Act is amended. Criteria for the use of water resources in agriculture, which require permits in certain cases, are stipulated in a regulation or incorporated directly into the Federal Water Act.

A clearly formulated requirement for obtaining permission for the use of fertilisers and plant protection agents can be provided for

- farms with a fertiliser surplus, i.e. more than 1.5 fertiliser units per hectare of agricultural land,
- certain intensive crops (maize, hops, wine, field vegetables, fruit),

- sites with permeable, shallow soils,
- sites with little spacing between arable land and waterbodies,
- site with sloping terrain.

More catchment areas should be allocated to water production plants. To ensure enforcement at least on a sampling basis, keeping of a field file is required for the areas concerned. In addition, investigation and remediation areas (where relevant) are established to monitor nitrate and plant protection agent concentrations.

b) Plant Protection Act (PflSchG)

In this scenario existing environmentally sound alternatives to pest control are included and stipulated in the approval procedure. A more realistic assessment of the impacts of plant protection agents is achieved by incorporating improper application in the approval procedure. The use of plant protection agents outside the areas of application designated in the approval is prohibited.

c) Federal Soil Protection Act (BodSchG)

The scenario assumes enactment of a Soil Protection Act which makes the precautionary principle a binding requirement, also for agricultural soil use according to good expert practice. This entails that soil loss, soil compaction and reductions in humus content are avoided as far as possible, and that the biological activity of the soil as well as a favourable soil structure are preserved and supported. The requirements formulated in the Soil Protection Act are based on the resolutions of the Conference of Agriculture Ministers.

d) EC Environmental Audit Regulation

As a result of the Environmental Audit Regulation, voluntary environmental impact assessment and certification of environmental management systems have been introduced for enterprises. In this scenario, farmers can also participate in the environmental audit scheme. This enables experience in the prevention of environmental stress to be acquired and disseminated.

IV 5.3 No sustainable food production without structural transformation and awareness raising

The economic and trade conditions that have prevailed in Germany and elsewhere for several decades have led to extreme polarisation in the world. The overabundance and waste of the affluent, predominantly in the industrialised nations, contrast with hunger and poverty in large sections of the world. Our agricultural, environmental, energy, economic and development policies of the past decades as well as the growth in global food trade have not led to any decisive improvements in either the environmental situation or the world food situation.

The problem of how to feed the world population is aggravated not only by political and social trends (urbanisation, population growth), but above all by environmental degradation (increasing loss of soil fertility, desertification, loss of genetic diversity, etc.). The Food and Agriculture Organisation of the

United Nations (FAO) along with various research bodies predict bottlenecks in the global food supply by the year 2020 at the latest, due mainly to lack of supply as well as distribution problems. To this extent there is a substantial need for action.

Feeding a growing world population can be secured on a long-term basis only through sustainable forms of land management on both a national and a global scale. Food must be predominantly produced where it is needed. Sustainable food production must be linked to sustainable consumption (see Chapter VI), particularly in the industrialised nations. Sustainable forms of production and consumption require structural transformation and awareness raising among all actors involved. Sustainability requires a change in values on the part of society because sustainable food production stands for more than cheap mass production. The cornerstones of a sustainable style of consumption include regional orientation, preservation, quality rather than quantity, durability and recyclability (Wuppertal Institute, 1995).

Education and communication are essential instruments on the consumer side for structural transformation and awareness raising. On the basis of environmentally aware buying decisions, the consumer determines which forms of land management will prevail in the long run. This necessitates a willingness to pay somewhat higher food prices for ecological farming products.

In Germany, a 4-person household spent 45% of its income on food in 1950, while the figure for 1995 was only around 15%, slightly more than what people spend on their cars on average. Viewed in this light, a moderate increase in the proportion of total expenses accounted for by food is acceptable.

With structural transformation and awareness raising, changes take place in the price structure for food as well as in consumer behaviour, including solidarity with the less developed countries. Sustainable life and consumption styles prevail. In addition to the technology-based efficiency improvements described in Section IV 4, the following development options emerge:

- Agricultural markets undergo regionalisation. This improves the economic situation of (regional) agriculture, alleviates transport problems and reduces greenhouse gas emissions.

- Food produced on an environmentally sound basis have better market prospects. Organic farming expands. Ecological services provided by farmers are valued and rewarded.

- Through reduced consumption of meat (as a result of higher prices, for example) and hence of animal processing, water resources are effectively protected and greenhouse gases are further reduced. Livestock farming is not mass production, but takes place on the land in ways appropriate to the specific breeds.

- The trend towards (energy-intensive) highly processed products is reversed. Greater importance is attached to fresh, unprocessed food.

In general, the development indicated here can only be brought about through changes in economic and social structures, which will certainly lead to resistance on the part of the actors affected (including retail and wholesale trade, enterprises in the food industry). Without these changes, however, it is not possible to achieve sustainable food production. Unless such changes are carried through, the pressure to adapt will mount and sooner or later force more drastic changes in our food production. Put another way: anyone who rejects the changes implied here contributes to further aggravation of the current

pressure imposed by problems in the food sector, and thus to an even more radical need for adjustment because the opportunity has been missed.

V Material Flow Management and Sustainability - the Case of Textiles

V 1. Necessity and objectives of material flow management

Reduction of mass flows

Most environmental problems, present and future, are no longer the result of specific pollutants or interference, but are caused by the way and the extent to which humankind uses nature. Parallel to successes in combating point source pollution, we are now witnessing growing environmental pressures from diffuse sources. Since all pollution is ultimately generated by the exploitation of material and energy resources and by the emissions and wastes that sooner or later result, reduction of mass flows is imperative.

Reducing mass flows is essential for sustainable development. Rapid exhaustion of scarce, non-renewable raw materials puts constraints on the development opportunities of future generations and thus violates the principle of intergenerational equity implied by sustainability for as long as substitutes do not exist or are not forthcoming.

Fig. V 1: Anthropogenic material flows and nature

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The availability of many raw materials declines as exploitation continues. This deteriorating situation not only burdens coming generations by making extraction costlier, but also (after reaching a technical optimum) generally creates growing environmental degradation per unit of resource (e.g. per tonne of coal, oil or copper). The more rapidly the copper concentration of copper ore declines, for example, the more overburden and slag are generated in the extraction of a unit measure of copper and the more energy and process materials are consumed. Over the past hundred years, the metal content of mined copper ore has fallen by a factor of around 10, from approximately 5% to about 0.5%. Moreover, sources of raw material, such as gravel pits for the building industry, are found less and less near the centres of demand. The consequences are increasing transport demand along with mounting environmental stress.

Therefore, even if certain mass materials (coal, oil, metals, etc.) are consumed at a constant level, pollution will continue to mount. Therefore, the only way to avoid overtaxing the carrying capacity of the environment is for economies to reduce mass flows.

Product information on environmental stress

In the previous chapters, it was shown that achievement of sustainable food production, mobility or energy use requires considerable endeavours to reduce the material and energy flows associated with these activities. Special efforts and methodical approaches are imperative to deal with the issue of sustainability in the production and use of complex products, such as textiles, furniture or electronic

equipment. The buyer (and the seller) of a wool pullover usually does not know whether the sheep at the beginning of the life cycle made a valuable contribution to conservation of a cultivated area in ecological terms or whether it contributed to soil degradation by overgrazing a sensitive ecosystem. In addition, the buyer/seller does not know whether the wool was treated with harmful chemicals, whether production wastewater was discharged into a waterbody in a purified or untreated state, whether potentially harmful dyes were used, whether the production processes were energy-intensive, or how much transportation was required in the production chain. The situation is even more complex when comparing the environmental impacts of products derived from different primary materials, such as wool or synthetic fibres. Yet these are precisely the questions increasingly being asked by environmentally conscious consumers. Retailers respond by demanding information from their suppliers on the environmentally relevant properties of products and by including a greater proportion of environmentally sound articles in their assortment wherever possible. Any attempt to find out and identify what the environmentally compatible alternatives really are and to indicate this accordingly - e.g. through ecolabelling (see Section VI 5.3) - involves major problems.

Only adequate knowledge of the entire product life-cycle, from extraction or primary production of raw materials through manufacturing and use phase to disposal/recovery, can provide the necessary insight into the extent and the ways in which the environment is strained. The substances contained in a product usually comprise only a few percent of the total mass moved and consumed for production and supply of the product. In addition to quantitative aspects of the consumption of material and energy resources and the release of mass pollutants, it is also necessary to consider the qualitative aspects of pollution as they relate to the specific product groups involved.

Materials control policy and material flow management

Knowing about the degree of environmental interference involved in the production and use of products, e.g. in the form of life cycle analyses, is not a sufficient basis for establishing which alternatives will lead to more environmentally sound achievement of the desired function or to satisfaction of underlying needs. In many cases, these alternatives must be created through optimisation processes encompassing several stages of production and use. What is needed are innovations by the players involved and the exertion of political pressure. These are the tasks of materials control policy or *material flow management.*

For the Enquete Commission of the German Bundestag on “Protection of Humanity and the Environment”, materials control policy refers to a policy “that embraces all political measures taken to influence the manner and extent to which materials are supplied and consumed, as well as waste treatment and storage, with the aim of securing the material base for industry on a long-term basis, keeping in mind the limited resources and restricted carrying capacity of environmental media”. (Enquete Commission, 1994c)

If materials control policy is to achieve its aims, then material flows or material systems must be shaped in a target-oriented, responsible, holistic and efficient manner. Such an approach is called *material flow management* and embraces not only ecological aspects, but also economic and social considerations.

The key features of material flow management are:

- a systematic and holistic analysis of material and energy flows “from the cradle to the grave” and

- a focus on the actors involved in product life cycles. These actors themselves should identify and use potentials for ecological improvement.

The reference system for material flow management is the chain of actors involved in the life cycle of a product from production to final disposal. The new approach to material flow management, which analyses product life cycles both in terms of environmental impacts and actors, is expressed in simplified form in the term “chain”. The “textile chain” encompasses all stages of production from primary fibre production to garment manufacture, use and disposal/recovery of textiles. This means we look at the material flows and environmental degradation at all stages from extraction of raw materials to disposal. Another focus concerns the actors and stakeholders involved in the value-added chain.

The differentiated analysis in this report on textiles/clothing as an area of basic human need provides a good example of the tasks and starting points of a material flow management geared to sustainability, to the extent that in this sector large-scale consumption of resources is coupled with specific impacts on the environment or human health, resulting inter alia from the use of numerous substances and processes at different stages in the product life cycle.

Fig V 2: Cognition of material flow management

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V 2. Material flow management as a strategic concept

The massive quantitative increase in and qualitative problems induced by the exchanges of substances and energy are totally unsustainable for the environment and the protection of resources. The concept of material flow management is aimed at systematic analysis of environmental aspects of economic activities. It is based on the realisation that the production methods deployed in the industrialised nations are not sustainable in respect of resource consumption, emissions and waste volume, and that they can be characterised as part of a “throughput economy”.

Mistaken assumptions of the throughput economy

Economic and technical development to date has been based on two basic assumptions of economic theory that are now seen to be inaccurate:

- Nature is an inexhaustible source of raw materials.

- Nature has an unlimited assimilation capacity.

For a long time, these basic assumptions matched people’s practical experience. The materials necessary for life had to be “wrested” from a natural world that was overpowering and hostile. It was not until the advent of industrialisation that use of the environment as a source and sink for anthropogenic material and energy flows took on such proportions that the limits to the carrying capacity of natural

systems were reached on a global scale. Today we see that these limits have already been exceeded in some areas.

The basic presumption that nature has unlimited resources and carrying capacity is tantamount to assuming an inexhaustible stock of natural capital. This explains why, until recently, the exploitation of nature as a production factor was given inadequate consideration in economic theory.

The limits of nature

Sustainable development, in contrast, states that exploitation of nature as the only material base of production is only possible in the long run if fundamental rules, such as those already pointed out in Section I 1.3, are complied with. The usable quantity of renewable resources depends on the productivity of natural systems, such as soils, waterbodies, ecosystems, etc., which can only be raised to a limited extent. Short-term productivity gains may only be attained at the expense of long-term preservation of the natural functions of these systems and is thus incompatible with the principle of sustainability. There are therefore absolute limits to the availability of both renewable and non-renewable resources.

As stated at the beginning of this chapter, the call not to worsen the material base of production for future generations is not the only argument against further uninhibited extraction of non-renewable resources. Another reason why consumption of such resources must be cut back substantially relates to the declining quality of raw materials and the concomitant rise in environmental stress per unit of resource. The precept of sustainability which requires that the release of substances accord with the carrying capacity of the environment in terms of quantity and time scale can be complied with only through substantial reductions in mass flows and controlled use of hazardous substances in production, use and recovery.

These requirements necessitate radical changes in the way that material and energy exchange between people and nature are understood. The aim of material flow management as a strategic concept is to translate these changes into practical activities.

V 2.1 Holistic analysis of material flows and relationships of actors

The actual volume of material flows associated with the production and use of products usually remains hidden from the eyes of the individual since he or she, as a producer or consumer, comes into contact with only few of the many stages in the - often global - life cycle of the various substances and products.

Eco-balances and product-line analyses are suitable methods for determining the material and energy inputs and outputs involved in the manufacture and use of products within defined systemic boundaries and for describing the pressures they impose on the environment. They enable environmentally sensible enterprises and consumers to compare products and, for the producers, to identify weak points in manufacturing. At the company level, material and energy balances obtained within the framework of environmental audits serve as an important information base for material flow management. They should be supplemented industry-wide by substance-related, sectoral or regional material flow analyses.

The terms product *line* analysis and material *flow* analysis suggest that the analysis involves a linear sequence of steps in the production and use process. This understanding is correct only at first glance,

however. In reality, material flows in the economic process form a branched network. In the textile/clothing sector, the sequence of steps from fibre production through manufacture to recovery/disposal of textiles can be designated as the "textile chain". This chain is linked in manifold ways to "secondary chains", which encompass the various steps involved in manufacturing the fertilisers and pesticides used in producing natural fibres, the auxiliary chemicals and dyestuffs for textile finishing or the detergents for textile care (Fig. V 3).

Information about certain parts of highly complex, networked material flows is needed for material flow management. To reduce complexity to the relevant areas, it is first necessary to focus on realistic options. The description and ecological assessment of material flows should therefore be supplemented at an early stage with an analysis of economic conditions and the relationships between actors.

Fig. V 3: Main chain and secondary chains of the textile production chain

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Source: Enquete Commission, 1994 c

Informational barriers impeding the development of less polluting products or processes often arise when the requisite knowledge about substances that is necessary for environmental improvements is not coupled with the knowledge required for market performance. The purpose of economic analysis is to determine the product and production costs of alternative solutions. An analysis of the actor chain covers the economic and informational relations and barriers between the respective actors, forms of cooperation and conflict, and derives from the opportunities for and possible constraints on material flow management within a specific sector (de Man, 1994). Which actor in material flow management performs which task and what information he or she needs for that purpose must be defined precisely.

V 2.2 Assessment standards for material flow management

To assess the sustainability of production methods, products or lifestyles and the related material flows, it is necessary to define standards that indicate whether or not certain material flows conform to the management rules for sustainability and the basic rules of a materials control policy developed from the latter. It is not possible to translate these rules into quantitative data without intermediate steps. Environmental policy objectives and a consolidated environmental policy concept are crucially important in this context.

Environmental quality targets and environmental action targets

Consistent and agreed on environmental quality and policy action targets are imperative for the ecological assessment on which material flow management is based, and particularly for defining the specific activities and reduction targets for the individual players. The current discussion on environmental quality and policy action targets is closely linked to the material flow concept.

Environmental quality targets specify requirements for the state of the environment, and for environmental media areas. They define limits for the impacts occurring at the end of harmful material flows.

The need for action thus formulated, for example in the form of target concentrations (mg/m^3), is inoperable in most cases. It first has to be translated for the specific factor that has to be changed, with maximum detail regarding the actual polluters involved.

Environmental action targets specify the reductions in specific factors (e.g. volume of emissions) that are necessary and adequate to achieve a desired state. They refer to the pressures caused by certain activities or driving forces, which impact in different combinations depending on the specific context. In this way, this are closely linked to environmental quality targets (Section VII 5.5). Environmental action targets take the form of "pollution reduction targets" and their objective is usually to mitigate harmful material flows as close as possible to the point of origin. On the basis of these environmental quality and policy action targets as well as knowledge about the material flows between actors/activities and the location of specific impacts (material flow analyses), response strategies for avoiding environmental pressures can be developed.

The assessment steps and procedures within material flow management must be adapted to the specific assessment tasks on the basis of standard basic requirements and principles to ensure that set goals are feasible, affordable and enjoy majority acceptance. A pragmatic procedure of this kind may borrow from existing assessment approaches used in connection with environmental management and environmental controlling, eco-balances or eco-labelling.

Participation by affected interest groups is very important when integrating economic criteria and social aspects into material flow management. Only thus can material flow management address the relevant actors and their roles.

In many areas of current practice there is already clarity about the action and approaches that are needed. This need for action exists regardless of whether or how the open issues regarding suitable assessment standards and procedures have been resolved.

V 2.3 Material flow management and alliances for environmental innovation

Sustainable material flows can only be achieved by integrating the environmental dimension into economic activities and through fundamental rethinking on the part of *all* economic players - namely enterprises, consumers and the state. This process of rethinking and changing behavioural patterns is difficult and involves a long learning process.

Initiatives within industry

The responsibility of enterprises for sustainable development was described at international level by the International Chamber of Commerce (ICC) at the Second World Industry Conference on Environmental Management (WICEM II) in April 1991. In the "Charter for Sustainable Development" adopted there, environmental protection is defined as a task having high priority in every enterprise.

The EC Regulation on environmental audits specifies the requirements which must be met in EU Member States when certifying environmental management systems. Companies participating in the scheme must formulate environmental objectives that go beyond compliance with existing environmental laws. Frequently such objectives cannot be met within a company's immediate sphere of influence. For example, some German clothing enterprises have the stated aim of reducing or even avoiding

adverse environmental impacts in all stages of the textile product life cycle. These goals can only be achieved on the basis of information and knowledge that are solely obtainable within the "textile chain" itself. This implies the existence of key interfaces between environmental auditing and material flow management. These interfaces must be studied in detail, and the actors that are vertically linked in the product chain must be shown how to combine the instrument of environmental auditing with a form of material flow management involving special alliances for ecological innovation.

Cooperation between enterprises

At present there is still a lack of institutions for environmentally oriented vertical cooperation between enterprises, i.e. cooperation between suppliers, producers, users and waste disposers. Tried and tested forms of organisation and appropriate forms of institutionalisation do not exist. Since material flow management generally requires that actors be brought together in vertical constellations that do not correspond to the usual horizontal structures of communication and cooperation and which are characterised by heterogeneous interests (differing allocation of expenses or profits), professional organisation of the cooperation process is necessary, e.g. through the intervention of a neutral mediator. Mediation offers a suitable and reliable procedure for such cases. The function of the mediator is to provide for balanced participation on the part of the actors and groups concerned, as well as to develop, consolidate and support cooperative working methods.

The traditional horizontal organisation of enterprises into sectoral associations is helpful for ecological innovations only to a limited extent (e.g. with respect to standardisation). As examples repeatedly demonstrate, this type of organisation may even have an inhibiting effect. The reason is that sectoral organisations tend to block advances in environmental protection in the misinterpreted interest of some of their members - behaviour that has been criticised time and again.

Forms of cooperation along the value-added chain suitable for sustainable material flow management are still relatively undeveloped. The cooperations that have been observed in the textile/clothing sector as well as proposals for new forms of cooperation are dealt with later in this chapter in the structural transformation and awareness raising scenario. The general objective of new forms of cooperation geared to material flow management is to overcome the obstacles generated by the market - its information barriers - through self-organisation by the actors.

The prerequisites and conditional framework for cooperative action

Participation of actors in cooperative approaches is the conditio sine qua non for material flow management. Readiness to enter into such cooperation cannot be assumed as given. Since cooperative efforts initially involve the deployment of additional financial and human resources, one cannot presume that joint endeavours to achieve ecological efficiency in a product life cycle will be undertaken by the actors merely on the grounds of growing environmental awareness. What is needed, instead, is external motivation. Such motivation may take the form of economic incentives, sanctions or the threat of sanctions. Both the public (press, consumer organisations and the like) and state institutions have important functions to perform in this connection.

The state plays a key role here. In particular, it has the following tasks:

- first, to define the environmental quality and environmental action targets to be generally pursued on the road to sustainability. The specific goals of material flow management must

address these principal policy objectives. Both the objectives and the specific action targets have to be discussed with all interest groups and defined on the basis of consensus, since otherwise the element of individual responsibility will not become an integral part of material flow management.

- second, to help overcome information gaps and barriers. Specifically, it should ensure or at least see that knowledge about "substances" and "markets" are combined appropriately.

- third, to acquire knowledge on environmentally weak points in production life cycles and pass it on to the actors involved.

- fourth, to be aware of the options for and obstacles to action on the part of the actors involved, to be in a position to support the organisation of cooperative set-ups.

- fifth, to define the legal, economic and social framework for material flow management. State agencies still have a significant need for concrete experience. Two aspects have an adverse impact in this connection: on the one hand, material flow management is an issue that always cuts across government departments and can therefore fall foul of the constraints on departmental responsibility. On the other hand, flexibility is of the essence. Even as far as the idea itself is concerned, there are (still) no general rules and regulations for implementing material flow management. There are many indications that legal regulations are dependent on contexts, i.e. on the conditions of material flow management in specific cases. They will have to be tailored to these conditions, not the other way around.

Limited interventions are not enough

Existing regulations provide an important framework for the minimum standards to be met by any system of material flow management. However, a comprehensive system of material flow management can create links between discrete areas of traditional environmental law, thus enabling greater efficiency in meeting the statutory requirements applying to particular substances or processes. As the analysis in this chapter of the material flows of the textile chain shows, isolated regulations and laws are not sufficient to achieve sustainability. What is more, any such approach which focuses on specific cases only shows a failure to recognise and exploit the major potential that exists for optimising the protection of resources and reducing pollution.

Legal regulations are essential when goals are not achieved through voluntary activities. The threat of statutory regulations being implemented if material flow management is not operated or does not produce satisfactory results is a major incentive for players to become active before the state does. Protective legislation is also necessary to ward off any competitive disadvantages that companies implementing environmental improvements may suffer. Indirect instruments for controlling behaviour, e.g. in the form of environmental charges, etc., help to ameliorate the cost situation for environmentally sound solutions (see Section VII 3).

V 2.4 Material flow management and international relations

Because of the transboundary nature of material and merchandise flows, issues of international environmental and development policy must also be taken into account in a material flow management concept. Since the Rio Conference, there has been a new understanding of development: instead of adaptation to the standards of the industrialised countries, focus should be placed on effective deployment of

resources within the specific country and on the environmental dimension. The industrialised states are called on here to provide assistance (financial, organisational, advisory). Transfer of environmental technologies was one of the central aspects of the UNCED's work programme, which provided for an examination of how material flow management methods can be made accessible to less developed and newly industrialising countries in the framework of technology and strategy transfer after relevant practical experience has been gained.

In the following, the major problem areas and the need for action in the textile/clothing sector will be treated first. The efficiency scenario in Section V 4 will then describe the potential for enhancing material and energy efficiency and avoiding pollution in the areas of fibre production, process engineering and emission reduction technology. The discussion of the structural transformation and awareness raising scenario will deal with the contribution that can be made by material flow management to actually tap this potential. This includes, in particular, an analysis of the role of consumers and how their behaviour can be influenced, as well as the ways in which they can contribute to sustainable development in this sector by changing their consumption patterns (see also Chap. VI).

V 3. Material flows in the textile sector

V 3.1 Textiles and sustainability

Clothing is a basic need, not only for protection against external elements such as cold or wetness, but also for a cultural desire to adorn and present oneself in a certain way. Industrial mass production has made textiles readily available, and their consumption rises with increasing affluence, although subject to economic fluctuations.

At the same time, textiles are relatively short-lived consumer goods nowadays. Their production and use involve high levels of material throughput and energy consumption. Specific environmental pressures are engendered due to the large quantities of harmful auxiliaries and dyes used in the production of raw material fibres as well as in textile processing and finishing. Activities aimed at sustainability must therefore ensure that the need for clothing can be satisfied in a more environmentally sound manner in future, in both quantitative and qualitative terms.

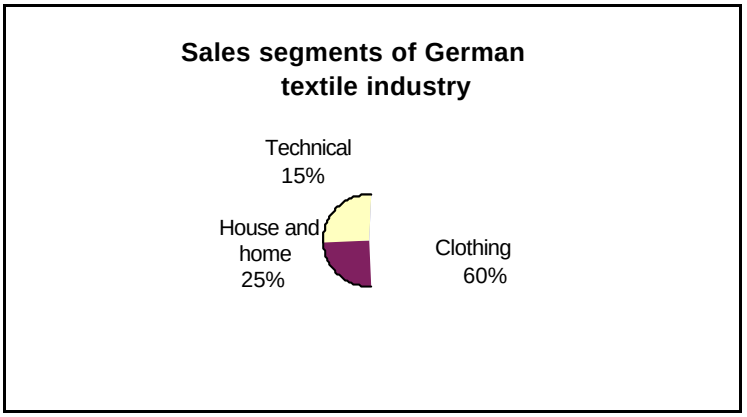
The individual consumer is scarcely aware of the extent to which the environment is polluted through the production, use and disposal of textiles. The reasons for this include the increasing internationalisation of the various stages of manufacturing, combined with growing worldwide trade in semi-finished and finished textile products, the participation of numerous actors in different countries as well as the complexity of the products themselves. In view of this complexity of material flows and actors, and the growing interest among consumers and the textile trade in environmentally sound products, material flow management would appear to be an appropriate strategy for developing innovative, environmentally sound products in the textile sector.

Economic frameworks and interdependencies in international trade

Textiles are primarily used to manufacture clothing (Fig. V 4). Other classical products are household textiles (e.g. towels, bed and table linen) and home textiles (e.g. curtains, carpets, furniture and decorative fabrics). Although "technical textiles" have recently been used to an increasing degree in very dif-

ferent areas of application (e.g. car seat covers, tarpaulins, belts or tyre fabric), their share of total textile production is still relatively low. Due to their special applications, they will have to be examined separately elsewhere.

Fig. V 4



Source: Cognis, 1994, modified

Although Germany is one of the world's largest exporters of textiles (see Table V 1), 80 to 85% of the clothing sold there is produced abroad. Particularly the (wage-intensive) manufacture of ready-made garments is carried out in low-wage countries while the proportion of goods processed in Germany is significantly higher, i.e. an estimated 30 to 40%.

Table V 1: The top trading countries on the world textile market* 1994 (figures in million US dollars)

Export			**Import**		
1.	PR China	35 550	1.	USA	39 118
2.	Hong Kong	33 948	2.	Germany	33 205
3.	Italy	23 354	3.	Hong Kong	27 751
4.	Germany	19 227	4.	Japan	20 389
5.	South Korea	16 345	5.	France	15 776
6.	USA	15 967	6.	Great Britain	14 201
7.	Taiwan	13 709	7.	PR China	9 969
8.	France	11 232	8.	Italy	9 566
9.	Belgium/Lux.	9 312	9.	Netherlands	8 674
10.	Great Britain	8 494	10.	Belgium/Lux.	7 668

*textiles and clothing

Source: Gesamttextil e.V., 1996, modified

About half of the clothing imports come from Member States of the European Union, the other half from further afield. Several newly industrialising countries have built up textile industries in recent dec-

ades and acquired substantial market shares in Germany, primarily through the cost advantages they enjoy in the form of lower wages and, in some cases, less stringent environmental legislation.

The Multi-Fibre Agreement (MFA), which enables the allocation of textile import quotas on a bilateral contractual basis, was concluded in the framework of the GATT/WTO agreement in order to avoid market imbalances. This agreement expires on a step-by-step basis over a ten-year period, beginning in 1995. As a result, the German textile industry is currently undergoing a difficult process of structural adjustment to an open world market. In 1992 Germany's foreign trade balance for textile and clothing products already showed an import surplus of DM 22.3 billion.

Figures on the worldwide production of textiles are not available since production statistics are kept in different units of measure (area and weight units as well as numbers of pieces). In the last few years, some 40 to 42 million t of raw fibre material were processed into textiles worldwide. Average clothing consumption is estimated at 5 to 7 kg per capita of the world population; however, the figure varies greatly between individual countries since there is a close link between the population's disposable income and consumption.

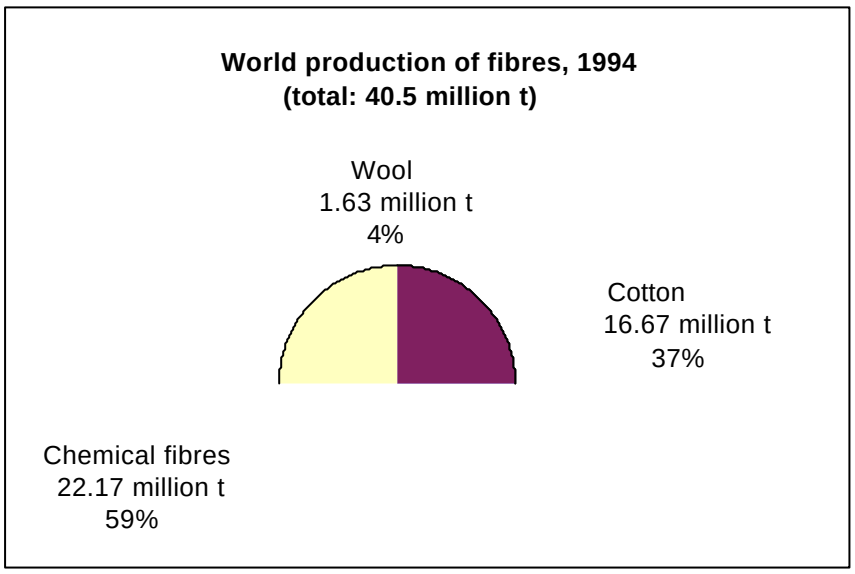
In the industrialised countries, textile consumption has now been largely decoupled from normal wear and tear, and is increasingly determined by the symbolisation function that clothing performs. Germany (west) is number one worldwide with an estimated total consumption of 20 to 23 kg of textiles per capita and annum. The share accounted for by clothing is estimated at around 11 kg per capita annually (in west German states), and reached a figure of 668,000 t in 1992. The textile industry in Germany now contributes 1% to the gross national product and is thus the largest sector in the consumer goods industry. In 1993, about 297,000 persons were employed in 1300 enterprises in the textile industry and 1626 enterprises in the clothing industry in the states of western Germany (Gesamttextil e.V., 1994).

V 3.2 Environmental relevance of textiles

The manufacture of textiles, starting from the production of natural and synthetic fibres, is carried out in numerous different processing steps over several stages of production and trading. An analysis of the entire life cycle of textiles must also cover use and disposal.

In 1994 approximately 40.5 million t of fibres were produced worldwide, with the share of synthetic fibres exceeding that of natural fibres (Fig. V 5). The volume of textile auxiliaries and dressing agents produced worldwide in 1992 reached a level of around 1.6 to 1.7 million t while 550,000 t of textile dyes were manufactured according to estimates for 1990. These substances flow into the textile chain and are later released into the environment as emissions, or accumulate as waste from production and after use of the textiles. As part of a comprehensive ecological analysis, one must also keep in mind that substantial material and energy flows are additionally generated through the production and transport of fibres, auxiliaries and dyes.

Fig. V 5



Source: IVC, 1995

The following environmental pressures, in particular, can be attributed to the various links of the textile chain:

Primary production, natural fibres:

- large-scale land consumption due to cultivation of natural fibres and livestock farming,
- large-scale deployment of insecticides, herbicides and defoliants,
- use of preservatives in the transport and storage of natural fibres,
- high water demand, with adverse impacts on the environment,
- use of fertilisers (soil nitrification) and
- use of non-renewable resources for transport and synthesis of the input materials (fertilisers, plant protection agents).

Primary production, synthetic fibres:

- use of non-renewable resources as raw materials and for the generation of process heat,
- emissions during manufacture of synthetic fibres,
- wastewater pollution during the production of synthetic fibres and
- formation of environmentally harmful secondary and complementary products.

Production of fibres, yarns, surface structures:

- energy requirement for spinning and weaving as well as knitting,
- deployment of auxiliaries that lead to emissions in subsequent processing,
- dust and noise pollution as well as
- textile wastes.

Finishing:

- utilisation of large quantities of textile auxiliaries and dressing chemicals,
- emissions released into water and air,
- high energy consumption,
- high water requirements and
- accumulation of sewage sludge.

Transport between the individual stages of the textile chain:

- high CO_2 emissions (greenhouse effect) and other emissions (NO_X,VOC, etc.) as well as
- high consumption of non-renewable resources.

Use:

- possible toxicological impacts of textile chemicals on consumer health,
- use of detergents and cleaning agents,
- distribution of ecologically relevant substances through the washing-out process (diffuse input into wastewater),
- use of ecotoxic substances in dry cleaning and
- high utilisation of energy for clothing care (washing, drying, ironing).

Disposal:

- use of landfill area and
- emissions during waste incineration and at landfill.

V 3.3 Environmental stress caused by fibre production

In west Germany, some 668,000 t of fibres were processed for clothing in 1991. The proportion of cotton fibres amounted to 354,000 t (53%), synthetic fibres 143,000 t (21%) and wool 36,000 t (5%) (Cognis, 1994a). The rest was made up of cellulosic man-made fibres. Linen, silk and hemp were used only in marginal quantities of less than 1% respectively.

Cotton growing

Cotton is grown on an area of 33 million ha worldwide; the mean world harvest over the last few years was approximately 20 million t (Brandt, 1993). The main producers are China and the USA. Cotton is sensitive to frost, so cultivation requires a warm and arid climate. During the early stages of growth an adequate water supply is necessary, and a dry climate later.

Because cotton is predominantly grown in large monocultures using intensive cultivation methods, the plants are very prone to infestation (particularly by the cotton boll weevil and the boll worm). To combat these pests, large quantities of plant protection agents, especially insecticides, are used - thus generating severe environmental problems. Even seeds are treated with organic mercury compounds or with fungicides. Estimates show that 18% of the plant protection agents produced worldwide, above all organophosphates and pyrethroids, are deployed in the cultivation of cotton. Moreover, defoliants are employed to make the capsules that are ready for harvest wilt and fall off so as to enable mechanical harvesting. The defoliants (e.g. chlorinated phenoxycarboxylic acids) have toxic impacts on humans, in addition to the ecotoxic effects of the above mentioned pesticides (Schultz, 1993). The large-scale use of agrochemicals in growing cotton impacts on the environment (especially soils, water and air) and causes health risks to those using such agents and to the people living in the catchment (particularly through groundwater and surface waterbodies). Furthermore, biodiversity in the areas under cultivation is considerably reduced as a consequence.

Another serious environmental problem associated with cotton farming is the high water consumption of plantations and the resulting soil erosion. Around 5 t of water are normally used to produce 1 kg of cotton fibre. According to estimates, the demand for water is between 6,000 and 11,000 m^3 per hectare. This high level of water consumption has far-reaching environmental and social consequences. Irrigation in arid climate zones frequently leads not only to soil erosion, but also to salinisation of soils (particularly in connection with mineral fertilisers) and hence to loss of fertile land that could be used for the production of foodstuffs. Moreover, the methods used in irrigation are often very wasteful, resulting in a severe water scarcity in some regions. Press reports have frequently referred to the catastrophic impact on the environment due to the desiccation of the Aral Sea, which is a direct result of irrigation systems for cotton-growing areas in central Asia. In addition, the economic losses have been so enormous that the overall balance sheet of the economy is definitively negative as well (Müller, 1993).

In some countries, cotton is grown on up to 40 - 50% of the cultivated area. Cotton growing competes directly with the cultivation of food crops, especially in areas where the demand for basic foodstuffs (i.e. grain, maize and plants containing starch) can only be met through large-scale imports. In addition, the consumption of energy in cotton production is considerable; depending on the degree of mechanisa-

tion, 0.3 to 1.0 kg of non-renewable energy in the form of crude oil equivalent is used to cultivate 1 kg of cotton.

In response to the environmental problems caused by cotton farming and the rising demands of specific consumer groups in the industrialised nations, some textile manufacturers are trying to change over to producers who use less environmentally harmful cultivation methods. For example, instead of using defoliants, fibres are harvested purely by hand (which is reflected in the price for the product, of course). These cultivation methods are often wrongly designated as "biological" or "ecological" cotton farming. In fact, however, they merely represent a reduction in the use of operating equipment and process materials, not a total abandonment of pesticide use. The IFOAM (International Federation of Organic Agricultural Movements) defines biological farming methods as genuinely biological or ecological if chemical-synthetic plant protection agents and mineral fertilisers are phased out completely.

Synthetic fibres

In 1994, 1,073,000 t of synthetic fibres were produced in Germany. The production figures for the most important types of fibres are given in Table V 2. Around 31% of the quantity produced is used for domestic production of garments.

In terms of environmental pressures, a distinction must be made between the synthetic fibres, i.e. polyester, polyamide and polyacrylnitrile, on the one hand, and the cellulosic fibres, i.e. viscose and triacetate, on the other. Whereas the cellulose used for the latter is a renewable plant-based raw material, the other fibres are synthesised from oil derivatives.

Table V 2: Domestic production of synthetic fibres

Type of fibre	Domestic production in t	
	1980	1994
Polyester	304,000	335,000
Polyamide	202,000	228,000
Polyacrylnitrile	192,000	216,000
Cellulosic synthetic fibres	138,000	197,000
Miscellaneous synthetic fibres	18,000	97,000
Total	854,000	1,073,000

Source: IVC, 1994

According to older data, production of synthetic fibres from oil derivatives requires around 1.75 to 2.0 kg of crude oil equivalent per kilogram of fibre. Incomplete data is available regarding the amounts of solvents, catalysts, stabilisers, etc. used and the resultant emissions. Of special relevance to the climate is the production of adipic acid, a starting material for polyamide (PA 6.6) synthesis, which generates substantial N_2O emissions. In the polyester production process, the polycondensation catalyst antimony trioxide is found in the product as well as in wastewater.

The production of cellulosic fibres and their raw material, cellulose, entails large-scale consumption of inorganic chemicals and leads to wastewater pollution from large amounts of sulphates, organic com-

pounds and zinc salts. Whenever cellulose is bleached with chlorine or chlorine-containing bleaching agents, a large number of organic chlorine compounds are created. In the production of viscose, considerable quantities of carbon disulphide are emitted in waste gas. The high resorption capacity of carbon disulphide through organisms may lead to high levels of exposure and damage to organs, especially the nervous system.

V 3.4 Textile finishing

Pollution caused by finishing processes

Textile finishing[1] is a key element within the textile chain and embraces a wide variety of processes and substances of varying environmental relevance. Since potential exists for innovations here in a sector which appears complex, at first glance, the major steps in the textile finishing process will be described as an example of a production area that is suitable for material flow management.

Fig. V 6: Schematic diagram of textile finishing in a continuous process

hier Graphik Buch S. 196

Source: Verband der Baden-Württembergischen Textilindustrie e.V.

The steps involved in the finishing of clothing textiles depend on the type of fibre being processed and the intended use of the final product. These steps are so varied and complex that it is not possible to describe them individually here. For cotton, for example, they usually encompass the following operations: singeing, washing (desizing), scouring/bleaching, mercerising, dyeing/printing and dressing. Fig. V 6 shows a schematic diagram of the sequence of operations involved in the treatment and finishing of cotton fabrics in a continuous process.

In the initial washing operation, desizing, the additives used to facilitate spinning and weaving, e.g. spinning preparations[2] and sizes[3], as well as any impurities adhering to the material are extensively washed out. Sizes account for the largest share (around 50 to 60%) of the wastewater load of organic carbon compounds generated here. In some cases they are either not easily biodegradable or not biodegradable at all.

Considerable pollution is caused by organic chlorine compounds during the bleaching process when bleaches containing chlorine are used.

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[1] In 1994 the textile finishing industry comprised 282 enterprises in Germany with a total production of 564,300 t. In 1993, by contrast, there were 294 enterprises, accounting for a total production of 608,000 t.

[2] To diminish the mechanical and thermal stresses caused by the high-speed spinning and knitting processes, various chemicals, so-called preparations, are applied to the fibres and yarns. They include softening agents as well as Con oils, warping oils and twisting oils, which frequently consist of mineral oils.

[3] During weaving the yarns are exposed to high frictional forces and therefore tend to tear. To smooth and strengthen the yarns, the warp yarns are treated with so-called sizes. The sizes used include, in particular, sizes on a starch base, carboxymethyl celluloses as well as polyacrylates and polyvinyl alcohols.

Mercerisation refers to treatment of the fabric in a 20 to 30% caustic soda solution while it is stretched to give it a bright finish, improve dye absorption and enhance dimensional stability. The used caustic soda solution is partly disposed of through wastewater.

The degrees of fixation for the individual dyes in the continuous dyeing process commonly applied today vary between 60% and 98%. The non-fixed portion is then washed out. At the end of the operation it is discharged into wastewater along with the unused dye preparation, the residual liquor from the dyeing machine and the portions remaining in the dye-feeding lines. According to estimates, the total loss incurred in this process is, on average, around 20% of the total quantity of dyestuffs used. Frequent changes in production due to small batch sizes, which in many cases amount to a material length of only 500 m nowadays, may even increase this proportion.

Similar environmental stresses result from textile printing. Although the actual printing operation, including the subsequent soap bath for washing out the surplus dye, initially has a less detrimental impact on wastewater, the highly concentrated, excess quantities of dye paste from the preparation tanks and printing paste vats are usually disposed of together with the cleaning water.

Different types of dressing give textiles certain optical properties or qualities relating to their subsequent use. The most important of these properties from the broad range available today are: wash-and-wear finish, antifelting treatment, sanforising finish, antislip finish and run-proof finish. The agent used include softeners, antistatic agents, agents for washing out dirt more easily, grip-enhancing agents as well as fillers and stiffening agents. The residual liquors created by use of these substances, which may display extremely high chemical oxygen demand (COD) values, are also disposed of with the wastewater.

Use of chemical substances

A wide variety of chemical substances are used in textile finishing or accumulate during this stage as a result of the previous processing stages, i.e. spinning, weaving and knitting. The 1994/95 textile auxiliary catalogue lists 6,791 products in commercial use; according to other sources, there are 7,000 to 8,000 preparations on the market. The number of individual substances contained in these products is estimated at 400 to 600. The Colour Index, a list of textile dyes and colouring agents, includes approximately 4,000 substances, of which around 1,500, on a larger scale about 800, are relevant to the market. Here again the number of commercial products is several times higher.

Reliable data on the consumption of chemicals in the textile industry are not available. According to estimates, more than 100,000 t of basic chemicals (1986), 11,300 t of dyes (1986) and 112,000 t of textile auxiliaries (1992) were used. Nearly 100% of the base chemicals, around 20% of the dyes and 71% of the textile auxiliaries were released into the wastewater. The organic substances are only partially biologically degraded in wastewater treatment facilities or eliminated through adsorption in sewage sludge so that substantial volumes go into surface waters. As a rule, the substance data are insufficient for assessing the ecotoxicological threat posed by the specific substances. However, in various European countries efforts are being made to classify textile auxiliaries according to environmental criteria, which necessitates the collection of data on the substances deployed.

Water consumption and wastewater

According to the textile finishing industry, the annual water consumption in Germany in 1992 was around 65 million m^3/a (TVI, 1994), while other sources estimate this figure at about 80 million m^3/a (Lepper and Schönberger, 1996). Of this volume, 65% comes from in-plant wells, 28% from treated surface water and 7% from public supply lines (Schek, 1993).

Around 4% of the production-specific wastewater volume generated by the entire processing industry in Germany emanates from the textile sector. Based on a consumption level of 80 million m^3, the production-specific wastewater volume comes to about 70 million m^3; the difference is a result of evaporation loss, especially during the hot-water processes and drying of the textile product. Depending on the make-up, type of finish desired and mechanical production method, water demand may vary between 60 l/kg and 350 l/kg of fabric.

Wastewater treatment produces approximately 60 to 70 kg of sewage sludge per kg of processed textiles; in Germany the total volume is around 50,000 t of sewage sludge (dry substance) a year.

Air pollution and energy consumption

The only data on gaseous emissions are again estimates. Besides the emissions associated with energy generation, emissions of volatile organic compounds (VOC) are of special relevance, including odour-intensive substances and volatile chlorinated compounds. Their total volume is estimated at around 3,000 t. They arise primarily through singeing, bleaching and drying of the textiles on the tentering frame.

The energy needs for textile finishing vary considerably and depend above all on the type of fibre. The estimated orders of magnitude range from 10 to over 100 MJ/kg. This corresponds to about 0.235 to 2.35 kg of crude oil equivalent, or around 0.34 to 3.4 kg of hard coal equivalent per kg of textiles. In 1973, energy demand by the German textile finishing industry, according to its own data, was 534,760 t of hard coal equivalent or 15,668,468 GJ.

V 3.5 Trade and transport

The international division of labour in the production of textiles means that raw materials as well as semi-finished and finished products are transported over long distances before they finally reach the consumer. The energy required and the emissions associated with transport form a significant part of the overall pollution engendered by textile production.

Analyses using models have calculated total transport distances of up to 19,000 km and energy demand of over 4 to 6 MJ per kilogram of goods, resulting in CO_2 emissions of nearly 300 to 400 g/kg of goods, in addition to other pollutant emissions (Cognis, 1994a). Accordingly, transport accounts for around 10% of the energy expenditure necessary on average for textile finishing. The energy requirements are considerably higher if the goods are transported by aircraft, as is particularly the case with fashion articles.

By way of comparison, the German ifeu Institute has calculated the average consumption figures for the transport of a tonne of goods in 1988 as follows:

- via long-distance road transport **1.49 MJ/tkm**,
- via rail transport **0.63 MJ/tkm**
- via inland shipping **0.46 MJ/tkm**

Energy consumption in air freight transport reached an average level of **10.73 MJ/tkm**, i.e. more than seven times the figure for road transport.

The example of NO_x emissions shows a similar picture:

- long-distance road transport, on average **1.18 g/tkm**
- rail transport, on average **0.35 g/tkm**
- inland shipping, on average **0.60 g/tkm**
- air freight transport (1995), on average **3.50 g/tkm**

Nearly 90,000 t of textiles were imported by air in 1994. Over 20% of all air freight were accounted for by these products, and the trend is upwards. Nevertheless, according to the DWI (1988), the percentage contributed by direct and indirect transport services to the production value of various product groups was around 1.5% for textiles and only 1.1% for clothing/leather goods/shoes. Moreover, transport costs will continue to fall with the increasing liberalisation of transportation markets.

Another area in which non-renewable resources are exploited to a substantial degree is the consumption of packaging and coat-hangers in the manufacture of and trade with ready-made garments. In the clothing sector, approximately 40,000 t of plastics are estimated to go into packaging, whereas around 211,000 t of synthetic fibres are used in making textiles.

V 3.6 Environmental stress due to textile care

A substantial portion of the energy consumption and other forms of environmental stress resulting from the textile chain is attributable to textile care - principally washing, but also dry cleaning, which cannot be dealt with here. In the west German states, around 85,000 t of detergents and 315,000 t of washing auxiliaries, including softeners, were used in 1988. These, together with about 200,000 t of dirt removed from textiles through washing, are discharged in household sewage. Equally important is the energy consumed by household appliances for washing, and ironing. Washing accounts for about 85% of the total energy consumed in manufacturing and using a piece of clothing (Cognis, 1994a). Water demand and wastewater pollution are also relevant in this context. Various consumption data for working clothes are compiled in Table V 3.

Although washing helps maintain the function of textiles, it causes wear on the fibres and thus reduces their life. (Whereby the durability of textiles is dependent on the type of fibre - clothing made of synthetic fibres is about twice as durable as that made of natural fibres.) There are fibre-specific differences in washing care as well. Synthetic fibres can be washed at lower temperatures and require less energy for drying and ironing than natural fibres. On the other hand, synthetic fibres have to be washed more frequently because they get dirty faster (Cognis, 1994a). Unfortunately, however, a detailed

comparative assessment of the environmental impacts of various fibre types (in the form of eco-balances, for example) is not possible at present due to lack of data.

Table V 3: Consumption involved in the care of working clothes

Amount	1 kg
Duration of use	4 years
Care cycle	weekly
Number of care or wearing cycles	approx. 208
Detergent consumption	4.5 kg
Water consumption	4,620 l
Process energy consumption for producing detergents	100 MJ
Primary energy consumption in washing	625 MJ
Primary energy consumption in drying	915 MJ
Primary energy consumption in ironing	260 MJ

Source: Cognis, 1994 b

V 3.7 Textile wastes

A comprehensive study on the accumulation of textile wastes from industry and private households was conducted for 1993 (Aumann et al., 1996). The results shown in Tables V 4 and V 5 are based on representative surveys of enterprises in the textile and ready-made garment manufacturing sector as well as private households.

Table V 4: Net production, waste rate (waste range and average waste rate), waste volume and gross material input in the textile and clothing industry in Germany in 1993

Stage	Net production in tonnes	Waste rate	Waste volume in tonnes	Gross material input in tonnes
Processing of fibres	626,000	3% - 7%, 5%	32,950	658,000
Processing of spun yarn	639,000	1% - 10%, 5%	33,350	673,000
Manufacture of ready-made garments	273,000	3% - 20%, 9%	26,300	300,000

Source: Aumann et al, 1996.

Table V5: Disposal volume (in t) and rates (in %) of selected textile end products for Germany, 1993

Disposal path	Clothing		Home textiles		Carpets	
Second-hand, acquaintances, relatives	142,000	19%	9,000	6%	25,000	6%
Collection of used textiles	289,000	39%	33,000	24%	13,000	3%
Disposal container, recycling centre	82,000	11%	13,000	9%	50,000	12%
Household waste	201,000	27%	79,000	57%	25,000	6%
Bulky waste	7,000	1%	3,000	2%	297,000	71%
Misc. disposal	21,000	3%	3,000	2%	8,000	2%
Domestic availability according to household survey	**742,000**	**100%**	**140,000**	**100%**	**420,000**	**100%**

Source: Aumann et al,1996

V 3.8 Environmental action targets for the textile sector

As already seen, the production, use and disposal of textiles generate high levels of emissions. Thus, to achieve sustainability, many different targets for environmental policy action must be formulated, taken into consideration and striven for. As with other basic needs and complex products, the key areas are energy, transportation and resource extraction. If environmental action targets for sustainable energy use (see Chap. II) and mobility (see Chap. III) are to be achieved, a major contribution will have to come from the textile sector. The production and processing of natural fibres come under the targets for sustainable agriculture (see Chap. IV).

A characteristic feature of the textile sector is the great number of substances used in finishing and care. Efforts to shape this sector along more environmentally sound lines have concentrated for a long time on eliminating substances with particularly harmful impacts on the environment, and on developing more environmentally sound alternatives. The main examples are textile finishing agents as well as detergents and cleaning agents. Detergents are one of the first product groups for which product-line analyses were conducted and eco-labels issued. In 1991 the national "Blue Angel" (RAL-UZ 70) eco-label was introduced for detergents having less detrimental impact on water resources; in1995, the European Union specified the environmental criteria for awarding the EC eco-label.

The multiplicity of environmentally relevant substances that have to be examined in this connection (along with an even larger number of by-products, most of which are unknown) makes it essential to have environmental action targets that address precisely this problem, over and beyond the focus on individual substances. These goals must provide for sustainability, which means in effect that the volume and time scale of substance loads to the environment are compliant with the carrying capacity and response time of environmental media and ecosystems. Irreversible changes to the structure and function of ecosystems and their constituents must be avoided at all costs. The following are examples of environmental action targets that meet these criteria:

- The deposition of persistent, bioaccumulating foreign substances (xenobiotics) in the environment must be avoided, regardless of their toxicity (zero emissions). This also applies to metabolites with such properties. This demand is based on the fact that an impact can gen-

erally be expected when foreign substances accumulate in living organisms and in the environment, given the complexity and interdependence of the cellular and molecular structures that are inevitably affected by this process. At present it is often not possible to verify a definite impact in specific cases precisely because of this complexity. To make sure we endow future generations with a viable and sustainable nature, undisturbed by unnatural material influences, special consideration must be given to the precautionary principle.

- The deposition of foreign substances with a mutagenic or endocrine impact on the environment must be avoided (zero emissions). This also applies to metabolites with such properties.

The justification for this environmental action target is similar to that applying to the call for zero emissions of persistent and bioaccumulating substances. Mutagenic and endocrine impacts affect key functions of organisms and ecosystems, namely the information function and reproductive capacity. Any change in these functions poses the threat of irreversible changes in the systems which cannot be verified scientifically at a sufficiently early stage.

These environmental action targets conform with the resolution of the 4th International North Sea Conference, Article 17 of which states: "The Ministers agree that the objective is to ensure a sustainable, sound and healthy North Sea ecosystem. The guiding principle for achieving this objective is the precautionary principle. This implies the prevention of the pollution of the North Sea by continuous discharges, emissions and losses of hazardous substances, thereby moving towards a target of their cessation within one generation (25 years) with the ultimate aim of concentrations in the environment near background values for natural occurring substances and close to zero concentrations for man-made synthetic substances."

This means that, in addition to the quantity reduction targets striven for by energy and climate policy, a special role is played in the textile sector by environmental action targets pertaining to the deposition of hazardous substances in the environment. The instruments available for achieving these targets include substitution, controlled life-cycle management and conversion into non-harmful substances after the use phase. The purpose of material flow management is to link these various instruments into an optimised system.

V 4. Potential for enhanced energy and material efficiency

The last few years have seen improvements in processes and products in specific segments of the textile sector that indicate an existing or foreseeable innovation potential for enhancing the energy and material efficiency of material flow management in accordance with sustainability goals. This potential will be described by examining the scope for shaping sustainable development in the textile/clothing sector that can be assumed in connection with the "structural transformation and awareness raising" scenario.

V 4.1 Fibre production

Given the quantitative limits to the cultivation and yields of natural fibres in accordance with ecological criteria, further use of both synthetic fibres and renewable sources of natural fibres will be necessary to meet the demand for textiles and clothing.

Cotton production

In India, Brazil and some countries in East Africa there are still enough reserve areas available for cotton growing up to the year 2010. However, the resultant gains in production volume will be largely offset by the withdrawal of other areas. Cotton farming competes with food production in some countries, and highly fertile soils especially will have to be reallocated to food production to ensure food security. Other areas already affected by environmental degradation in the form of erosion, salinisation or acute water shortage will no longer be economically viable, or will no longer be suitable for cultivation in a sustainable form.

Yields per hectare could be raised in some countries by cultivating improved varieties (higher fibre content, improved disease and pest resistance) and by improving farming and irrigation techniques. Biological or organic cotton production in accordance with IFOAM guidelines (see V 3.3) must be developed and expanded. The ecological stresses as well as the toxic threats to human health in conventional cotton production will remain into the near future. However, growing coloured cotton and using it for naturally coloured textiles would obviate the need for dyeing, and may thus help to abate the pollution caused by finishing.

Growing more flax and hemp

The supply of natural fibres could be expanded by the year 2010 by growing more flax, for which limited reserve areas are still available in Germany. Flax needs less fertiliser than cotton, is less prone to harmful organisms and produces higher yields of around 1000 kg of flax fibre per hectare (Brand, 1993). Compared to other field crops, flax farming is less detrimental to the environment. The same applies to the cultivation of hemp, which is much discussed at present, especially since its fibres are well-suited for technical uses. Diversifying agriculture by growing fibre plants has beneficial effects on the environment. Further investigations are necessary to determine the extent to which flax and hemp farming is feasible and makes environmental sense under present conditions.

Production of synthetic fibres

It is not possible at present to assess the extent to which the pollution generated in the production of synthetic fibres can be reduced by the year 2010, since there are no reliable data, even on current production methods, and because the potential for savings cannot yet be specified. No reductions will be achieved through the use of naphtha and natural gas as raw materials, apart from the processing and recycling of spent materials. The potential for cutting back on process energy demand cannot be assessed at present. Reductions in emissions via the wastewater path are mainly dependent on the further development of wastewater treatment plants.

V 4.2 Textile finishing

Greening the complex processing methods used in textile finishing requires a great number of specific technical and organisational measures for the respective process steps. To coordinate these numerous activities, an integrated concept is needed for reducing material and energy flows with material flow management techniques. By the year 2010, corporate material and energy balances should be common

practice as the information base underlying such an integrated approach. Their purpose is to compile all flows of commodities, materials and energy into or out of a plant, including the sites where these are consumed, converted or wasted.

Lowering emissions requires not only greater efficiency on the part of "end-of-pipe" technologies, but also increased implementation of production-integrated avoidance strategies involving a wide variety of activities geared to the different processing methods (Schönberger and Kaps, 1994). Only the most important of these measures can be described in simplified form here.

Knowledge of the potential environmental threats posed by the various process materials is very important in this context. By the year 2010, each individual substance in auxiliaries, dyes and dressing agents should have been evaluated on the basis of environmentally relevant and health-related data. In the case of substitutes, this enables the most environmentally sound alternatives to be selected. "Overloading" of mixtures with a large number of individual substances can be cut back and the number of such substances reduced to a technically feasible minimum. Labelling of agents on the basis of a simple classification system with respect to environmentally relevant substance properties would enable human- and eco-toxicologically oriented selection on the part of users in the textile industry, and could lead to further improvement of the recipes through preferential use of relatively safe substances. Negotiations are currently taking place on a voluntary commitment by manufacturers to classify textile auxiliaries.

The major specific steps required for optimisation of textile finishing include:

- use of easily degradable or reusable sizes,
- substitution of bleaching agents containing chlorine,
- reduction of the systemic importance of machinery and introduction of minimum batch sizes in finishing,
- automated dosing of dyeing liquids according to needs,
- use of dyeing machines with extremely reduced volume of dyeing vat,
- use of dyestuffs with high specific fixation rate,
- lowering of pollutant loads through use of dyes containing no heavy metals,
- dyeing of polyester yarns without water or wastage, using overcritical carbon dioxide as a solvent,
- modified recipes for printing pastes used for textile printing,
- recycling of residual dyes and dressing agents accumulating in the plant,
- return of residues that can no longer be used in the plant, including containers, through suppliers for the purpose of external recovery or proper disposal,
- separation of wastewater in textile finishing plants on the basis of a wastewater survey according to three pollution categories,

- treatment to destroy (by incineration or microbial mineralisation) highly polluted residual dye and dressing agent liquors, fixing and reaction baths, etc.,
- separating agents and slightly polluted wastewater, such as rinsing water, using automatic dye or conductivity measurements, and in-plant reutilisation after purification,
- reduction in water consumption and energy savings by deploying washing machines that operate according to the reverse flow principle,
- energy recovery from hot wastewater as well as
- wastewater-free process control management.

V 4.3 Textile care

Despite the considerable improvements made in recent years, washing textiles remains an area where significant savings could be achieved. Resource consumption due to washing can be cut back substantially through better utilisation of washing machine capacity, using more effective detergents that permit cleaning at lower temperatures, using water- and energy-saving washing machines as well as through reduced use of dryers.

V 4.4 Textile wastes

Through the introduction of separate collections and return through the retail trade, the current volume of second-hand clothing and used home textiles from private households can be doubled. The proportion of clothing suitable for further use in the framework of emergency or disaster assistance as well as the second-hand clothing trade will rise only at a moderate rate from the present level, in that extensive operations are already in place here. However, the export of second-hand clothing to less developed countries may conflict with sustainable development objectives if such exports distort traditional production structures and markets.

The proportion of second-hand clothing that can be used as secondary raw material will grow significantly. Development of sensor systems for mechanical sorting of textiles according to type of fibre can contribute to this growth. Due to the particular problems of mixed fibre waste, more products should be developed that consist of only one type of fibre or are designed so that separation of the different types of fibres and re-use of the material are possible.

V 5. Environmental improvements through structural transformation and awareness raising

When assessing the potential scope of the innovations discussed in the efficiency scenario, it is essential to bear in mind the dominant trends in the world textile market. At present, per capita consumption of clothing textiles in the specific countries corresponds with the disposable income of the population

and thus shows considerable variation. The trend, however, is for consumption in the industrialised countries to continue rising, though at a lower rate. In the less developed countries and particularly in the newly industrialising states, on the other hand, one can expect relatively strong growth in consumption since disposable income is increasing and will most likely be spent to an disproportionate degree on clothing. Also, the growing world population will continue to be a driving force that pushes up total consumption.

These trends imply that improvements in technical efficiency, and the concomitant reductions in specific environmental stress per product unit, will not be sufficient to achieve sustainability. What is also needed are appropriate steps to counteract the aforementioned trends through structural transformation and awareness raising in such a way that the demands for textiles and clothing can be met with a declining, or at least stable, level of environmental consumption in absolute terms.

V 5.1 The international framework

The fact that textiles are produced and traded on a worldwide scale makes it imperative to view the conditional framework for structural transformation and awareness raising in respect of textiles/clothing from an international perspective. Reference has already been made, for example, to the global distribution of environmental pressures and the high proportion of textiles on the domestic German market that are produced abroad.

Adaptation of international trade relations

GATT provisions effectively prevented any influence being exerted on production conditions in other countries. However, the GATT reform through the Agreement establishing the World Trade Organisation (WTO) led to greater consideration being given to environmental concerns, though this has yet to be specified. Nevertheless, it is likely that developing and newly industrialising countries will also come to realise that substantial negative impacts on the environment cause correspondingly high external costs, and that the economic advantages gained from low environmental standards will not outweigh the long-term and, in some cases, irreversible environmental damage thus engendered. Technology transfer and cooperation between enterprises and state institutions in the industrialised states and less developed countries can make significant contributions to building energy-efficient and environmentally friendly production capacities in newly industrialising and less developed countries.

In view of the large and rapidly growing fibre and textile production capacities outside Germany and Europe, international harmonisation of environmental protection standards is an important prerequisite for further progress. It is evident that the development of minimum environmental standards within the framework of OECD and WTO membership is closely linked to the concept of material flow management. Government agencies need to develop new ways of thinking and a capacity to present innovative, flexible solutions in order to perform the balancing act between stipulating requirements for products, which is permissible under trade law, and imposing stipulations for production methods, which would involve impermissible barriers to trade. There are no patent solutions in this difficult field.

Harmonisation of environmental requirements

Harmonisation of environmental legislation in the states of the European Union, e.g. through the directive on integrated pollution prevention and control, can be expected in the course of the next fifteen

years. Moreover, several eastern European states will most likely be admitted to the EU during the same period. Within the framework of international conventions for the protection of the North Atlantic and the North Sea (OSPARCOM) as well as of the Baltic Sea (HELCOM), minimum standards and recommendations for lowering emissions via the wastewater path in the textile finishing industry, inter alia, are currently being developed on the basis of best available technologies (BAT) and best environmental practice (BEP). The provisions of these agreements must be updated and put into practice by enterprises in the Member States.

Over and above international agreements, the textile trade must accept responsibility for making comparable minimum requirements a basis of trade relations outside the European region as well.

V 5.2 Material flow management in the textile chain

Improving information exchange

Lack of transparency in the textile chain is the primary reason why so little attention has been directed to the environmental pressures and resource consumption attributable to the production of textiles. Improvements in the information base and in the communication of information on environmentally relevant factors are of crucial importance for the achievement of sustainability goals in the field of textiles and clothing. As a consequence, structural innovations for material flow management in the textile chain should initially be introduced in the areas of information and cooperation.

To date, information exchange between the various links in the textile chain has been confined almost exclusively to technical and operational factors. Information on the production record, including environmentally relevant information, is partially or completely lost in the process. This loss or lack of information is one of the main obstacles for material flow management of the textile chain. In developing strategies to overcome these obstacles, two different kinds of knowledge have to be taken into account. As far as environmental aspects are concerned, utmost relevance is attached to the knowledge about substances that is primarily held by the chemical industry, processors and all other actors responsible for the production of substances. Consideration of consumer needs and their changes, on the other hand, requires special knowledge about markets, which is disposed of largely by the retail trade and, to a certain extent, garment manufacturers. To manage material flows, it is imperative to forge links between these two kinds of knowledge so that innovations for protecting the environment can be launched on the market.

The role of retail trade

In general, the retail textile trade is insufficiently informed about the material components as well as the material origins and ecological background of the products it sells. However, it is confronted with questions by consumers who expect this knowledge to be forthcoming. In response to this lack of knowledge transfer and the detriments it gives rise to, many different initiatives aimed at eliminating these informational barriers have developed recently.

Large retail corporations have introduced a quality management system to which suppliers along the textile chain input data on the various substances used or produced. This narrows the gap between "substance" and "market" knowledge. The quality system also gives the trade an instrument for exerting influence on suppliers and for monitoring compliance with quality parameters. Manufacturers are

increasingly requesting substance data from their suppliers and imposing quality conditions as part of a quality management system with defined exclusion criteria. The *Dialog-Textil-Bekleidung e.V.* (Association for a Textile/Clothing Dialogue) has set up a sort of networked information system. Within this network, representatives of the garment manufacturing sector as well as of the upstream stages in the textile chain take part in information exchange.

One means of improving the information flow in the textile chain is to provide documents along with the goods, containing details based on process data sheets regarding the type of processing, as well as the auxiliaries and finishing agents used. Such documents can help the trade to give expert advice to consumers and in general create the necessary transparency in the textile chain. Retailers are demanding such information from producers to an increasing extent. In this way, they exert pressure on the upstream links in the textile chain to comply with the required standards. This pressure, however, can only become effective if retailers apply verifiable criteria, and garment manufacturers and processors are able to meet such specifications. These two conditions are still a long way from being met. They can be established, however, if actors on the production of the textile chain are willing to participate in the cooperative endeavours necessary to exploit their potential for ecological innovation.

Forms of voluntary cooperation

Examples from Switzerland show that major environmental damage through textile production can be largely avoided through voluntary cooperation on the part of different actors. For Swiss weaving mills, for instance, size recipes whose components are easy to eliminate in wastewater treatment plants were specially developed and introduced in the plants. In addition, a classification system based on water ecology was devised for textile auxiliaries and dressing chemicals, enabling manufacturing companies to evaluate their recipes.

Although positive results and environmental cooperation can already be observed in certain parts of the textile chain, there are still shortcomings with regard to the organisational structures and information necessary for systematic "ecologisation" of the entire life cycle. The Enquete Commission's work on material flow management of the textile chain has led to the identification of two types of organisational and informational relations: the "upstream model" and the "downstream model".

The upstream model describes actor relationships that are influenced or established through environmental demands on the part of certain buyer segments. These are passed on by the trade and clothing producers to processors and primary producers upstream. Initiatives are based on market knowledge, with efforts directed at translating this knowledge into substance-related action by imposing requirements on primary suppliers.

In the downstream model, the assumption of responsibility by substance producers leads to downstream impacts. It is necessary in this case to win the support of suppliers to the textile industry, in particular the chemical industry and textile machine and plant builders - in cooperation with appropriate research institutes - for solving environmental problems in textile processing.

Under present conditions, neither model is able to ensure effective material flow management in the textile chain since both represent only parts of the chain. For this reason, creation of a "chain network" is proposed as a vertical counterpart to the horizontally organised industrial association. In such a chain network, which would forge an ecological innovation alliance composed of the actors at all levels of the product life cycle path, the various links in the chain provide for material flow management through

joint activities, and establish a suitable institution as appropriate (ARGE Textil, 1994). This new institution would mainly perform a bridging function between textile finishers and garment manufacturers, resulting in further dismantling of the information barriers between substance knowledge, on the one hand, and market knowledge, on the other. The structure and organisational form of this "transmission belt" has yet to be specified in detail, but proposals have been put forward regarding the tasks it would perform, namely:

- specifying the relevance of material flows,
- collecting information,
- assuring quality,
- organising an appropriate system for exchange and
- documenting information.

V 5.3 Changing consumer behaviour

Clothing textiles are mainly produced for private consumption, so it is consumers who ultimately decide on the quantity and quality of material flows involved in the production, care and disposal of textiles. Special focus must therefore be placed on their role in material flow management of the textile chain.

Practical and sociocultural significance of clothing

The consumption of clothing textiles is influenced by a wide variety of factors because, apart from providing protection, clothing also performs a social and cultural function. Every purchasing decision of a consumer is based on an individual weighting of the specific factors, depending on the intended use of the piece of clothing. In addition to consumer expectations regarding use-related properties such as wind and weather resistance, heat retention capacity, capacity for withstanding mechanical loads, etc., there are other demands which play a role. Clothing is an expression of affiliation to social or other groups in society, it serves as a status symbol or as adornment and is an expression of one's individuality. Fashion is of special relevance here. Designed in rapid succession as an expression of artistic creativity and praised at high advertising expense, it offers an incentive for more and more consumption.

The key determinants of consumption are the importance attached to clothing in the value system of a society as well as the economic capacity to consume beyond one's basic material needs. It is characteristic of our society that its per capita consumption of clothing is the highest in the world, and the proportion of private income spent on clothing in Germany is higher than in other industrialised states. Accordingly, this is where one can expect the greatest amelioration potential through altered consumption habits.

Environmentally sound clothing - more than just hand-knitting!

Although great importance is attached to environmental protection in the scale of values of the German population, only a small minority has made efforts thus far to express this through the selection of clothing. This discrepancy can be attributed to different factors (see Section VI 3.5). One of the main reasons is that little information about which pieces of clothing have been produced on an environmen-

tally sound basis is available to consumers. With the exception of the EU eco-label for bed linen and T-shirts, there is still no eco-label for textiles that provides a comprehensible overview of all environmental damage involved in making a textile product. The environmental and health labels developed and introduced by the textile industry, trade and other institutions are primarily health-oriented and at best take only isolated environmental aspects into consideration. However, TÜV Rheinland is developing a label ("ecoproof") that will encompass more comprehensive, production-related criteria. Moreover, the eco-label developed at EU level will be extended to include criteria for additional textiles.

Only when the individual buyer can be made aware of, and demonstrate to others, the contribution he or she makes to sustainability by selecting an environmentally sound product through reliable and comprehensive eco-labels, will it be possible to bring about a significant change in buying behaviour on the basis of environmental awareness.

While the lack of transparency of the textile chain and its environmental relevance has considerably impeded the achievement of environmentally driven consumption patterns in this sector, so far at least, the high status value of clothing offers an opportunity of demonstrating, through the clothing itself, an attitude committed to sustainability. One option is to counter the rapid change and wear of fashions and materials by basing lifestyle on sustainability. Clothing that claims to be produced with environmentally sound manufacturing methods covers only a small spectrum of the fashions in demand, however.

Another major reason behind the development of sustainable consumption patterns can be found in the distorted price or cost structure in the textile/clothing industry and other sectors. Apart from the widely varying wage costs in the various countries, differing environmental standards also affect prices. Environmental standards may relate to environmental technology, such as treatment plants or filters, or to the use of cheap dyes or textile auxiliaries that are harmful to the environment and human health. As long as clothing produced with negative environmental impacts, and thus at high expense to society, is cheaper than the environmentally sound alternative, ecologically motivated buying behaviour will remain a privilege of the few. Buyer groups with limited budgets are hardly in a position to translate higher environmental awareness into concrete buying decisions unless they fall back on second-hand and hand-knitted goods.

Prices that speak the environmental truth are also important with regard to the key aspect of product life. It must become worthwhile again to mend a hole in a shirt or pair of trousers, or to have a handed-down piece of clothing altered, as opposed to purchasing a new product. Even in the area of second-hand use there is still considerable potential that can activated by changing cost ratios.

V 5.4 Enhancing the conditional framework

The example of material flow management in the textile chain shows that a policy instrument for a single substance is insufficient by itself to tackle all the different problems arising in the course of the chain. What is needed is an instrument mix that takes into account the great number of different players, the existing legal framework, the interdependencies in international trade and the networked production sequence in the textile chain. To achieve sustainability, appropriate legal regulations must be enacted, and external costs determined and internalised. Comprehensive measures aimed at a general reduction in energy and material intensity, and activities for abating specific pollution and promoting

ecological innovations within the framework of material flow management are both important in this regard.

Development of sustainable production methods, products and consumption patterns in Germany must not be confined to purely national environmental goals. Activities in Germany to improve the environment must also keep in mind the risk that rising costs induced by environmental protection measures may lead to further relocation of production to countries without such regulations. This would be tantamount to exporting pollution through relocation of production, and would not accord with the dictates of sustainability. For this reason, great significance is also attached to efforts to improve the environmental quality of imported textiles. The role of the textile trade in material flow management must be underlined here since it can also induce manufacturers to take sustainability aspects into consideration, independently of international environmental policy measures. Mail-order houses, in particular, are endeavouring to play an active role in material flow management of the textile chain (Merck, 1996). As a decisive link between production and consumption, the retail and wholesale trade can pass on the environmental demands of consumers to producers and inform its customers about appropriate action taken in response.

Internalisation of environmental costs and expansion of environmental law

Non-renewable energy sources are being used to an increasing extent in the production of textiles. By the year 2010, internalisation of external costs should result in a noticeable rise in energy prices (see Sections II 6 and VII 3.5.3). Moreover, implementation of more stringent legal specifications for economical utilisation of energy is expected by that time. Substantial savings potential can be tapped, e.g. through waste heat utilisation in spinning and weaving mills, multiple heat use and heat recovery in textile finishing, reduction in transport, exploitation of cogeneration in suitable plant structures and sizes, etc. The aim is to reduce CO_2 emissions by 20% in comparison to the base year, 1990, by the year 2005.

Since the textile finishing industry numbers among the most wastewater-intensive sectors, further key prerequisites for exploiting ecological improvement potential include updating and tightening water law provisions worldwide as well as allocation of wastewater treatment costs according to the polluter pays principle. It is assumed that sewage fees for indirect dischargers will be raised in Germany to a level that corresponds to the actual wastewater treatment costs, thus making in-plant avoidance and reduction measures profitable. Introduction of more efficient wastewater purification and recycling methods as well as production-integrated avoidance measures and even wastewater-free operation is less a technical problem today than a question of costs. Together with legal requirements, allocation of costs according to the polluter pays principle will lead to extensive avoidance of water pollution and to in-plant water cycle management.

The export of pollution through the import of textiles whose production has not complied with strict environmental standards must be avoided. The textile trade is called on here to contribute to compliance with production-related environmental standards in other countries, too, through appropriate requirements placed on its suppliers.

Promotion of cooperation

The actors in the textile chain must be encouraged to cooperate for sustainability through alliances for environmental innovation, and be supported in assuming greater responsibility by means of suitable

measures. To expand existing positive approaches based on individual initiative, the state should establish incentives for participation in industry-wide material flow management and further develop the conditional framework accordingly. This involves establishment of an information and collection centre for ecological classification of the finishing agents (textile auxiliaries, dyes) at national and EU level. State incentives should be created for setting up an information transmission centre in the textile chain for further development of existing initiatives aimed at environmental and health protection. Extension of the labelling requirement as well as development of a standardised eco-label for textiles can enhance the transparency of the textile chain. Incentives for implementing material flow management in the textile chain can also be created through a requirement to observe appropriate purchasing criteria in the public sector.

The most important target groups for supporting measures are consumers, whose consumption decisions are crucial for establishing alternative ecological products and services. Through more intensive environmental and consumer advisory services and corresponding public relations work, consumers must be made aware of the environmental consequences of their consumption behaviour, on the one hand, and they must be given assistance in looking for alternative products and services, on the other.

VI Consumption Patterns for Sustainable Development

VI 1. Sustainable consumer behaviour - a challenge to society

The previous chapters have dealt with issues concerning the technological and structural modification of production patterns. We now examine the last part of the chain - the consumption of goods and services.

Changing consumption patterns, especially in the industrialised world, is one of the key imperatives for achieving sustainable development. There is no alternative but to change behaviour, including behavioural patterns in everyday life. Many people now recognise this necessity. Public awareness of the crisis of life style patterns in industrial societies has grown to such an extent that the basic need to change our way of life has become public knowledge, as surveys have repeatedly confirmed. In one representative survey carried out in Germany in January and February 1996, people were asked to respond to the statement "If we continue to live in the same way, we will come closer to the brink of ecological disaster". About two thirds of those surveyed in east and west Germany agreed more or less, and a further quarter chose the response "partly agree, partly disagree". Only 12% of the survey sample in west Germany and 11% in east Germany disagreed entirely with the statement (BMU, 1996). Similar results have been frequently obtained in social scientific environment research - the level of anxiety regarding the lack of environmental policy action is relatively high, and is also expressed by many people (see also Schluchter et al., 1996).

However, the situation is very different when addressing the issue of consequences for everyday life. Surveys and more differentiated social scientific studies indicate a lack of orientation, as well as a substantial degree of dissatisfaction and even disillusionment with "politics" in general. At the same time, however, empirical studies in certain fields signalise considerable willingness to take action if the right conditions are met - such as the right kind of information and realistic options. Distinct environment regulations and economic incentives are important in this context, because otherwise those who take environmental aspects into account in their buying decisions would suffer disadvantages.

Changing consumption patterns is a prevailing political issue as well. In Agenda 21, it is addressed immediately after international cooperation and combating poverty as a key social and economic dimension of sustainability in Chapter 4. However, since calls to bring about changes in consumer behaviour should not be narrowed to some kind of moralistic mission, other chapters of Agenda 21 are equally important in this connection - for example Chapters 35 ("Science for Sustainable Development") and 36 ("Promoting Education, Public Awareness and Training"). There is thus a growing realisation that developing sustainable consumption patterns is a task with sociocultural and societal dimensions: If humankind is to survive in conditions that preserve the dignity and worth of the individual, then both the values held by individuals and the dynamics of cultural trends must be adapted in such a way that they comply with environmental imperatives.

However, this raises an ethical dilemma centred on the extent to which it is legitimate to limit people's freedom to act. The greening of lifestyles is necessary to protect the environment, but this might limit individual freedom and opportunities for personal growth in ways that are unacceptable and violate human dignity and worth. Quite obviously, there is no simple way to resolve this dilemma. The only alter-

native is to raise awareness through information and to implement environmental policy measures in a consistent and convincing manner so that everybody can adopt sustainable consumption patterns.

VI 1.1 The importance of consumer behaviour for sustainable development

The environmental relevance of consumption

One cannot over-emphasise the importance of consumer behaviour for modern society. At least 30 to 40% of all environmental problems are directly or indirectly attributable to prevailing patterns of consumer behaviour. Some of the facts:

- Private consumption in 1993 accounted for 57.7% of the gross national product (total value of all domestically produced goods and services).
- Over 80% of passenger transport is provided in the form of individual motorised transport, with over 50% of all trips being for leisure and holiday purposes. Private cars continue to be a major source of air pollution.
- 17% of primary energy consumption is directly accounted for by private households (excluding transport).
- Private households dominate consumption of many products, such as detergents and cleaning agents, paints or paper.
- Moreover, private households are by far the most important buyer group for many durable consumer goods, such as household appliances, home electronics equipment and do-it-yourself and garden equipment. Even in the case of motor chain saws, otherwise regarded as untypical for consumers, 60% of the annual sales are to hobby gardeners.

Possibilities for action

However, consumption patterns do not lie entirely within the discretion of private households, and the choice that people have is often very small. Long distances, lack of public transport, conventional product ranges and shopping infrastructures as well as shortage of money to take advantage of more expensive alternatives often reduce the level of choice available between adjustment and doing without.

This is compounded by individual barriers in the perception and realisation of options. Concepts, strategies and activities aimed at sustainable consumption patterns must therefore become a central focus of efforts, taking into account that there is considerable potential for technical, legal, economic and social change:

- The drastic reduction in material intensity of production and consumption called for in the efficiency scenarios applies to almost the entire spectrum of consumption, e.g. durability and ease of repair, recycling-oriented production and recovery of materials, or increased energy efficiency of products.
- The change in value systems and lifestyles addressed in the structural transformation and awareness raising scenarios is of key relevance to consumer behaviour, particularly with regard to the use of substances and products, the development of alternatives and final disposal of products and waste.

- In the end, many environmental problems can only be solved through participation on the part of the population, e.g. by avoiding traffic and switching to other transport modes, saving energy, reducing consumption, or separating waste.

Individual differences in consumer behaviour

Germany's population is among that 20% of the world's population which is responsible for around 80% of total resource consumption. So much for the global perspective. At the individual level, however, there are considerable differences in resource consumption. These depend on the classical, objectifiable socioeconomic variables, such as age, income and gender, but the latter are not necessarily reflected accordingly in lifestyles, value patterns, or the ways in which people see themselves and the world.

The targets for sustainable development currently under discussion, namely an 80 to 90% reduction in material consumption, a 70 to 80% reduction in CO_2, NO_x and VOC emissions, and energy savings in the order of 50% by the year 2050, make a profound reorientation imperative. The necessity of radical change is reinforced by the foreseeable exhaustion of important fossil fuels, such as oil and natural gas, and by the mounting problem of how to distribute the remaining resources equitably in the face of population growth and the need for economic development in the developing world.

Strategies, concepts and measures for the development of sustainable consumption patterns must be developed further on the basis of the state of the art, while at the same time being supplemented by new ideas and activities. For these measures, a time horizon for the requisite policy action for sustainable consumption should be set to the year 2010.

However, a much longer time frame must be assumed for implementing the quantitative and substance-related environmental goals mentioned, for example, in Chapters II - V, as they pertain to consumption. Time must always be borne in mind when discussing strategies and measures for sustainable consumption. The greater the adjustment period, the easier it will be to generate a social consensus. However, there is no doubt that change has to start immediately.

VI. 1.2 "Sustainable consumption patterns" in the international context - Agenda 21

Even though the global aspects of sustainable consumption cannot be treated here in detail, they do play a significant role - indirectly, at least. Chapter 4 of Agenda 21 ("Changing Consumption Patterns") outlines two programme areas for promoting the development of sustainable consumption patterns:

- "Focusing on unsustainable patterns of production and consumption;
- Developing national policies and strategies to encourage changes in unsustainable consumption patterns" (Agenda 21, Chapter 4).

The following general activities are needed to meet these objectives:

- pursuing an international strategy and international cooperation,
- intensifying research on consumption,

- developing new concepts of sustainable economic growth and prosperity,
- encouraging greater efficiency in the use of energy and resources,
- minimising the generation of wastes,
- assisting consumers and households to make environmentally sound purchasing decisions,
- exercising leadership through government purchasing,
- moving towards environmentally sound pricing and
- reinforcing values that support sustainable consumption (i.e. consumption patterns and life-style).

Many of these and other elements referred to in Agenda 21 are already included in the instrument mix developed in Germany for product-related environmental protection and for consumer information. What is necessary, above all, is the intensification and dissemination of these activities.

VI 1.3 The meaning and significance of consumption

Utility value and symbolic value

If we are to come closer to the necessary reductions in material flows and waste production through changes in consumption and consumer behaviour, we have to look into the lifestyles, the meanings and the significance attached to buying and consuming of products in everyday life. In general, products have not only a functional utility value, but also a symbolic meaning, a symbolic value.

The latter can be described in terms of the diverse functions that products perform: for example, the function of differentiation between social classes, or the importance of these values for individual identity. In particular, clothing, style of furnishing and leisure activities are used to draw conclusions about the person in question. The symbolic value of products and services for individuals is no less significant by definition than the pure utility value, because social status, milieu-specific lifestyle and, last but not least, individual taste are all communicated through the symbolic value of objects and behaviour.

“Luxurious consumption” is when products are bought less for their use than for their symbolic value. “Luxury” is often used in a pejorative sense, however; one has to be careful about value judgements here, since the core issue concerns the acknowledgement of standards individuals have with respect to their personal lifestyle and their specific social and individual identity.

It is undisputed within social scientific debate that the relationship between utility and symbolic value has undergone a major shift in modern industrialised society (see below in more detail). Institutionalised patterns of ascription to life situations and lifestyles - as were common in feudal societies - have lost their significance, while the amount of products and services has expanded immensely through the enormous increases in productivity.

This feature of many products - having both a utility and a symbolic value - is exploited above all in advertising, which entices consumers with the promise that the very act of buying has a specific emo-

tional value and specific social impacts. Buying and consuming are overlaid with categories that used to belong in other areas of life: after buying Product X, we are supposed to feel better and less anxious, be more intelligent and more attractive.

The psychological dimensions of consumption

Modern society would be unthinkable without advertising. Information and communication technologies of all kinds, especially mass media entertainment, have become more and more important for the development of perceptions. We are globally informed, but have fewer and fewer opportunities to check within our specific lifeworld on the truth and relevance of such external influences, or to place them in the context of traditional forms of knowledge. Product advertising and organisations concerned with protecting people and the environment against unacceptable risks exploit this development in exactly the same way.

This means that the symbolic value of goods and services within consumption is acquiring a new quality, with design becoming a key element both in product design and in communication on product benefits. This also means a chance for sustainable development: social acceptance of this principle would also mean that particular goods and services obtain additional value because of their specific propensities in terms of sustainability, which then constitutes their symbolic value. However, the essential condition for that is effective and confidence-building environmental communication.

When thinking of the shift towards more sustainable consumption patterns, we must take into consideration both the symbolic and the functional value of products. For example, it is no doubt legitimate to want to save time by using household appliances, and in this way gain greater freedom in everyday life. Whether this wish is actually satisfied or not after buying a particular technical appliance is quite a different matter. There are more and more examples of excessive technologisation in private households leading to extra time-consuming work, e.g. maintenance and repair work.

This outline of the various meanings of products suggests that consumer behaviour is highly complex, with objective aspects playing a role just as important as subjective expectations, including emotional needs, fantasies and opportunities to shape social roles. For this reason, any changes to products according to sustainability criteria, such as durability, ease of repair or the sharing of products, implies not just technical and organisational innovation. Thus, to bring about the changes in consumer behaviour associated with such innovation, it is essential to take the social and psychological dimension of consumption into consideration, all the more so when reducing consumption is to be achieved by simply doing without.

VI 1.4 Ecological consumer behaviour

Environmentally aware lifestyles and consumption

With increased environmental awareness, the debate on "ecological consumption" has widened in scope and perception. However, it is also hampered by the lack of transparency engendered by individualisation and the pluralisation of society (Habermas' *"neue Unübersichtlichkeit"*, 1985), and must now deal with the parallel existence of many different styles of consumption, on the one hand, and the descriptive models used in each case, on the other.

Although the issue has become more complex, there are clearly certain trends which suggest it is being deideologised. A broader discourse on the possibilities and opportunities for ecologisation is beginning to develop, one which is no longer confined to subcultures. Consumer advisory bodies, for example, have entered a process of reflection on how environmental concerns can be integrated into public awareness campaigns and consumer education (*Stiftung Verbraucherinstitut*, 1995), and surveys show that consumers themselves believe there is a large and yet unsaturated demand for green products (GfK, 1995).

According to social science research on the relationship between environmental awareness and consumer behaviour, however, the issue remains rather complex. The impacts exerted by the intervening variables which characterise the specific situational circumstances are usually so noticeable in studies that, apart from small social groupings with an explicitly ecologically based lifestyle, there is still no consistent picture of "the" environmental consumer. The inconsistencies in the data on consumers' willingness to pay for green products or production methods are largely attributable to this situational complexity, which includes, after all, the personal life situations and lifestyles of individuals.

Environmental awareness as awareness of disasters

Environmental awareness, when manifested as awareness of ecological catastrophes, is accompanied by the conviction that the development of industrial society will end in disaster if it continues to focus on economic growth. We have already mentioned the frequently confirmed survey findings in which large sections of the population express considerable anxiety about the potential ecological consequences of present-day patterns of production and consumption. However, the everyday response of most people is to adopt environmentally friendly behaviour only occasionally, and even then on condition that the additional costs they incur are relatively minor (Diekmann und Preisendörfer, 1992). The conclusion one can draw - cautiously, but substantiated by further studies - is that the high level of environmental awareness is primarily articulated as awareness of impending disaster. The problem is that the main impact of such awareness is to paralyse any form of active response, since a general fear of change can result in an undifferentiated "business as usual" response appearing as the lesser evil, albeit with the consequence that the processes of transformation and renewal unavoidable in a dynamic market economy cause new and greater fears.

In recent years there is evidence that the dynamics of the environmental debate have increased (see, for example, Brand, 1993; Huber, 1993), because the core demands are no longer for "sacrifice" or even "dropping out" of the industrial and consumer society: the discussion now centres on the close links between the environmental, economic and social dimensions of human development. This debate must be encouraged by generating and fostering environmental awareness, also in the form of advising consumers with regard to ideas and help in switching to more sustainable consumption patterns.

VI 2. Societal and sociocultural conditions

VI 2.1 Critique of consumerism

It is frequently overlooked, in the critique of consumerism and culture that has now regained popularity, that the latter is much older than industrial society. Historical evidence shows that, ever since humans began to write down ideas, people have reflected on Man's obsession with possessing and using mate-

rial things. The biblical image of the "dance around the Golden Calf" has been translated into our everyday language, clearly indicating the religious dimension in the debate on consumption and its reduction with regard to the material and non-material satisfaction of needs. This long tradition of questioning consumerism within intellectual and cultural history, which has flourished again in the age of modernity from Rousseau to Erich Fromm, cannot be derived either from the environmental problems in industrialised societies or from the real development of consumption and living standards. What is genuinely new and typical for industrial society is the affluence of broad sectors of the population enjoying a relatively high level of consumption.

Despite the long history of the critique of consumerism, one must not overlook the fact that the present affluence of large parts of the population is a recent development of the post-war decades. Current research on consumption has evidence that there is no such thing as the average consumer any more (Szallies, 1991): the success of the market economy, and the technologisation of households that arose in the 1960s especially, which brought about new forms of private life (double-income households, declining birth rates, etc.), was followed by a "democratisation of affluence", in the course of which the average expenditure on private consumption between 1960 and 1993 multiplied by a factor of more than seven (Federal Office of Statistics, 1994, p. 109). However, if one takes price increases rises into account, then the latter factor falls to two and a half, although this is mainly attributable to the enormous rent increases over that period (ibid., p. 113). Nevertheless, an average four-person household with blue- or white-collar earners was able to spend DM 732 a month on leisure in 1992, including culture and vacations (in west Germany), compared to only DM 94 in 1965 (ibid., p. 140). This increase in disposable income has been described as the starting point of the "*Überflußgesellschaft*", the over-consuming affluent society.

VI 2.2 "Efficiency revolution" versus "sufficiency revolution"

Various proposals have been made to enhance the notion of ecological efficiency, with its scientific and technological bias and its focus on material and energy efficiency, with the notion of sufficiency, or, put another way, "deceleration" (the discovery of leisureliness), "divestment" (the elegance of simplicity), etc. (Sachs, 1994). However, it is unclear who is supposed to do without what and how these acts of sacrifice can be implemented politically.

It is difficult for the state to foster the principle of sufficiency; it can do so only to a limited extent and at most on a long-term basis, for example through environmental education and public role models. The difficulties here can be illustrated by the fact that the first major step towards sufficiency, the introduction of a speed limit (there is no general limit on Germany's autobahns), is a highly controversial political issue. General acceptance of the sustainability principle, extending to the need to implement sufficiency, is inadequate as long as such relatively broad-based measures are not accepted. However, experience teaches us that even behavioural options initially disapproved of may be accepted if they are made generally binding (e.g. compulsory use of seat belts).

VI 2.3 From less consumption to new models of wealth"

The debate on sustainable development has gained ground through changes that ecological discourse has undergone since the early 1990s, bound up with the recognition that ecological, economic and social

aspects are closely linked and must be looked at in terms of their various interdependencies. The political challenge of the "ecologisation" of production and consumption patterns must also be recognised in this context. One consequence since the beginning of the decade, and more so since UNCED, is the switch in attention away from "reducing consumption" and more towards "new models of wealth".

However, it cannot be ignored that a policy that assumes global responsibility is incompatible with the present distribution of wealth and the excessive use of Earth's resources by the industrialised countries. In the long-term interest of developed and less developed countries, it is necessary to stop the growth of energy and resource consumption in the industrialised countries and to reduce current consumption to sustainable levels. The distribution of wealth in the industrialised countries must also be analysed critically: a "one third - two thirds society" of have's and have-not's is unlikely to have sufficient political stability to effect genuine steps towards sustainability. A new model of prosperity cannot therefore be based on consumption patterns alone. To that extent, the popular notion of the need for an environmentally oriented change of values requires explication, since it easily misleads people into thinking that the challenge of creating sustainability requires nothing more than a change in peoples' preferences

Without detracting from the importance of value changes, it is essential to point out that the creation of specific response options and willingness to act can be fostered by all institutions and actors involved, but that the development of a fundamental change in values and its acceptance within society must be seen exclusively as the result of diffuse social processes. This change in values can only be influenced by the state over the longer term, by supporting educational processes and specific role models.

There should be no difficulty finding a consensus in society for environmental principles in the context of the proposed "sufficiency revolution", as long as this is not linked to a debate on measures for implementation. Because of the need for broad social consensus, and the lack of positive models, there is a risk that large parts of the population might be difficult to reach. Moreover, care must be taken to avoid creating any impression among the public of religious or missionary zeal, which would meet with little acceptance nowadays.

VI 2.4 From the three-class model to the "lifestyle society"

The last twenty years have seen a tremendous increase in public environmental awareness in Germany. This surely enforces positive attitudes towards ecologically acceptable consumption and/or pricing that takes the environment into account. Having said that, it is essential not to over-simplify matters. Modern industrial society is not a homogeneous entity, and although the notion of "the" lifestyle of industrial societies has a certain comparative significance - e.g. to distinguish the latter from less developed countries or, historically, from the pre-modern age - it can all too easily conceal the fact that industrial societies have developed highly complex social systems in which there is a wide divergence of lifestyles which are difficult to boil down to common elements. The situation is similar with "consumer behaviour". Consumers and consumption form pluralities; reducing them to singular entities is an unacceptable simplification. A large number of surveys have revealed the following range of opinions: 80% of the population in Germany consider themselves to be environmentally aware, 60% are potentially prepared and interested to act in an environmentally conscious way, while 20% follow environmental issues with considerable involvement and are prepared to change their behaviour radically along ecological lines.

Changing values and post-materialism

As a result, it is essential to take into consideration the complexity of today's social and sociocultural situation when debating the need to change consumption patterns. Since the 1970s, value changes have been the subject of discussion within the social sciences. The influential research by Ronald Inglehart (1977) has identified a "silent revolution" in the attitude of people in highly developed industrial societies, namely a transition from materialist to post-materialist values.. His work confirmed that, especially among the better-off, and particularly among the younger and better educated, "higher" needs, i.e. those of a social and self-actualisation as opposed to physiological needs have become comparably more important, provided that there is an adequate and secure material basis. However, major misunderstandings and false interpretations have followed in the wake of this thesis. It makes sense to view this shift in attitudes as a silent cultural revolution (Inglehart, 1989), to the extent that they then remain stable - something which has been verified to a certain extent. But the interpretation that this must automatically involve a reorientation towards sustainable consumption patterns is by no means logical or self-evident (see ISOE, 1997). Caution must therefore be exercised vis-à-vis talk about a transformation of values, whether as something that has already happened but not yet sufficiently widespread, or as an organisational or even educational task. The term post-materialism encourages not only "idealistic" (or straight ideological) misunderstandings, but can also be misleading if post-materialist attitudes are automatically associated with less consumption of environmental resources. The latter is not necessarily the case at all, and the obvious discrepancies between environmental awareness and environmental behaviour indicate that there are no simple correlations can be assumed between the two.

A new cultural model

Another explanation for changing values is the thesis that a "new cultural model" (Zoll, 1992) has developed, an expression used primarily to refer to new attitudes towards work and leisure, family, and self-image. The cultural model of the past implied an ethics of fulfilling one duties, of self-denial and self-sacrifice; thus providing an ethos of diligence and thrift appropriate to industrial society and its concern with growth. In the new model, work and "achievement" are no longer values or ends in themselves, but imperatives that must be met in order to live in a satisfying way. This, on the other hand, is the very heart of the matter - our opportunities to live a satisfying and meaningful life. To that extent the change in value systems described by social science represents a change in needs rather than a new kind of value system.

The pluralism of today's lifestyles may be seen as a direct consequence of this new cultural model. One way in which recent sociological research has responded to such changes is the widespread renunciation of the social stratification models prevalent up to the 1970s, and the shift in focus to the distinctions between social milieus. Analysis now embraces the objective dimension (described using classical indicators such as level of formal education, income and occupational prestige) as well as subjective lifestyles (described in terms of consumption patterns, cultural and political interests, personal philosophies of life and similar). Different social milieus can thus be identified, and distinctions drawn between the relevant patterns of behaviour and consumption. There are now numerous studies in this field, and they have become highly influential, above all in market research (e.g. Reusswig, 1994).

In contrast to the stratification models of the 1950s and 1960s, social structure and sociocultural constellations are now seen to possess highly dynamic features. While the basic pattern of industrial societies has not yet disintegrated, it has been weakened through the coexistence of pluralised and individu-

alised life and lifestyles. Of course, such a dynamic process must be coped with and managed at the cognitive and emotional level. For this very reason, various studies have identified an hitherto unknown degree of political disinterest and frustration, even among the "winners" of the modernisation process (Vester et al., 1993). This is compounded by the increasing marginalisation of people who, primarily as a result of unemployment, increasingly face social milieus characterised by deprivation.

The "crisis of affluence"

However, these sociostructural and sociocultural changes imply key elements on which the "ecologisation" of behaviour can be based. One must assume here, of course, that there are major ambivalences in people's modes of orientation and behavioural patterns. Although there are obvious tendencies towards a growth of hedonism, the new cultural model also involves a certain "dematerialisation". Conspicuous consumption is losing its previous value, while the internal communicative structure within the respective social milieus and the corresponding subculture-specific identities and attitudes are gaining in importance. The attitude towards work is undergoing a transformation. For more and more people, performing meaningful activities are becoming more important than the mere quantitative raising of consumption. The difficulties in putting these new orientations into practice within growth-oriented industrialised societies can be perceived as a "crisis of affluence" (Strümpel, 1977). In this context, a positive guiding principle such as sustainability can perform an important function in the creation of meaning, and for certain - albeit still very small - groups, it already does so.

VI 2.5 Ethics in a pluralist society

Current trends in sociological research indicate a "patchwork" of lifestyles and cultural orientations in industrial societies, not only at the level of society as a whole, but also in relation to the modes of orientation of individuals. Many political analysts and cultural critics see a lack of "ethics" within modern societies in general, and with reference to cultural modernity in particular. This opens up a complex and difficult issue that is only starting to be seriously discussed. On the one hand, norms and rules of behaviour are essential for any society, and especially for social systems constituted on the basis of market economies, in which increasing consumption can serve to promote growth. On the other hand, individual freedom and opportunities for self-realisation are themselves core "values" of modern societies. This would seem to generate a fundamental dilemma for reasoning. Calls for a general "renunciation" of non-sustainable modes of behaviour are indispensable, but at the same time the issue is raised as to the legitimacy of interference in individual lives and behaviour.

Pragmatically, however, it is questionable whether some fundamental distinctions, such as those frequently made between "ethics" and "economy", are genuinely unavoidable. Every system of social order imposes a conditional framework on individual action. Even market economies do so through various restrictions and opportunities. The situations and structures of needs must always adjust to these frameworks, without opposing the "value" of self-determination. Analogously, the critique of needs and wants in the context of an ecological "ethics" can be substantiated by the idea that self-determination is inconceivable without a willingness to accept responsibility. This makes it easier to project the argument to specific areas and situations.

If we look at the genesis and development of need structures we have to realise, for example, that, through the positively sanctioned social forms of personal presentation via fashion, clothing is used far shorter than the time it actually takes to wear it out (see Chap. V). Nor will it escape such an analysis that more than 50% of all kilometres driven by cars are for leisure purposes (see Chap. III). A public debate on needs and wants can point to the consequences of such behaviour and to the lack of responsibility implied. This provides opportunities for productive alternatives. Environmentally benign behaviour could become an attribute constituting part of a person's self-esteem.

It is imperative in connection with such attempts at influencing behaviour that all strategies and measures are non-manipulative in character, but open and communicative instead. Environmental awareness raising and ecological ethics would counteract themselves if they were to slide into dogmatism of a fundamentalist or ideological nature. The multi-perspectivity of orientations and standpoints that is a core element of modernity, as well as the cultural pluralism and individualism this generates, are a given fact. Regulatory and economic measures, too, must be so designed as to ensure that their rationale is understood and that they can be put into practice in everyday life. The critical issue is not the difference between "hard" and "soft" instruments in environmental policy, but their proper integration.

VI 3. Ambivalences in current consumer behaviour

VI 3.1 Trends before UNCED

The issue of "environmentally sound consumption" has been the subject of intense debate since the mid-1980s. There was a realisation that the high degree of environmental awareness called for practical consequences. It was also realised that the success of numerous regulatory instruments, e.g. for saving energy or reducing wastes, depends on the active participation of the population. Since then, environmental protection has been regarded as a challenge for everyone.

Furthermore, in addition to equipment-based environmental protection, product-based environmental policy established itself as an independent policy field. Here a major role was played from the beginning by specific framework conditions such as the focus on the European Union, or the growing importance of voluntary instruments such as voluntary agreements on the part of industry. Since the mid-1980s, Germany has seen a number of success stories:

- Environmental protection has gained importance in product marketing and competition, leading, inter alia, to greater significance of eco-labels.

- Industry has become more and more pressured to improve the environmental properties of products - in addition to conventional consumer advisory services, environmental consulting has become an established feature particularly at consumer advice centres and in local government.

- Relevant issues are given prominent treatment in the media.

- Conceptual approaches have been elaborated and initial experience has been gained in respect of activation of the issue in the retail trade, the craft trades and other societal institutions, e.g. *Stiftung Warentest*.

VI 3.2 Environmental discourse since the 1992 Rio Conference

Although the basis for argumentation in environmental issues has expanded considerably since the beginning of the 1970s, the limits to growth were no issue for the general public until the beginning of the 1990s, also because of the 1992 UNCED Conference in Rio. This applies particularly to the controversial issue of "sustainable consumption".

Recent years have seen a number of specialised conferences on developing sustainable consumer behaviour which brought together researchers and practitioners. Three publications of special importance in this context should also be mentioned:

- the 1994 Report of the Council of Experts on Environmental Issues,
- the 1994 Report of the Enquete Commission of the German Bundestag on the "Protection of Humanity and the Environment",
- the 1995 Report entitled "Sustainable Germany", prepared by the Wuppertal Institute.

A major discrepancy is found to exist between orientation-guided and action reports and discussions. Some of the major players are particularly interested in discussing the question, "What should happen in individual fields of action in the near future?" A number of noteworthy activity manuals have recently appeared in this connection (see, for example, *Verbraucherzentrale NRW*, 1994, 1995a, 1995b; UBA, 1994a). For others, the focus is on reaching agreement on perspectives for a fundamental reorientation of economic activity, including the requisite monodisciplinary and interdisciplinary investigation and analysis.

Both the orientation-guided and the action-guided strands must interact when concepts, strategies and measures for sustainable consumption are being developed.

The spectrum of projects covered by a study on sustainable consumption ranges from "pioneer projects", which take new paths towards sustainable consumption and post-materialist lifestyles both formally and with regard to content, frequently initiated and implemented by "pioneers", to "mainstream" projects which have meanwhile been accepted and implemented in broad sections of the population. Many of the current "mainstream projects" were "pioneer projects" a few years ago. For example, waste separation and recycling were first practised by a minority of society, and were not adopted by the mainstream until suitable systems were introduced (e.g. the Dual System for collecting packaging waste in Germany). It cannot be assumed that all current pioneer projects will later become part of the mainstream, but in any case they are "experimental fields" in which the opportunities and limits of certain modes of conduct and lifestyles can be identified that can be practised by and transferred to large sections of the population.

Pioneer projects are good examples of what constitutes a sustainable lifestyle under present conditions; they show that immaterial well-being can substitute for the satisfaction of material wants, and that substantial savings can be achieved in specific environmental areas. Moreover, they demonstrate quite clearly that their success depends on the commitment and cooperation of very different people, and that the majority of such initiatives are locally and regionally focused.

"Mainstream", on the other hand, does not imply less commitment on the part of those involved, but refers instead to how widespread such approaches are in practice. The first German car-sharing project, StattAuto in Berlin, was initially a pilot project; due to the widespread implementation of the concept car-sharing, it is now on the way to becoming mainstream.

Cooperation and small-scale (local and regional) structures are a basic prerequisite for viable projects and initiatives to contribute to environmentally sound, socially just and economically sustainable behaviour - whether as mobility centres, environmental workshops, consulting bodies, actions such as "using instead of consuming", working groups for organic farming, seals of quality for semi-natural cultivation, or alternative distribution channels such as "StattKauf" or "Eco direct". Together they form a plethora of projects, initiatives and campaigns, supplemented by collective living arrangements, working groups, consumer associations, study groups, "eco-villages" and a diverse range of initiatives addressing environmental and North-South problems. Through their existence and commitment, they anticipate the civil society based on sustainability that W. Bierter describes as follows: "A civil society is established when people at a certain place are able through mutual assistance to address tasks jointly, to develop and acquire skills, and to rediscover a feeling of community. Neighbourhood associations, rural and urban grassroots organisations, etc. lend expression to the local dimension of civil society. To the extent that the members of a community identify the external reasons for their problems, an awareness may be created for the interrelationships between different situations and problems, and coalitions can be formed at regional and national level." (Bierter, 1995)

VI 3.3 Important issues

The specific issues that must be addressed in a strategy for developing sustainable consumption patterns in Germany are closely related to issues that have already been the subject of environmental advisory programs and awareness raising, for example:

- purchasing environmentally friendly/environmentally sound products and services,
- environmentally sound management and use of goods and services, e.g. using bicycles instead of cars for certain trips, and
- environmentally sound waste disposal systems.

The following have evolved as the dominating issues in recent discussions:

- transport and - in connection with that -
- regionalisation of the supply structure in order to reduce transport (see Chap. III),
- energy - in connection with climate protection (see Chap. II),
- food (reduction of meat consumption) (see Chap. IV),
- leisure activities and tourism,
- purchase and use of textiles (see Chap. V) and

- fair trade with Third World products.

Pilot projects are especially important in this context. Reports on experience gained in pilot projects with regard to selected aspects of environmental behaviour play a major role in all discussions. There is also a high level of interest in local and regional initiatives in which proposals, projects or indeed visions are firstly developed and subsequently assessed on the basis of the general applicability of their results, for example in "green villages" initiatives in the east German *Länder*. Successful activities addressing the issue of "Ecological Prosperity at Regional Level" have already been carried out, for example with the "Brucker Land" trademark in the rural district of Fürstenfeldbruck, Bavaria. For further work on the issue of sustainable consumption pilot projects in all fields of action are of great importance in order to identify the prerequisites for environmentally conscious and sustainable consumer behaviour.

VI 3.4 Barriers to pro-environmental behaviour

Identifying the factors which inhibit pro-environmental behaviour is critically important when developing a strategy for sustainable consumption. This aspect is also a key focus of social science research in this field. The discrepancy observed between environmental awareness and environmental behaviour is attributed to the following factors:

- Objective obstacles, including situational barriers such as lack of information, "disputes among experts" on issues leading to a feeling of insecurity, and lack of available options for taking action locally, e.g. lack of product alternatives on the market or lack of disposal options (information barriers).

- Negative experience (or presumptions) regarding the impacts of pro-environmental behaviour, e.g. with local public transport, when switching to other products, or with regard to hygiene standards in the household. It is assumed that environmentally sound behaviour results in higher prices, more time and more effort, and that it therefore induces "eco-stress" (behavioural barriers).

- Lack of perceptiveness for negative changes in the environment; inadequate assessment of the role played by the individual (perception barrier).

- Psychological defence mechanisms, on the one hand as diffuse anxieties about increasing degradation of the environment and the future of the life-support systems on which humankind depends, and, on the other, in the form of suppression and feelings of helplessness once people realise the extent of their responsibility for these threats (emotional barriers).

- Social obstacles in the form of conventions, e.g. the significance of car and clothing for image purposes, and the fear of social exclusion in the case of "deviant behaviour", especially among population groups with "externally guided" orientations (social barriers).

These obstacles must be reflected as ambivalence in consumer behaviour, because an individual's willingness to change his or her basic orientation does not automatically lead in the right direction in a situation of general crisis. If other people continue to behave in ways that fail to protect resources and nature, then for those who do not have a stable view of themselves the "personal contribution" towards saving the environment ultimately means an additional handicap (and one for which the individuals in question have only themselves to blame). This is a clear indication of the enormous importance of the

social dimension for the environmental challenge: the increasing environmental threat is not only caused by the development of mass consumerism within society - the difficulties of environmentally sound behaviour at the individual level are effectively a social “distribution problem”, i.e. the real and symbolic weight of “social balance” in society from which people can derive their self-respect.

VI 3.5 Environmental awareness and environmental behaviour

Empirical studies on the environmental behaviour of consumers paint a more complex picture. The basic thrust of their results can be summarised as follows:

The thesis, frequently propounded in social science research, that a gap exists between environmental awareness and the actual environmental behaviour of consumers must be viewed with discretion. Instead, one must assume a conglomeration of different action-specific valuations, according to which private households - accessible with the respective issue - implement the relevant recommendations either

- fully, e.g. by buying paints bearing eco-labels, compact detergents, or through environmentally informed disposal or controlled use of plant protection agents,
- partially, e.g. by saving heating energy, power and detergent, or by purchasing recycled paper products,
- to a limited extent only, e.g. by buying cars with low petrol consumption, reducing car use for business and leisure purposes, reducing speed.

The issue of cars and traffic indicates the limited impact of environmental advice and public awareness campaigns. The only way that changes seem possible is through infrastructural improvements (local public transport) or massive financial incentives (e.g. higher petrol and diesel fuel prices, emissions-based road tax, new regulations regarding expenses for business-related travel or comprehensive regulatory measures, e.g. speed limits and restrictive parking space management).

Major determinants of consumer behaviour are a high degree of environmental awareness in conjunction with available or easily accessible information, e.g. through eco-labels, warning labels, recommendations or information leaflets. Of equal importance is an infrastructure that permits the translation of environmental awareness and information into action, e.g. through commercially available eco-friendly products, easily accessible sites for the disposal of separated household waste, and other local services. Other key factors are financial incentives and a willingness to pay, i.e. the willingness to spend more money on environmentally sound solutions.

Fig VI 1: Consumer behaviour

hier Graphik von Buch S. 242

VI 4. Models for sustainable consumption in the future

One of the major issues addressed by present-day environmental discourse concerns the development of integrated models for sustainable future trajectories (e.g. "Sustainable Netherlands", "Sustainable Germany", etc.). Efforts are directed first and foremost at identifying current resource consumption according to plausible and consistent criteria, and the attempt to reach agreement on this basis with regard to environmental reduction targets for material flows and emissions. The Council of Experts on Environmental Issues (SRU) and the Enquete Commission of the German Bundestag on "Protection of Humanity and the Environment" have also called for agreement on generally recognised environmental targets - usually in a sequence of stages until the year 2050.

As has already been mentioned in various contexts, these models all call for radical limitations on consumption from each and every individual compared to today's typical consumption patterns - based on a fundamental reorientation of traditional notions of growth and prosperity.

To perform their function as guidelines for activity, model trajectories for sustainable consumption to the middle of the next century need environmental targets extending to the year 2010. In addition, they should always address concepts and strategies for the initial steps to be implemented.

VI 4.1 Options and limitations of advertising

Chapter 4 of Agenda 21, on "Changing Consumption Patterns", emphasises that every individual person should bear responsibility for consuming only environmentally sound goods and services. Governments and producers can promote pro-environmental consumer behaviour through public campaigns and positive advertising for environmentally friendly products and services.

Agenda 21 addresses both the responsibility on the part of each individual and the responsibility of government and the private sector. To the extent that individuals are empowered to make their own decisions, they should contribute as far as possible to sustainability. Governments and private-sector undertakings must respond appropriately where consumers are merely the final link in a chain involving resource-consuming and environmentally harmful goods and production processes to which they see no alternative.

Enhancing the symbolic value of environmentally sound products

Where it is clear that many non-sustainable products are purchased less for their utility value and primarily for the symbolic value they represent for consumers (see Section VI 1.3 above), then governments and enterprises must counteract this phenomenon in their public awareness campaigns. Advertising, in particular, must be adapted in such a way that sustainable consumer behaviour acquires a high symbolic value. It would be conceivable, for example, to attach such a high symbolic value to car sharing (e.g. as displaying ecological responsibility, sense of community and social competence) that driving a private car is considered an egoistic form of behaviour detrimental to the community. Advertising has concentrated its energies on the symbolic value of products, i.e. the individual and social ascriptions of meaning that they implicitly represent. The primary motivation is to sell more of the same, but with higher social prestige attached. However, the advertising industry could deploy its capabilities to construct social reality through mass media in such a way that buying less of the same is encouraged, and

that ecologically wise alternatives are imbued with high symbolic value within society. This symbolic value need not be confined to the "ecological" aspect of image, but may also be conveyed through purchasing products of regional origin that address regional identity.

In essence, advertising is highly suited as a medium for communicating environmental information. The fact that it makes use of special aesthetic and communicative instruments means that it can contribute towards consolidating and intensifying environmental awareness and knowledge, on the one hand, and, on the other, can address other sections of the population that are difficult to reach with traditional types of environmental awareness campaign.

Creating a clear product profile for goods and services vis-à-vis competing products is a function of advertising that can also be utilised as a vehicle for environmental information. Here, too, advertising creates opportunities to highlight the benefits of environmentally sound products compared to those that are less sound, and hence to assign a higher social prestige to the former. To ensure that the information conveyed is not rejected by consumers who adopt a critical stance towards the media and advertising, it must be designed in a form that meets with acceptance and achieves the desired impact.

Communicating ecological messages

Good environment-related advertising can create an awareness for the interlinkages between visually presented environmental problems and possible solutions - even beyond the specific context of the product being promoted. For example:

- Greenhouse effect ←→ Thermal insulation materials
- Traffic problems ←→ Alternatives to individual motorised transport
- Waste problems ←→ Advertising for products made from recycled or recyclable materials
- Material flows ←→ Repairing and modernising instead of buying new products

It is more difficult to achieve this where the need for a transition to sustainable consumption patterns conflicts with the basic orientation of marketing and advertising to typical consumer habits and behavioural patterns. However, there is scope here, too, for environment-related advertising, e.g. with regard to environmentally oriented handling of products, or disposal aspects. Examples include:

- replacing old and less energy-efficient household appliances and heating installations,
- purchasing energy-efficient light bulbs,
- rational space heating,
- tips on how to collect waste and
- information about how to return products to producers.

Environmentally related advertising approaches its limits when it wants to induce a fundamental change of consumption patterns, in the sense of consuming carefully or not consuming at all. However, these limits are not limits of advertising as such, but are generated externally by its clients - companies wishing to promote their products. If these clients take an appropriate attitude, they can, of course, use advertising to propagate the renunciation of non-sustainable consumption patterns and to promote alternatives: booking a holiday in one's own region rather than flying far afield (tourism), using public transport instead of one's private car (mobility), sharing goods or repairing them instead of buying anew (using durable goods).

VI 4.2 Developing indicators

The development of indicators for sustainable consumption bears a close relation to the ecological discourse mentioned above (see Section VI 3.2). These indicators should be able both to set targets and to reveal trends in consumer behaviour (see Section VII 5).

Data on the following would be appropriate for assessing future trends in consumption, and hence as indicators:

- changes in the market shares of products complying with environmental standards,
- changes in environment- and household-related emission variables (e.g. waste gas, wastewater and solid wastes),
- inventory variables (e.g. percentage of households with certain equipment),
- consumption variables (e.g. materials, products, heating energy, electricity and water) and
- behavioural variables (e.g. transport behaviour).

In addition to collecting these data, it is essential to develop ecological procedures for household management based on relevant data input. Opportunities to provide households with intelligent feedback on the current state of and changes in their own behaviour are exploited far too little.

The sustainability of consumption patterns can be derived, in particular, from the per capita volume of waste, especially since durability, repairability, recyclability and reductions in the material intensity of consumer goods are directly or indirectly mirrored in this one variable. The same applies to changes in the consumption of heating energy and electricity, and to the consumption of drinking water. A major role is played by the vehicle or passenger kilometres accounted for by private households, and the fuel consumption and emissions this involves. The general level of environmental awareness must be related to actual purchasing behaviour before it can be an appropriate indicator of sustainable consumption. The market shares of environmentally sound products (e.g. those bearing eco-labels) and the extent to which households are equipped with durable consumer goods (cars, refrigerators, televisions, video recorders, etc.) that comply with certain environmental standards are also recommended as indicators of sustainability.

VI 4.3 Replacing products by services

An important new aspect concerns a change towards using products as opposed to owning them. This is accompanied by efforts to extend the lifetime of products, to ensure their repairability and - by designing them for future recycling - the return of products to producers in order to recycle the materials used. The overall effect of these measures is to bring about definite reductions in the material, substance and energy flows caused by products.

With this in mind, a number of instruments are being considered that are all aimed at making the utilisation of products more ecologically efficient, thus reducing the overall consumption of materials and energy. Examples referred to in this context include:

- "eco-leasing", including providers' responsibility for repair and recovery,
- using services, including hiring, instead of buying products,
- sharing products among several users, e.g. car sharing,
- enhancing the supply of repair services,
- extending product lifetimes (modular construction, longer warranty periods),
- promoting markets for second-hand goods (second-hand shops, flea markets, "swap markets", special "exchange and mart" newspapers) and
- commitments by producers to take goods back and recycle them.

The Federal Environmental Agency attaches special importance to these goals in the debate on refining ecological standards for products, e.g. in the context of eco-labelling, the work of *Stiftung Warentest* (a consumer organisation that tests products), or in the development of product standards. Another area of activity is to develop incentive-based instruments for promoting the environmentally efficient use of products. Efforts to implement these goals must be reinforced through cooperation with all concerned, e.g. in the retail trade, the craft trades and industry.

VI 5. A framework of measures

VI 5.1 Basic principles

Measures aimed at promoting environmentally sound consumer behaviour in order to move towards sustainable consumption patterns should address broad sections of the population as a matter of principle. Positive impacts on the environment can only be achieved if a large majority of the population is persuaded to adopt pro-environmental forms of behaviour. Government must therefore focus its efforts on this target group in particular when taking further action. However, the experience already gained in pioneering groups is also highly significant, especially on account of the impacts they generate among the general public and the extent to which they can be imitated, e.g. in the organisation of car-sharing systems.

As with the management of material flows, the promotion of environmentally sound consumer behaviour and sustainable consumption patterns is only feasible in a framework involving cooperation between government bodies and actors in society, with special consideration being given to non-governmental organisations (environment and consumer organisations, the trade unions and the churches, as well as the various subsidiary organisations of the latter). Sustainable consumption patterns can only be achieved if all actors participate and are encouraged to bring in their respective contributions through a common understanding based on consensual guiding principles.

Government and environmental organisations can be considered as single actors among many when working towards this objective, and to that extent can only initiate activities within their own sphere of responsibility. However, in view of its political responsibility for the overall development of society, the state should provide stimulation and support (including financial assistance) to positive achievements of other actors and to appropriate forms of cooperation with the latter.

The impacts of idealistic and immaterial incentives as expressed in an environmental "Code of Consumer Conduct" are viewed with some reservation - except in the case of highly committed pioneer groups - as long as such incentives are based on ethical and moral principles aimed at fostering a change in lifestyle on the basis of "global awareness". In the light of Agenda 21 and its demands for responsible consumer behaviour, this strategy will have a chance only if the alternatives on offer are subjectively assessed, "on their own merits", as producing benefits for the individual. These processes need to be explored in pilot projects. Focusing instead on "examples of successful change" is generally considered to have greater potential of success. The UN Commission for Sustainable Development (CSD) has stated in this connection that "Behavioural change of all actors involved can best be motivated by presenting the attractiveness of alternatives, not preaching a didactic message" (CSD, 1994).

VI 5.2 Cooperation and support frameworks

Efforts must be made within the framework of collaborations and support mechanisms to establish an understanding in society on guiding principles of environmentally sound consumption. Networks of pilot projects for testing steps towards sustainable consumption patterns have proven to be a useful tool for such endeavours, with the participation of the social actors, in the areas of consumption, energy, waste, transport, hobby and leisure.

More support must be given to nation-wide environmental consulting projects organised by associations and institutions, the aim being to establish "sustainable consumption patterns" as a key area of support. Topics for such projects might include:

- projects with do-it-yourself and garden centres to set up rental services for their respective tools and equipment,
- reflection on actual needs regarding car and engine size, with the aim of "downsizing" (use of compact cars),
- giving preference to more durable, classical (as opposed to fashionable) textiles,
- encouraging excursions to nearby regions as an alternative to long-distance holiday travel,

- designing consulting strategies and marketing concepts for the promotion of regional products,

- agreement on rules for "good environmental advertising" and the use of advertising for pro-environmental consumer behaviour, and

- computerised analysis of household and consumer activities with the aim of identifying environmental amelioration potential that may also have cost-saving effects.

Cooperation with the *Deutsche Bundesstiftung Umwelt* (German Environment Foundation) and *Stiftung Warentest* must also be improved. This could enhance the development of product comparison methods, e.g. with regard to product durability, repairability and recyclability, including life cycle assessments.

In a discussion held at the Federal Environmental Agency on 9/10 May 1996 with experts from the social sciences, business (industry, trade and the craft trades) and consumer and environmental organisations, the participants agreed that in view of the degree of cooperation required, much greater use should be made of networked projects in promoting sustainable consumption in future, and that they should receive research support in order to identify supporting and inhibiting factors and draw generally valid conclusions. This approach is based on the realisation that meaningful progress in encouraging sustainable consumer behaviour can only be achieved if the actors proceed in a coordinated fashion and general agreement exists. In the framework of the discussion several useful project proposals were drawn up, including projects:

- on the establishment of a memorandum of understanding among the group involved on basic principles for encouraging sustainable consumer behaviour

- on options for the retail trade regarding the inducement of new ecologically adapted consumption patterns, e.g. renting products, second-hand products or leasing (with consumer institutions)

- on options for the craft trades to offer repair services to an increasing degree or to present their special know-how for long-lived products in a better manner (with environmental consulting institutions)

- for networking Third World products

- for promoting regional products

- for identifying high-priority areas of conventional consumer behaviour based on environmental aspects, including elaboration of a canon of key indicators for continuous evaluation of the development of consumer behaviour

- for exploring the impacts of individual lifestyles on the environmental behaviour of 100 selected private households.

VI 5.3 Information and advice

Special importance is attached to enhancing the provision of information to consumers, primarily on products. In this way incentives can be created for manufacturers to improve their products in terms of environmental soundness and their positioning in competition. Moreover, the information requirements in respect of the declaration of ingredients and hazardous substances and instructions on environmentally oriented use and disposal, e.g. with paints and lacquers, wood preservatives and other household chemicals, as well as the origin of the products must be further developed. The "Blue Angel" eco-label should be further improved with a focus on:

- refining the criteria for awarding the label, across different media, taking into account the entire product life cycle and additional requirements regarding repairability, returnability and recycling-based design,
- further development of eco-label criteria for ecological product standards,
- inclusion of innovative long-lived products, such as communications and entertainment electronics, as well as products of everyday consumption,
- inclusion of products from less developed countries (currently initiated for rattan, jute and sisal).

In addition, labelling requirements or voluntary labelling must be extended, e.g. in the area of textiles (see Chap. V), timber (initially tropical timber, later all types of usable timber) or also in the services provided by environmentally oriented retail enterprises. Another issue is the promotion of data-aided environmental household management.

VI 5.4 Enhancing financial incentives

In recent years, various ways of providing financial incentives have been discussed which have not been implemented to date for various reasons, e.g. charges on packaging, wastes, fertiliser, or a general CO_2/energy tax. Other financial incentives are conceivable using the following financial policy measures (see also Section VII 3):

- successive raising of mineral oil excise duty,
- revising regulations governing the tax deductibility of expenses for commuting to the workplace by car. Instead, an equal fiscal treatment of cars, local public transport and cycling is needed.
- tax incentives for extending the durability of products and for reducing the costs of repair services,
- VAT exemption for organic farming produce,
- increasing the amount of consumption in the calculation of heating costs,
- linear tariffs for electricity and consumption-based water rates (currently in Germany they are degressive - the more you use the less you pay)
- volume-based fees for wastes, and

- introduction of a landlord share of costs for energy consumption reductions in flats for which more efficient heating systems are installed and/or thermal insulation measures have been taken.

These are examples for initial proposals, aimed at documenting areas where additional financial incentives for encouraging pro-environmental behaviour are possible.

VI 5.5 Enlarging the scope of regulatory instruments

As far as regulatory instruments are concerned (see Section VII1), the existing regulations on substance restrictions, emission values or efficiency requirements should be further developed on a ongoing basis. Regulations requiring the recovery of used products, such as those already enacted for packaging, used cars and used paper, are to be introduced for additional product groups, e.g. electronics products and batteries. Furthermore, special weight should be placed on local and regional regulations, such as parking space restrictions, building regulations, etc.

VII Instruments and Indicators of Sustainable Development

Why a separate chapter on instruments?

Accepting the need for fundamental change in our industrialised society as a basic precept, we attempt in this report to specify the guiding principle or paradigm of sustainable development in a succession of steps.

The first stage of specification consisted of four basic principles, similar to those by the "Protection of Humanity and the Environment" Enquete Commission of the German Bundestag. In the second step, we illustrated the notion of sustainability using four selected action fields, which are examined, using various scenarios, in respect of their compatibility with environmentally sound and sustainable development. Assessment is based on environmental quality targets and environmental policy action targets specific to each field. At the end of each scenario, the foreseeable state generated by "business as usual", a technological efficiency revolution and by full-scale structural transformation and awareness raising is evaluated using the sustainable development paradigm. The conclusion arrived at is that measures for improving technological efficiency are not enough in themselves to initiate and ensure a sustainable development pathway. Sustainability involves more than a mere combination of technical know-how and modifications to major social frameworks.

The key issues in this context include the instruments with which sustainable development is to be started and carried through. The most important field- or sector-related policy measures for promoting sustainable development were generally described in the respective chapters. Instruments for sustainable development are an issue of such importance, however, that they need to be addressed in a trans-sectoral analysis going beyond the problem-specific instruments and activities.

The following section starts with a look at how instruments within environmental law should be refined, then analyses the potential for modifying the economic system in the interest of sustainable development, before continuing with an examination of the opportunities and limits of environmental awareness raising. Since what is also needed are instruments for measuring the disparity between projected goals and the current situation, i.e. instruments which can show where we stand in terms of sustainability, the chapter closes by considering potential indicators with which to assess process of sustainable development.

The introduction to this Report has already emphasised the necessity of deploying the full range of instruments at our disposal, especially legal regulations and planning instruments (e.g. regulations, plans and programmes), economic instruments (e.g. charges, levies, subsidies and voluntary agreements) and the instruments for fostering environmental awareness. Any confinement to individual instruments or sets of similar instruments would be a failure to address the complexity of the task, and would severely limit the scope for political action. Although there are some problems for which certain instruments are more suitable than others (i.e. deploying legal instruments for setting insulation standards for new buildings, while economic instruments are more appropriate for addressing the complex field of CO_2 emission reductions), there is no such thing as *the* legal, economic or sociocultural instrument applicable to any field of activity and any problem imaginable. The transition to sustainability in society and industry can only be accomplished with the entire range of instruments.

When examining different pathways to sustainable development within the selected areas, we used the scenario technique as a means of illustrating potential futures. Here, where the issues are not centred on specific activity fields but primarily on the wider social context, the technique does little to advance our understanding. Our dispensing with scenarios should not be misunderstood to mean that the legal, economic and awareness-raising conditions necessary for Germany's transition to sustainability can be analysed without reference to the time axis of development. Every instrument and every bundle of instruments has to be examined with regard not only to its potential contribution to sustainable development, but also to its compatibility with a liberal society's capacity to learn. The deeper and more comprehensive the interventions in society, the longer the time needed to adapt and take action by those affected . A distinction must therefore be made between short-, medium- and long-term problems and solutions - particularly in the debate on conditional frameworks within society.

VII 1. Environmental law in the different scenarios

One issue that needs to be addressed on the road to a sustainable Germany concerns the form legal instruments must have in order to achieve the manifold aims, objectives and targets described above. A whole series of activities and opportunities for achieving the latter has been discussed in Chapters II to VI. The main concern at this point is therefore to describe fundamental positions such as the principles of environmental policy, or to outline the legal framework that need to apply not only in the various sectors, but over and beyond them.

Unlike Chapters II to VI, the content here is no longer structured according to the various scenarios, but focuses purely on the question as to what the basic strands of environmental law should be in the structural transformation and awareness raising scenario. The latter is based throughout on the integrated analysis of economic, environmental, social and cultural factors, and from the very outset requires extensive and sometimes radical changes to existing legislation. The point is not to adapt specific regulations to minor socioeconomic and geographical trends, but that a crucial dimension of structural transformation and awareness raising involves adapting legal structures and modifying fundamental values within the legal system.

Of the two theoretical alternatives - further development on the basis of the existing legal system, or establishment of a new system - we consider only the former. Viewed abstractly, one might think that sustainable development could be promoted with the help of totally different substantive and legal principles than those now in existence. However, because of the problems involved in adaptation and the frictions associated with this course of action the latter alternative cannot be given serious consideration. On the other hand, the legal changes described below cannot be limited to individual instruments within the complex and fragmentary field of environmental law; what needs to be done, in fact, is to overhaul the *entire* legal framework in order to improve the transparency and comprehensibility of regulations and thus their application. Most importantly, this involves assembling and consolidating key environmental regulations in an "Environmental Code", where regulations can be standardised, harmonised, or simplified where necessary (UBA, 1990 and 1994 e).

VII 1.1. Requirements for further development in the structural transformation and awareness raising scenario

Taking current legal structures as the starting point, what is required, firstly, is the further refinement of substantive regulations, especially laws that influence or govern behaviour directly and indirectly. Secondly, it is important to review planning, procedural and organisational regulations as well. In addition, the constitutional framework must be compatible with the objectives of sustainable development. The latter can only be promoted with all these regulations if two conditions are met: firstly, it is important that the substantive content of regulations is adapted to the aims and objectives described above, e.g. by setting stricter limits, by weakening the legal protection afforded to installations that have adverse effects on the environment, and by imposing bans or restrictions on activities that cause environmental stress. Existing *formal* legislation (i.e. acts of parliament) does not always have to be changed in this process. In many cases, they are worded in such general and abstract terms that the problem is not so much to reformulate them but to make them more specific through well-designed sub-legislative regulations congruent with the goal of sustainable development. One example is Section 5, sub-section 1 BImSchG, according to which "installations requiring approval must be constructed and operated in such a way that

- adverse environmental impacts and other risks, major detrimental effects and serious impairments are not caused to the general public and the neighbourhood,
- precautionary measures are taken to counteract adverse environmental impacts, especially through the use of best available technologies for limiting emissions,
- waste is avoided, unless it is properly recycled without causing harm, or, if avoidance and recycling are technically impossible or unreasonable to expect, disposed of without detriment to the public good, and
- thermal energy is used for the operator's plant and machinery, or transferred to third parties who have consented to take delivery, to the extent that the type and location of the plant render this technically possible and reasonable and that this accords with the obligations laid down in items 1 to 3 above."

This regulation is open to various interpretations based on sustainable development principles. In many cases, however, the legal ordinances and administrative regulations aimed at closer definition of vague statutory terms, i.e. precise and manageable criteria for terms such as "adverse", "substantial" "best available technology", "free of harm" or "without detriment to the public good", often fail to comply with sustainability principles. This regulatory technique within environmental law, whereby laws are abstractly formulated and enable sustainable development, while legal ordinances, administrative regulations and the like are specific, but not always conducive to sustainability, leads to a situation where contradictions arise in operative regulations on the goal of sustainable development, above all at sub-legislative levels and at the level of privately defined standards[4]. Section 7a of the Federal Water Act (WHG), for example, requires that wastewater discharges comply with best available technology and

[4] Privately defined standards are standards formulated by associations such as the union of German engeneers (Verband Deutscher Ingenieure). Under German law, these associations are private legal entities and thus cannot set binding legal rules.

therefore with sustainability, whereas some administrative regulations provide for limit values for wastewater discharges that are inadequate for this purpose.

In addition, sustainable development requires that the legal framework is constituted as effectively as possible, i.e. that the organisation of authorities, the distribution of responsibilities and procedures be regulated in such a way that problems in the application of laws are avoided as extensively as possible. In most of the fields of interest here, there are already legal regulations that are at least partially supporting sustainable development, and which can be used - with changes in content wherever appropriate - to further this aim even more. One of the most significant problems in this connection is the fact that regulations currently in force are not always applied in accordance with their original purpose (referred to here as "shortcomings in execution" (*Vollzugsdefizite*). Attention has been repeatedly drawn to these difficulties since the 1970s (see the detailed study by Mayntz et al., 1978). They could be eliminated in part through improved staffing levels, endowment with equipment and organisation of the responsible authorities. However, one must not underestimate the underlying causes, which are related to the current structure of environmental law itself. Shortcomings in the execution of regulations result from the fact, for example,

- that key terms such as "best available technology" are not specified sufficiently for legal practitioners (the authorities have too little in the way of up-to-date and essential information),
- in many cases, that several official decisions are required for one and the same project,
- that these decisions have to be taken in accordance with many, insufficiently harmonised laws,
- that a large number of different legal and administrative regulations laid down by different bodies have to be complied with parallel to each other (regulations at federal, *Länder*, local government and even EU level) and
- that in the case of planning decisions, assessment of the various concerns („Abwägung") is not a "technical" procedure, but one that occurs in the political domain and is therefore subject to a complex negotiation process.

One of the intentions behind the planned Environmental Code is to eliminate some of the factors that give rise to these shortcomings in execution.

Objectives and structure of the discussion of environmental law

The recommendations for refining environmental law in line with sustainability are partly drawn from ideas already developed in various sections of the specialist literature. In some cases, they will require major changes in the existing legal "landscape". Moreover, some of them would probably lead to substantial economic shifts that cannot be the focus of analysis in our specific context. Our aim in the following is not to provide detailed arguments for and against the various proposals, but to give a basic outline of the legal instruments with which sustainable development can be enhanced. This section does not contain an assessment or analysis of current writing on the subject. Nor is it possible to predict the consequences of the proposed changes to any degree of *precision* - for the simple reason that a broad overview is all that can be given at this point, and not a detailed analysis of specific instruments in their

socioeconomic contexts. The recommendations and proposals cannot be classified according to importance - instead, sustainable development can only be promoted in an effective way if regulations are applied as part of an overall complex. Another reason why we do not assign priorities is because the specific aspects we discuss pertain to more fundamental (cross-cutting) issues.

We focus, firstly, on the legal framework and the political principles that play a role in shaping environmental law. As far as the individual legal fields are concerned, it is advisable to start with planning law, because plans and programmes can exert an influence on the basic direction of development, usually over the longer term. Plans and programmes mostly serve to influence the basic situation *indirectly*, e.g. by setting particular objectives for other authorities who must then comply with these when taking action with a significant bearing on regional development. Detailed measures and requirements directly binding on those concerned are found only in some specific plans, e.g. in plans by which approval is granted for infrastructural projects such as trunk roads, plans for the designation of protected areas (under Sections 12 et seq. of the Federal Nature Conservation Act - BNatSchG and Länder legislation), and in land-use planning. Apart from the precise stipulations in certain specific areas, plans generally only define the basic tendency for developments in their respective domains. Accordingly, improvements in legal frameworks must be directed here quite generally at enhancing the importance of sustainable development as a goal within the planning process. In addition, environmental concerns and precautionary action to protect the environment should be assigned greater weight within the key regulatory frameworks.

Once these steps have been taken, the next task is to ensure *fine control* of development by means of norms and standards having direct and indirect impacts on behaviour (e.g. conditions for development consent, bans, regulations on public levies, etc.). These systems for management and control relate to individual behaviour (e.g. by enterprises or private consumers), and operate in many fields independently of the planning process itself. Administrative decisions made on the basis of relevant regulations are applied to single cases, and therefore have a much more specific impact in general than plans. They relate to virtually all economically and environmentally relevant areas, from straight bans and restrictions (e.g. bans on the production of certain substances), through accreditation and approval procedures, or checks on environmentally relevant projects and other activities (e.g. transport of hazardous goods), to supplementary regulations (e.g. duty to notify authorities, obligation to appoint management representatives for environmental protection). A distinction can be made here between *interventional regulations* (such as bans or monitoring procedures) and other regulations which require authorities to provide specific *services* (e.g. eco-labelling standards or directives on access to official information). The pertinent substantive regulations are supported by rules and regulations governing organisational aspects, responsibilities and procedures. Another important issue concerns the opportunities for judicial review of official decisions.

VII 1.2. Legal frameworks

The Basic Law (the German Constitution)

The legislature, the executive and the courts are all bound to the constitution. Although the Basic Law in Germany does not contain any provisions that use the term “sustainable development”, the basic human rights laid down in the constitution, even before the constitutional reforms of 1994, place the state

under an obligation to protect the life, health and property of the individual, which implies, indirectly at least, that the environment must also be protected. From these and other constitutional norms, it is possible to derive environmental protection as a duty and goal of the state, however vague that goal may be. Article 20a, which was added to the Basic Law in 1994, expressly commits the state to protect the natural basis for life. The Article explicitly states that this duty also includes "responsibility for future generations". In this way, the constitution directly addresses the question of sustainable development.

Although this definition of the fundamental aims of state policy does not substantiate any right on the part of the individual to bring an action against the state in environmental protection matters, the addition of Article 20a to the Basic Law established a legal standard that compels the state to measure its activities against this goal. The German constitution is not only open towards a legal regime for ensuring sustainable development - it actually *requires* that such a system be operated.

European Community law

German environmental law is already shaped to a considerable degree by European directives, regulations and standards, and to an increasing extent also by international laws. However, European Community law has much greater force than the latter.

European laws and standards have defined the environmental legislation in the Member States of the European Union since the early 1970s to an ever-greater degree. Since 1987, when the Treaty establishing the European Economic Community was amended to include explicit provisions on environmental law, this area has undergone major development. European law plays a highly important role in other policy areas as well, such as trade, agricultural and transport policy. It is therefore important that European policy be focused in general on the goal of sustainable development. The provisions of the treaty, especially Articles 130r et seq., provide an excellent basis in this regard. The treaty highlights the cross-cutting nature of environmental policy, as can be seen from the third sentence of paragraph 2 of Article 130r, which states that "environmental protection requirements must be integrated into the definition and implementation of other Community policies." However, as far as the goal of sustainable development is concerned, the issue is not only to "integrate" it or to take it "into consideration" in some indeterminate way when defining other political activities. Instead, the Community must declare sustainable development itself to be one of its cardinal aims. In the first part of the treaty ("Principles"), support for sustainable development should be expressly mentioned as one of the Community's objectives. The goal of sustainable development should also be integrated into the basic provisions governing the various policy fields referred to in the treaty, for example in Article 39, which defines the objectives of the common agricultural policy, in Articles 129 et seq. (trans-European networks), Article 130 (industry) and Article 130 et seq. (research and technological development).

Harmonisation and national sovereignty

One of the core problems in European trade law concerns the demarcation lines between the EU's legislative competence and that of the Member States. The relevant provisions in the Treaty establishing the EC are not consistent in this respect. Several provisions in the treaty restrict the regulatory authority of the individual Member States in such a way that some of their unilateral regulations on environmental protection are impermissible. The question whether such regulations may be adopted or not is posed in two particular cases: firstly, when a given matter is already regulated by European law, and secondly, when the matter relates to non-tariff barriers to trade that are not subject to specific EC

regulations. In the former case, European law prohibits not only unilateral regulations that do not go as far as the European legislation - this poses no problem - but also more stringent regulations on the part of Member States. The requirements that such norms must comply with depend on the relevant provisions in European law. If the latter is a legal act of the EC for the approximation of laws which have as their object the establishment and functioning of the internal market (Article 100a EC Treaty), then the provisions of Article 100a, para. 4 of the EC Treaty shall apply, according to which stricter regulations in the individual Member States, inter alia on the protection of the environment and health, shall be permitted. If the legal act is based on the environmental protection provisions (Article 130s of the ECSC Treaty), then the admissibility of more stringent measures adopted by individual Member States is determined by the rather different terms of Article 130t, which allows Member States to maintain or introduce more stringent protective measures if such measures are compatible with the treaty. However, the provisions of the latter are sometimes unclear, and are subjected to different interpretations.

Article 36 of the EC Treaty states as a basic principle that prohibitions or restrictions on imports, exports or goods in transit ("non-tariff trade barriers") are not permissible. The regulation permits such measures by Member States in certain exceptions only: when they are "justified on grounds of public morality, public policy or public safety; the protection of health and life of humans, animals or plants; the protection of national treasures possessing artistic, historic or archaeological value; or the protection of industrial and commercial property", and if they do not "constitute a means of arbitrary discrimination or a disguised restriction on trade between Member States". Thus, one of the grounds on which Member States may implement unilateral measures is to protect the environment. The specific conditions under which trade restrictions of the aforementioned kind may be "justified" is a question to which the treaty contains no explicit answer.

Compared to pre-1987 days, the Member States of the EU now have more scope to improve on European laws with tougher regulations of their own. European legislation basically only prescribes certain minimum standards to which the Member States must adhere. However, this basic rule should be expressed more clearly and established more firmly. Otherwise, a minimal Europe-wide standard could effectively block efforts of individual Member States to implement above-average measures for protecting the environment. If states are able to improve on the level of protection afforded by European law, such divergent regulations often act as an incentive for the Community to adapt its own regulations to the more far-reaching regulations of individual Member States.

VII 1.3. Principles of German environmental law

Environmental law in Germany is based primarily on the precautionary principle, the "polluter pays principle" and the principle of cooperation. For many years, these three principles have enjoyed full acceptance by all those involved in the establishment and application of laws, as well as by the scientific community. Since 1990, the legislature has been obliged to observe these principles by virtue of a special regulation in Article 34 (2) of the Unification Treaty. They may also be used, without further adaptation, as the basis for the legal changes needed in order to pursue sustainability. The European Community's environmental policy, too, "shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay" (Article 130r, para. 2, sentence 2 ESCS Treaty).

The precautionary principle

The only one of these principles that relates explicitly to goals and objectives is the precautionary principle. In essence it states that environmental risks and damage shall be avoided as far as possible from the very outset, i.e. that they should not occur or develop in the first place. The principle thus refers to precautionary action to protect humans and the environment against adverse effects, risks and threats. Minimisation of risks is called for even when the likelihood of damage is very small. Laws (e.g. the Federal Immission Control Act) sometimes distinguish between "precautionary action" and "risk aversion". In such cases, the objective of risk aversion is to prevent specific (i.e. more probable) threats, whereas the notion of precautionary action refers to the minimisation of remoter causes of damage (i.e. less probable in relative terms), or causes for which the potential impacts have not been clearly identified.

The precautionary principle clearly plays a major role in the context of sustainable development. Precaution to protect the environment and sustainability are two objectives with powerful affinities. The environment is both a foundation and a constraint on the development of any human society. This means that sustainable development is not possible without environmental precautions. Sustainability is therefore a result of optimal precautionary action. The precautionary principle can be retained in its current form - there is no need to reformulate it into some kind of "sustainability principle". It should, however, be taken into consideration more often and more intensively in future when environmental regulations are being drafted - with regard to the need for such regulations as well as to their specific content. Decisions regarding regulations of indirect relevance to environmental protection (e.g. simplification of planning procedures) must also observe the principle.

The "polluter pays principle"

According to the polluter pays principle, the costs for environmental remediation and compensatory measures must be borne by the party or parties responsible for causing the damage. The latter must similarly pay the costs incurred in preventing such damage (e.g. costs for approval or monitoring). The objective here is to internalise the external costs of environmental protection (costs which the public must otherwise bear) by allocating them to the individual agents. A cost-allocation principle of this kind is imperative for fundamental policy reasons: it prevents too wide a gap opening up between the private and social costs of economic activities such as consumption and production, and thus avoids the misdirection of capital flows and reductions in economic performance. The "polluter pays principle" is sometimes understood to be more than a cost-allocation rule, i.e. as a more general principle for allocating *responsibility*. Regardless of its precise meaning, operation of the principle in practice requires that the responsible party take at least some precautionary action to prevent adverse effects on the environment, if only in his or her own financial interest. The extent to which responsible parties are obliged to take such action should be laid down in statutory regulations based on the precautionary principle. To that extent, the polluter pays principle provides an important basis for regulatory measures aimed at achieving sustainable development. Regardless of whether the internalisation of externalities is achieved by regulations, charges, liability regulations or other policy instruments, it can be effective in reducing the consumption of natural resources to a sustainable level.

The principle of cooperation

The principle of cooperation relates to the framework within which environmental objectives are pursued. It emphasises that environmental protection is a matter for which not only the state is responsible, and that the latter cannot achieve environmental protection by merely imposing it as an obligation on industry and society. On the contrary - what is needed is an approach for achieving environmental objectives that is based on maximum division of labour, cooperation and consensus. One core aspect is that decisions are based on all actors being informed to the same high degree. Another is that the purpose of the principle is to reach acceptance of environmental measures among all those involved or affected. Examples of such cooperation are public-law contracts or environmental commitments by sectors of industry ("voluntary commitments"; see Chapter VII 1.8). In the approval procedures for environmentally hazardous projects, participation by the public and by bodies representing the public interest are an expression of the cooperation principle. In the planning process, examples of the principle in operation include consultation procedures with neighbouring communities, between local and regional planning levels, as well as consultation on plans by various political committees.

This basic principle for environmental policy can similarly be applied in unchanged form to the goal of sustainable development. In certain policy areas, collaboration between all social groups probably helps to achieve more measures in this direction than would be the case if the state were to act of its own accord and impose regulations unilaterally.

VII 1.4 The contribution of planning law to sustainability

The instruments of planning law offer extensive opportunities for attaining the objectives of sustainable development, some of which have been underestimated in the past. A traditional distinction is made here between *sectoral planning*, which focuses on sectorally specific tasks (e.g. planning of waste disposal systems or trunk road construction), and *overall planning*, which is the management of all regional development in a given area (e.g. regional planning, land-use planning, development planning, etc.). Landscape planning can be allocated to both fields, since it pursues both sectoral objectives (e.g. in the form of leisure planning) and cross-cutting objectives (landscape planning as an ecological contribution to overall planning).

VII 1.4.1 Sectoral planning

Planning by environmental departments

Current legislation provides a useful basis for sectoral planning in the environmental field, such as air quality or waste management planning. Air quality plans, for example, can be developed in the form of remediational or precautionary plans. The latter variety is particularly suitable for pursuing sustainability. However, this would require that plans of this kind be drafted more commonly than hitherto. The legal option to develop precautionary plans should be translated, as far as normal cases are concerned, into an obligation on the part of authorities to draw up such plans and maintain them. The situation is similar with the other main types of sectoral planning.

In some cases, it makes sense to supplement the list of possible elements of plans. For example, Section 36b of the Federal Water Act (WHG), the basis for water resources planning, should stipulate clearly that plans for water resources management also be drawn up (where required) when the affected water resources are to serve purely ecological purposes (i.e. should not be used by humans).

Furthermore, there should be legal clarification that landscape planning - as an independent and region-wide activity - be responsible for providing basic ecological planning and the assessment criteria by which to solve conflicts between different forms of land use (for transport, housing or industry) and the natural support systems on which life depends. In addition, there should be stronger links between the separate fields of environmental planning at sectoral level, which should be oriented to the basic principles and objectives of general environmental planning as recommended in the so-called 'professorial' draft of the Environmental Code (General Part) (1991).

A problematic aspect is that the measures contained in some environmental protection plans cannot be implemented in full under current legislation because they are merely recommendations with no legal force. Such plans would be more efficient and have greater impact if their binding force on national and local government authorities were strengthened. For example, granting approval to hazardous activities could be made dependent on the activities being congruent with plans. Such regulations already exist in some areas.

Sectoral planning of relevance to the environment

The situation is different where planning carried out by other departments has environmental relevance. The planning objective here usually runs counter to environmental protection targets (e.g. meeting energy demand in the planning period, or the construction of a new trunk road). If the aim is to achieve a sustainable form of development in these fields as well, then the only alternative is to change the content and the outcome of the separate planning stages.

One must distinguish here, too, between different forms of planning. On the one hand, planning can be aimed at achieving a particular political objective in the long term, whereby the measures planned can only be implemented on the basis of additional, subsequent decisions. Plans of this kind can be adopted in a variety of different legal forms, with corresponding variation in binding force. Examples include the Federal Transport Network Plan (public requirement plan), the route plan for specific transport infrastructures, or more "informal" plans, e.g. an energy programme. On the other hand, the objective of planning can be to grant legally binding approval to certain large-scale projects, such as national motorways, inland waterways or landfills ("project approvals" - Planfeststellungen). These official decisions function primarily as direct management of behaviour, in that they regulate the permissibility of the project in a final and absolute way. Due to the considerable scope for decision-making that the authorities possess in such cases - the Federal Court of Administration speaks of "freedom of planning" - project approvals are generally classified as planning instruments.

Required modifications to sectoral planning procedures

The modifications needed in order to promote sustainable development as an objective are illustrated using the legal basis for project approvals. According to established case law, such planning procedures require

- that a need exist for the project in question, i.e. that there is justification for the plan,
- that all mandatory legal regulations (the guiding principles of planning operations) be complied with,
- that the authorities have weighed up all public and private interests in an equitable manner.

The overall weighing of interests, for its part, is only legally acceptable if the authority in question

- is aware of its scope for assessment,
- includes all concerns of relevance to the case in its assessment,
- weights the individual concerns according to their objective significance in a "reasonable" way, and
- does not make any decision, when arriving at its final assessment (i.e. when giving preference to particular interests to the detriment of others), that is out of proportion to the objective weight of the interests.

For the topic that interests us here, this means that the relevant laws must contains rules that control the need for the relevant project (e.g. "new roads may only be built and existing roads developed if there is an urgent and indisputable need"). Furthermore, *guiding principles for planning* should be adopted that have a similar restrictive effect, such as the ban on destroying or fragmenting areas of natural beauty - e.g. as provided for by Section 20c, sub-section 1 Federal Act on Nature Protection (BNatSchG) - ,or the obligation to revert other existing roads to 'natural' land when a new road is built or an existing one enlarged. The results of the environmental impact assessment that must be carried out in such cases under current legislation would have to acquire the status of planning principles. Finally, it is advisable to have clearer stipulations for the assessment of interests. Under current law, it is assumed that the laws view all interests *abstractly* (i.e. independently of the specific case at issue) as having the *same* value. This means that it is up to the responsible authority to identify the weight of each interest when the specific case arises, and depending on the situation. There are, of course, many exceptions to this principle. A general prioritisation of specific interests can be derived to a certain extent from various legal norms (e.g. the protection of soils clause in Section 1, sub-section 5, sentence 3 BauGB (Building Code) or Section 50 BImSchG). Several regulations require an official decision that ensures the optimal protection of particular interests ("*Optimierungsgebot*" - optimisation imperative). These approaches are not sufficient for achieving sustainable development, because it is often unclear and disputed how far such "ranking" clauses extend, and what precisely they require. One and the same standard is seen by one expert as a (strictly binding) planning principle, an by another as a (mere) optimisation rule.

Priority for environmental protection

The meaning of the "optimisation imperative" is a similar bone of contention. Clear regulations prioritising environmental protection should therefore be added to the relevant laws. Two variants would be

possible: either absolute prioritisation of environmental protection (i.e. in all cases), or a milder form in which environmental interests are accorded greater weight than opposing interests - not in all cases, but in circumstances that would have to be precisely defined - i.e. depending on the individual case. Absolute prioritisation rules are obviously more suitable than relative ones for promoting sustainable development. The legal literature considers them to be anti-constitutional, however, because the duty for comprehensive equalisation of interests in the planning process can be traced back to the constitution ("*Rechtsstaatsprinzip*" - the principle of the state governed by laws, especially the principle of proportionate means ("*Verhältnismäßigkeitsgrundsatz*") and because no such special value or prioritisation is accorded environmental interests in the constitution. This analysis, which was developed in the 1970s and 1980s, may require revision following the addition of Article 20a to the Basic Law; however, it illustrates clearly that statutory provisions granting absolute or relative priority to the environment must be based on firm constitutional foundations.

With rules such as the above, planning decisions at sectoral level could be directed along sustainable development lines to a certain extent. Another drawback, though, is the very imprecise way in which the relevant laws outline how and which decisions are to be made, that they grant authorities broad scope in their decision-making ("*planerische Gestaltungsfreiheit*" - freedom of planning). Official practice until now has shown that, for a variety of reasons, environmental interests tend to have worse chances of being asserted in the assessment of interests than opposing interests (e.g. business, transport or regional policy interests). This is generally the reason behind projects being approved despite the serious adverse effects on the environment. It may be possible to reduce this de facto imbalance with a statutory requirement to prioritise environmental interests. The remaining imbalance could be partially eliminated if the authorities had detailed assessment criteria - in the form of administrative rules and directives, for example - on which to base their decisions, rules that could include ambitious environmental quality targets or even standards. The importance of environmental interests in administrative procedures could also be improved if the nature conservation authorities were not only consulted in all cases of this kind, but their approval required for the decision to enter into force ("*Einvernehmen*" - veto rights or principle of consent).

With regard to sectoral planning procedures and other forms of interference with nature and landscapes (see Section 8 BNatSchG), reference should be made in the context of sustainability to the avoidance and compensation rules, in nature conservation law, governing interference with nature. Under existing law, interference with nature and landscapes must be prohibited if the degradation or harm associated with it cannot be prevented or compensated for to the required extent and if the interests of nature conservation and landscape management rank higher when balancing all demands on nature and landscape resources. An intervention is balanced or equalised if, when it has ended, no major or persistent disruption of the balance of nature remains and the visual appearance of the landscape has been restored or reshaped in an appropriate way. The weaknesses of this regulation are partly attributable to the imprecise terminology used. Moreover, the decision whether priority of interest is accorded to those carrying out the interference or to nature and the environment is often taken to the detriment of the latter.

To regulate the relationship between intervention rules and building law, precautionary action to ensure adequate balance and compensation occurs beforehand at the level of land-use and development planning, rather that in the subsequent approval procedure (Section 8a ff. BNatSchG). Applying these regulations, which were not adopted until 1993, has involved various problems that could have been

avoided through clearer formulation. Another major problem concerns the regulation that the local authority must decide on compensation for adverse effects "in the framework of the balance of interests". This opens the door for development plans to lay down only *partial* compensation for the planned interference. In addition, compensatory and substitute areas do not enjoy any form of special protection in the plans, with the result that they can be designated for other uses if plans are later changed.

The nature conservation rules on interference can only be utilised for achieving sustainable development if the importance attached to nature and landscape is considerably enhanced in decision-making on development consent or development plans. This requires a number of measures, some of which are listed below:

- exposure of nature and landscape to airborne pollution must be classified as interference,
- the criteria for equalising the nature and landscape concerns, on the one hand, and those of the project organisers, on the other, must be specified as fully as possible and demand high standards of nature conservation,
- transparent evaluation methods would have to be developed or, if already in existence, refined further,
- responsibility for decision-making should be assigned to the nature conservation authorities; failing this, decisions should require the approval of the latter before they can enter into force,
- the local authorities should be under an obligation to stipulate full compensation for interference with nature and landscape in the land-use and building plans.

VII 1.4.2 Overall planning

Much of the above applies to overall planning as well. The purpose of overall plans - such as regional development, urban development or regional land-use plans - is to coordinate different and often competing demands to use the respective area (e.g. for housing, transport, recreational or industrial purposes) in a trans-sectoral and superordinate process. They define priorities and posteriorities of development and are drafted at several levels, whereby there are differences in standard practice among the *Länder*. In those *Länder* covering very large territories (e.g. Bavaria), general plans of this kind are prepared for the entire state ("*Landesplanung*" - state planning), often for sub-domains ("regional plans" or "area development plans"), at local level for the entire local authority ("*Flächennutzungspläne*", or land-use plans), and for sections of local authority areas ("*Bebauungspläne*" - building plans). Plans relating to the *Land* as a whole contain central, but still relatively abstract stipulations requiring further specification of detail, which then occurs at the subordinate levels down to final building planning level, where the general stipulations are expressed as detail plans for separate plots or areas in the local authority. Building planning is concerned with all types of land use - not only buildings, but also free areas of land. As with planning at sectoral level, assessment criteria (methodological requirements, sustainability indicators and similar) can contribute within

framework programmes, rules or decisions towards environmental concerns being appropriately weighted in the planning process.

Objectives and principles in the overall planning process

The most important content in the overall plans are the *objectives for land-use and state/regional planning*, which define the direction of future development and therefore have to be complied with by all authorities at national and *Länder* level as well as by other public-law planning agencies. At local level, the contents of the land-use plan are binding on the local authority itself and, to a certain extent, other authorities as well. The stipulations in the building plan are legally binding in general - particularly on individual citizens, for whom they are primarily intended.

The scope for decision-making on the part of the responsible planning bodies is thus considerable. This scope is constrained at regional level by the constitution, of course, but specifically by the Federal Land-Use Planning Act* (*Raumordnungsgesetz* - ROG) and by the regional planning laws of the *Länder*, which lay down certain general objectives (see Section 1 ROG) and principles (see Section 2 ROG). The Federal Land-Use Planning Act itself contains references to sustainable development and a cross-sectoral perspective on ecological, economic and social aspects. Section 1, sub-section 1 ROG, for example, states that "The territory of the Federal Republic of Germany shall be developed, taking into consideration the natural environment, population growth as well as economic, infrastructural, social and cultural needs, and in accordance with the following general objectives, in such a way that it

- best serves the personal growth of the individual within the wider community,
- ensures the protection, management and development of the natural resource base,
- keeps the options for land use open in the long term and
- offers or leads to equality of living conditions for people in all regions and areas."

The importance of these general provisions for resource management should not be underestimated. The guiding principle of sustainable development should therefore be explicitly mentioned in this context - as an additional objective in Section 1 ROG and - with specific details - as a principle governing land-use planning under Section 2 ROG. These regulations refer, even today, to the protection, management and development of the natural resource base; but this does not mean that a reformulation to include sustainable development would be superfluous in any way. Guiding principles for sustainable regional and settlement development in accordance with the precautionary principle for environmental protection - such as internal before external development, mixture of land-use types, geographical concentration of urban development, or linkage between free areas - must form an integral part of such reformulation. Given the crucial significance of the term "sustainable development", it would make perfect sense to stipulate this principle as the fundamental goal of overall planning processes. The draft version of the planned re-enactment of the Federal Land-Use Planning Act which was presented earlier this year is indeed in line with this and contains such a clause.

General provisions laying down planning objectives can be found for the local level in Section 1, sub-section 5 of the Building Code (*Baugesetzbuch* - BauGB). This regulation, too, should refer explicitly to sustainable development as a goal of development planning. The specific interests which must be

taken into consideration by planning operations (Section 1, sub-section 5, sentence 2 BauGB) would have to be amended or supplemented accordingly. Further additions would be called for in Section 1, sub-section 5, sentences 3 and 4 BauGB.

Balancing environmental protection and other concerns

In essence, the permissible contents for plans are adequately defined in existing regulations (Section 5 ROG, planning laws of the *Länder*, Sections 5 and 9 BauGB). The only restrictions on building plans are those stipulated in Section 9, sub-section 1 BauGB. For example, such plans may not include stipulations of relevance to water resources management if the relevant measures are governed by other legal principles. The consequence is that local authorities are effectively prevented from using building or land-use plans to protect water resources. Nor are local authorities permitted in their building plans to impose limit values for emissions or immissions in connection with particular areas of land. In all cases of this kind, they should be entitled in future to lay down more stringent regulations that those stipulated by national law.

As far as equalisation of interests is concerned, all concerns that must be taken into consideration in the overall planning process are currently being assessed as abstractly equal. Here, too, the planning authorities decide themselves - after consultation with the other relevant authorities and departments, and after full evaluation of competing concerns - on the objectives to be integrated into the scheme or the plan, and which developments are to be prioritised. Indeed, this equality of interests is seen frequently as essential for land-use planning and *Länder* planning to be superordinate to sectoral planning operations and possess an overall, trans-sectoral function. Nevertheless, the situation here could also be changed to enhance sustainable development. Statutory guidelines can well be reworded to give this goal more weight. Such a change is nothing but a logical consequence if the principle of sustainable development is stipulated in law as the ultimate goal of the planning process, or at least as one of several guiding principles. Although it would lead, in theory at least, to environmental concerns being prioritised in specific planning processes, which would mean abandoning the abstract equality of all interests, this poses no problems if the goal of sustainable development were established in the constitution. Even without such a constitutional norm, it should be realised that special weighting of specific interests and concerns can already be derived in many cases from certain statutory values, which means it is doubtful at present whether the principle of abstract equality of all interests can really be upheld.

Finally, the relationship between sectoral planning processes and overall planning processes at regional level should be modified. On the one hand, privileges for sectoral plans and project approval procedures that are detrimental to environment should be dismantled. On the other hand, the role of environmental planning, e.g. landscape planning, should be strengthened vis-à-vis urban construction and land-use planning, and their weight within the consultation procedures for overall planning should be enhanced.

Reference should also be made in closing to the fact that “informal” planning instruments (planning levels) are becoming increasingly important in managing the environmental and developmental problems of the municipalities and regions in Germany, as evidenced by urban development programmes, agendas for development, expertises on sub-regional areas, etc. A key management instrument for sustainable urban and settlement development are the Local Agendas referred to in Chapter 28 of Agenda 21, as adopted by the Earth Summit in Rio. Section 28.3 requires that “Each local authority should enter into a dialogue with its citizens, local organisations and private enterprises and adopt a local Agenda 21”. A

full report on the development and current status of the Local Agenda 21 process in Germany, and the activities at federal level in support of that process, can be found in 'Umwelt' 6/1997, published by the Federal Ministry of the Environment.

Problems that remain

Even if the above improvements are implemented, it will still be the case that not all plans can be utilised in an equally effective way for achieving sustainable development. The potential impacts of most planning instruments are limited. Direct influence on human behaviour is only possible when the plans themselves perform a kind of "gatekeeper" function, which is only the case with project approval procedures (even here there are exceptions). It is a regular occurrence, in contrast, that building plans fail to provide full details on land use. The content of such plans can be specified and modified by subsequent decisions regarding approval for the construction projects. Moreover, the less precise the content of plans, the less influence they will exert on behaviour. Another negative factor is that the drafting and renewal of each plan consumes a considerable amount of time and effort. It is partly for this reason that the full potential of planning instruments has not been fully exploited until now. In many fields, such as water resources management, very few plans have been produced so far. Many local authorities in Germany still have no land-use or landscape plans of their own. These are the reasons why behavioural management through direct and binding decisions by local authorities, discussed in the next section, plays such a key role.

VII 1.5 Sustainable development through direct management of behaviour

The predominant methods used in direct behavioural management are still the traditional regulatory instruments of intervention and control. These include statutory bans (e.g. a prohibition to manufacture certain hazardous substances such as chlorofluorocarbons), directives (e.g. the requirement to equip an industrial installation with additional pollutant filters) and administrative instruments of control (e.g. the requirement to obtain approval for hazardous equipment, the requirement to notify the authorities about certain other activities with environmental impacts, the obligation to provide authorities with certain types of information, or to measure emissions and immissions). Public authorities require those at the receiving end of such instruments to behave in a certain way - to perform, tolerate or refrain from certain activities. This system has been extensively developed, particularly in the field of environmental law.

Targets of behavioural instruments

Measures for behavioural management frequently take the form of interventions to avert existing threats or potential risks. These instruments involve more than the classical tradition of warding off dangers as practised by police authorities. They are based in part on the precautionary principle as well. For example, the operator of an installation requiring approval under Section 5, sub-section 1 (2) BImSchG is obliged, inter alia, to take precautionary action to ensure that no damage is done to the environment. Several rules of this kind can also be found in the laws governing water resources. For example, Section 26, sub-section 2 WHG (the Federal Water Act) prohibits the storage or deposition of substances in the vicinity of water resources if there is cause for concern that this may result in the water being polluted, or in detrimental changes to the properties of the water or the streamflow. Sec-

tion 17 ChemG (the law on chemicals) provides authorisation to impose precautionary bans or restrictions on certain substances. Laws of this kind thus contain certain elements of sustainable development.

What is particularly important in this connection is that the precautionary aspect be stipulated in *all* relevant regulations, and that the relevant provisions be amended to give greater weight to environmental precautions. The duty to ensure that avoidable environmental stresses are really avoided in practice should be maintained - not only in the case of installations covered by the Federal Immission Control Act and certain other types of project and activity, and not only when the impacts lead in specific cases to dangers, serious adverse effects or severe nuisance. A generalised obligation of this kind may indeed be difficult to enforce, in that the word "avoidable" is open to interpretation and because monitoring compliance often involves problems. However, in many fields one might consider developing case groups of avoidable activities, such as leisure trips in private cars, and in this way specify the term in more detail.

Enhancing precautionary measures is an imperative in the nature conservation field as well, one of the few areas of legislation that already deploy the concept of sustainability. Above all, the goals and principles of nature conservation (Sections 1, 2 BNatSchG and the corresponding laws at *Länder* level) should be amended to give much greater weight to nature conservation and landscape management. The introductory clauses on "equalisation of interests" in the Federal Nature Conservation Act should be deleted. The latter demand that the various nature conservation requirements be weighed up amongst each other and against other demands on the part of society in general. In addition, the objectives of nature conservation and landscape management must be attained in accordance with these provisions (only) to the extent necessary, possible and reasonable, taking all requirements into account, in order to realise those objectives in each specific case. The weakness of the nature conservation regime in Germany to date can be traced back to these regulations, which dilute from the very outset the relevance of natural environmental and landscape concerns to a considerable degree. Another clause that should be deleted is Section 1, sub-section 3 BNatSchG, which relates to agriculture. The imperative of avoidance and compensation implicit in the regulations governing interventions under the nature conservation law must not be compromised by other regulations. In the relationship to building planning law, the regulations on interference must continue to have a firm foundation in the Federal Nature Conservation Act (BNatSchG), and be oriented to the goals of nature conservation and landscape management.

The ministerial bill for the re-enactment of the Federal Nature Conservation Act accords with this demand in principle, but it is critically dependent for its practical effectiveness on the refinement of good expert practice. The draft for the new Nature Conservation Act does not view land use by agriculture, forestry and fisheries as interference, provided that the goals and principles of nature conservation and landscape management are given due consideration. As long as land use by agriculture, forestry and fisheries complies with good expert practice, it does not usually run counter to these goals and principles. To ensure that this regulation operates in favour of nature conservation and environmental protection, the respective laws need to further refine and specify what is good expert practice. An example would be the Federal Soil Protection Act, which currently exists in the form of a bill.

The integrated approach in environmental regulations

If environmental law is to contribute to environmentally sound and sustainable development in all areas, it makes little sense to have separate and non-harmonised laws for each environmental medium - soil, water, air, nature and landscape - or for isolated problematic sectors (chemicals or waste). Such an approach would fail to take account of the linkages and interactions between the various components of the environment, and there would be no excluding the possibility that one environmental medium is protected at the expense of another, thus shifting the problem from one domain to another. Policymakers have been endeavouring for some time now to formulate environmental regulations in such a way that they operate across the boundaries between different media.

The most important instrument in this connection is the environmental impact assessment, which forecasts and evaluates the impacts of certain activities on all areas of the environment. Environmental impact assessments in Germany are based on an EC Directive dating back to 1985. The content of this European law, which relates to the assessment of particular projects in the public and private sectors, has recently been extended. Another EU Directive on the environmental impact assessment of plans and programmes is being prepared.

The EU Directive of 24 September 1996 concerning integrated pollution prevention and control requires an integrated approach for ensuring that permits for certain types of installation are only issued if emissions into air, water or soil are prevented. While pursuing an integrated, cross-media approach, the Directive does not go as far as that on environmental impact assessment. Implementation of this Directive requires administrative changes with regard to responsibilities and procedures, as well as redefinition of the conditions with which installations must comply.

The environmental audit is similarly aimed at integrated protection of the environment as a whole. The core purpose of this scheme, in which enterprises participate on a voluntary basis, is to control all types of pollution from individual sites, for example by integrating environmental protection into production processes rather than using “end of pipe” technologies.

The goal of sustainable development implies that these approaches be generalised and that steps are taken to ensure, in all relevant cases, that all environmental issues be given adequate consideration in one and the same decision by means of cross-cutting analysis. To accomplish this, it is necessary to coordinate the specific requirements laid down in the various regulations governing permits for installations and sites. The important thing is that environmental aspects form a continuous element of these requirements and that their weight compared to other interests - e.g. economic or regional policy interest - is adequately defined (“external” integration). Moreover, they must be adequately weighted in relation to each other (“internal” integration of environmental interests; see Storm, 1997).

Scope for authorities

A further modification must be made to a whole series of regulations aimed at controlling behaviour; the options open to authorities must be tailored to the precautionary aims of the respective laws, i.e. authorities must be granted greater leeway or discretionary powers than hitherto. This has already been accomplished in the field of water resources management, for example. Management of public water resources (surface water, groundwater and coastal waters) is the responsibility of the state; private individuals have no rights to dispose of such resources. Ownership of a plot of land, for example, does

not include the groundwater under the surface. Land owners therefore have no 'automatic' legal entitlement to utilise water resources - instead, water authorities may decide after due consideration and at their own discretion whether to permit or approve specific uses of such resources (e.g. withdrawals). Similarly, the subsequent imposition of requirements and stipulations on a permit, or the rescission of permits and approvals are possible to a relatively wide extent.

Similar public-law rules for resource management could become necessary for other natural resources as well (whereby their obvious differences and functions would have to be taken into account), if the goal of sustainable development is to be taken seriously. Use of the air by installations which cause emissions is a case in point. In concrete terms, this means that the conditions laid down in Section 6 BImSchG for approval of installations (which entitles a company to a permit if the legal conditions are met) would have to be replaced, for installations of a certain minimum size at least, by a discretionary decision. The stipulations contained in the regulations governing projects subject to approval procedures ('Planfeststellung')provide an example for such an approach. These tend to be couched in very general terms (e.g. "the project must be in the general interest"). Such clauses demand full consideration of all interests involved and therefore commit the responsible authority to take environmental concerns into account in an integrated manner. The only exception is when the project is likely to engender risks, serious adverse effects or severe nuisance for people. In such cases, these negative impacts cannot be "equalised" by the positive effects the project may have for other environmental assets.

In practice, however, the difference between discretionary and rule-bound decisions is not necessarily as great as it might at first seem. The critical point is always the wording of the respective legal norm: in the system of rule-bound decisions, the conditions for approving an activity that poses a threat to the environment can be worded relatively vaguely (e.g. "approval shall be granted if the project is not expected to have serious adverse effects on the environment"). This provides the authority with a certain amount of interpretational leeway. Of course, such an approach would tend to weaken the entitlement to approval. For this reason, the scope enjoyed by authorities has been narrowed considerably by the courts in the case of rule-bound decisions. The control options open to the authorities may thus be greater if they are granted wider discretionary powers (or "freedom of planning"). The opportunity to grant permits only to those projects that conform most to the needs of sustainable development is something that is not provided for under immission control law, for example. This is possible, on the other hand, where the authority enjoys planning discretion. The project approval authority, for instance, is under a basic obligation to examine all planning alternatives that present themselves.

Explicit guidelines for decision-making

On the other hand, granting additional discretionary powers to authorities does not necessarily lead to decisions that promote sustainable development in an optimal way. As long as the relevant legal and administrative regulations do not specify precisely the manner in which the authorities must weigh up the individual interests, there is always a risk that environmental concerns will not be taken fully into account and that the role they play in the decision-making process becomes difficult to determine with any precision. To prevent the scope of authorities from being used in a manner that runs counter to the goal of sustainable development, the authorities must be given concrete rules to follow - particularly in the form of tough environmental quality and emissions standards. There are already numerous regulations defining environmental quality and emissions standards: for example, there are several directives pertaining to the Federal Immission Control Act, the Technical Guidelines on Air Pollution Control and

Noise Control, and the Administrative Framework Regulations on Wastewater. Most of these define emissions standards, however. Quality standards are stipulated in only a few areas of German law; moreover, many of them are not based on the precautionary principle in the wider sense, but are designed to avert specific threats (e.g. the limit values for noise in the 16th Federal Immission Control Regulations). The goal of sustainable development requires that quality standards be used as a precautionary instrument and that they be reworded to this effect. Also, limit values based on the precautionary principle should be defined for substances that have not been specifically mentioned in the relevant regulations so far.

The important point here as well, however, is to pursue an integrative approach. If emissions and environmental quality standards are defined for individual media only, without taking account of the linkages and interdependencies between the separate compartments of the environment, then the standards might lead to problems merely being shifted from one domain to another, without reducing the environmental problems on balance.

Additional forms of state intervention

In some areas unilateral regulations will have to be imposed more widely, especially statutory bans, or control through a mandatory requirement for official approval. The last 25 years have seen repeated cases where non-binding recommendations for environmental protection (e.g. speed limits, car-free days or reduced packaging) have had limited impacts, if any. Voluntary committments by various sectors of industry have not always led to the desired result. Where such recommendations, cooperative solutions and voluntary activities do not suffice, the only remaining option is to promote sustainable development by means of national measures introduced by the state. When deciding which instruments to use, the time, effort and expense that they imply for those involved, for the authorities and for monitoring bodies are all key factors.

One idea, for example, would be to couple the production of packaging materials to the technological, environmentally benign and economically attractive option of recycling. Certain elements pointing in this direction can already be found today in the laws on recycling and waste. Another example would be the freight transport field, where road transport could be limited to certain maximum levels. Flexible design of such quantitative restrictions blurs the boundaries to economic instruments - such as compensation schemes or environmental licensing.

Regulations governing competence of authorities and public participation

The substantive regulations described above can only operate efficiently if they are complemented by regulations governing accountabilities and procedures. The decision on whether a particular project (a road construction project, for example) is to be assessed as interfering with nature and landscape, and on the legal consequences that are brought to bear, should not be taken by the administrative department with immediate responsibility (in this case the road authorities), but by the nature conservation authorities instead. If responsibilities continue to be allocated as they are today, then the nature conservation authorities should at least be granted powers to veto such projects.

Participatory rights of accredited nature conservation organisations in procedures relating to the environment should also be enhanced. Another recommendation would be to make greater provision for public participation in approval and planning procedures. The expertise of environmental organisations

and individual persons can be utilised in favour of environmental protection and sustainable development in all decisions concerning us here.

Enlargement of scope for legal action by associations

The effectiveness of environmental regulations also depends on whether and to what extent the courts are able to review official decisions. Under German law, the only people who can take legal action against the authorities in such a context are those who can claim that their subjective rights have been violated by a decision or absence of decision. Legal action of this kind is always dependent on whether the relevant regulations grant the plaintiff a subjective right in the matter, or whether the regulations are only "objective" law. In nature conservation law, inter alia, there are many purely objective norms which merely guarantee a certain behaviour on the part of authorities, without substantiating any legal position on the part of individuals. As a consequence, compliance with such norms is not generally subject to judicial review.

To eliminate this shortcoming in the legal system, twelve *Länder* have introduced the so-called "*Verbandsklage*" (legal action instituted by an association in the interest of its members or the general public). In these *Länder*, it is possible for accredited nature conservation organisations to appeal against official decisions in certain matters without having to prove that their own rights have been violated. The right to institute legal action is conditional on a number of factors that vary from one federal state to the next.

The *Verbandsklage* can obviously play a role in monitoring the legality of administrative acts, and thus serve to eliminate shortcomings in a sub-domain of environmental protection. This assessment is corroborated by experience with similar legal rights in other states (e.g. in France, Switzerland or the USA). Previous reservations that the right of organisations to take legal action against administrative decisions would lead in Germany to the administrative tribunals being "flooded" by litigation have not been confirmed. The principle of competitive equality dictates that this right to legal action on the part of organisations should be harmonised at national level and established in national law. In parallel, the new regulations should avoid existing ambiguities, superfluous restrictions on the right to take legal action, and similar mistakes.

VII 1.6 The role of environmental impact assessments

Environmental impact assessments (EIA) are an important instrument within the planning process as well as for certain forms of direct behavioural management. Through prior assessment of environmental impacts, they can help authorities prepare decisions (such as granting approval for the construction of a major trunk road, or the decision to accept a building plan). This involves both the prediction and evaluation of such impacts. As already mentioned, environmental impact assessment is aimed at *integrated* assessment of impacts on all environmental media (soil, water, air, human beings, fauna, flora, etc.) in order to identify the interactions between these domains as well. Provided it is optimally designed and efficiently applied, the EIA is an important tool for enhancing sustainable development,

one reflection of this being the fact that it is the only instrument explicitly mentioned in the Rio Declaration.

The analysis of environmental impacts within the EIA procedure should not be confined to the preparation of an internal administrative expertise. Instead, the expertise or report must be made available not only to all relevant authorities, but also to the general public, and revised in the light of public and official response. The assessment thus functions to raise environmental awareness and to improve public participation in decisions taken by the executive. Various procedural options exist for organising such participation.

For EIA procedures to be efficient, it is essential in each specific case that

- the expected environmental impacts of the activity are comprehensively and reliably forecast and adequately assessed (quality of assessment),
- the results of the assessment have an optimal influence on the subsequent decision whether to permit the activity (implementation of results) and
- that the activity is monitored at a later date to identify any deviations from the ex-ante assessment (monitoring).

Widening the scope of application

However, one must be aware of the limited scope of environmental impact assessments. In most cases the instrument is applied to prevent or at best reduce the environmental stresses and risks associated with innovations, but not to improve the status quo. Only in those rare cases in which an *environmentally benign* activity (e.g. a river renaturation project) is assessed can the positive impacts be enhanced in certain circumstances through the assessment procedure. On the other hand, the major benefits for the environment associated with the avoidance or prevention of additional environmental damage should not be underestimated; the wider the scope of application that environmental impact assessments are granted, the greater the benefits that can be achieved.

As a precautionary instrument with cross-cutting, cross-sectoral character, EIA needs to be integrated within the overall system of environmental law and environmental policy. Only through linkages with other fields (e.g. environmental planning, or the approval procedures for hazardous substances) can conflicts between the separate fields of responsibility and instruments be avoided.

Based on the wealth of experience already acquired with EIA in many countries since the early/mid-1970s, particularly in the USA, the assessment system must comply with the following requirements:

The assessment must cover all activities that may have more than irrelevant environmental impacts. These include not only specific projects (e.g. trunk roads, industrial installations), but also plans (e.g. waste disposal and wastewater treatment plans) and programmes (e.g. regional development programmes). Important political decisions (e.g. cabinet decisions on energy or transport policy) should be subjected to similar assessment. The same applies for draft bills, public-law contracts, etc.

The EIA is intended, inter alia, to produce the most favourable decision from the ecological perspective. This can only be achieved if the most important options are known in each case, i.e. if alternatives

and their environmental impacts are included in the environmental impact assessment along with the activity itself. In the case of projects, these include locational, production and waste disposal alternatives as well as the so-called "zero alternative" - complete rejection of the project.

EIA must take into consideration all environmental impacts of relevance to the case in question. In detail, this means analysing each separate phase of a specific project - construction, operation (normal operation, disturbances and accidents), decommissioning, demolition and subsequent uses of the site. In addition to direct effects on the environment, "impacts" can be indirect, short-, medium- and long-term, permanent, temporary, positive or negative, and induced by singular causes or causal complexes. Where activities have transboundary impacts, these must also be covered in the assessment.

Environmental impact assessment and decision-making processes

The results of the assessment will only have a real influence on decision-making if the relevant laws and regulations prescribe it: either in general form (e.g. "Development consent for the project shall only be granted if this accords with the results of the environmental impact assessment") or in greater detail (e.g. "The project shall have no serious adverse impacts on soil, air, water, nature, landscape, .. (etc.)"). Where regulations delegate final decision-making to the authorities to a greater or lesser degree (e.g. "The project may not be detrimental to the common weal"), an efficient assessment system is required to ensure that these indeterminate clauses are further specified in detailed *environmental quality targets*. All such regulations must be directed not only at averting threats, but must be based - as befits the purpose of the assessment - on the goal of precautionary environmental operations. Responsibility for formulating such environmental targets should be assigned first and foremost to the environmental planning authorities.

Experience, particularly in the USA, has shown that EIA can only operate as effective environmental instruments when the courts are able to monitor whether and how they are being implemented. Legal action by associations plays a key role in this connection (see Section VII 1.5).

VII 1.7 Sustainable development through indirect management of behaviour

Environmentally relevant behaviour on the part of people and institutions can also be influenced by indirect means, especially market instruments. Here, the attempt is made to achieve the targets of state control in an indirect way by motivating the relevant actors to act in a certain way; creating financial benefits or drawbacks is a common technique in this respect. Precisely the debate on "shortcomings in execution" has led to closer attention being devoted to the opportunities for and limits to control that are provided by such indirect instruments. One must realise in this context that these measures are no exception in requiring a certain amount of administrative effort, which can sometimes impose considerable limitations on the supposed efficiency of such measures.

Examples of such instruments can be very diversified, for example

- taxes on products, materials or activities (e.g. petrol tax),
- charges for using environmental assets (e.g. groundwater charge),

- emissions charges (e.g. wastewater charge),
- disposal fees and charges (e.g. waste disposal fees),
- compensation schemes (e.g. under the Federal Immission Control Act; flexible fleet consumption regulations for road vehicles),
- environmental licences (e.g. for hazardous substances, waste, packaging or CO_2),
- liability regulations (e.g. an Environmental Liability Act),
- recycling systems (recovery and recycling of packaging on the basis of deposit regulations),
- eco-labels,
- environmental inspections in enterprises (eco-audit scheme).

Instruments for indirect control of behaviour provide a wide range of options for promoting the idea of sustainable development. For example, taxes on fossil (i.e. non-renewable) fuels can lead to reduced consumption purely on account of the costs aspects involved. However, it should be realised that financial benefits and drawbacks must be of sufficient magnitude before they can operate as an efficient means of controlling behaviour. Targeted modifications of behaviour can only be achieved among those obliged to pay such charges if the costs for reducing adverse effects on the environment are lower than the payments that otherwise have to be made (see Section VII 3).

One of the instruments for indirect behavioural management is the environmental audit introduced at European level (Council Regulation (EEC) No 1836/93 allowing voluntary participation by companies in the industrial sector in a Community eco-management and audit scheme). Any company operating a site and wishing to participate in the scheme must adopt a company environmental policy. This must include commitments not only to comply with all relevant regulatory requirements regarding the environment, but also to ensure continuous improvement of the company's environmental performance. On the basis of this policy, the company develops an environmental programme for the site, and operates an environmental management system covering all activities there. The environmental policies, programmes and management system must be examined by accredited environmental verifiers who must be independent of the site's auditor. For every site participating in the scheme, an environmental statement designed for the public is then prepared. The environmental statement is also examined by an independent environmental verifier to validate whether it complies with the requirements of the Regulation. Participation in the scheme can lead to reduced consumption of resources and to reduced emissions to air, water and soil for the simple reason that causes of excessive material and energy intensities on the site as well as any unnecessary damage to the environment are identified during the environmental audit.

VII 1.8 Sustainable development through activation of the cooperation principle

Voluntary agreements such as those frequently made in the past - usually by associations representing specific sectors of industry - may possibly be, to a limited extent at least, a useful means of promoting

sustainable development. Declarations of this kind do not require any special statutory regulation and for this reason are relatively flexible. They provide an opportunity for implementing certain measures quickly and without complications. However, since their effectiveness depends on a number of different factors, they are not always appropriate in certain fields. In no sense can they operate as a complete substitute for regulatory laws - in particular not in core areas.

As far as the actual content of such declarations is concerned, the fact that they are generally the result of negotiation between a particular industrial association and public authorities (e.g. a ministry) is something that must be taken into consideration. The commitments made by the relevant industry are often less than the maximum conceivable position, all the more so when the association must take account of corporate members who take a non-cooperative stance. Authorities may accept certain compromises in order to achieve such commitments on the part of industry. The problem that arises in connection with the implementation and impact of such declarations is that the industrial association can only enforce this decision on its members on the basis of general legal regulations. Self-imposed commitments therefore require a high degree of organisation, something which not all sectors possess. Another significant difficulty, particularly in the context of European integration, is that such commitments apply only to domestic companies, but do not involve any commitment for foreign companies operating in the same sector in the same country. Moreover, the differentiation between production, distribution and consumption must be taken into consideration. A declaration of commitment by an association of *manufacturers* of certain substances, to the effect that production of these substances shall be restricted, does not usually affect imports of the substances. Finally, monitoring compliance with the declarations can generate problems; in most cases, there are no judicial means for enforcing them.

Many of these problems can be eliminated or at least reduced by making changes to the formulation procedures, content and operational aspects of the declarations, as exemplified by the "Covenants" system in the Netherlands (Rennings, 1996). Even then, however, it is necessary to acquire more experience with these innovative instruments. For the time being, declarations of commitment are a feasible option only in areas where statutory regulation is not possible.

VII 2 The necessity of an Environment Code

The recommendations put forward here are a clear illustration that environmental law needs refining in many respects in order to contribute effectively towards sustainable development. A key factor concerns the ease with which environmental regulations can be applied - i.e. they must be transparent, comprehensible and free of internal contradictions. The implication is that the diversity and fragmentation evidenced by the present legal system needs to be reduced. However, there are constitutional restraints in this regard, in that legislative authority in the environment field is shared by both federal government and the *Länder*. Moreover, it will be difficult in the long run to get around the splits between formal laws, statutory regulations, administrative rules and plans having different legal status.

Much preparatory work has already gone into drafting a new Environment Code. Proposals for a General Section and a Special Section of the Code have been put forward by a professorial commission (UBA; 1990 and 1994e). By the end of 1997, the Independent Commission of Experts on the Environ-

mental Code will submit a draft proposal for an Environment Code in the preparation of which practitioners in the various fields were also involved (UBA, 1996).

Environmental law as a whole can be greatly enhanced by such a Code. Its unifying and standardising force will have impacts on legislation at *Länder* level, where further regulations are necessary to ensure that the ease of application emphasised above is provided throughout. The Environment Code can regulate key areas in a new and forward-looking way, based on the principles of sustainable development. These would include redesigning procedures for granting permits for installations, as required by the Community Directive concerning integrated pollution prevention and control. Key elements in this process are improvements to authorisation procedures for installations (e.g. through greater focus on EIA) and an integrated analysis of potential effects on the environment. The Environment Code can regulate, in a standardised and transparent manner, the rights and duties of all those who make use of environmental resources (private individuals, companies, government authorities and organisations). Another intention is to harmonise legislation and regulations (including the definition of environmental standards) in areas that were previously subject to single laws. It includes regulations on interventions and monitoring activities by authorities, as well as "soft" instruments such as environmental audits, environmental information schemes for companies, environmental liability, environmental charges and subsidies. In addition to the above, there remains a need for regulations governing the more traditional areas of environmental protection, such as nature conservation and landscape management, protection of water resources, nuclear energy and radiation control, genetic engineering, hazardous substances and waste management. The draft prepared by the Commission of Experts envisages further changes in specialised areas of environmental law, such as the integration of energy supply and transport facilities into environmental law.

VII 3. The greening of public finance

VII 3.1 The need for reform - basic elements

The importance of the fiscal system

The public sector in Germany is of extreme importance for the national economy: in 1994, public spending accounted for 51.5% of the gross domestic product (GDP), while taxes and social insurance contributions amounted to 44% of GDP. Through its fiscal policies, the state has an enormous influence on social, economic and environmental developments. Income tax and social insurance contributions have had a much greater impact on the level of real earnings in recent years than any increase in wages achieved through collective bargaining agreements. Value added tax, as well as special consumption taxes on petrol, tobacco, alcoholic beverages and other items, already have a greater influence on the prices of many products than the actual production costs (SRU, 1996). Fiscal policies have a critical impact on the relative prices of products and the costs of production factors. In this way, they have a noticeable effect on economic decisions concerning consumption, investment and production, and are thus an important determinant of the prevailing consumption and production patterns. Government subsidies, too, play a key role in this context. For some sectors of industry, such as coal mining, subsidies are actually more important than the revenue generated from selling the respective products. In agriculture - which has particular impact on the environment - about half the total income is obtained in the form of government subsidies (see Chapter IV).

A sustainability strategy can only achieve its objectives if financial policies are stringently based on the goals of sustainable development. Environmental considerations must lie at the heart of all decision-making by the state with regard to fiscal policies and public spending. Current financial policies display serious shortcomings in this respect: environmental aspects are given only marginal consideration within the German finance system. Indeed, some government regulations even promote activities that have adverse effects on the environment. Against this background, all measures relating to state revenues and public spending must be scrutinised for their environmental impacts and modified accordingly within the framework of a environmental budget reform. This would enable the dismantling of existing barriers to the development of sustainable patterns of production and consumption, and the establishment of economic incentives that promote sustainable development.

Influencing the market by means of environmental charges

Markets are somewhat "blind" when it comes to ecology. Whereas the supply of goods is matched to demand through the instrument of pricing, this is not the case with environmental assets, since these are usually common property and therefore can be used for free. Since there is no price indicating the scarcity of these assets to consumers, they tend to be used in a wasteful manner that surpasses sustainability limits. Government therefore has to ensure that environmental assets become more expensive so that prices comply more than hitherto with the "environmental truth". Environmental charges - meaning all levies in the form of taxes, fees, contributions and special levies that are aimed at achieving environmental objectives - are key components of any fiscal policy geared to environmental protection.

There is another important reason why environmental charges should be introduced, or existing charges increased. The use of scarce natural resources and environmentally harmful activities are mostly exempt from any form of fiscal levy or taxed only to a slight extent. In contrast, recent decades have seen a dramatic increase in the level of taxes and social insurance contributions imposed on labour. The proportion of all charges accounted for by income tax and social insurance contributions rose from 35% in 1970 to 62% in 1993. This fiscal trend has contributed to an overexploitation of the environment and a declining demand for labour. A green budget reform that counteracts this mismanagement by shifting the burden of taxes and charges could therefore advance not only the protection of nature, but also the reduction of unemployment. This, too, would be a contribution towards sustainable development.

Fig. VII 1 Taxes and social insurance contributions in Germany

hier Graphik einfügen aus Buch S. 290

VII 3.2 Components of an environmental reform of public finance

Greening the public finance system involves virtually all areas of policymaking. It therefore requires an integrated approach in which ecological and non-ecological objectives are harmonised. For example, if efficiency aspects and the political feasibility of environmental charges are taken into consideration, then the obvious conclusion is to link the introduction or the raising of charges to other, non-environmental reforms that are currently needed within the existing system of taxation and social insur-

ance. The potential negative impacts of activities that are beneficial to the environment on non-ecological objectives should also be taken into account. Measures implemented as part of an green budget reform need to be embedded into integrated concepts for environmental policy (the "policy mix" approach).

The central objective of an green budget reform is to establish economic incentives in order to induce sustainable patterns of consumption and production. A distinction must be made here between the following strategic approaches, each of which is analysed in greater detail below:

- aligning subsidisation policies to the goal of sustainable development (abolishing subsidies that result in environmental degradation, refocusing and redesigning subsidies to comply with environmental requirements),
- basing charges and contributions on environmental factors
- redesigning existing taxes and special levies, and
- increasing existing charges and introducing new charges on activities that damage the environment,

The latter two approaches have recently been the subject of intense and controversial debate over the issue of a green tax reform.

In addition, however, a transition to a sustainable Germany requires that the state base its own economic activities on the principle of sustainability, both in public administration and in public-sector enterprises. There are various ways to achieve this. The public sector can send out important signals by deploying environmentally friendly procurement policies, for example, and can play a leading role in the use of environmentally sound products (UBA, 1993). To ensure that environmental protection is systematically pursued outside public procurement, efforts should be made to extend the use of environmental audits and to establish environmental controlling systems within the public sector. Another area of major importance concerns government investment policies, for example in the transport field, where a shift to more environmentally friendly transport modes (see Section III 4.3) will not be feasible unless government funds are switched from road construction to the expansion of public transport systems.

VII 3.3 Basing subsidies on environmental considerations

Depending on their specific design, subsidies can exert positive or negative impact on the environment. The crucial element is the way in which they influence the behaviour of consumers and producers.

Reducing environmentally damaging subsidies

Subsidies that favour and reward behaviour that has adverse effects on the environment are opposed to the aims of sustainability. They have therefore be reduced step by step and ultimately eliminated or replaced by environmentally sound support measures. In the long run, it is unacceptable that billions are spent on the support of environmentally harmful production methods that subsequently necessitate the earmarking of additional billions of public finance in order to partially compensate for the respective environmental impacts.

Various studies have shown that there is considerable potential for eliminating subsidies with adverse environmental effects (BLAK, 1993; IFO, 1994; FIFO, 1994). Additional tax revenue amounting to several billion Deutschmarks per year could be generated by abolishing all environmentally counterproductive subsidies in connection with the fuel tax alone.

One particularly drastic example of environmentally counterproductive subsidisation is the exemption of aircraft fuels from mineral oil excise duties (pursuant to Article 8 (1b) of Council Directive 92/81/EEC). Under this arrangement, airlines need only pay about 30 pfennigs per litre of kerosene. In combination with other subsidies, this not only results in a distortion of competition to the detriment of other, more environmentally sound transport modes, but also promotes the development of non-sustainable consumption patterns. For example, one German airline ran an advert in early 1995 claiming that a flight to Munich for an afternoon shopping trip would only cost about DM 200!! If kerosene were subject to the same rate of excise duty as diesel fuel, a flight to Thailand would cost about DM 550 more, to Gran Canaria nearly DM 200 more, and to Mallorca about DM 85 more. Eliminating subsidies for air travel would send clear signals to consumers that they can take environmental considerations more into account when deciding on where they want to travel.

Table VII 1: Environmentally damaging subsidies (1994)

Benefit	**Volume of subsidies (in DM millions)**
Exemption of air travel from mineral oil excise duty[5]	6,760
Exemption of commercial inland navigation from mineral oil excise duty	350
Different rates of excise duty on diesel fuel and petrol[6]	9,040
Gas oil subsidies to agriculture	855
Exemption of agricultural vehicles from road tax	600
Non-collection of road tax for excess trailers	165
Lump-sum allowances for travel expenses	3,000
Special depreciation rates for ships and aircraft	40
Exemption of mineral oil and gas production companies from mineral oil excise duty	250
Subsidised electricity for coal mining	7,500[7]
Charcoal subsidies	3,110

Source: BMF, 1995; DIW, 1995, *Arbeitsgruppe Steuerrechtsvereinfachung*, 1993 and own calculations

5 About DM 420 million in tax revenue are lost through domestic flights, and DM 6,340 million through international flights starting from Germany.

6 The additional tax revenue resulting from the higher road tax on diesel-engined cars is not taken into account.

7 In 1996

Table VII 1 provides an overview, by no means complete, of environmentally damaging subsidies. As can clearly be seen, the majority of these subsidies go to the sectors of transport, energy and agriculture. The respective environmental impacts of eliminating or reforming the relevant regulations would be highly divergent, however. Some changes, for example the elimination of the exemptions from mineral oil excise duty for airlines, or reforming the fiscal rules on travel allowances - would generate substantial benefits for the environment. The effects achieved by modifying certain other regulations would probably be marginal in comparison from the environmental perspective, simply on account of the low quantitative level of subsidies concerned. Nevertheless, dismantling such minor subsidies is not an option that should be waived, in that such measures would demonstrate the government's will to base financial policies on the sustainability principle, and because the elimination of tax benefits generally contributes to greater equity within the taxation system and to its much-needed simplification.

In many cases an immediate abolition of national subsidies with adverse environmental impacts is not possible due to legal barriers in the form of EU regulations, or bilateral and international agreements. Political pressure will have to be exerted here at international or supranational level in order to eliminate such environmentally detrimental subsidies. The key areas where action is needed are the exemption of airlines from mineral oil excise duty and value added tax, and the special privileges enjoyed by mineral oil and gas producers, who are similarly exempted from mineral oil excise duty as far as their own consumption is concerned. The Federal Government has already announced that it will push for the abolition of these exemptions when the relevant EU Directive (92/81/EEC) comes up for review in late 1997 (BT-DRS 13/2156, 1994). In some cases - e.g. for social policy reasons - it may be necessary and advisable to replace previous subsidies with other forms of assistance that meet the criterion of environmental soundness. This is particularly so in agriculture. As already emphasised in Chapter IV, the important thing in this sector is to ensure, in the long run, that direct income transfers are paid only to those farms which operate in a sustainable manner, and that existing subsidy flows are diverted accordingly step by step.

Changes in subsidisation - towards sustainability

Sustainability demands fundamental changes of the current production patterns and technologies. This represents a tremendous challenge for industry's innovation capacities, and one that must be tackled in a major offensive. It is absolutely imperative in this connection to boost the structural transformation of industry by implementing support measures (e.g. marketing assistance for product launches) that promote the use and development of new, environmentally sound products and production processes. When budgetary constraints are as severe as they now are in Germany, dismantling subsidies in the interests of environmental protection is a matter of key importance. Three different yet complementary perspectives for reform can be subsumed under the general banner of "ecological dismantling of subsidies":

- redirecting subsidy flows in accordance with the guiding principle of sustainable development,
- integrating elements of ecological management into support programmes that are not directly related to the environment, and
- improving the efficiency of existing ecological support programmes.

The first two aspects are especially important for sustainable development.

The proportion of subsidies directed specifically at environmental protection has been very low until now. According to the German Institute for Economic Research (DIW), the figure in 1992 was only 2% of the total. What is more, there is a whole series of environmentally counterproductive subsidies (see above), as well as various subsidies aimed at protecting uncompetitive industries, which obstruct the structural transformation that is needed, not to mention their enormous costs for the economy. From the sustainable development perspective, there is an obvious need to set new priorities in the field of subsidisation policy, i.e. to eliminate step by step all environmentally counterproductive subsidies and subsidies to ailing industries, and to use some of the funds thus released to subsidise sustainable forms of production instead. The principles of efficient subsidisation policy should be complied with in this process. These include the principle of "help for self-help", limiting the duration of support, appropriate levels of cost coverage on the part of recipients, and the prevention of unwanted accumulation and take-away effects.

Misguided support policies in the energy field

The current subsidisation policies in the energy sector highlight the necessity and ecological importance of strategic options for a transition to sustainable development. The scenarios in Chapter II showed that rational energy use and greater utilisation of renewable energies will play a key role in the transition to a sustainable energy supply. As Table VII 2 shows, the subsidisation practices that have been operated in the energy sector until now are highly inadequate in the situation we are faced with.

Table VII 2: Federal subsidies to the energy sector 1983 - 1994, in DM millions

	1983	1986	1990	1994	1983 to 1994
Renewable energy sources	272	189	277	333	3,219
of which					
Photovoltaics	54	58	92	88	945
Wind energy	16	12	22	41	232
Nuclear energy	1,679	1,083	662	498	10,833
Coal	5,249	6,653	11,500	12,300	111,560

Source: Rheinisch-Westfälisches Institut für Wirtschaftsforschung, 1995

Subsidies aimed at maintaining the German coal mining industry still form the majority of support in the energy sector. Between 1983 and 1994, around DM 112 billion in subsidies were disbursed in this area. This is in stark contrast to the level of subsidies in support of renewable energies, which at DM 3.2 billion was minimal by comparison. Were only a fraction of the funds now deployed to support the German coal mining industry to be used instead to promote rational energy use and the utilisation of renewable energy sources within an environmental restructuring of subsidisation schemes, this would promote rational energy use far in excess of current impulses.

Adjustment of support programmes

As already mentioned, another way to restructure subsidies along ecological lines is to integrate environmental aspects into support programmes that are not directly related to the environment. This can be achieved first and foremost by modifying the eligibility criteria for support, or by providing different levels of support. The main areas where there are opportunities for such integration are the agricultural sector and the government assistance schemes for housing. Some progress has already been achieved in this respect. The law governing grants for owner-occupied housing (the *Eigenheimzulagengesetz*), which entered force at the end of 1995, provides additional support to measures that save heating energy, and to the construction of low-energy houses. This was the first time that an ecological component was included in government schemes for promoting the ownership of housing. In 1996, support for CO_2 reduction measures in the housing sector were included in the support programmes of the *Kreditanstalt für Wiederaufbau* in the form of low-interest loans. In addition, some of the *Bundesländer* have now integrated environmental criteria into their support guidelines for subsidised housing.

Interesting though these steps may be, there is still a great deal to be done. One example concerns the generous assistance provided for the modernisation and rehabilitation of housing in eastern Germany. Although these support measures are already helping to promote rational energy use in the "new" *Bundesländer*, the ecological efficiency of the relevant support measures could be greatly enhanced if they required compliance with minimum energy standards - e.g. the stipulations laid down in the buildings insulation standards - especially if assistance is dependent on a thermal analysis being carried out before rehabilitation and an energy efficiency analysis being conducted on completing such projects.

VII 3.4 Basing charges and contributions on environmental considerations

Economic incentives for more environmentally sound behaviour can also be generated through policies for charges and contributions. Charges are levied for services that authorities perform for individuals, whereas contributions are made in return for the provision and hence potential use of public services. In addition, they can serve to offset the public expenditure induced by an individual or a group. The local authority (e.g. a municipality) is able to influence the intensity with which public services are utilised by making appropriate adjustments to the schedule of charges and contributions, and in this way support environmentally sound behaviour.

Enhancement of environmental management through charges

The main areas in which there is practical experience with environmentally based charges are waste and wastewater charges, parking charges and toll charges. *Waste disposal charges*, in particular, have been the subject of reform proposals and pilot projects for some considerable time now. Many municipalities have already introduced waste disposal charges based on the quantity or volume of waste, sometimes under their own management and sometimes in cooperation with the respective *Länder* in the context of research and development projects. The state of Baden-Württemberg has now enacted a new law on waste that aims at volume-based waste disposal charges. From the viewpoint of sustainable development, one advantage of systems involving variable waste charges based on the amount of waste is that they generate incentives for recycling and waste avoidance. This implies a potential contribution towards the protection of natural resources and to the reduction of environmental

stresses. If systems of this kind were to become more widespread, this would signify substantial progress. However, it is important to realise when differentiating charges that no incentives for illegal disposal are generated (illegal dumping, using neighbours' bins, public waste containers).

Charges as indicators of scarcity

Under the laws now governing public charges, the purpose of such charges is to cover the costs for public-sector tasks (waste disposal, wastewater treatment, etc.). Another function, almost as important, is to signalise how scarce public services really are, so that excessive use is avoided. Daily traffic jams in city centres, for example, are an expression of the (temporary) scarcity of road space. For participants in traffic, over-utilisation of this space leads not only to wasted time, but also to consequential environmental expenses of major dimensions, in the form of consumption of precious natural resources and emissions of pollutants (see Section III 1.2). However, one must realise that the temporal and spatial shifts in traffic induced by toll charges can be just as problematic as far as environmental protection is concerned. This example shows that any policy that bases charges on the sustainability principle must also see these charges as reflecting scarcity, and set them accordingly. Such policies are particularly needed for traffic. *Parking charges* and *toll charges*, if combined with the measures described in Chapter III, could ensure that the economic and environmental costs of traffic jams are avoided from the outset.

Basing contributions on environmental aspects

Utility connection costs are an obvious area where contributions can be based on environmental aspects. They are charged by local authorities to ensure that land and house owners bear part of the costs for connecting property to the public infrastructure. These contributions, which are used to finance road infrastructure but not the local public transport system, have exclusively favoured individualised transport. If connection contributions were widened in scope, this would remove the discrimination against local public transport and encourage a shift away from individual motorised transport to improved local public transport services. Such regulations could also help towards achieving the goal of sustainable mobility (see Chapter III). This is already being practised in some countries: in Los Angeles, for example, owners of land and office space in the area serviced by a new underground rail system must pay a one-off contribution amounting to 0.7 to 2% of the rent, with the revenue thus generated being used to finance the new rail system. Corresponding changes in connection charges are one way to finance environmentally sound transport links for companies (e.g. for rail freight transport or local public transport). However, there are legal restrictions here that need to be considered and which it may be possible to extend in certain circumstances.

VII 3.5 Greening the tax system

In public and political debate, environmental reforms of the tax system tend to be confined in many cases to the introduction of new environmental charges or raising existing charges, and even to the mere introduction of an energy tax or CO_2/energy tax. In reality, however, there is a diverse range of approaches for using taxes (and special charges) as an instrument for making the transition to sustainable development. The following sections aim to illustrate this.

A distinction is made between the greening of existing taxes and special charges, on the one hand, and the increasing of existing or introduction of new environmental charges, on the other, though the boundaries between the two groups of measures are not clear cut.

VII 3.5.1 Redesigning existing taxes and special charges along ecological lines

Experience to date, e.g. with the differentiation of mineral oil duty between unleaded and leaded petrol, or the full or partial exemption of low-emission cars from road tax, has shown that the greening of existing taxes and special levies is an important lever for advancing towards sustainable development. The response options in this respect are far from being exhausted. Reforms are needed in connection with mineral oil excise duty and road tax. Another possibility is to reinforce the environmental management impact of wastewater charges, and to create incentives for thrifty and protective use of land through a reform of land tax. These and other points will be dealt with in greater detail below.

Tax differentiation on mineral oil

Tax differentiation between leaded and unleaded petrol, as mentioned above, is already used as an instrument for promoting the use of less environmentally harmful fuels. Lead concentration is not the only determinant influencing the environmental stress caused by fuel consumption, however. For this reason, tax differentiation should also be based on other criteria as well, especially the benzole concentration in petrol. Because benzole is a proven carcinogen, petrol with a high concentration of benzole should be subject to higher taxation if the limit value of 1% by volume favoured by the Federal Government is not imposed throughout the EU in the near future.

In contrast to the tax differentiations referred to above, there is no ecological foundation for the existing differentiation of mineral oil tax between diesel and petrol, in that the consumption of diesel fuel leads to relatively higher CO_2 emissions as well as emissions of carcinogenic smoke particles. Current tax differentiation is historically based and primarily serves nowadays to enhance the competitiveness of German haulage companies in the European context. The demand that emanates from this background is that the minimum tax on diesel fuel in the Single Market be brought into line as soon as possible with the tax on petrol. Unless the minimum tax on diesel fuel is raised substantially, it will not be possible to limit the forecast growth of road freight transport, which is incompatible with the goal of sustainable development (see Chapter III).

Reshaping road taxing

Proposals have been made for some years now to reform the road tax system along ecological lines. Since February 1994, road taxes for lorries have been differentiated according to emissions of air pollutants and noise. However, the economic incentives to buy low-emission lorries that this has generated have been diluted by the simultaneous reduction of road taxes.

In March 1997, the Federal Government adopted a new emissions-based road tax system for cars that enters into force on 1 July 1997. As already emphasised in Chapter III, this reform may speed up considerably the development and marketing of low-emission cars. In particular, the new regulations will help the Federal Government to achieve its professed aim of taking all cars without catalytic converter off the roads by the year 2000. They also comply with the polluter pays principle to a greater extent

than the previous regulations, according to which road tax was based solely on the capacity of the car's engine. However, environmental management impacts of a sufficient order can only be expected from an emissions-based road tax if it creates definite financial benefits when buying low-emission cars. This requires that the road tax on cars vary across a very wide range depending on the emissions intensity of the car. In this respect, the emissions-based road tax adopted by the Federal Government does not yet comply with the long-term imperatives of environmental protection. Imposing a wide band of road taxation levels would produce higher tax revenues, at least in the first years after adoption. If one takes into account the fact that road tax was last raised in 1955 and that the tax burden is only a fraction of the actual costs, a strong case can be made for a temporary increase in road tax revenues, particularly since higher taxes would only be imposed on those who give no consideration to environmental soundness when purchasing their car, and who therefore impose an disproportionate burden on the environment.

The environmental management impacts that can be achieved by basing road tax on emissions vary considerably over time. They are particularly intense in the *short* term, while the anticipated trend in the medium term, i.e. from the year 2000 onwards, is that legislation will allow only low-emission cars to be purchased. The only incentive that can then be generated through road taxation, given the imperative need to modernise the national car fleet, will be to scrap old cars. The entry into force of emissions-related road tax is therefore a welcome step in the right direction.

Land tax reform

Land tax is another area where the tax system could be reshaped along ecological lines. Taxes on land and real property are levied at present not only on land or nature as such, but on a fictitious revenue from landed property determined primarily on the basis of rateable values set as far back as 1964. This means that the current form of land taxation gives no consideration whatsoever to ecological aspects, despite the fact that it pertains to a taxable object of immense relevance for environmental policy. Another drawback of the current land tax system is that it requires a large administrative apparatus. The long overdue reform of land taxation should be seen as an opportunity to create economic incentives furthering the protection and wise management of land resources. What is needed in this connection is a greater linkage between the taxation of land area and the actual type of land use. Such changes could counteract the unbroken trend towards surface sealing, consumption of landscapes and nature, and the production of more and more traffic, all of which are incompatible with sustainable development.

Enhancing the environmental management function of wastewater charges

Wastewater charges represent the first, indeed the only environmental charge in Germany at the federal level. The charge is based on the volume and pollution level of wastewater discharges, whereby the basis for calculation is generally the limit values stipulated in the relevant part of the official water regulations. The charges are levied on all direct dischargers to waterbodies, i.e. primarily on local authorities as operators of public-sector wastewater treatment plants and large industrial installations with their own wastewater treatment plants. The rate charged from 1997 onwards is DM 70 per unit of pollution. However, the charge is reduced by 75%, and from 1999 onwards by 50%, if the statutory regulations are complied with. Moreover, wastewater charges in the east German *Bundesländer* may be set-off against investments to modernise wastewater plants.

The special reductions and set-off possibilities that have been successively bolstered through the various re-enactments of the laws governing wastewater charges have led to the latter losing any function they may have had as an instrument of control by basing charges on the polluter pays principle. This means that they are no longer a suitable means for harnessing market forces for sustainable development through "environmental pricing". Instead, they have become an instrument that primarily operates to support the enforcement of regulatory mechanisms. The economic and ecological efficiency of wastewater charges has thus been reduced to a substantial degree. This process must now be reversed so that, by reducing the opportunities to receive specially reduced rates and to set-off charges, wastewater charges are reinstated as a tax on pollution that functions in the interests of environmental management.

Enlarging the scope of nature conservation charges

All the *Bundesländer*, except Bavaria, Lower Saxony and Saxony-Anhalt, levy a compensation charge under the nature conservation laws; this is a special charge imposed on land users or land developers who interfere with nature and landscapes, when there is other way to compensate nature (UBA, 1994c). The specific regulations vary from one state to the other, and the charges involved generally fail to reflect the full external costs associated with such interference. The environmental management impact is comparatively low. Greater linkage to the objectives of nature conservation law, and a corresponding increase in the level of charges are necessary before the nature conservation charges can have a genuine impact on behaviour (Hartje, 1994). A national nature conservation charge could bring about a harmonisation of the divergent regulations at *Länder* level.

VII 3.5.2 Increasing existing charges and introducing new charges on activities that damage the environment

Increasing existing charges and introducing new charge on activities that damage the environment represents the most important component of an environmental reform of the public finance system as far as environmental management impacts are concerned. Unless environmental charges are used to a greater extent as an instrument of environmental control, it will not be possible to adjust existing patterns of production and consumption to the imperatives of sustainable development.

Many environmental problems that can be observed today are no longer attributable to a small number of causal agents that could be subjected relatively easily to administrative control, but result instead from millions of individual decisions made each day by producers and consumers. This is exemplified in the field of climate protection, in the transport sector, as well as in agriculture. Under such conditions, relying purely on regulatory measures is inadequate as a response, particularly since statutory regulations do little or nothing to generate the necessary and drastic efficiency improvements through advances in environmental engineering (see the efficiency scenario sections in Chapters II and III on this point).

On the other hand, environmental charges are not an "all-purpose" weapon for environmental policy-making. The only area where they make sense is where they go beyond the direct aversion of risks. To that extent they can only be a supplement to, and not a substitute for regulatory measures. Another important aspect is to avoid the system of taxes and charges being overburdened by an excessive number

of minor charges. The imposition of new taxes should therefore be confined to key areas of focus of special strategic importance from the environmental perspective.

Introduction of a CO_2/energy tax

Taxes on CO_2 and energy are fully compliant with the principle above. Reference has already been made in Chapter II to the fact that the measures needed in respect of rational energy use and greater reliance on renewable energy sources cannot be achieved with energy prices at their current level, and that there is no alternative here but to raise energy prices. The Commission of the European Communities recognised this as early as 1992 in its proposal to introduce a CO_2/energy tax in all EU Member States. The proposed directive envisages a tax on all fuels (with the exception of fuelwood and charcoal) amounting at first to US$ 3 per barrel oil equivalent, rising within seven years to US$ 10 per barrel oil equivalent. The tax would involve two equal components, an energy component and a carbon dioxide component, while the tax on electricity would be based solely on the amount of energy delivered. However, the draft Directive and amended version proposed in 1995 have failed to obtain the acceptance of all Member States, so implementation is blocked.

Following the failure to introduce an EU-wide CO_2/energy tax, the idea of raising the minimum excise duty on petrol and diesel fuel within the EU in a series of steps over the next five years is being examined, as is taxing the consumption of other energy sources such as coal and natural gas. In the meantime, a number of countries have introduced CO_2 and/or energy taxes at national level (Denmark, Norway, Sweden, Finland, the Netherlands), or are about to do so (e.g. Switzerland). Germany should follow their example, especially since forecasts show that the Federal Government's CO_2 reduction target will not be attained without additional reduction measures.

The contribution that a CO_2/energy tax could make towards reducing CO_2 emissions and other environmental stresses is critically dependent on the level of taxation to be applied. If one takes the relatively moderate taxation level proposed in the 1992 draft Commission directive, a reduction in annual CO_2 emissions of about 3% could be achieved in the west German states by the year 2005 relative to the reference situation, according to the *Rheinisch-Westfälisches Institut für Wirtschaftsforschung* (RWI) (RWI, 1995). This shows that the taxation rates proposed by the European Commission should not be undercut if the aim is to achieve substantial CO_2 reductions through levying a CO_2/energy tax.

Raising mineral oil excise duty

Chapter III has already shown that making fuel more expensive is a key element in reducing the volume of traffic and bringing about a shift in transport modes. Previous increases in the rate of mineral oil taxation on fuels have far from compensated for the falls in real fuel prices that have occurred over the past few decades, with the result that the real price for petrol in 1995 was still around 40% less than it was in 1960. In view of the ambitious goals for sustainable mobility (Chapter III) and the impact of fuel prices on transport trends, an indispensable element of any ecological finance reform must be a *increase in mineral oil excise duty*, especially on vehicle fuel, according to a planned sequence; this measure must be supported by promoting alternatives to car traffic and imposing tougher environmental standards on cars. The mineral oil excise duty on cars, and the distance-based heavy transport charge on lorries (road pricing) would have to cover at least those external costs of transport that are not yet internalised (see Chap. III).

Fig. VII 2 The development of fuel prices in Germany

Graphik Buch S. 304

Introducing a fertiliser charge

There are many reasons why a *charge on fertiliser* should be introduced, if possible throughout the EU, in order to mitigate the negative environmental effects of agriculture and to promote sustainable production methods in this sector (see also Chap. IV). With the help of such a charge, the economic framework for agriculture could be designed in such a way that it would be in the interest of farmers to operate within ecological limits more than has been the case so far. This instrument would not involve any monitoring problems, as with the enforcement of land management practices or compliance with "good expert practice" in connection with fertiliser use. Because fertiliser charges offer no incentive to reduce organic nutrient loads, high nutrient surpluses can be expected to continue in regions with large amounts of livestock, in spite of such a fertiliser charge. For this reason, limiting the total volume of fertiliser or imposing a *charge on liquid manure* should be examined as possible options.

A number of quantitative forecasts have been made for Germany and EU countries with regard to the impacts of charges on fertiliser use. For example, a study carried out by Becker (1992) on behalf of the Federal Ministry for Food, Agriculture and Forestry showed that an EU-wide fertiliser charge amounting to 50% of current mineral fertiliser prices would reduce the use of mineral fertilisers by 30% and lead to a dramatic decline in nutrient surpluses. However, it is not yet possible to assess the long-term impacts that such a charge would have on price structures, especially in connection with further liberalisation of the world food markets.

If a charge were to be imposed on fertiliser or nitrogen, social considerations and incomes policy would require that most of the revenue be channelled back to the farmers in the form of agricultural assistance. Such support should be granted in the form of a fixed subsidy for every hectare of land used for agricultural purposes.

VII 3.6 Guidelines for a green tax reform

Careful design is of crucial importance if green tax reforms are to succeed ecologically and economically. In this section we draw up some guidelines that should be followed when developing environmental tax reforms.

Clear targets are essential

The first question that is raised in connection with a green tax reform concerns the goals and targets that such a reform is supposed to achieve. It is essential to realise that clarity of objectives is an important element in any wisely conceived reform. The goals being pursued in introducing new and raising existing environmental taxes must be made very clear to the public and industry alike. A strategy of this kind produces various benefits: firstly, the additional burdens represented by environmental taxes are more likely to be accepted if the benefit to the environment is easily understood. This enhances the

political feasibility of a green tax reform. Secondly, clearly stated aims can help prevent a planless, fiscally motivated form of interventionism from developing; the latter would not only be environmentally inefficient and of dubious regulatory effectiveness, but would also undermine the credibility and acceptance of a green tax reform from the very outset.

Another benefit deriving from clear objectives is that they provide a solid basis for planning on the part of enterprises and private households. Industry is right in demanding a reliable policy framework regarding the environment, since this ensures the minimisation of adjustment problems and substantial reductions in the costs of adjustment.

Tax neutrality by reducing other taxes and levies

The overall level of taxation and social insurance contributions has now reached a historical peak in Germany. Further increases in the relative level of taxes and social contributions would weaken Germany's competitive position as a location for industry and severely impair the level of acceptance for a green tax reform. It is imperative, when basing fiscal revenue more on environmental protection, that the state does not emerge as the sole winner in the long run. On the contrary - if initiatives geared to sustainable development are to be given sufficient space to develop, total levies must be permanently reduced in the medium term. This means that additional revenue through environmental taxes must be given back to taxpayers in some other form. Exceptions to this tax neutrality principle should only be permitted as adjustment aids during the transition period when this is necessary for reforms to be economically and socially acceptable.

If revenue from environmental taxes is earmarked for reducing other taxes and levies, this offers an excellent opportunity to exploit the resultant fiscal scope to implement much-needed reforms in the current system of taxation and social security contributions. A conceivable approach would be to use the revenue from environmental taxes to finance some external services and benefits currently provided within and financed by the medical, unemployment and pension insurance schemes. This would enable a noticeable reduction to be made in social insurance contributions and hence in employers' labour costs. Research studies indicate that such a strategy helps reduce problems on the employment market (EU Commission, 1995; DIW, 1995; WIFO, 1995). However, another conceivable approach would be to finance reforms of the tax laws, e.g. a reform of taxes on individual incomes and on companies, through a green tax reform.

Ensuring economic and social acceptability

Sustainable development embraces not only environmental, but also social and economic aspects. Economic and social compatibility therefore plays an important role in the context of a green budget reform. However, this is not the same as saying that the income and wealth of individuals must not be allowed to deteriorate. The crucial issue is to take into account the limited adaptive capacity of companies and to maintain their international competitiveness, as well as to prevent unreasonable burdens on low-income strata and other groups in society already bearing a disproportionate burden.

A wide range of options are available here: economic and social compatibility can be achieved, on the one hand, by careful design of taxes and charges. It is particularly advisable in this context to implement a successive rise in levies in accordance with a medium-term plan, since this enables - as already mentioned - the transmission of the relevant signals and information, the creation of planning security

and substantial reductions to be made in the severity of adjustment problems. For example, Great Britain decided in 1992 to increase mineral oil excise duty by 5% in real terms each year until the year 2000 (although this must be confirmed each year by parliament). Another option is to exempt certain fields of production exposed to severe international competition, if an ecological tax reform is liable to endanger their competitiveness. Compensatory reductions in other charges, as part of a tax-neutral ecological finance reform, may also be highly conducive to economic and social compatibility. Various studies have shown, for example, that the distributive impacts of an energy tax in conjunction with a reduction in other charges are by no means as regressive as often assumed (DIW, 1995; Prognos, 1992).

A further option consists in granting government assistance to regions, sectors or private households that are particularly hard hit. If such adjustment aid is not financed from other sources, it may make sense to deviate from the principle of tax neutrality to a limited extent and for a limited period. It is important for economic and social compatibility and for enhancing environmental management impacts that the state make it easier for companies and private households to adjust to the new system. The instruments available for this purpose are wide-ranging. They include environmentally-based support programmes, e.g. for more efficient energy use in private households and in small and medium-sized enterprises, as well as supporting advances in environmental engineering through government research policies, government investments to improve the attractiveness of local public transport, and information on cost-efficient avoidance of adverse effects on the environment.

Parallel measures

As emphasised before, the measures adopted as part of an green budget reform must be integrated into a overall concept for environmental policy. Major synergy effects can be achieved, precisely in connection with environmental charges, by implementing parallel measures. By means of such measures, it is possible to improve the operation of markets and hence reinforce the environmental management impacts of environmental taxes. One problem concerns rented housing, for example, where increases in energy prices induced by higher taxation are liable to be ineffective on account of the so-called investor-user dilemma, in that neither property owners nor tenants have sufficient economic self-interest in improving the efficiency of space heating by making the relevant investments (e.g. in thermal insulation, modernising heating plant, etc.). Measures to mitigate or eliminate this dilemma, such as introducing heating passes or making greater use of contracted services, would therefore improve the efficacy of an energy tax. Furthermore, experience in other countries has shown that information campaigns organised parallel to the introduction of environmental taxes can greatly enhance the efficiency of the latter (ISI/IFO, 1993).

Environmental taxes can also contribute to the success of other environmental policies, such as measures to support the development and launching of environmental technologies or renewable energies, which can be enhanced by influencing market structures. The effectiveness of regulatory measures can be increased through environmental charges, for example by linking the obligation to carry out certain environmental protection measures to requirements regarding their economic efficiency, and by ensuring that the latter is increased through the levying of charges. This is the case, for example, with the buildings insulation regulations, planned for the future but not in force at present. These regulations aim to make the obligation to insulate buildings dependent on the pay-back period for the investments required (i.e. the pay-back period must be shorter than the write-off period).

Although an ecological reform of the public finance system will bring us a long way towards an environmentally sound economy, to achieve a sustainable Germany it will also be essential to refine the instruments of environmental law, promote technology transfers, raise environmental awareness and implement additional measures aimed, for example, at reshaping world trade along more environmentally and socially compatible lines.

VII 4. Environmental awareness raising and sustainable development

VII 4.1 Significance and development of environmental awareness

Ever since Agenda 21 and the concept of sustainable development began to shape ecological discourse, it has been generally accepted that ecological, economic and social development are closely interrelated. Therefore we expect ecological and economic activities to be "socially compatible" - though admittedly there is no comprehensive theory as of yet that offers a definition or even a more detailed description of social compatibility. Societies or cultures are complex and dynamic systems, especially under the conditions prevailing in the modern age since the Industrial Revolution. People are exposed to such a wide variety of influences and sources of meaning that social scientists often refer to an "individualisation" and "pluralisation" of present-day lifestyles. This makes it difficult for guiding principles such as sustainability to be generally valid to disseminate or establish themselves, particularly if they are new and unfamiliar.

The necessity of guiding principles

However, it is an indisputable fact that environmental protection cannot be practised without the active involvement of the citizens. This does not apply solely to democracies, but it does apply to them to a special degree. To this extent, the concept of sustainability in particular depends on an "understanding of guiding principles": i.e. the knowledge of citizens about what sustainability means, when and how violations against it occur and what action and rules of conduct it necessitates.

Such an understanding is important first of all as a basic prerequisite for the effectiveness of regulatory and economic instruments:

- If people don't understand the importance and the purpose of rules and bans in environmental policy, even the most well-meant environmental legislation can quickly conflict with the behavioural routines of everyday life and, provided it is not undermined in real political terms by "shortcomings in execution", may lead to what social scientists call a "crisis of legitimation".

- If people don't understand the importance and the purpose of financial incentives generated by environmental policy - ranging all the way to an ecological reform of the public finance system (see Section VII 3) - the success of such attempts is uncertain. New value patterns that contradict the desired behavioural patterns may establish themselves on this basis, e.g. when possession and use of automobiles are given higher status.

Hence, the fundamental significance of awareness raising for sustainable development derives from its function of making these policy instruments and their effects on people and their everyday life comprehensible. This function alone makes environmental awareness raising a major prerequisite for the willingness and capacity of people to participate (see also Section VII 1). Finally, it was shown in Chapters II to VI that many environmental problems can be attributed to lack of environmental knowledge and understanding, for example. This became especially obvious in Chapter V with textiles. And there are also several studies on the development of awareness among farmers, for instance, that indicate the enormous role of orientation problems resulting from the clash between real transformation and unchanged traditional patterns of thinking. Thus, the practical importance of environmental awareness raising can hardly be overestimated.

Environmental education initiatives

The basic task of education was realised early and has led to major initiatives as well as national and international activities, the following marking the most important stages in this development:

- In 1971 the need to disseminate environmentally relevant knowledge in all areas of education was pointed out in the Federal Government's environmental programme.

- The 1972 UN Conference on the Human Environment in Stockholm recommended an international programme for environmental education.

- The Intergovernmental Conference on Environmental Education, which was held jointly by UNESCO and UNEP in Tiflis and where 41 recommendations were adopted for the development of national programmes for environmental education, followed in 1977.

- In its resolution entitled "Environment and teaching" in 1980, the Conference of Ministers of Culture in Germany declared environmental education to be a basic educational principle.

- In 1987, the UNESCO/UNEP Conference in Moscow proposed an international action plan for environmental education containing a broad array of proposed measures, starting with integration of environmental education in existing educational institutions and ranging from public relations work through the mass media.

The necessity of a change in awareness was thus recognised at an early stage, and significant success has been achieved in the meantime, evident in a considerable environmental awareness of a large parts of the population, in the creation and consolidation of environmental training programmes, as well as in the inclusion of ecological aspects in curricula.

As a consequence of these attempts, the term "environmental protection", which was not introduced until the end of the 1960s, became not only a common word in everyday language, but one which also appeared frequently in the media. According to E.U. v. Weizsäcker (1993), the general level of environmental awareness in 1988 had even crossed "a critical threshold": since that time every citizen has been aware that the next century will be and must be a century of the environment.

VII 4.2 The current state of debate on environmental awareness raising

New ethics and old lifestyles?

However, since the beginning of the 1990s attention has been drawn to shortcomings and misguided developments in the many different kinds of educational efforts. In some cases, environmental education has suffered because of the fragmentation of global environmental discourse already referred to (see in particular Section I 1.2). This fragmentation is manifested, on the one hand, in a focus on natural science and technology, where the debate centres on the stress-bearing capacity of ecosystems and the opportunities for a quantum leap forward in technological efficiency, while discourse within the social sciences and humanities call for a new ethic, new lifestyles and models for welfare, as well as, in many cases, sacrifice and asceticism, a return to core values, and solidarity with the rest of the world and future generations. These high-flown and often very fundamental demands, in terms not only of objectivity, but also morality and solidarity, can easily exceed the capacity of individuals and overload educational situations.

Compounding this situation - and indeed as a consequence of it - environmental discourse within some parts of society and especially in the mass media has tended towards what can be described as "disaster rhetoric". Attention is concentrated so much on environmental catastrophes or scandals that awareness of the general need, implicit in the sustainability principle, to change our ways of thinking and reorganise society may actually be lowered rather than raised. Or, lifestyles in industrial society are contrasted in a very generalised way - e.g. in a form of neo-Rousseauism that is currently very popular - with the ideal of naturalness, simplicity, absence of needs and authenticity, extending even to a romanticisation of pre-modern lifestyles in which everybody was supposedly happy and in harmony with nature. These are forms of discussion that seek their audience in certain subcultures, but are unsuitable as instruments for enhancing the willingness of "normal" people to involve themselves in environmental reforms. Moreover, the influence of superficial ways of perceiving environmental issues is reinforced by the impression that policy is stagnating, or that politics and industry are failing to address the environmental challenge in an adequate manner.

Between manipulation and enlightenment

Promoting environmental awareness and environmental education cannot be based on the mere dissemination of knowledge alone. The impact on value systems is equally important. This applies both to environmental education in the stricter sense, i.e. as limited to educational institutions, as well as to environmental awareness raising in the wider sense, which encompasses consulting and information aimed the general public. Cognitive as well as normative aspects are always implied where knowledge and values, the conveying of information and development of insight, or the influencing and modification of attitudes are concerned; the objective of awareness raising is, after all, to effect real changes in behaviour in accordance with the principle of sustainability. This poses a special challenge for environmental awareness raising: it runs the risk of manipulating people, but also has a chance to bring about a fundamental ecologisation of the educational system.

These specific problems also dominate the most recent and very critical discussion in Germany on the development and fundamental reorientation of environmental education. Kahlert (1990), for example, has analysed the everyday understandings implicit in various environmental education concepts and detected a disturbing tendency toward argumentation methods that rely purely on the strength of personal convictions. Heid (1992) has examined some of the theses repeatedly advocated in the field of

environmental education, concluding that people threatened by environmental damage are all too often brought to believe that they are the ones who should feel responsible for the causes of this damage, especially in their function as consumers. De Haan (1993) even refers to the "fables" of environmental education and calls for a cultural reorientation.

Self-critique in environmental education

According to Jüdes (1995), the main points of criticism regarding environmental education can be summarised as follows:

- environmental education has yet to be integrated into a general concept for education and has not yet become a cross-cutting topic in all school subjects;
- in practice, environmental education is restricted to analyses of specific problems, learning goals are not clearly operationalised, and the respective significance of cognitive and emotional, or natural scientific and artistic-aesthetic aspects often remains unclear;
- there is a lack of sufficient evaluation research and
- research on environmental education has, in general, barely got off the ground.

It is therefore no coincidence that environmental education is to some extent a "1% discipline" (de Haan, 1995); from a quantitative perspective, German pupils receive no more than eight hours of environmental education per school year on average. The situation at universities and in adult education is no better, since there is hardly any cooperation with other social sciences. The cultural change advocated by de Haan should therefore involve commencing and critically reflecting on research into environmental awareness and environmental behaviour, on the one hand, and in the sociology of lifestyles, on the other.

However, the sustainability movement has brought about some steps into this direction. Recent years have seen much effort aimed at intensifying environmental awareness raising, and part of this effort has also involved the development of new conceptual approaches.

VII 4.3 Proposals for future developments

Based on the recent debate outlined here in brief, we conclude with some thoughts on options to advance the process of environmental awareness raising. A distinction must be made between institutional progress and advances with respect to content.

Institutional advances in the field of environmental education

In its 1994 Report on the Environment, the Council of Experts on Environmental Issues (SRU) drew up a list of institutional measures with which environmental education or environmental awareness raising could be advanced, with the following key proposals:

- establishing an interministerial committee on environmental education,
- holding *Länder* conferences on environmental education,

- setting up an environmental service centre,
- establishing a reporting system on environmental education, with a comprehensive report to be prepared every two years,
- holding a national conference on environmental education every four years,
- provide greater support to cooperation networks and
- creating a database on environmental education.

These measures are aimed at closing the aforementioned gap between environmental research (especially in the social sciences) and environmental education, on the one hand, and compensating for what the SRU calls the "inappropriate federal distribution of competencies" in respect (also) of environmental awareness raising, on the other.

Advancing the content of environmental education

The SRU report also contains important starting points for advancing the content of environmental education. They are based on the SRU's concept of "retinence". The term refers in this context to the coherence or mutual interdepency of all natural and social processes. On the basis of this concept, several general thoughts evolve about the reorientation of environmental awareness raising:

- The path to sustainability cannot imply the "return" to pre-modern or allegedly nature-adjusted patterns of behaviour and orientation, but requires instead an intensification, as well as a fundamental redefinition of "progress". There is a growing awareness that the viability of technological, socioeconomic and sociocultural development hoped for and striven in the context of sustainability can only be attained through a consequent restructuring of lifestyles and behavioural patterns in industrialised societies, a process that has to be advanced in an active way (since it will never come about of its own accord "by default").
- Environmental awareness raising must take this into consideration by disregarding the popular notion of "nature" as some kind of "paradise lost". The alternative must be to consistently pursue a form of enlightenment based on the natural and social sciences - whereby it is equally essential to inform the public about the limits of science and human knowledge in general, including ecological and normative knowledge. To this extent, environmental awareness raising can be understood as the total range of measures aimed at promoting the capacity and willingness of people to participate in the restructuring of industrial society.

Environmental awareness and education in the context of sustainable development

Although the term "environmental awareness" can be defined normatively (an example being the definition coined by the Council of Experts on Environmental Issues in 1978 - "realisation of the threat posed by humanity to its own life-support systems, combined with willingness to take corrective action"), the concept of environmental awareness defined in this way cannot be equated with the much more comprehensive notion of "awareness of ecological problems". The latter must address the interdependence between ecological problems, on the one hand, and social and economic issues, on the

other, in order to comply with the aforementioned "understanding of guiding principles" with respect to sustainable development.

Of course, a normative definition of environmental awareness has the advantage of facilitating the derivation of educational and related measures to influence behaviour and thinking. But this could easily lead to the entire array of social science problems associated with such measures being overlooked. This dilemma has had detrimental effects on both social scientific environment research and environmental education in general. A more general notion of "awareness of ecological problems" may help as well to keep the relevant discourses and research efforts relatively open to further development. The point at issue, in other words, is to shape environmental education into "education for sustainable development".

In place of a generalised form of education aimed at human improvement, such an approach would imply a set of pragmatic and didactic tasks, the most important being:

- acquiring the capacity to handle complexity, meaning the ability to think in terms of interlinkages and interactions,
- anticipatory learning, i.e. developing the capacity to reflect on causal hypotheses and normative attitudes in terms of their conceivable future (inter)action,
- cooperative learning - developing ability to elaborate definitions of reality and future projections discursively, i.e. by addressing the different viewpoints, life situations and value systems of other people and other cultures.

Environmental awareness raising can thus be understood above all as the promotion of learning (methods) that are geared to complexity, anticipation and cooperation.

One issue that is addressed increasingly in connection with the debate on redirecting environmental awareness raising is whether a refocusing of educational efforts along these lines would necessitate a radical reform of the education system in its current form. In the end, ecological learning implies and requires a new concept of education. The special challenge raised here consists, on the one hand, of ensuring "holism" in the way that problems are addressed and understood, the latter being something that ecological learning must promote, and, on the other hand, the open-ended nature of awareness raising that requires lifelong learning. Practice-oriented learning (which can also be achieved through project-based teaching in schools) as well as learning from models to be emulated (see Section III 4) are particularly important in this context. As long as adults give no thought to the environmental consequences of their behaviour, it will be difficult to convey to children and young people the necessity of sustainable behaviour. As long as people bearing responsibility in government and society as well as people in higher professional positions or income brackets do not gear their behaviour to appropriate standards, it will be difficult to find reasons why others should do so. To this extent, environmental awareness raising is, not least of all, a question of social responsibility.

VII 5. Measuring sustainability - indicators for sustainable development

VII 5.1 The purpose of sustainability indicators

As has already been emphasised on several occasions, the various measures and activities implemented to date are not sufficient to bring about or ensure sustainable development. This statement will now be examined on the basis of certain targets which define whether progress is compliant with the criteria and management rules for sustainable development. At this point in time, the extent to which sustainability can really be achieved by taking the proposed steps can only be surmised on the basis of more or less reliable forecasts. So how can we assess whether and to what extent our development complies with the principles of sustainable development?

It is not practicable to base such a review on large-scale, costly and time-consuming analyses of resource consumption, the state of the environment and the impacts of all individual activities and political developments. Firstly, this would be a merely static analysis of the situation at the very time of the assessment. Secondly, the analyses would be so comprehensive and complex that they would be ill-suited as an information base on social and political change. The problem when assessing sustainability is not a lack of data or knowledge, but the difficulty of selecting the relevant information and condensing it in such a way that general and meaningful conclusions can be drawn.

It therefore makes sense, alongside the collection of data and analysis of the state and the development of environment and society, to track changes in aggregated variables that are closely related to the environmental, social and economic situation and which are thus able to display these in a rough form at least.

The development of indicators of sustainable development is an activity specified in Chapter 40 of Agenda 21 for bridging the information gap on the way towards sustainability. Such indicators are useful in selecting and aggregating much complex information, and are intended to summarise the conditions within the economy and society generally that are of relevance for sustainable development. The aim is to establish a basis for policy decision-making at all levels. Just as body temperature, pulse, blood pressure or the functioning of reflexes enable conclusions to be drawn about a person's state of health (but without substituting for a precise diagnosis), sustainability indicators can provide information about a society's "state of health". While they are no substitute for detailed investigation, they can uncover unsustainable developments at an early stage and signal the need for corrective action. In addition, they enable trends in different countries to be compared.

VII 5.2 The concept of environmental indicators

The debate on sustainability indicators is closely linked to theoretical work on the development of environmental indicators. The central issue is to define a set of indicators which enable an assessment of the environmental strategies and situation in a country (or region). The aim is to aggregate the wealth of information, much of it complex and often involving non-quantifiable factors. The very selection of indicators for inclusion in such a set is a difficult process.

A large number of indicators have been identified and used in Germany until now. The "Environment Data" series published by the Federal Environmental Agency comprises hundreds of single indicators

for the various environmental compartments. It is necessary, therefore, to condense this large number of variables into a system of selected and relevant indicators

- to improve the information base and communication on the state of the environment,
- as an aid for environmental policymaking,
- to simplify environmental reporting and
- to ensure comparability between different countries.

International work on the development of environmental indicators is largely based on a subdivision of indicators into four categories according to the "driving force-pressure-state-response" concept. A distinction is thus made between causal agents or *driving forces*, the *pressure*s their activities exert on the environment, the changes in *state* that result from these impacts and the *response* of society to such changes.

- Driving force indicators refer to causal factors (e.g. transport performance or the consumption of energy and resources),
- Pressure indicators reflect environmental stresses (e.g. levels of emissions and waste production, or the consumption of landscape),
- State indicators portray the quality of the environment (e.g. immissions situation, quality of waterbodies),
- Response indicators describe the activities and strategies adopted by society (e.g. connection rate to sewage treatment plants, percentage of cars with catalytic converters, choice of transport mode, etc.).

Driving force and pressure indicators are usually combined, with the result that only three categories are distinguished.

Fig. VII 3: Pressure-State-Response Indicator Systems

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Interactions occur between these indicator types, since change in one will always result in and condition changes in the others. Environmental policy action is a response to the state of the environment and aims at mitigating pressures.

The framework proposed by the OECD, which is similarly based on the pressure-state-response (PSR) concept, is of particular importance for the development and future application of an environmental indicator system. The OECD puts forward a core set of PSR indicators for eleven different fields as well as a general, cross-cutting category. Specific indicators are described for the greenhouse effect and ozone depletion, eutrophication, acidification, urban environment, biodiversity/landscape protection, waste, water resources, forestry, fish stocks, soils, radiation levels, as well as general indicators; the latter are intended to cover general factors determining environmental pressures which do not impact directly and which cannot be assigned to any separate environmental category. The PSR concept de-

veloped by the OECD has gained wide international acceptance. A set of indicators based on this concept is now being developed in Germany for state-of-the-environment reporting. The PSR framework is particularly significant for the development of indicators of sustainable development, one reason being its differentiated portrayal of the environmental side. However, through its focus on environmental and resource problems, the OECD approach lacks the capacity to reflect the wider aspects of development associated with sustainability, although the indicator system does allow certain links to economic and social development over and beyond the purely environmental domains.

VII 5.3 Economic and social indicators

Environmental indicators merely record the state of the environment as well as trends regarding some causal factors and mitigation strategies. They say little about the economic and social dimension of development. Here the 'classic' economic indicators are still widely used, with the possible addition of social indicators (such as level of education, distribution of incomes, etc.).

National accounting and gross national product

Indicators describing economic development are particularly common in the System of National Accounts (SNA). The purely quantitative description of economic processes (e.g. in terms of sales turnover) does not permit any general conclusions to be drawn about the welfare of a particular country, however much public opinion and politicians may continue to dispute this. The rate at which gross national product grows is very limited as a measure of how successful a country's development really is (from the purely economic perspective).

The predominant form of national accounts, showing national income, national product, balance of foreign trade and the development of individual industries and sectors, conveys nothing about sustainability. National product is not an indicator of welfare and does not take into account the development of natural capital stock or environmental quality. However, the indicator was not developed with such purposes in mind. Quite the contrary: the depletion of finite resources (e.g. through energy consumption) and environmentally destructive activities (e.g. transport) enter the system of national accounts as factors that increase the national product, while the loss of resources and environmental quality is left entirely out of the reckoning. For these and other reasons (for a critique of national product, see inter alia Daly & Cobb, 1989), GNP cannot function as an indicator for sustainability.

Environmental accounting

Environmental accounting (in Germany *Umweltökonomische Gesamtrechnung*, or UGR, the "Environmental Economic Account") is an attempt to supplement the traditional SNA with information about the negative impacts on the environment, by assessing the consumption of environmental resources and the level of environmental pressures in a given period. This involves assessing the scarcity of environmental assets and non-renewable resources, which are not reflected in market prices, as well as taking environmental pressures into account, including increasing scarcity. Concepts developed so far for the system of environmental accounts attempt to integrate various aspects of natural asset consumption into national input-output accounts. Results have been obtained for expenditure on environmental protection and for the development of material flows. They are drawn up in Germany by the Federal Statistics Office and included in the UGR (Radermacher/Stahmer, 1994).

Despite considerable progress in ascertaining the costs of environmental degradation, there has been little success so far in integrating the monetarisation of environmental damage (which is based on very different methodological approaches) into the SNA. Moreover, analyses of the approximate overall economic dimension of external costs can only be made for a certain point in time at most, based on subjective value judgements and far-reaching assumptions. A full assessment of the costs incurred through environmental damage, capable of being compared even approximately with the data in the SNA, is not possible with the current state of knowledge. This means that environmental accounting provides no adequately reliable data on sustainability, and is only marginally suitable for assessing sustainable development. Nevertheless, the obvious existence of external costs in certain fields means that they can be used as an indicator, or even better as an index for non-sustainable development in this particular area. This is the case in the transport sector, for example, where a figure in excess of DM 160 billion in non-internalised external costs was determined for the year 1993 (see Section III 1.2).

Alternative measures of economic welfare

The criticism levelled at GNP as an indicator of economic welfare has led not only to the system of national environmental accounting, but also to work on an alternative monetary indicator of welfare. As early as 1972, Nordhaus and Tobin derived a "Measure for Economic Welfare" (MEW) from the traditional system of national accounts which includes the factors leisure, housework, durable consumer goods, impacts of urbanisation and essential "defensive" expenditures (e.g. on internal security, health services). However, the MEW correlates strongly with national product, thus providing additional justification for the traditional notion of economic growth.

The debate on modifying and interpreting the MEW has produced further indicators of welfare. One that has been used particularly often for specific national studies is the "Index of Sustainable Economic Welfare" (ISEW) developed by Daly and Cobb. The starting point for the ISEW is private consumption, which is weighted by an index for income distribution. Purely defensive expenditure to offset the unwanted side effects of production (e.g. environmental protection, the health system and the education system), changes in capital production, deterioration in environmental quality and the loss of natural capital are then subtracted from this figure, as is the value of non-monetary welfare indicators (e.g. housework). The calculations for obtaining the ISEW for different countries vary in the methods used, due to differences in the availability of data and the state of knowledge in each case. The development of the ISEW index has also been calculated for Germany (Diefenbacher, 1991). This shows a stagnation in the early 1970s, followed by a brief rise before falling back again in the course of the 1980s. Similar trends in welfare have been measured for the USA and Great Britain. The welfare of all countries analysed using the ISEW has failed to improve over the last 15 years, but has tended to deteriorate instead. The main factors accounting for this trend are the growing gap in the distribution of incomes and the growth in defensive expenditure on protecting nature and the environment, and on health. Due, amongst other things, to the lack of correlation between GNP and ISEW, the advocates of the ISEW question the suitability of GNP as a basis for formulating economic policy decisions (FhG-ISI, 1995, S. 44 ff.).

Calculating the ISEW is also based on political valuations, e.g. on the weighting of income distribution, the delineation of defensive expenditures and the assessment of environmental quality. This means it is not possible to use it as an objective, non-valuing measure of welfare.

VII 5.4 Material, energy and transport intensities

A rather different approach for making sustainability visible and measurable is to place much greater focus on the material throughput of an economy. The perspective switches here from the impact side, in other words from outputs in the form of emissions, products, etc., to the use of resources, i.e. inputs in the form of materials, energy, etc. Attention is centred above all on material intensity as the key variable (Schmidt-Bleek, 1994). The latter comprises all materials consumption over a certain period for all economic output, and is intended as a measure of the total consumption of primary input materials (including energy) over the entire product life cycle (production, marketing, utilisation, disposal). The quantities of materials that do not form part of the product itself are taken into account as a kind of "ecological backpack" (Schmidt-Bleek, 1994). The material intensity per unit of service (MIPS) can then be calculated. The MIPS concept is based on the assumption that potential environmental pressure is mirrored by the consumption of resources or materials. The weaknesses of the approach lie in precisely this assumption, however. It stands to reason that materials use alone does not enable reliable conclusions to be drawn about the respective environmental impacts, due to the divergence of materials involved, the transformations they undergo and the material goods and services that result. A reduction of material intensity does not necessarily imply that production and consumption patterns are more environmentally sound than they were before. Nevertheless, material and energy intensities can be very informative when used in conjunction with other indicators, Although the MIPS concept cannot solve the problem of how to evaluate different material inputs and material flows, input-oriented indicators are likely to gain in importance in the future if links are successfully forged with environmental quality targets and emissions.

Energy-related indicators, such as energy consumption per unit added value, can be calculated in addition to material intensity. One such energy-related indicator is "cumulative energy demand" (CED). CED is an aggregate for all energy-related pressures on the environment caused by energy-intensive processes and services (Glatzel/Kaschenz, 1995). CED makes it easier to compare different production processes, especially individual energy conversion systems, including preceding and succeeding process stages. Although the cumulated energy demand indicator was not developed for assessing the sustainability of national trends, it is possible to draw conclusions about the sustainability of energy conversion systems and energy use patterns by looking at the market shares of energy conversion systems with different CEDs.

Another input-oriented indicator is land consumption, defined as the land intensity per service unit (LIPS), which can similarly be correlated with economic output. However, the indicator is of limited usefulness due to the major differences in the type and intensity of land use.

Transport intensity, too, can serve as an indicator, in this case for sustainable mobility. It is calculated from the modal split, capacity utilisation, transport performance and transport-related pressures on the environment, and can be similarly correlated with production output. Even though transport in Germany displays a relatively high level of technological efficiency, the mobility structure is unfavourable on the whole, also within an international comparison, due to public transport's low share in all transport activities, the high density of traffic and the low degree to which cars are utilised, over-powered engines and the high number of vehicle kilometres. Data on the transport intensity of products and product lines

can provide an important boost towards ecological optimisation, e.g. by switching to other transport modes or modifying logistics systems.

VII 5.5 Environmental quality targets and environmental action targets

A completely different strategy for assessing sustainability and developing indicators is to describe the human-induced stresses on environmental assets, environmental media and ecological systems using natural scientific procedures. From these impact-related, mainly quantitative descriptions of environmental states and stress limits one can derive criteria with which sustainability can be defined. From this viewpoint, sustainability is achieved when the scientifically derived and/or normatively defined environmental quality targets are complied with in all fields, and when functional capacity and quality is guaranteed in the target fields.

The basic principles for deriving environmental quality targets can be scientifically defined and described with sufficient certainty for some areas, and related to economic activities and trends. For example, it is possible to identify the tolerable emissions of climate-forcing substances from the atmospheric concentration of CO_2. The normatively defined environmental quality target in this connection is the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system and which provides ecosystems with sufficient time to adapt naturally to climate changes. Limiting mean global temperature increase to 0.1°C per decade is the specific expression of this goal. To achieve this target, greenhouse gas emissions, measured as CO_2 equivalents, must be reduced worldwide by 50% relative to 1990 by the middle of the next century. Maximum annual emissions can then be determined on this basis. Any emissions of the relevant pollutants in excess of this limit are incompatible with sustainable development.

Scientifically derived targets for environmental quality, which can then be used to define sustainability in a quantitative way (in the form of critical levels/loads) are available at present for a few fields only. Full specification of sustainable development in all its dimensions must take into consideration the complexity of people-environment relations. These can be described in the form of scientifically derived environmental quality targets to only a limited extent. Due to the limited number of parameters and gaps in our knowledge of interactions, even large-scale environmental observation and information systems result in a reduced description of natural relations.

Environmental quality targets describe a certain state of the environment that is to be maintained or attained, at least in particular domains, and aim at defining the tolerance limits of impacts (as limit values). They thus form an important foundation on which to base further steps towards sustainability. Before environmental policy action targets can serve as guidelines for sustainable development, they must specify the reduction in environmental pressures that are necessary on the whole to ensure a sustainable state. Even though environmental policy action targets (e.g. reduction targets) have operated for some time now as elements of environmental policymaking, there is no proven method for deriving environmental target that establishes a systematic interrelation between sustainability requirements, environmental quality targets, stress factors and particular groups of causal agents. Here, too, the complexity of actual relations obstructs the search for a comprehensive system of precise environmental targets based on scientific research. However important it may be to specify in detail what is meant by sustainable development and what environmental targets are necessary for activities aimed at meeting that

goal, it is not yet possible in any direct way to ascertain the degree of sustainability from the extent to which environmental targets are attained. Additional indicators are absolutely essential.

VII 5.6 A set of indicators for a sustainable Germany

Many international bodies are currently in the process of developing sustainability indicators. The UN Commission for Sustainable Development (CSD), the World Bank and the Scientific Committee on Problems of the Environment (SCOPE), among others, are working on indicator sets that provide reliable information on the sustainability of developments within human society. The specific problems encountered in the development and application of indicators vary from one country to the next, depending on the severity of problems, the availability of data and the need for information on the part of policy decision-makers. The requirements which a set of sustainability indicators for Germany must satisfy are different of necessity to those needed for a less developed country, for example, due to the highly divergent conditions operating in each respective case (see also Table VII 3).

The task now is to select, from the range of approaches and concepts already existing, those indicators that are of special significance for a sustainable Germany. The attempt is therefore made in the following to put together a series of variables, targets and data for establishing whether and to what extent current trends are compatible with the guiding principle of sustainable development. Since there is no comprehensive system of sustainability indicators either for Germany or for other countries that can be used, these must be taken over from existing concepts and applied to the various fields. Only in this way is there an assurance that targets are reached through the diversity of activities and steps in the right direction. Corresponding to the objectives and structure of this report, we derive indicators for the fields of energy use, mobility, food production, material flows and consumption patterns and compile them into a set of indicators.

Indicators of sustainable energy use

Indicators of energy use can be specified for climate and resource protection in particular. A primary indicator for sustainable management of energy resources relates to CO_2 emissions (which is closely linked to energy consumption) and deviations from the CO_2 reductions profile for an 80% reduction in CO_2 by 2050 (relative to the 1990 base year). The carrying capacity of the atmosphere as a medium absorbing greenhouse gases is after all the critical bottleneck for our current energy consumption patterns. Other indicators are energy intensity, i.e. the energy consumption per capita or GNP unit, changes in energy intensity, and the energy efficiency of power stations, industrial installation, heating systems, etc. The proportion of renewables in total energy consumption is an indicator that can be measured over the short term and which is geared to environmental targets. Finally, energy prices can be an important indicator showing whether energy markets and energy-related finance policies transmit the right scarcity signals with respect to sustainability.

Indicators of sustainable mobility

Indicated actions in the transport sector are signalised above all by deviations in the actual situation from the relevant environmental targets. These can be defined in the fields of climate protection and CO_2 emissions, for surface ozone, noise, waste and waste disposal, nature conservation and landscape protection, and for the quality of residential surroundings and urban compatibility (see Section III 1).

Additional indicators are transport intensity (traffic performance per unit of GNP), the modal split, or the proportion of public transport in the total volume of traffic. Finally, the costs of transport services (which are also affected by government measures such as taxes, subsidies and infrastructure provision) and the external costs of transport are key indicators of sustainable mobility.

Indicators of sustainable food production

Sustainable agriculture is an important element contributing towards sustainable food production. The main potential indicators in this field are the nutrient surpluses of nitrogen and phosphates, and the intensity with which plant protection agents are used. Plant nutrient surpluses show the difference between nitrogen and phosphate loads and the uptake of nutrients by crops during growth. The intensity of land use by crops can similarly be used as an indicator of sustainable agriculture. As far as climate protection is concerned, deviations from the 50% reduction target for greenhouse gas emissions relative to 1990 are one way to indicate the need for corrective action. Finally, the share of organic farming can be an indicator for trends in agricultural production. Energy and transport intensities, i.e. the energy consumption or transport performance per unit of turnover, are possible sustainability indicators in respect of food processing.

Indicators of sustainable management of material flows

Many aspects of significance for the sustainability of material flows are already accounted for through indicators in other fields, especially energy and transport intensities and the volume of waste production. Given that material flow management is geared to controlling material throughputs and hence the environmental damage caused by individual products, product lines and sectors (e.g. in the textile industry), indicators pertaining to material flows must be disaggregated at the level of products and industries. The confusing number and variety of product categories and industries means it is not possible to achieve this to any degree of comprehensiveness, so assessment of the sustainability of material flows within the economy as a whole makes little sense if a small number of indicators is to be used. Instead, deviations from flow-related targets for air pollution control, water resource protection, waste production and waste disposal, hazardous substances, energy consumption and CO_2 emissions, land consumption and health protection indicate where and to what extent further measures are needed in order to achieve sustainable management of material flows.

Indicators of sustainable consumption

The sustainability of consumption patterns can be read above all from per capita waste volume, since the durability, ease of repair, recyclability and reduced material intensity of consumer goods are reflected directly or indirectly in this one parameter. However, transport performance on the part of both private households and the trade play a significant role in this context. The general level of environmental awareness is not a suitable indicator for sustainable consumption unless it is related in a specific way to the actual behaviour of consumers. For this reason, the recommended indicators of sustainability are the market shares enjoyed by environmentally sound products (e.g. those bearing some form of eco-label) and the extent to which households use or possess durable consumer goods (cars, refrigerators, televisions, video recorders, etc.) that comply with certain environmental standards.

A set of indicators as an environmental "litmus test"

The indicators mentioned so far can be compiled as a set of indicators that must then be filled with data, updated and evaluated on an ongoing basis. Such an indicator set would be sufficiently straightforward to identify cross-cutting aspects in various fields and to signalise where corrective action is needed. It enables the current environmental situation as well as economic and social trends to be seen at one glance, thus acting as a guideline and aid to decision-making for policymakers, while operating at the same time as a monitor and review instrument for policies aiming at sustainable development. The criteria that should be met by a good set of indicators are manifold and often contradictory. Indicators should be as clear, simple, representative and informative as possible. A set of indicators should show not only the environmental, social and economic situation and the underlying trends, but also the interdependencies and interactions that operate. Last but not least, the requisite data must be readily available, meaning that they can be updated with relative ease.

A set of indicators meeting all of the above criteria is not yet available. However, various organisations are currently engaged (some on behalf of the Federal Environmental Agency) in developing a suitable framework for Germany. In line with the objectives and content of this report, we propose an initial, pragmatic set of indicators. It reflects the various targets and recommendations in the respective chapters on sustainable mobility, energy supply, food production, material flow management and consumer behaviour (see Table VII 3). Within each of the latter, we refer not only to relevant indicators but also to areas where deviations from targets necessitate corrective action.

Table VII 3: Indicators and required action for a sustainable Germany

Field	**Indicators**	**Deviation from target**
Energy use	- CO_2 emissions (in tonnes per annum) - Energy consumption per capita / GNP - Average efficiency of large furnaces (power stations, industrial plant, heating plant) - Share of renewable energy - Energy prices	- Deviations from CO_2 reduction target (25% reduction between 1990 and 2005; 80% reduction by 2050
Mobility	- Transport performance per capita / GNP - Proportion of public transport - Transport prices / costs - Dimension of external costs	- Deviations from transport-related environment targets for VOC emissions Traffic noise Carcinogenic air pollutants CO_2 emissions Waste and waste disposal Land consumption Nature conservation and landscape protection
Food production	- Nutrient surplus of N and P - PPA use per unit land / yield - Proportion of production from ecological farming - Energy consumption and transport performance per unit turnover - Proportion of biotope areas on farming land	- Relationship between soil loss and soil formation - Deviation from the target of 10% of land surface for biotope networks - Deviation from the emissions reduction target for greenhouse gases to the year 2010
Material flows	- Consumption of materials and natural resources - Consumption of fossil energies - Waste volume	- Deviation from material flow-related environmental targets for Air pollution control Water resource protection Waste and waste disposal Hazardous substances Energy consumption / CO_2 Land consumption Protection of health
Consumption	- Volume of product waste per capita - Leisure-related transport per capita - Market share of eco-labelled products - Ownership of environmentally sound durable consumer products - Energy consumption of private households	

REFERENCES

AGENDA 21 (1992): United Nations Conference for Environment and Development in Rio de Janeiro, June 1992. Conference documents.

AGRA EUROPE (1996): Geringe ökonomische Effizienz vom Agrarumweltprogramm. In: Agrar-Europe 41/96.

ALTNER, G.; DÜRR, H.-P., MICHELSEN, G. - GRUPPE ENERGIE 2010 (1995): Zukünftige Energiepolitik - Vorrang für rationelle Energienutzung und regenerative Energiequellen. Bonn.

APEL, D. (1994): Grenzen verträglicher Verkehrsbelastungen in der Stadt sowie Folgerungen für Städtebau und Verkehrsplanung. in: Gestaltungsfelder und Lösungsansätze. Reports from the projects "Forschungsverbund Lebensraum Stadt" (Eds.): Vol. III/3, Berlin.

APEL D: et al. (1995): Flächen sparen, Verkehr reduzieren - Möglichkeiten zur Steuerung der Siedlungs- und Verkehrsentwicklung. DIFU-contributions to urban planning, Berlin.

ARBEITSGRUPPE STEUERVEREINFACHUNG (1993): Report by the working party on tax law reform established by the Conference of Finance Ministers on 22.04.1993. Hanover.

ARGE, TEXTIL (1994): Die Organisation des ökologischen Stoffstrommanagements; Umweltverträgliches Stoffstrommanagement - Konzepte Instrumente Bewertung. Study commissioned by the Enquete Commission of the German Parliament on "Protection of Humanity and the Environment" (Eds.), Vol. 4. Bonn.

ARNOLD, D. (1993): Research project "Modellhafte Entwicklung und Erprobung eines bundesweiten Monitoring zur Ermittlung der Belastung von Lebensmitteln mit Rückständen und Verunreinigungen". Central Data Collection and Assessement Unit for Environmental Chemicals (Zentrale Erfassungs- und Bewertungsstelle für Umweltchemikalien - ZEBS), BjVV. 1988-1993.

AUERSWALD, K. AND SCHMIDT, F. (1986) Atlas der Erosionsgefährdung in Bayern - Karten zum flächenhaften Bodenabtrag durch Regen. GLA Technical Report No. 1. Munich.

AUMANN ET AL. (1996): Erstellung einer Datenbasis für das Recycling und die Entsorgung von Produktionsabfällen in der Textil- und Bekleidungsindustrie und für Alttextilien. Darstellung der Logistik und des Standes der Technik. Interim report for a study commissioned by the Federal Ministry for Education, Science, Research and Technology. Münster.

BACH, M. AND FREDE, H. G. (1994): Gewässerbelastungen durch landwirtschaftliche Flächennutzung. In: Die Lahn - ein Fließgewässerökosystem, pp. 128 ff. Gießen Regional Commission.

BAHRER, L. AND BLEISENBERG, A. (1992): An Ecological Tax Reform in Germany. Prognos AG. Basle.

BECHMANN, A.; MEIER-SCHAIDNAGEL, R. AND RÜHLING, I. (1992): Landwirtschaft 2000 - Ist flächendeckende ökologische Landwirtschaft finanzierbar? - Greenpeace, Hamburg/Berlin.

BECK, U. (1986): Risikogesellschaft - Auf dem Weg in eine andere Moderne. Suhrkamp, Frankfurt/M.

BECKER, H. (1992): Reduzierung des Düngemitteleinsatzes, Federal Ministry for Food, Agriculture and Forestry, No. 416. Münster-Heltrup.

BEESE, F. (1993): Gasförmige Stickstoffverbindungen - Kurzstudie D: Stickoxide und Distickoxide. Research programme in agriculture. Munich.

BFLR (1994) - BUNDESFORSCHUNGSANSTALT FÜR LANDESKUNDE UND RAUMORDNUNG: Die Flächenerhebung 1993, Working paper 11/94.

BFN (1994) - BUNDESAMT FÜR NATURSCHUTZ: Entwurf einer Strategie zur biologischen Vielfalt (unpublished, status: 10.08.1994).

BFN (1996) - BUNDESAMT FÜR NATURSCHUTZ: Liste gefährdeter Pflanzenarten. Schriftenreihe für Vegetationskunde (Botany Papers) No. 28. Bonn.

BGA - JETZT BGVV(1993) - BUNDESINSTITUT FÜR VERBRAUCHERSCHUTZ UND VETERINÄRMEDIZIN: Richtwerte für Schadstoffe in Lebensmitteln. BGA announcement in Bundesgesundheitsblatt 5/93. Berlin.

BICKEL, P. AND FRIEDRICH, R. (1995): Was kostet uns Mobilität? Externe Kosten des Verkehrs. Heidelberg.

BIERTER, W. (1995): Wege zum ökologischen Wohlstand. Birkhäuser, Basle.

BLAK (1993) - BUND-LÄNDER-ARBEITSKREIS: "Steuerliche und wirtschaftliche Fragen des Umweltschutzes" Gesamtkonzept Umweltabgaben/Steuerreform - Comprehensive Concept Environmental Levies/Green Tax Reform. BLAK.

BMF (1993) - BUNDESMINISTERIUM DER FINANZEN/FEDERAL MINISTRY OF FINANCE: Bericht der Bundesregierung über die Entwicklung der Finanzhilfen des Bundes und der Steuervergünstigungen für die Jahre 1991 bis 1994 (Fourteenth Report on Subsidies - Subventionsbericht). Bonn.

BML (1993) - BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND FORSTEN/FEDERAL MINISTRY ON FOOD, AGRICULTURE AND FORESTRY: Statistical Yearbook on Food, Agriculture and Forestry. Bonn.

BML (1994a) - BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND FORSTEN/FEDERAL MINISTRY ON FOOD, AGRICULTURE AND FORESTRY: Statistical Yearbook on Food, Agriculture and Forestry. Bonn.

BML (1994b) - BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND FORSTEN/FEDERAL MINISTRY ON FOOD, AGRICULTURE AND FORESTRY: Report on agriculture of the German Federal Government. Bonn.

BML (1995) - BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND FORSTEN/FEDERAL MINISTRY ON FOOD, AGRICULTURE AND FORESTRY: Agricultural report of the German Federal Government. Bonn.

BML (1995a) - BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND FORSTEN/FEDERAL MINISTRY ON FOOD, AGRICULTURE AND FORESTRY: Waldzustandsbericht der Bundesregierung 1994; Council of Experts on Environmental Issues (Sachverständigenrat für Umweltfragen) 1987. Report 1987. Berlin.

BML (1996a) - BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND FORSTEN/FEDERAL MINISTRY ON FOOD, AGRICULTURE AND FORESTRY: Zur Neuorientierung der Landnutzung. Angewandte Wissenschaft, No. 453/96.

BML (1996b) - BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND FORSTEN/FEDERAL MINISTRY ON FOOD, AGRICULTURE AND FORESTRY (EDS.): Perspektiven der Agrarpolitik im kommenden Jahrzehnt - Konzeptionelle Überlegungen. In: Agra-Europe 26/96 vom 24.06.96.

BML (1996c) - BUNDESMINISTERIUM FÜR ERNÄHRUNG, LANDWIRTSCHAFT UND FORSTEN/FEDERAL MINISTRY ON FOOD, AGRICULTURE AND FORESTRY: Agricultural report of the German Federal Government. Bonn.

BMU (1992) - FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY: 5. Immissionsschutzbericht der Bundesregierung; Federal Ministry for Environment, Nature Conservation and Nuclear Safety. Bonn.

BMU (1992a) - BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ UND REAKTORSICHERHEIT/FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY: Bericht der Bundesregierung über die Konferenz der Vereinten Nationen für Umwelt und Entwicklung im Juni 1992 in Rio de Janeiro (report of the Federal Government on the United Nations Conference on Environment and Development - UNCED - in Rio de Janeiro 1992). Bonn.

BMU (1993) - BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ UND REAKTORSICHERHEIT/FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY: Klimaschutz in Deutschland - National report of the Federal Republic of Germany. Bonn.

BMU (1994) - BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ UND REAKTORSICHERHEIT/FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY: Klimaschutz in Deutschland. Erster Bericht der Regierung der Bundesrepublik Deutschland nach dem Rahmenübereinkommen der Vereinten Nationen über Klimaänderungen. Bonn.

BMU (1996) - BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ UND REAKTORSICHERHEIT/FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY: Umweltbewußtsein in Deutschland 1996. Results of a representative public poll commissioned by the Federal Environmental Agency. Berlin

BMU (1996a) - BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ UND REAKTORSICHERHEIT/FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY: 6. Immissionsschutzbericht der Bundesregierung, Bonn.

BMU (1997) - BUNDESMINISTERIUM FÜR UMWELT, NATURSCHUTZ UND REAKTORSICHERHEIT/FEDERAL MINISTRY FOR ENVIRONMENT, NATURE CONSERVATION AND NUCLEAR SAFETY(EDS.): Auf dem Weg zu einer nachhaltigen Entwicklung in Deutschland. Bericht der Bundesregierung anläßlich der VN-Sondergeneralversammlung über Umwelt und Entwicklung im Juni 1997 in New York. Bonn.

BMV - FEDERAL MINISTRY OF TRANSPORT (1996): Qualifizierung, Quantifizierung und Evaluierung wegebauinduzierter Beförderungsprozesse. Report of a pilot study commissioned by the Federal Ministry of Transport, FE-No. 9043/95.

BMWi (1996) - BUNDESMINISTERIUM FÜR VERKEHR/FEDERAL MINISTRY OF ECONOMICS: Energiedaten '96. Bonn.

BOYSEN, P. (1992): Schwermetalle und andere Schadstoffe in Düngemitteln. TEXTE 55/92. Federal Environmental Agency, Berlin.

BRAND, K.-W. (1993): Strukturveränderungen des Umweltdiskurses in Deutschland:. In: Forschungsjournal Neue Soziale Bewegungen, Vol. 6, 1993, pp. 16-24.

BROWN, L. ET AL (1996): State of the World. Worldwatch Institute. Earthscan Publications, London.

BRUNDTLANDT COMMISSION (1997): Unsere gemeinsame Zukunft. Der Brundtland Bericht der Weltkommission für Umwelt und Entwicklung. Eggenkamp, Greven. (see WCED)

BT-DRS 13/2156 (1995) - GERMAN PARLIAMENT: Antwort der Bundesregierung auf die Kleine Anfrage der Abgeordneten Steenblock, Schmidt und der Fraktion Bündnis 90/Die Grünen: Steuerausfälle durch ökologisch schädliche Steuervergünstigungen im Rahmen der Mineralölsteuer. Bonn.

BT-DRS. 12/4626, (1993) - GERMAN PARLIAMENT: Antwort der Bundesregierung auf die Große Anfrage der Abgeordneten Otto Schily u.a. der Fraktion der SPD, 25.03.1993. Bonn.

BT-DRS. 12/7282 (1994) - GERMAN PARLIAMENT: Antwort auf die Große Anfrage der SPD, Bonn.

BT-DRS. 12/8283 (1994) - GERMAN PARLIAMENT: Antwort der Bundesregierung auf die Große Anfrage der Abgeordneten Klaus Kirschner u.a. der Fraktion der SPD, 05.07.1994. Bonn.

BUND UND MISEREOR (Eds.) (1996): Zukunftsfähiges Deutschland. Ein Beitrag zu einer global nachhaltigen Entwicklung. Birkhäuser, Basle.

BUNDESANSTALT FÜR GEOWISSENSCHAFTEN UND ROHSTOFFE (1992): Umsetzung des Bodeninformationssystems: Begleitstudie zur bundesweiten Bodenzustandserhebung im Walde (BZE-Wald), 4 vols. Bundesgesundheitsblatt. Hanover.

BUNDESANSTALT FÜR STRAßENWESEN (1994): Vorläufige Schätzung der Personenschäden durch Straßenverkehrsunfälle in Deutschland für das Jahr 1992. Bergisch Gladbach.

BURDIG, B. (1994): Ökolandbau - eine klimaverträgliche Alternative. In: Ökologie und Landbau, No. 90/1994, pp. 38-41.

COGNIS (1994a.) - GESELLSCHAFT FÜR BIO- UND UMWELTTECHNOLOGIE MBH: Textilien/Kleidung 1992 (Vorstudie), in: ENQUETE COMMISSION "Protection of Humanity and the Environment" (Eds.): Stoffstrommanagement - Konzepte - Instrumente - Bewertung, Vol. 4. Bonn.

COGNIS (1994b) - GESELLSCHAFT FÜR BIO- UND UMWELTTECHNOLOGIE MBH: Untersuchung des Bekleidungsverbrauchs einer bundesdeutschen Behörde, in: Enquete Commission "Protection of Humanity and the Environment" (Eds.): Stoffstrommanagement - Konzepte - Instrumente - Bewertung, Vol. 4. Bonn.

CSD (1994) - COMMISSION ON SUSTAINABLE DEVELOPMENT: Elements for an International Work Programme on Sustainable Production and Consumption. Oslo conference paper.

DALY, H., COBB, J. B. (1989): For the Common Good. Beacon Press. Boston, USA.

DE HAAN, G. (1993): Reflexion und Kommunikation im ökologischen Kontext. In: Apel, H., de Haan, G. und Siebert H. (eds.): Orientierungen zur Umweltbildung, Bad Heilbrunn/Obb., 1993, pp. 111-164.

DE HAAN, G. (1995): Perspektiven der Umweltbildung/Umwelterziehung: DGU-(Deutsche Gesellschaft für Umwelterziehung) Nachrichten, No. 12, Oct. 1995, pp. 19-30.

DE MAN, R. (1994): Erfassung von Stoffströmen aus naturwissenschaftlicher und wirtschaftswissenschaftlicher Sicht - Akteure, Entscheidungen und Informationen im Stoffstrommanagement; Umweltverträgliches Stoffstrommanagement - Konzepte Instrumente - Bewertung. Reports commissioned by the Enquete Commission "Protection of Humanity and the Environment" (Eds.), Vol. 1, Bonn 1994.

DE VEER ET AL (1993): Zehn nach Grün. Agrarwirtschaft, Vol. 42, No. 6.

DGE (1993) - DEUTSCHE GESELLSCHAFT FÜR ERNÄHRUNG: Richtig essen. Bundeszentrale für gesundheitliche Aufklärung.

DIEFENBACHER, H. (1991): Der "Index of Sustainable Economic Welfare" - Eine Fallstudie über die Entwicklung in der Bundesrepublik Deutschland. In: Diefenbacher, H., Habicht-Erenler, B.: Wachstum und Wohlstand - Neuere Konzepte zur Erfassung von Sozial- und Umweltverträglichkeit, pp. 73 - 88. Marburg .

DIEKMANN, A. UND PREISENDÖRFER, P. (1992): Persönliches Umweltverhalten. Diskrepanzen zwischen Anspruch und Wirklichkeit, Kölner Zeitschrift für Soziologie und Sozialpsychologie 1992, Vol. 44, pp. 226-251.

DIW (1991) - DEUTSCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG / GERMAN INSTITUTE FOR ECONOMIC RESEARCH: Verkehr in Zahlen 1991. Federal Ministry of Transport (BMV). Bonn.

DIW (1992) - DEUTSCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG / GERMAN INSTITUTE FOR ECONOMIC RESEARCH: Berechnung der Wegekosten und Wegeausgabendeckungsgrade für den Straßenverkehr in den alten Ländern der Bundesrepublik Deutschland für das Jahr 1991. Gutachten im Auftrage des Bundesministers für Verkehr. December 1992. Berlin.

DIW (1993) - DEUTSCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG / GERMAN INSTITUTE FOR ECONOMIC RESEARCH: Verkehr in Zahlen 1993. Federal Ministry of Transport (BMV). Bonn.

DIW (1994 a) - DEUTSCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG / GERMAN INSTITUTE FOR ECONOMIC RESEARCH: Verminderung der Luft- und Lärmbelastung im Güterfernverkehr 2010. Berichte 5/94. Federal Environmental Agency, Berlin.

DIW (1994) - DEUTSCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG: Wirtschaftliche Auswirkungen einer ökologischen Steuerreform. DIW, Berlin.

DIW (1995) - DEUTSCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG: Verkehr in Zahlen 1995. Federal Ministry of Transport (BMV). Bonn.

DÜRR, H. J.; PETELKLAU, H.; SOMMER, C. (1994): Literaturstudie Bodenverdichtung. Final Report Federal Environmental Agency, R+D Project 107 02 004/09.

ENDRUWEIT, G. (1987): Soziologische Thesen zur Identitätskrise auf dem Lande. In: Planck, U., Identitätskrisen im ländlichen Raum, papers on agricultural policy and agrarian sociology, pp. 41-53. Linz.

ENQUETE-COMMISSION (1990): "PROTECTION OF THE EARTH'S ATMOSPERE" Schutz der Erde - Eine Bestandsaufnahme mit Vorschlägen zu einer neuen Energiepolitik. Economica, Bonn.

ENQUETE-COMMISSION (1994): " PROTECTION OF THE EARTH'S ATMOSPERE " Mobilität und Klima, Wege zu einer klimaverträglichen Verkehrspolitik. Bonn.

ENQUETE-COMMISSION (1994a): " PROTECTION OF HUMANITY AND THE ENVIRONMENT" " Die Industrie gesellschaft gestalten - Perspektiven für einen nachhaltigen Umgang mit Stoff- und Materialströmen. Bonn.

ENQUETE-COMMISSION (1994b): "PROTECTION OF THE EARTH'S ATMOSPERE": Mehr Zukunft für die Erde - Nachhaltige Energiepolitik für dauerhaften Klimaschutz. Economica, Bonn.

ENQUETE-COMMISSION (1994c): "PROTECTION OF HUMANITY AND THE ENVIRONMENT":. Die Industrie gesellschaft gestalten.German Parliament publication no. 12/8260, Bonn.

ERNÄHRUNGSBERICHT (1992): Deutsche Gesellschaft für Ernährung e.V.

EU-COMMISSION (1995): Tax Reform and Sustainable Development, europe environment, no. 448, EU Commission. Brussels.

EU-COMMISSION (1996): Faire und effiziente Preise im Verkehr. Politische Konzepte zur Internalisierung der externe Kosten des Verkehrs in der Europäischen Union. EU Bulletin, Supplement 2/96.

FEGER, K.-H. (1995): Natürliche und anthropogene Komponenten des Säurehaushalts von Waldböden - Beteiligte Prozesse und Konsequenzen für die Hydrosphäre. In: Umweltministerium Baden-Württemberg: Saurer Regen - Probleme für Wasser, Boden und Organismen, Ecomed Verlagsgesellschaft. Landsberg.

FELDWISCH, N.; FREDE, H.G. (1995): Maßnahmen zum verstärkten Gewässerschutz im Verursacherbereich Landwirtschaft. DVWK-Materialien, 2/1995.

FHG - ISI (1995) - FRAUNHOFER INSTITUT FÜR SYSTEMTECHNIK UND INNOVATIONSFORSCHUNG: Synopse ausgewählter Indikatorenansätze für Sustainable Development. Final Report R+D Project No. 101 05 016 "Weiterentwicklung von Indikatorensystemen für die Umweltberichterstattung". TEXTE 37/97, Federal Environmental Agency, Berlin.

FHG (1990) - FRAUNHOFER INSTITUTE FOR FOOD TECHNOLOGY AND PACKAGING: Emissionssituation in der Nahrungsmittelindustrie. Study carried out by the Fraunhofer Institute for Food Technology and Packaging, Freising.

FIFO (1994) - FINANZWISSENSCHAFTLICHES FORSCHUNGSINSTITUT AN DER UNIVERSITÄT ZU KÖLN: Umweltorientierte Reform des Steuersystems. Cologne.

FIP (1993) - FÖRDERGEMEINSCHAFT INTEGRIERTER PFLANZENANBAU: Anbauorientierungen für den Integrierten Pflanzenbau, Inhalt und Ziele. No. 8.

GESAMTTEXTIL E.V. (1994): Jahrbuch der Textilindustrie, published by the German Textile Industry Federation (Gesamtverband der Textilindustrie in der Bundesrepublik Deutschland). Eschborn.

GFK (1995) - GESELLSCHAFT FÜR KONSUMFORSCHUNG: Press release of 15.5.1995.

GLATZEL, W.-D.; KASCHENZ, H. (1995): Der kumulierte Energieaufwand als der Kennwert in Ökobilanzen - Bedeutung und Grenzen: VDI report No. 1218, pp. 69 - 78.

GÖPPERT, K. (1992): Konsumtrends. Wirtschaftswoche No. 47 of 13.11.1992, pp. 184-188.

GRUNOW, W.; SCHMIDT (1990): Ernährungsrisiken durch Schadstoffe, Federal Health Gazette (Bundesgesundheitsblatt) 12/90.

GÜNDRA, H. et al. (1995): Bodenerosionsatlas Baden-Württemberg. In: Agrarforschung in Baden-Württemberg. Vol. 24. Stuttgart.

HAAS, G.; KÖPKE, U. (1994): Vergleich der Klimarelevanz ökologischer und konventioneller Landbewirtschaftung, Studie commissioned by the Enquete-Commission of the German Parliament "Protection of the Earth's Atmosphere".

HABERMAS, J. (1985): Die Neue Unübersichtlichkeit. Kleine politische Schriften V, Frankfurt/M.

HAMM, A. (1991): Studie über Wirkungen und Qualitätsziele von Nährstoffen in Fließgewässern, Academia, St. Augustin.

HAN, SIN-LING (1994): An Overview of Persistant Organic Pollutants in the Environment. Report Prepared by Canada for the UNECE Task Force on Persistent Organic Pollutants.

HANDELSBLATT (1994): Entsorgung sorgt weiter für Ärger. Handelsblatt, 08.12.1994.

HANSMEYER, K.-H. (1994); u.a.: Umweltorientierte Reform des Steuersystems. Finanzwissenschaftliches Forschungsinstitut an der Universität zu Köln. Cologne.

HARTJE, V. (1994): Naturschutzabgaben. Eine ökonomische Bewertung ihres Einsatzes nach dem Bundesnaturschutzgesetz. In: Umweltpolitik mit hoheitlichen Zwangsabgaben? Karl-Heinrich Hansmeyer zur Vollendung seines 65. Lebensjahres, pp. 331-347. Duncker und Humblot, Berlin.

HARTMANN, H. (1994): Die Stellung der Biomasse im Vergleich zu anderen erneuerbaren Energieträgern aus ökologischer, ökonomischer und technischer Sicht. R+D 90 NR 025. Technical University Munich.

HAUPTMEYER, C.-H. (1983): Das alte Dorf - Gemeinschaft und Zwang. In: Das alte Dorf u.a., Annäherungen an das Dorf, pp. 148-163.

HÄUßERMANN, H. UND SIEBEL, W. (1995): Dienstleistungsgesellschaften. Suhrkamp, Frankfurt/M.

HEID, H. (1992): Ökologie als Bildungsfrage. In: Zeitschrift für Pädagogik 1992, Vol. 38, pp. 113 - 138.

HEINLOTH, K. (1993): Energie und Umwelt - klimaverträgliche Nutzung von Energie. Teubner, Stuttgart

HENNING, F.-W. (1988): Landwirtschaft und ländliche Gesellschaft in Deutschland. Band 2: 1750 bis 1986.

HOFMANN, K. (1994): Nitrat in Lebensmitteln und mögliche Auswirkungen auf die menschliche Gesundheit. Mitteilungsblatt der Bundesanstalt für Fleischforschung Kulmbach, 33. Vol. 126, December 1994.

HOHLS, F.W. (1991): Umweltorientierte Unternehmensführung für die Lebensmittelindustrie. Lebensmitteltechnik 10, pp. 547-555.

HUBER, J. (1993): Ökologische Modernisierung: Zwischen bürokratischen und zivilgesellschaftlichem Handeln: Volker v. Prittwitz, Umweltpolitik als Modernisierungsprozeß. 1993, pp. 51-70. Opladen.

HUCKESTEIN, B.; VERRON, H. (1996): Externe Effekte des Verkehrs in Deutschland. In: Mobilität um jeden Preis ? Wxpert workshop on the external costs of traffic and possibilities to for reduction. TEXTE 66/96, Federal Environmental Agency, Berlin.

HURLE, K.; LANG, S.; HERRMANN, M. (1994): Unbeabsichtigte Einträge. DFG (Deutsche Forschungsgemeinschaft): Ökotoxikologie von Pflanzenschutzmitteln, Weinheim.

HURLE, K.; LANG, S.; KIRCHHOFF, J. (1993): Gewässerbelastung durch Pflanzenschutzmittel. In: Belastung der Oberflächengewässer aus der Landwirtschaft - gemeinsame Lösungsansätze zum Gewässerschutz. Agrarspektrum, Vol. 21, pp. 47-65.

IFEU (1992): Motorisierter Verkehr in Deutschland. Berichte 8/92, Federal Environmental Agency, Berlin.

IFO (1994 a) - Institut für Wirtschaftsforschung: Ansatzpunkte für eine ökologische Steuerreform: Überlegungen zum Abbau umweltpolitisch kontraproduktiver Einzelregelungen im Deutschen Steuerrecht: Triebswetter, U; Franke, A., Sprenger, R.-U. Ifo reports on environmental economics, No. 21. Munich.

IFO (1994) - INSTITUT FÜR WIRTSCHAFTSFORSCHUNG: Gesamtwirtschaftliche Auswirkungen preispolitischer Maßnahmen zur CO_2-Reduktion im Verkehr, Interim report commissioned by the Federal Ministry of Transport. Munich.

IFO (1995) INSTITUT FÜR WIRTSCHAFTSFORSCHUNG: Wirtschaftskonjunktur No. 9. Munich.

INFRAS/IWW (1995) INFRAS AG: External Effects of Transport, Project for the UIC. Paris.

INGLEHART, R. (1989): Kultureller Umbruch. Wertwandel in der westlichen Welt. Campus, Frankfurt/M.

INTERDISZIPLINÄRER ARBEITSKREIS FÜR LÄRMWIRKUNGSFORSCHUNG BEIM UMWELTBUNDESAMT (1990): Belästigung durch Lärm: Psychische und körperliche Reaktionen, in: Zeitschrift für Lärmbekämpfung, 37, 1990

IPCC (1996) - INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE: IPCC Second Assessment - Synthesis of Scientific-Technical Information Relevant to Interpreting Article 2 of the UN Framework Convention on Climate Change, Port Chester, NY.

IRMER, U.; MARKARD, C.; BLONDZIK, K.; GOTTSCHALK, C.; KUSSATZ, C.; RECHENBERG; B.; SCHUDOMA, D. (1994): Ableitung und Erprobung von Zielvorgaben für gefährliche Stoffe in Oberflächengewässern. UWSF-Z. Umweltchem. Ökotox., 6 1994, pp. 19-27.

IRMER, U.; WOLTER, R.; KUSSATZ, C. (1993): Wasserwirtschaftliche Probleme mit Pflanzenschutzmitteln: Belastung der Oberflächengewässer aus der Landwirtschaft - gemeinsame Lösungsansätze zum Gewässerschutz. Agrarspektrum, Vol. 21, pp. 22-23.

ISERMANN, K. (1991): Stickstoff- und Phosphorbilanzierung der Landwirtschaft im Vergleich westeuropäischer Länder. 102, VDLUFA-Kongreß Berlin, "Landwirtschaft im Spannungsfeld von Belastungsfaktoren und gesellschaftlichen Ansprüchen".

ISERMANN, K. (1994): Lösungsansätze und Lösungsaussichten zur ursachenorientierten und hinreichenden Minderung der Emissionen umweltschädlicher Spurengase aus den Bereichen Energiewirtschaft/Kfz-Verkehr und Landwirtschaft/Tierhaltung (unpublished).

ISERMANN, K. (1994a): Lösungsansätze und Lösungsaussichten für eine hinsichtlich des Nährstoffhaushaltes Nachhaltige Landwirtschaft in Deutschland bis zum Jahre 2005, Study for the Center of Technology Assessment in Baden-Württemberg (unpublished).

ISI/IFO (1993) - FRAUNHOFER-INSTITUT FÜR SYSTEMTECHNIK UND INNOVATIONSFORSCHUNG / INSTITUT FÜR WIRTSCHAFTSFORSCHUNG: Analyse von Hemmnissen und Maßnahmen für die Verwirklichung von CO_2-Minderungszielen. Final report for the studies C 3.1 und C 3.2, of the Enquete-Commission "Protection Of The Earth's Atmospere", ISI/Ifo, Karlsruhe, Munich, Leipzig.

ISING, H; BABISCH, W.; KRUPPA, B (1996): Risikoerhöhung für Herzinfarkt durch chronischen Lärmstreß, in: Zeitschrift für Lärmbekämpfung, 43, 1996.

ISOE (1997) - INSTITUT FÜR SOZIAL-ÖKOLOGISCHE FORSCHUNG: Nachhaltige Konsummuster und postmaterielle Lebensstile. Preliminary study commissioned by the Federal Environmental Agency. To be published in TEXTE, Federal Environmental Agency, Berlin.

IST GmbH (1994): Umweltbewußtsein Landwirtschaft. Arbeitspapier zur Fallstudie im Rahmen des F+E-Projektes "Analyse der Bedingungen für die Transformation von Umweltbewußtsein in umweltschonendes Verhalten". Federal Environmental Agency Berlin.

IVA (1996) - INDUSTRIEVERBAND AGRAR: IVA-Informationen. Pressestelle 8.6.1996.

IVC (1994) INDUSTRIEVEREINIGUNG CHEMIEFASER E.V.: Die Chemiefaser-Industrie in der Bundesrepublik Deutschland. Frankfurt/M.

JÜDES, U. (1995): Hat Umweltbildung eine Zukunft? In: Umweltbildung in Rheinland-Pfalz, Dokumentation des Runden Tisches Umweltbildung am 28.6.95 in Mainz.

KAGESON, P. (1993) et al.: Getting the Prices Right - A European Scheme for Making Transport Pay its True Costs. European Federation for Transport and Environment (T&E). Stockholm.

KAHLERT, J. (1990): Alltagstheorien in der Umweltpädagogik. Weinheim.

KAULE, G. (1986): Arten- und Biotopschutz. Ulmer, Stuttgart.

KLIPPEL, P. (1993): Straßenverkehrslärm - Umweltqualitätsziele und Lärmminderungsmaßnahmen, in: Handbuch der kommunalen Verkehrsplanung, Vol. 2.3.1.1, Bonn.

KOMEU (1992) - EU COMMISSION: Towards Sustainability. EU Fifth Environmental Action Programme. Brussels.

KOMEU (1995) - EU COMMISSION: Alternative Strategien für die Entwicklung der Beziehungen im Bereich Landwirtschaft zwischen der EU und den assoziierten Ländern im Hinblick auf deren künftigen Beitritt. Strategy paper on agriculture.

KTBL (1991) - KURATORIUM FÜR TECHNIK UND BAUWESEN IN DER LANDWIRTSCHAFT: Datensammlung für die Betriebsplanung,12th edition. Darmstadt.

KTBL (1994) - KURATORIUM FÜR TECHNIK UND BAUWESEN IN DER LANDWIRTSCHAFT: KTBL-Taschenbuch der Landwirtschaft - Daten für die Betriebskalkulationen; 17th edition 1994/95.

KTBL (1995) - KURATORIUM FÜR TECHNIK UND BAUWESEN IN DER LANDWIRTSCHAFT: Schwermetalle in der Landwirtschaft. Working paper No. 27. Darmstadt.

KUTSCH, T. U.A. (1991): Mensch und Ernährung 2000. In: Szallies, R, and Wiswede, G. (Eds.): Wertewandel und Konsum, Landsberg/L. 1991, 2. ed., pp. 309-361.

LAGA (1994) - LÄNDERARBEITSGEMEINSCHAFT ABFALL: Qualitätskriterien und Anwendungsempfehlungen für Kompost. Entwurf der LAGA-AG BioKompost. May 1994.

LAI (1992) - LÄNDERAUSSCHUß FÜR IMMISSIONSSCHUTZ: Krebsrisiko durch Luftverunreinigungen - Entwicklung von "Beurteilungsmaßstäben für kanzerogene Luftverunreinigungen",, study commissioned by the Conference of Environment Ministers, issued by the North-Rhine Westphalian Ministry of the Environment, Regional Planning and Agriculture. Düsseldorf.

LANDESAMT FÜR UMWELTSCHUTZ BADEN-WÜRTTEMBERG (1994). Handbuch Wasser 2 - Übersichtskartierung des morphologischen Zustandes der Fließgewässer in Baden-Württemberg 1992/93.

LAWA (1993) - LÄNDERARBEITSGEMEINSCHAFT WASSER: Fließgewässer der Bundesrepublik Deutschland - Maps on water quality 1982 - 1991.

LAWA (1995) - LÄNDERARBEITSGEMEINSCHAFT WASSER: Bericht zur Grundwasserbeschaffenheit Nitrat. Stuttgart.

LEINWEBER, P. ET AL (1994): Phosphorgehalte von Böden in einem Landkreis mit hoher Konzentration des Viehbestandes. Zeitschrift für Pflanzenernährung und Bodenkunde No. 157, pp. 383-385. VCH Verlagsgesellschaft mbH. Weinheim.

LEPPER, P. UND SCHÖNBERGER, H. (1996): Konzipierung eines Verfahrens zur Erfassung und Klassifizierung von Textilhilfsmitteln, study commissioned by the Federal Environmental Agency, R&D report No. 109 01 210, Berlin 1996 (in preparation).

LÜNZER, I. (1993): Bio-Kost im Konsum. In: G. Altner et al: (Eds.): Jahrbuch Ökologie 1993, pp. 228-236.

MATTHES, F. (1995): "Nachhaltige Energiewirtschaft - Zur Operationalisierung einer unscharfen Zielkategorie" in Nutzinger, H.-G.: Nachhaltige Wirtschaftsweise und Energieversorgung - Konzepte, Bedingungen, Ansatzpunkte. Marburg.

MAYNTZ, R. et al. (1978): Vollzugsprobleme der Umweltpolitik. Verlag Kohlhammer. Stuttgart.

MERCK, J. (1996): Der Handel als erstes Glied der Kette. In: Ökologisches Wirtschaften, No. 5, pp. 19-20.

MICHAELIS, P. (1991): Theorie und Politik der Abfallwirtschaft. Eine ökonomische Analyse. Springer, Berlin.

MICHAELIS, P. (1993): Ökonomische Aspekte der Abfallgesetzgebung. C.B. Mohr, Tübingen.

MÜLLER, F. (1993): Ökonomie und Ökologie in Zentralasien. In: Aus Politik und Zeitgeschichte. Beilage zur Wochenzeitung 'Das Parlament', 17.9.1993, B 38-39/93, pp. 21-37, Bonn.

MÜLLER, E. UND MÜLLER, H. (1994): Die ökonomische Beurteilung einer Abfallabgabe unter besonderer Berücksichtigung des Vermeidungs- und Verwertungsgebotes. Umweltpolitik mit hoheitlichen Zwangsabgaben? Duncker und Humblot, Berlin.

NIEDERSÄCHSISCHES UMWELTMINISTERIUM (1996): Stickstoffminderungsprogramm. Bericht der Arbeitsgruppe aus Vertretern der Umwelt- und Agrarministerkonferenz.

OBERBECK, H. U. UND OPPERMANN, R. (1994): Agrarwirtschaft und Dörfer am Scheideweg. Erfahrungen von Landwirten mit dem Wandel gesellschaftlicher Akzeptanz der landwirtschaftlichen Intensivproduktion. In: Soziale Welt 1994, Vol. 456, No. 3, pp. 259-278.

ÖKOLOGISCHE BRIEFE No. 46 (17.01.1994): Mehr Lebensmittelzusatzstoffe durch EU-Richtlinien.

PARIS-KONVENTION ZUR VERHÜTUNG DER MEERESVERSCHMUTZUNG (1993): Dritte Sitzung der Ad-Hoc-Arbeitsgruppe zu Maßnahmen zur Reduzierung der Nährstoffeinträge aus der Landwirtschaft, Anlage 1: PARCOM-Richtlinie für die Berechnung Mineralbilanzen.

PFLANZENSCHUTZGESETZ/FEDERAL PLANT PROTECTION ACT (15 September 1986)

PLANCO CONSULTING GMBH (1990) Externe Kosten unterschiedlicher landgebundener Verkehrsträger. Expertise commissioned by the German Railways. Essen.

PROGNOS AG (1991) Wirksamkeit verschiedener Maßnahmen zur Reduktion der verkehrlichen CO_2-Emissionen bis zum Jahr 2005. Expertise commissioned by the Federal Ministry of Transport (BMV). Basle.

PROGNOS AG (1993) Entwicklung der Emissionen von Luftschadstoffen und CO_2 durch den Verkehr in Ost- und Westdeutschland bis 2010. Research report commissioned by the Federal Ministry of Transport (BMV). Basle.

PROGNOS AG (1995) Die Energiemärkte Deutschlands im zusammenwachsenden Europa - Perspektiven bis zum Jahr 2020. Report commissioned by the Federal Ministry of the Economy (BMWi).

RADERMACHER, W.; STAHMER, C. (1994):Vom Umweltsatellitensystem zur Umweltökonomischen Gesamtrechnung: Umweltbezogene Gesamtrechnungen in Deutschland - Erster Teil. Zeitschrift für angewandte Umweltforschung, Vol. 7 (1994), No. 4, pp. 531 - 541.

RENNINGS, K. et al. (1996): Nachhaltigkeit, Ordnungspolitik und freiwillige Selbstverpflichtung. ZEW Schriftenreihe Umwelt- und Ressourcenökonomie. Heidelberg.

REGULATION (1988): relating to maximum amounts of contaminants in foods, 23.03.1988.

REGULATION (1989): relating to maximum amounts of certain solvents in foods, 25.07.1989.

REGULATION (1994): relating to maximum amounts of residues of plant protection agents, pesticides, fertilisers and other substances in or on food and tobacco products, 01.09.1994.

REUSSWIG, F. (1994): Lebensstile und Ökologie: gesellschaftliche Pluralisierung und alltagsökologische Entwicklung unter besonderer Berücksichtigung des Energiebereichs. Verlag für Interkulturelle Kommunikation, Frankfurt/M.

RICHTER, W. (1994): Monetäre Makroindikatoren für eine nachhaltige Umweltnutzung. Eine Diskussion theoretischer und praktischer Aspekte des Ökosozialproduktkonzeptes. Marburg.

RWI (1995) - RHEINISCH-WESTFÄLISCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG: Strukturpolitische Restriktionen für ökonomische Instrumente zur CO_2-Minderung, RWI. Essen.

SACHS, W. (1993): Die vier E's. Merkposten für einen maßvollen Wirtschaftsstil: Politische Ökologie, Special: Lebensstil oder Stilleben, Sept./Oct. 1993, pp. 69-72.

SCHEFFER, F. UND SCHACHTSCHABEL, P. (1992): Lehrbuch der Bodenkunde, Ferdinand Enke, Stuttgart.

SCHEK, M. (1993): Stellungnahme der Sachverständigen zu dem Fragenkatalog für die öffentliche Anhörung am 16. und 17. März 1993 zum Thema: "Die Stoffe, aus denen unsere Kleider sind - Stoffströme in der textilen Bekleidungskette". Enquete-Commission " Protection of Humanity and the Environment " 12/8c. Bonn.

SCHILDHAUER, J. (1993): Energieverbrauch der Investitionsgüter- und Nahrungsmittelindustrie der alten Bundesländer. Final Report of the Energy Industry Research Unit (Forschungsstelle der Energiewirtschaft).

SCHLUCHTER, W. ET AL. (1996): Analyse der Bedingungen für die Transformation von Umweltbewußtsein in umweltschonendes Verhalten. Research report commissioned by the Federal Environmental Agency. TEXTE 49/96. Federal Environmental Agency, Berlin.

SCHMIDT-BLEEK, F. (1994): Wieviel Umwelt braucht der Mensch? MIPS - Das Maß für ökologisches Wirtschaften. Birkhäuser, Berlin.

SCHÖNBERGER, H. UND KAPS; U. (1994): Reduktion der Abwasserbelastungen in der Textilindustrie. TEXTE 3/94. Federal Environmental Agency, Berlin.

SCHUBERT, C. (1997): Nährstoffausträge, Vegetation und Wirbellosenbesiedlung in Gräben der Marsch am Beispiel des St. Peterkooges (NF). TEXTE, in preparation, Federal Environmental Agency, Berlin.

SCHULTZ, I. (1993): Globalhaushalt, Globalisierung von Stoffströmen, Feminisierung der Verantwortung. Verlag für interkulturelle Kommunikation, Frankfurt/M.

SCHWERTMANN, U. ET AL. (1987): Bodenerosion durch Wasser. Vorhersage des Abtrags und Bewertung von Gegenmaßnahmen. Eugen Ulmer, Stuttgart.

SEEL, P.; KNEPPER, T.; GABRIEL, S.; WEBER, A.; HABERER, K. (1994): Einträge von Pflanzenschutzmitteln in ein Fließgewässer - Versuch einer Bilanzierung. Vom Wasser, 83, 1994, pp. 357-372.

SENATSVERWALTUNG FÜR STADTENTWICKLUNG UND UMWELTSCHUTZ BERLIN (1993): Studie zur ökologischen und stadtverträglichen Belastbarkeit der Berliner Innenstadt durch den Kfz-Verkehr, Berlin 1993.

SHELL (1995): Aktuelle Wirtschaftsanalysen 9/1995 No. 26.

SIMONIS, U. E. (1990): Basiswissen Umweltpolitik. Edition Sigma, Berlin.

SOLBRIG, O. T. (1994): Biodiversität. Wissenschaftliche Fragen und Vorschläge für die internationale Forschung. Deutsches Nationales Komitee für das UNESCO-Programm "Der Mensch und die Biosphäre. MAB. Bonn.

SRU (1985) - SACHVERSTÄNDIGENRAT FÜR UMWELTFRAGEN: Umweltprobleme der Landwirtschaft. Metzler-Poeschel, Stuttgart.

SRU (1994) - SACHVERSTÄNDIGENRAT FÜR UMWELTFRAGEN: Umweltgutachten 1994 - für eine dauerhaft-umweltgerechte Entwicklung. Metzler-Poeschel, Stuttgart.

SRU (1996) - SACHVERSTÄNDIGENRAT FÜR UMWELTFRAGEN: Umweltgutachten 1996 - Zur Umsetzung einer dauerhaft-umweltgerechten Entwicklung. Metzler-Poeschel, Stuttgart.

STATISTISCHES BUNDESAMT (1994): Datenreport 1994. Zahlen und Fakten über die Bundesrepublik Deutschland. Bonn.

STEGER, U. UND HÜTTL, A. (1994): Strom oder Askese? Auf dem Weg zu einer nachhaltigen Strom- und Energieversorgung. Campus, Frankfurt/M.

STENSCHKE, R. UND JÄCKER, M. (1996): Einfluß von Reifen und Fahrbahnen auf das Reifen-/Fahrbahngeräusch von Kraftfahrzeugen und administrative Maßnahmen zur Verminderung, in: Zeitschrift für Lärmbekämpfung, 43.

STEUBING, L.; BUCHWALD, K. UND BRAUN, E. (1995): Natur- und Umweltschutz - Ökologische Grundlagen, Methoden, Umsetzung. Stuttgart.

STIFTUNG VERBRAUCHERINSTITUT (1995), Nachhaltiger Konsum - aber wie? Berlin.

STOCKHOLM ENVIRONMENT INSTITUTE (1993): Boston Center: Towards A Fossil Free Energy Future - The Next Energy Transition. Boston, USA.

STORCHMANN, K.-H. (1993): Abgaben auf den Pkw-Verkehr und ihre Wirkungen auf den Kraftstoffverbrauch im internationalen Vergleich, in: RWI-Mitteilungen, Vol. 44, 1993, pp. 345-374.

STORM, P.-CH. (1997): Umweltrecht. Wichtige Gesetzte und Verordnungen zum Schutz der Umwelt. 10th edition. Munich.

STRÜMPEL, B. (1977): Die Krise des Wohlstands. Das Modell einer humanen Wirtschaft. Stuttgart.

SWEDISH ENVIRONMENTAL PROTECTION AGENCY (1996): Towards an Environmentally Sustainable Transport System. Final Report from the Swedish EST-project. Report 4682.

SZALLIES, R. (1991): Zwischen Luxus und kalkulierter Bescheidenheit - Der Abschied von Otto Normalverbraucher, in: Szallies, R, und Wiswede, G. (Eds.): Wertewandel und Konsum, Landsberg/L. 1991, 2nd edition, pp. 41-60.

TVI (1994) - GESAMTVERBAND DER DEUTSCHEN TEXTILVEREDELUNGSINDUSTRIE: Jahresbericht 1993. Eschborn.

UBA (1990) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Umweltgesetzbuch - Allgemeiner Teil, Berichte 7/90, Federal Environmental Agency, Berlin. 2nd edition 1991.

UBA (1992) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Daten zur Umwelt 1990/91, Berlin.

UBA (1993) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Handbuch "Umweltfreundliche Beschaffung", Federal Environmental Agency, Berlin.

UBA (1993a) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Ökologische Bilanz von Rapsöl bzw. Rapsölmethylester als Ersatz von Dieselkraftstoff (Ökobilanz Rapsöl), TEXTE 4/93, Federal Environmental Agency, Berlin.

UBA (1994) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Daten zur Umwelt 1992/93. Erich Schmidt, Berlin.

UBA (1994a) UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Das Umweltverhalten der Verbraucher - Daten und Tendenzen. TEXTE 75/94. Federal Environmental Agency, Berlin.

UBA (1994b) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Ökonomische Konsequenzen des anthropogenen Treibhauseffektes - Ein Überblick. TEXTE 40/94. Federal Environmental Agency, Berlin.

UBA (1994c) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Umweltabgaben in der Praxis - Sachstand und Perspektiven. TEXTE 27/94. Umweltbundesamt, Berlin

UBA (1994d) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY:Stoffliche Belastung der Gewässer durch die Landwirtschaft und Maßnahmen zu ihrer Verringerung. Berichte 2/94. Federal Environmental Agency, Berlin.

UBA (1994e) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Umweltgesetzbuch - Besonderer Teil (UGB-BT). Berichte 4/94, Federal Environmental Agency, Berlin.

UBA/LAI (1994) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Ermittlung des Standes der Technik der Ammoniak-Emissionsminderung bei der Rinderhaltung. (LAI-Bund-Länder-AG). TEXTE 13/94. Federal Environmental Agency, Berlin.

UBA (1995) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Maßnahmenplan Umwelt und Verkehr - Ein Konzept für eine nachhaltig umweltverträgliche Verkehrsentwicklung ("Environmentally Sustainable Transport") in der BRD, Entwurf 1995.

UBA (1995a) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Passenger Car 2000 - Requirements, Technical Feasability and Costs of Exhaust Emission Standards for the year 2000 in the European Community, TEXTE 61/95, Federal Environmental Agency, Berlin.

UBA (1996) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: HDV 2000 - Requirements, Technical Feasability and Costs of Exhaust Emission Standards for Heavy Duty Vehicle Engines for the year 2000 in the European Community.

UBA (1996a) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY:: Weitergehende Reinigung von Brauereiabwässern. UBA-Demonstrationsvorhaben No. 7029. Federal Environmental Agency, Berlin.

UBA (1996b) - UMWELTBUNDESAMT/FEDERAL ENVIRONMENTAL AGENCY: Zukunftssicherung durch Kodifikation des Umweltrechts. Politisches Kolloquium zu Umweltgesetzbuch am 19. Oktober 1995 in Potsdam. Berichte 2/96, Federal Environmental Agency, Berlin.

UHLENHAUT, T. (1993): Treibhauseffekt und Landwirtschaft. In: Agrarbündnis e.V. (Eds.): Kritischer Agrarbericht, 1993, pp. 156-166.

UN (1992) - UNITED NATIONS: Energy Statistics Yearbook. New York 1992.

UNCED (1992) - UNITED NATIONS CONFERENCE FOR ENVIRONMENT AND DEVELOPMENT: Framework Convention on Climate Change. Rio de Janeiro.

VAN DEN WEGHE, H. (1994): Wettbewerbsfähige und umweltverträgliche Tierhaltung - Handlungsbedarf: KTBL - working paper No. 210, pp. 108-125.

VCI - VERBAND DER CHEMISCHEN INDUSTRIE E.V. (1995): "Verantwortliches Handeln" Leitfaden. Frankfurt/M.

VDA (1991): Auto 90/91, Jahresbericht, Frankfurt.

VEERHOFF/BRÜMMER (1994): Ausmaß und ökologische Gefahren der Versauerung von Böden unter Wald. R&D project commissioned by the Federal Environmental Agency, FKZ-No. 107 02 004/14. Federal Environmental Agency, Berlin.

VERBRAUCHERZENTRALE NRW (1994): Aktionshandbuch für die verbraucherorientierte Abfallberatung. Düsseldorf.

VERBRAUCHERZENTRALE NRW (1995a): Aktionshandbuch Klimaschutz. Düsseldorf.

VERBRAUCHERZENTRALE NRW (1995b) Aktionshandbuch für die verbraucherorientierte Abfallberatung . Düsseldorf.

VESTER, M., V. OERTZEN, P., GELLING; H., HERMANN, T., MÜLLER, D. (1993): Soziale Milieus im gesellschaftlichen Strukturwandel. Cologne.

VOGEL, H. (1988): Naturschutzprogramme mit der Landwirtschaft in der BRD (alt) - Übersicht. Jahrbuch für Naturschutz und Landschaftspflege, Vol. 41, pp. 183-195.

WBGU (1995 a) - GERMAN ADVISORY COUNCIL ON GLOBAL CHANGE: Scenario for the derivation of global CO_2 reduction targets and implementation strategies. Statement on the occasion of the first Conference of the Parties to the Framework Convention on Climate Change, adopted at the 26th Session of the Council on 26.02.1995 in Dortmund.

WBGU (1995b) - GERMAN ADVISORY COUNCIL ON GLOBAL CHANGE: World in Transition: Ways Towards Global Environmental Solutions, Springer, Berlin/Heidelberg.

WCED (1987) - WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT: Our Common Future. Oxford.

WEC (1993) - WORLD ENERGY COUNCIL: Energy for Tomorrow's World. New York.

WEC (1995) - INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS (IIASA) UND WORLD ENERGY COUNCIL (WEC): Global Energy Perspectives to 2050 and Beyond, London.

WEIZSÄCKER, E. U. (1993): Erdpolitik. Ökologische Realpolitik an der Schwelle zum Jahrhundert der Umwelt. 3rd edition. Darmstadt .

WEIZSÄCKER, E.U., LOVINS A.B., LOVINS, L.H. (1995): Faktor vier : doppelter Wohlstand - halbierter Naturverbrauch. Der Bericht an den Club of Rome. Droemer Knaur, 1995

WENDE, H; MALOW, M (1996): Entwicklung der Geräuschbelastung der Bevölkerung in Deutschland, in: Fortschritte der Akustik, DAGA 96 - Bonn.

WENDT, H. (1993): Zur Situation der deutschen Ernährungswirtschaft 1993. In: Agrarwirtschaft 42 1993, No. 11, 395-408.

WERNER, W.; WODSAK, H.-P.; BEHRENDT, H.; DANNOWSKI, R.; DEUMLICH, D. ET AL. (1994): Stickstoff- und Phosphateintrag in die Fließgewässer Deutschlands, unter besonderer Berücksichtigung des Eintragsgeschehens im Lockergesteinsbereich der ehemaligen DDR. Agrarspektrum, Vol. 22.

WIFO (1995) - ÖSTERREICHISCHES INSTITUT FÜR WIRTSCHAFTSFORSCHUNG: Makroökonomische und sektorale Auswirkungen einer umweltorientierten Energiebesteuerung in Österreich. (Köppl, A. et al..) WIFO. Wien.

ZOLL, R. (1992): Ein neues kulturelles Modell. Opladen.

ZOLL, R. (1993): Alltagssolidarität und Individualismus. Zum Soziokulturellen Wandel. Suhrkamp, Frankfurt/M.