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# Sustainable Development: Environmental, Economic and Social Aspects*

**Michael F. Jischa**
*Technical University of Clausthal, Adolph-Roemer-Strasse 2A, D-38678 Clausthal-Zellerfeld, Federal Republic of Germany*

The term sustainability appears throughout this paper, which is divided into four parts, the first concerned with the term sustainability itself. Its ideal character and history, threats to sustainability and conflicts in its practice are described. In the second part the problem of developed societies is brought to light using three examples: the 1950s syndrome, the increasing gap between gross national product and quality of life, and three traps of civilisation: acceleration, innovation and progress. In the third part the question of what we can know about the future is considered. Following a description of the present situation and the strong influence by technology, the prognosis, which is shockingly time limited, is handled, and obviously unavoidable developments are indicated. The first three parts are limited to generally recognised facts and diagnoses. Either we chose to be aware of these facts or we choose to ignore them. *Therapies* are suggested in the final part of the paper, along with a description of what we should and can do.

## SUSTAINABILITY

> *The extensive political aim of sustainable development, obligatory since the 1992 United Nations Conference on Environment and Development in Rio, contains a programme, which can be revolutionary if taken seriously, for managing mankind's future. Sustainable development is nothing less than the recognition that economic, social and environmental developments must necessarily be seen as a unit. Social crisis can bring about irresponsible use of natural resources just as well as narrow views towards economic growth. Sustainable growth therefore encompasses environmentally sound economic processes co-ordinated to the carrying capacity of environmental systems as well as social compensation for poorer economies always falling behind. This is a radical correction to current views on progress and growth. The fate of humankind depends on whether it can finally come to a strategy for development that addresses the interrelated dependence of economics, the society and environment* [1].

This is how the consultants for environmental issues summarised their statements in the 1994 *Environmental Report*. In the report they spoke about a continuing and environmentally friendly development (sustainable development) as an ideal model for the environmental politics of the future. Since the committee of specialists is made up of scientists, it is interesting to observe how industry has reacted to this model for sustainability. Surprisingly these ideas have been accepted quickly by most in German industry. A 1994 position paper of the Association of Chemical Industry states:

> *The ideal model of sustainable development, a lasting and sustainable development, was set as a common goal for the international community at the International Conference on Environment and Development in Rio de Janeiro. This model requires that natural resources be so sparingly and efficiently used that the needs of people living today be satisfied without compromising the options for development of future generations. Future development must be so fashioned that economic, environmental and social goals are striven for... In* economic *terms sustainability*

* An address presented during the 90th Anniversary Jubilee Official Ceremony

*means an efficient allocation of limited goods and resources. In* environmental *terms sustainability means remaining within the limits of capacity of the ecosphere, preserving the natural conditions for life. In* social *terms sustainability means a high degree of equal opportunity, freedom, social justice and safety* [2].

Such statements are found in a similar form in the environmental reports of large companies. So much agreement catches our attention since conflict of interests are preprogrammed. The convincing nature of the ideal model of sustainability is obviously at least as great as its vagueness. Before going into this, it is worth quickly considering the term's history and the threats to sustainability.

The term sustainability is not new to our generation. Conceptually it was first used in forestry when increasing population and consumption of wood (for fuel and building material) made forestry management necessary. At the end of the eighteenth century in Germany, law was enacted to limit the cutting of trees to only that which is replaced with regrowth. The term sustainability was coined in forestry. In the early twentieth century, the term was introduced to fishery with the purpose of maximising catch without endangering fish population.

The idea of sustainability comes from considerations in the natural sciences, especially biology. It was not much longer before the term was carried-over into general sciences. It took the Brundtland Report and the Rio Conference however for the term to achieve its current status and for confirmation that our western economy and lifestyle are not sustainable.

The 1987 Brundtland Report of the World Commission for Environment and Development, entitled *Our Common Future*, and a short time later the German version, *Unsere gemeinsame Zukunft*, brought the problem to the attention of a wide audience [3].

There are several German translations in use for the term sustainable development. It is generally taken to signify the harmonisation of environmental, economic and social goals so that the needs of people living today are satisfied without destroying opportunities for subsequent generations to choose their own life style.

The breakthrough to the current level of discussion came after the Rio Conference on Environment and Development in 1972. The United Nations had planned to have a second conference twenty years later in Stockholm, but from the beginning this plan was almost constantly accompanied by conflict. In the industrialised nations environmental protection has high priority and third-world population explosion is seen as the primary reason for the environmental crisis. The developing nations on the other hand see waste and non-stop consumption in the developed countries to be the main reasons for the environmental crisis and demand *first development then environmental protection.*

The World Conference replied by renaming itself the UN Conference on Environment *and* Development (UNCED). Even the mammoth conference produced only a few concrete results. The current situation was made clear in tragic proportions however. The consequence of developing countries achieving the success of developed countries (what they are more or less successfully trying to do with our help), will be the environmental collapse of the planet. Extrapolate consumption of primary energy sources and raw materials in industrial countries, along with the associated environmental problems, combined with increased consumption in developing countries and the collapse is obvious.

The third world can no longer become what the first world is, and the first world can no longer remain as it is. Simply put, the life style in developed countries is not exportable.

## Threats to sustainability

What threatens sustainability? Three problem areas or traps can be summarised as our *Future Challenge* [4]:

- *The demographic trap*: The uncontrolled population explosion in many countries of the third world causes hunger, poverty, migration and political problems of asylum.
- *The supply trap*: How long is the non-renewable supply of coal, oil and natural gas expected to last? How long will the mineral raw materials last? At what price can the growing population be fed?
- *The disposal trap*: The main environmental problems are the green house effect; dying forests; the ozone hole; accumulation of garbage; soil, water, and air pollution; large scale technical catastrophes; and last, but not least, the extinction of species.

The first report of the Club of Rome, with the provocative title *The Limits to Growth*, came out in 1972 (German translation in 1973) by D. and D. Meadows *et al* [5]. The main point of the analysis is that our supply of raw materials is limited and will run out. The problem of limited resources is, for the time being, diffused through increased recycling, additional finds of deposits, improved technology in the developed countries, and through reduced demands (lowered buying power) in the impoverished third world and the decaying second world.

When *The Limits to Growth* was written no one

had imagined the coming innovations. For example, glass fibres, vital to the developing global information and communication technologies, have postponed the exhaustion of certain raw materials; copper supplies would never have sufficed for the revolution in the information and communication fields, whereas the raw material for glass fibres is literally as plentiful as sand on the beach.

It should not be held however, as many naive technical fans do, that technical solutions will always come to our rescue. For now the limits to growth seem to be postponed. Key words here are catastrophic climatic change; dying forests; ozone hole; acidification of the oceans, rivers and soil; air and water pollution, as well as the growing mountains of garbage.

The following three figures should make these three *traps* clear. Figure 1 shows the development of world population and energy consumption since the industrial revolution. At the time of Christ, world population was about 0.25 billion, about 1 billion in 1830, 2 billion in 1930, and about 5.8 billion today. While the world population from 1900 till today multiplied *only* by a factor of 3.5 (1.65 to 5.8 billion), the consumption of primary energy carriers grew in the same time period from 1 billion tons of hard coal units (to which all primary energy carriers are converted for purposes of comparison) to 12 billion, a factor of 12. All indications are that the world energy consumption will continue to increase faster than population growth.

Figure 2 outlines the history of man's energy use. Until the industrial revolution, humankind lived in the first solar-powered civilisation: power from human and animal muscle, wind and water, and fire from wood and biomass.

Coal first began to be used on a large scale during the industrial revolution, more than 200 years ago. The steam engine and the coking of hard coal, which allowed large scale smelting of iron ore, were two important innovations in England that made industrialisation possible; until then iron ore was fired with wood coal. The coal and steel era had begun.

For over 100 years, the second large fossil energy

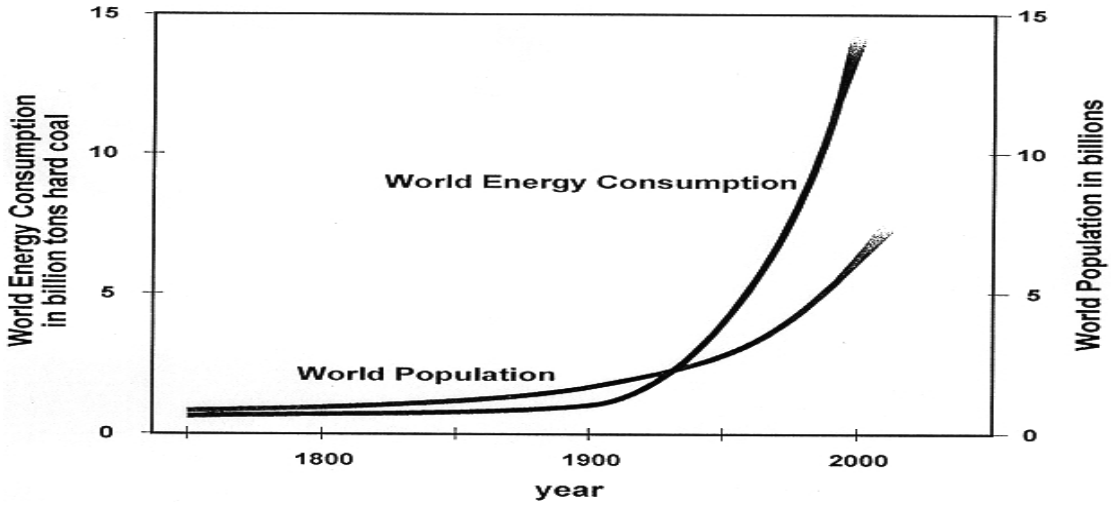


Figure 1: World population and world energy consumption since the industrial revolution.

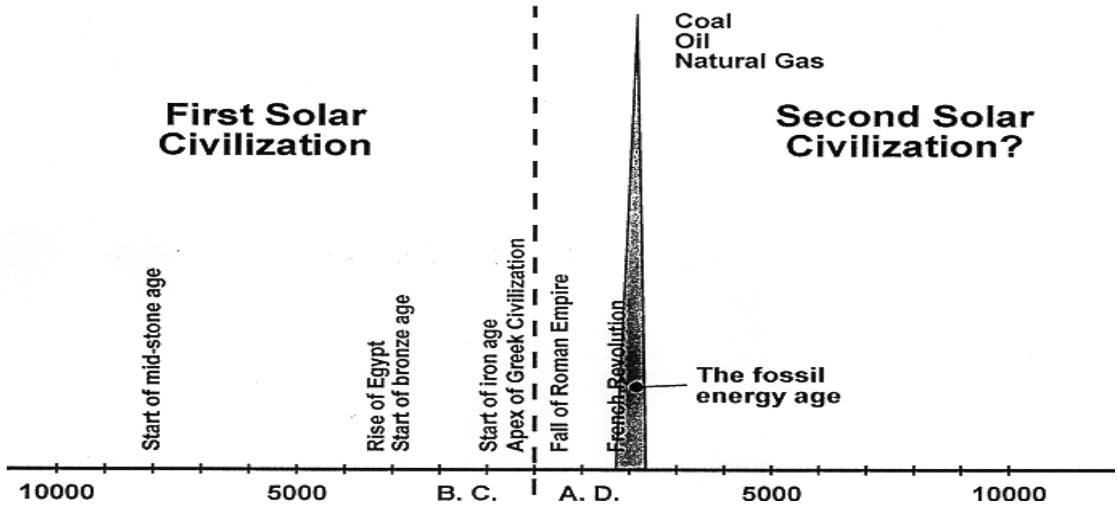


Figure 2: Energy history of mankind.

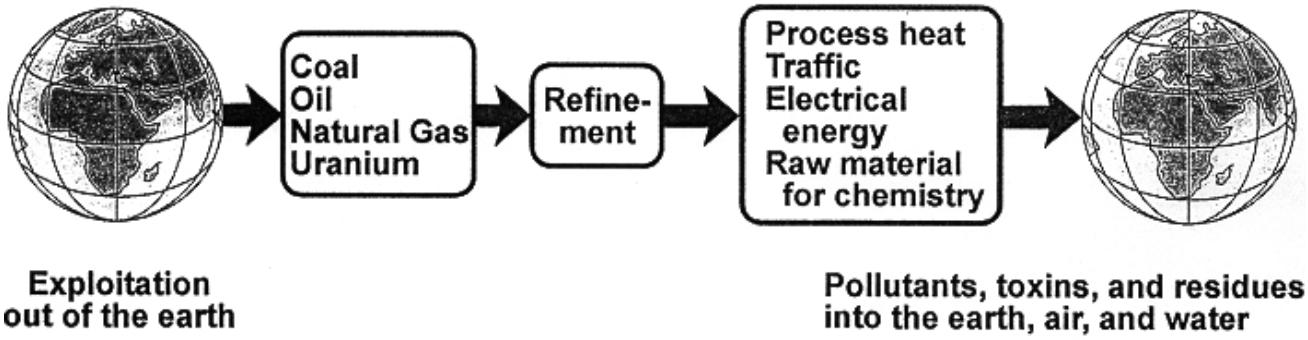


Figure 3: Todays energy supply.

carrier, oil, has been fuelling two industrial branches that have greatly contributed to our standard of living: the automobile and chemical industries.

Natural gas first appeared as the third fossil primary energy carrier only about 50 years ago, at the same time that atomic energy was harnessed. Coal, oil and natural gas now make up about 90%, and nuclear energy about 5%, of the world energy consumption. Water power makes up the much of the remaining 5%. Wind and solar energy still play minor roles.

Since the beginning of the industrial revolution, it could be said that mankind (in the developed world in any case) has been behaving as an irresponsible business man, living off the capital and not off the interest of the capital. Over many geologic time periods, the earth has stored energy from the sun in the form of coal, oil and gas. Mankind will need only a few centuries to burn it up.

Without going into the complexities of supply prognosis and definitions of probable and certain reserves or static and dynamic ranges, one can roughly say that coal, oil and natural gas reserves will now last only about as long as they have been in use. The first 200 fossil years are just the blink of an eye in comparison to the earth's history. The question will be whether mankind after the first long solar civilisation will smoothly enter into a second, intelligent solar civilisation, or whether mankind will pursue a massive build up of nuclear energy, necessarily a breeder technology.

Figure 3 shows the relationship between the supply and disposal aspects and our present energy problem. The mining of raw materials for energy and the release of pollutants and residue back into the environment is not sustainable as an open system.

The still rather new realisation of the disposal trap has brought forth many drives in environmental protection that have been emphasised in teaching and research. The founding of the Clausthal Environmental Technology Institute Ltd and the commencement of studies in Environmental Protection at the Technical University Clausthal are examples of such drives. Generally, many of these drives have shifted focus from aspects of supply to those of disposal, following the motto *from mining engineering to disposal engineering*.

## Conflicting interests

In concluding the first part of the paper, consideration will be given to the *conflicting interests* mentioned at the opening that are involved with the ideal model of sustainability. Reference is made to a discussion between the ecologist W. Haber, the economist P. Klemmer and the labour representative B. Heins in which each of them commented on the three pillars on which the ideal model of sustainability is based, namely environment, economy and society [6].

- *Environment*: Human development (especially technical, industrial) has irreversibly disregarded nature's sustainable organisation. At best it is possible to correct serious excesses of this development.
- *Economy*: In what time period and dimension should sustainability be attempted? How are resources to be distributed between the developed and developing nations, as well as present and future generations? Does a valid and acceptable global rule for justice even exist?
- *Society*: Our present growth butts up against the environmental limits and is at best limited in creating jobs. The causal chain - growth of production, growth of jobs, growth of income, which finances the social state - can no longer hold. End of the pipe social technology can no longer be financed.

Without a doubt, environmental thinking often conflicts with economic considerations. However, there is an increasing number of examples of reconciliation between environment and economy, especially encouraged by the increasing costs for water, waste water treatment, disposal and other. Solid waste treatment, in terms of material or thermal recycling; recycling of inorganics; and exhaust gas and waste water treatment are examples.

It is becoming clearer that the social question will

take on a central role in political considerations. Poignantly said: *How can we fully enjoy a clean river for swimming if we are all unemployed?*

The obvious conflicts among the three pillars of sustainability must constantly be reconsidered by society. Political debates show this. The preferences of interests groups (employers, labour unions, churches, environmental associations) and political parties can easily be categorised under one or two of the three pillars.

## PROBLEMS OF DEVELOPED SOCIETIES

The first part of the paper dealt with the central question of *what* threatens mankind's sustainability. The next question of course is *why* the threats exist. The answer will be presented on three levels.

### The 1950s syndrome

Reference here is made to an extraordinarily interesting publication from the Academic Commission of the University of Bern, which is backed up with much empirical information [7]. Set up in 1985, this commission was familiar with the application of interdisciplinary science to societal problems and it took on general ecology as its first theme. The results of a series of different meetings have been summarised as follows [7]:

> *The post-war boom has been discovered in our time as an epoch of fundamental change of course, which characterises our present society. Up to 1950 Europe moved forward on a relatively environmentally friendly course. Only in the following decades was there a significant increase in energy consumption, gross national product, land demand for housing, volumes of garbage and the pollution of air, water and soil. This thesis of the 1950s syndrome postulates an epoch, which separates our time from one with less dynamic, evolutionary destructive relations between mankind and his environment, and considers the long term reversal of the relative energy price as one of the primary driving forces of the development till now.*

In the time shortly after the second world war, the miner in our land was at the top on the worker's income scale, because energy (then primarily coal) was expensive. The cost of energy remained connected to the cost of work.

This changed with the oil flood, essentially unaffected by two short oil price-shocks. Since the second half of the 1950s the price of oil and later, to some degree, natural gas have constantly fallen relative to the price of most other consumables. This is one reason why oil and to some extent natural gas have partially displaced coal as the basic energy carrier.

The study gives the following example:

> *In 1950 one litre of gasoline in Switzerland was ... 20% less expensive than a kilogram of black bread ... A trained worker could buy at least four litres of gasoline with his hourly wage ... In 1990 bread cost three times as much as gasoline and a trained worker could buy twenty litres of gasoline with his hourly wage. In terms of wages, energy has become five times less expensive in the last forty years* [7].

### Gross National Product (GNP) and *welfare*

For a long time it seemed that the measurement of gross national product (first introduced during the second world war) would run parallel with our subjective feeling for *welfare*. It has been clear for some time that consequences of technical developments, espe-

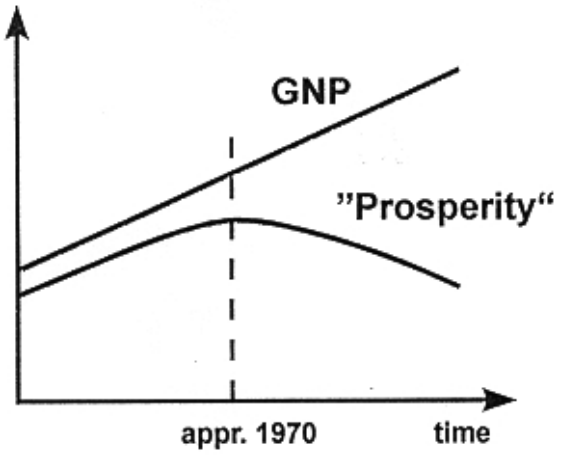


Figure 4: Typical development of gross national product and prosperity in rich societies.

cially the non-intended, lead to a widening of the gap between GNP and welfare, as shown in Figure 4.

For example, ambulances and tow trucks are kept busy and provide work, and hospitals and automobile repair shops make growing profits because of the growing mass of accidents on our highways. None of this however has much to do with an increase in the standard of living.

Effort has recently been made to develop a better measure for living standards. Here too the Rio Conference made an important contribution: *Indicators for the ideal model of sustainability must be developed as a solid basis for decision making and as a contribution to a self-regulating sustainability of integrated systems* [8].

One of the last reports of the Club of Rome, *Taking Nature into Account*, speaks to this problem as does the study *Zukunftsfähiges Deutschland* from the Wuppertal Institute for Climate, Environment and Energy [9][10].

Examples of efforts in this area are the *Index of Sustainable Economic Welfare* (ISEW), the *Human Development Index* (*HDI*) and the *Environmental Accounting to convert from a Gross National Product to a Green National Product*.

Germany is high on the list for GNP but significantly lower on the list for HDI. The HDI from the United Nations includes soft factors, like life expectancy and education, in addition to growth.

The following is a description of the problems of developed societies with different civilisation traps.

## The acceleration trap

The term acceleration crisis was coined by the physicist P. Kafka. He writes in his book *Gegen den Untergang,* in which he pleads for a deceleration in our actions, that:

> *Only permanent changes offer chances for success; those who hold with tradition have already been defeated! Only one thing should not be changed: the basic idea of scientific, technical and economic progress, which has become the ideal model for the whole world. Most people do not even question the model, because it seems to be a law of nature* [11].

## The innovation trap

C.F. von Braun, consultant for technology and organisational development, argues in a similar way in his book *Der Innovationskrieg* [12]. In it he analyses the constant acceleration of product life-cycles and comes to the following conclusion:

> *The new (product) has taken the place of the durable and lasting. Newness is now permanent.* The research race *leads to an innovation trap (similar to the arms race). In the triad of the large economic powers, investment for research and development grow many times faster as company turnover. Additionally, rash product renewal contributes to waste of resources.*

## The progress trap

This has been discussed by the economist and managerial consultant C. Handy [13]. He describes the dilemma that characterises a rich society and he speaks of paradoxes typical of our time. He discusses nine paradoxes: those of intelligence, work, productivity, time, wealth, ageing, individuality, justice and organisation, a few of which are considered below.

Intelligence is the new transitory form of ownership. A new factor, which is constantly becoming more important, has been added to the classic factors of work, capital and resources: the workers' intelligence, known as human capital or human resources. Is this the symbolic end of the industrial revolution? Intelligence has become the decisive factor for production. The traditional basics of capitalism are now in the hands of the workers.

The paradox of work is that unemployment compensation must in the end come from the organisations that the workers let go. The paradox of productivity leads to better and better paid work for fewer and fewer workers and consequently to a new growth sector, black markets. Why should a house painter want to work for a week to pay a plumber legally hired for a day?

Every thesis on the question of distribution can be posed in the name of justice. Summed up from the point of view of the politicians: do your or my constituents pay? Our capitalistic system is based on the basic principle of inequality: whoever attains the most should get the most. But is this the best way to just and efficient distribution?

In an organisation's planning and flexibility, differentiation and integration, mass production and niche in the market, quality and modernity all have to be optimised. Managers must be masters of the paradoxes.

## WHAT DO WE KNOW ABOUT THE FUTURE?

Our sustainability is threatened. What, however, can we know about our future? Let us begin with a short description of our present situation:

> *Nothing has affected the modern industrial*

> *society more than technical innovation. Nothing has changed societies more radically than technical change, which is constantly becoming faster. We have known for a couple of years that certain technical developments have serious and to some degree irreversible consequences, which irresponsibly burden future generations... This is nothing new. At least since the industrial revolution, technology is the characterising factor of modern societies* [4].

Of all the factors that have changed and will change the world, technology is the most dominant. Napoleon is supposed to have said to Goethe that *politics is our fate*. The business man and politician Rathenau has formulated, *economy is our fate*. Today we should say, *technology is our fate*.

Our fate can be seen everywhere we look. For example, the learning ability of pupils is more strongly affected through computers, videos and video games than from pedagogical theories. Factory work has been more affected from just-in-time production than from union pressure. This is also true for office work, which is characterised by modern communication technologies. It would appear that we have not made it clear enough to ourselves how much our life is influenced by technology and how characteristic technology is for our culture.

The physicists and philosopher K.M. Meyer-Abich writes:

> *The forms of parliamentary democracy originate in the time when science was not yet a factor for power, and in the political sphere, the interests for science and technology are till today still not especially well developed. Politics will become very un-political when it forgets that science has developed past the parliamentary democracy to a new form of power* [14].

Where is the development in technology going? What can we know at all about our future? What about the limits of prognosis? Let us begin with a sobering thought for technocrats, which can be called the *Popper Theorem* after the recently deceased philosopher K. Popper [15]. It is approximately formulated as: *We can and will always know more. But one thing we cannot know, namely what we will know in the future, otherwise we would already know it now.* Which means that we are always becoming more knowledgeable but remain helplessly blind towards the future. Prognostibility of the development of modern societies decreases with advancing developments. There was never a time in which we knew so little about the immediate future as today. At the same time, the number of innovations grow constantly, which mostly irreversibly change the structure of the situation of our lives. The philosopher H. Lübbe stated that *the (technical, cultural ...) evolution of mankind is a dynamic process without a main actor* [16].

However, who is in charge and who takes responsibility for technological progress? Is it the multinational companies, Siemens and Sony, Daimler Benz and General Motors, Hoechst and Ciba-Geigy?

To the question of responsibility, intellectuals and sociologists have made statements; well-known authors in the German literature include G. Altner, C. Amery, G. Anders, U. Beck, S. Daecke, F. Gethmann, O. Höffe, V. Hösle, C. Hubig, A. Huning, H. Jonas, H. Lübbe, K.M. Meyer-Abich, H. Lenk, J. Mittelstraß, J. Nida-Rümelin, C. Perrow, K. Popper, F. Rapp and W. Zimmerli. The other half of what C.P. Snow called the *two cultures* has been very reserved in the debate on responsibility. Natural scientists, such as H.-P. Dürr, P. Kafka, H. Markl, H. Mohr, H. Sinn, C.F. von Weizsäcker and E.U. von Weizsäcker, are even more clearly represented than the actual *actors*, the engineers.

Only recently have some engineers, K.A. Detzer [17], K. Henning [18], G. Ropohl [19] and the author [4], reflected on their own actions and the question of responsibility for technology. The activities of the Association of German Engineers (VDI) are worth mentioning [20].

Returning to the limits of prognosis, even when the future cannot be known, it is essential to take an interest in it, as we will, after all, spend the remainder of our life *there*. It is vital to have some idea about the future.

## Inevitable developments

Some inevitable developments seem to be obvious.

Demographic data and observed trends show some developments, at least in a time span of one to two generations, to be inevitable. Four important trends were pointed out in 1986 by the political scientist C.D. Kernig [21]. World population will grow from 5.8 billion today to 8.5 billion by 2025 according to a United Nations prognosis. Well over 10 billion is expected in the year 2050. This growth will take place primarily in third world countries where population will grow from 75% today to over 85% of the world's total.

Secondly, the worldwide consumption of primary energy will increase from 12 billion tons hard coal today to 18 billion tons in the next 20 years, an increase of about 50%. These approximations have recently been corrected upwards. This growth will take place exclusively in the world regions catching up in devel-

opment, such as China (with over 100% growth in twenty years), India, Indonesia. Such growth will no longer continue in western countries. Germany, with 80 million people (1.4% of world population), consumes 480 million tons of hard coal, 4% of the total 12 billion tons. In comparison, per person US Americans consume almost twice as much.

Thirdly, third world population growth will clearly outgrow its ability to keep up food production in the next decades. Fourth, and last, the gap between the first and the third world will grow.

Summarised, the rich will get richer (at least relatively), older and fewer and the poor will get poorer, younger and more numerous. It is quite doubtful if such a world system can remain politically stable.

## WHAT SHOULD AND CAN WE DO?

This is the last and clearly the most difficult part for consideration. To begin then, a description of our present actions follows.

We follow false models. Politics and economics are controlled by false signals (economically one sided). We think constantly in partial systems. We optimise parts of subsystems instead of total systems. Summarised, we draw the wrong system boundaries *and* we make wrong balances.

The volumes of trucking observed daily on our highways and roads make clear the craziness. Pigs transported from the Netherlands to Italy end up as ham in Germany . North Sea shrimps first go over Poland or even Marokko for processing before being eaten in Germany. Onions are shipped from Argentina to supermarkets in Europe, so that international trade can balance out.

This shipping around is apparently good for business, (otherwise they would not take place) but is a horrendous drain on society's wealth and invites environmental disaster. A. Peccei, one of the founders of the Club of Rome, has commented:

> *Modern economics has cheated us. In theory and practice it runs against people's interest. We must find new economic basics, because our present economics no longer harmonises with present reality.*

Growing competition undoubtedly forces businesses to solve its problems at the cost of society (and also the environment). Such a situation cannot be sustained. Former German Minister of the Environment K. Töpfer has commented that *we subsidise our welfare at the cost of the environment, the third world, and future generations*.

From such obviously unavoidable developments, let us consider developments over which we can have influence to the degree we want to, or perhaps better said as far as we are forced to. Three areas are especially important:

- The factor-of-production, workers, should be taxed lower and consumption of resources should at the same time be taxed higher.
- Subvention of German hard coal has more to do with regional politics than with sustainability. Experts call the agricultural politics of the European Union scandalous. Less subvention is needed in areas of non-sustainability and more subvention is vital for sustainable technologies, such as solar energy, or technologies that reduce our energy consumption.
- With state subvention as high as 50%, as in Germany, the question is asked whether we have a market-orientated or state-orientated economy. The constantly growing share from the state is justified with the *social question*. The third requirement therefore is that the social question must not be taboo.

Potential relative losers from change will always argue that it cannot be done or that such changes must take place at the global level or not at all. There is no better alibi for doing nothing.

It must be possible to realise intelligent solutions for sustainability at the national level, or better at the European or the OECD level, where no less is at stake than the sustainability of mankind.

There are further reasons for a change of course. K. Seitz, author of the book *Die japanisch-amerikanische Herausforderung* wrote a short article *Germany Stays Stuck in Industrial Age* in which he observed:

> *In the twentieth century Germany still produces the best nineteenth century products: chemicals, steel, electronics, automobiles, and machines* [22].

Germany is between the grinding stones of the countries with cheap wages (below) and the countries with advanced technology (above). The lower grinding stone grinds away layer after layer of our traditional industries. The upper grinding stone blocks the way upwards and decimates our high-technology industries before they can get a foothold.

The boundary conditions set by the state make good conditions for grinding. An excess of laws is the result of an increasing complexity of regulation and detail. This leads to non-transparency, to growing bureaucracy and to increasing costs and backlogs. Every

flood of regulations has loopholes and can hardly function without corruption. Bureaucratic limits in particular do not stimulate new technological solutions. Instead they tend to preserve the existing status quo and inhibit innovation.

Before making suggestions, which derive out of an ideal model of sustainability, it would be prudent to summarise the preceding argument: shifting production to countries with cheap wages and selling the products to the unemployed in the countries with high pay is not a sustainable model.

The sustainability of mankind is threatened. It is necessary to adjust our actions to the ideal model of sustainability. This means a change of paradigm and processes of transformation in part by changing the boundary conditions on three levels:

- Politics and Economics

  First and foremost, environmental tax reform, which means lowering tax on the factor of production work and increasing it for resource-consumption. It is necessary to internalise external costs, to shift subsidies to sustainable technologies and more economical instruments instead of those for maintaining order. Concrete certificates and licences are more intelligent than rigid limits.

- Society

  Knowledge is needed in order to understand systematic relations in the areas of economy, ecology, society and technology. This is *environmental education* in the widest sense. Only then can an understanding of the urgency follow, a change in values, lifestyle, and in (consumption) behaviour.

- Science

  The environmental and social problems are (or will be) of such dimensions, consequence and complexity that all scientific disciplines must contribute to the solution. The interdisciplinary task for natural scientists and engineers can, with respect to sustainability, be formulated as follows: How can technology be made so as to be humanely, socially and environmentally sustainable? This task encompasses the central focus of the new discipline *Technology Assessment*, which is being established in teaching and research at some universities.

Engineers have always evaluated technological developments; the question is not new. Until now their evaluation has almost without exception concerned itself with two areas: technical functionality and safety as well as the economic question within legal and financial frameworks.

The ideal model of sustainability is much more comprehensive. From now on the horizon of values for technological developments must be expanded to questions of environmental quality (compatibility with the environment) and quality of life (compatibility with society and individuals). This is a high ranking, interdisciplinary question.

Generally, the subject *society and technology* should be anchored in research and teaching in the natural and engineering sciences. Teaching in the specialised fields and knowledge for orientation in system-, social-, and communication-competence all belong together.

## CLOSING COMMENTS

Mankind stands before a *trilemma*. How can economic growth (not quantitative but qualitative, organic, lasting; in short sustainable); lasting supplies of raw materials (energy, inorganic raw materials, food, water, air); and environmental protection be connected together?

Instead of sustainability there is only one alternative, namely deepening the gap between the first and third world, increasing conflicts over distribution and war as a consequence.

Unfortunately, it is obvious that practically all of the activities for securing sustainability have not changed the relevance of the three poignant statements by K.M. Meyer-Abich:

- *This cannot go on.*
- *What instead we have to do is already well known.*
- *Nevertheless nothing really happens* [23].

Obviously, we need a vision in order that what has to happen becomes reality. Two visions are offered below, the first, from a sense of personal responsibility, in the context of the natural and engineering scientists. What would happen if the natural and engineering scientists focus their research and teaching on the central theme of sustainability, for instance, resource and energy efficiency; sustainable and appropriate technologies; economic, environmental and socially relevant technologies?

Generally, knowledge should be taught for orientation along with the essential basics. We should not only discuss means but also goals and ideal models and support interdisciplinary thinking instead of hindering it. The problems of the real world can no longer be described with the classical academic disciplines. To quote Lichtenberg, *whoever only understands chemistry, doesn't even understand this*.

And finally, to the political elite.

How would it be if the political parties are newly defined, so that:

- conservative means maintaining and preserving nature for following generations;
- social means solidarity with the environment, our fellow man and future generations;
- liberal means to freely decide when not to consume and to decide on new goals.

If my remarks in this fourth part appear too subjective or too emotional, then allow me to recall that the etymology of the word professor is to speak out; in German *Bekenner*. I hope for more *Bekenner*.

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## BIOGRAPHY

Michael F. Jischa was born in Hamburg, Germany, in 1937. After an apprenticeship in motor mechanics, he studied engineering in Hamburg, and subsequently mechanical engineering at the Technical University of Karlsruhe. He was awarded the degree of Dipl-Ing in 1965 together with the Redterbacher award. He then worked as research and teaching assistant at the Technical University of Berlin, where he received a doctorate in Engineering in 1968 and a Habilitated degree in 1971 for the subject of fluid dynamics.

He continued research and teaching at the Institute of Thermo- and Fluid-Dynamics within the University of Bochum, and was awarded the title of Applied Professor in 1971. In 1974 he worked in the Department of Fluid-Dynamics of the University of Essen, and was appointed Professor by the Department of Applied Mechanics in 1981. He also received guest professorships at Haifa-Technion, Israel; Marseille, France; and Shanghai, China.

As well as his teaching obligations, Professor Jischa was managing director of the German Technical Academy, Helmstedt, GmbH, from 1989-1993. From 1993-1996 he was Chairman for the Assessment of Technology and the Formation of Environmental Protection in the Centre of Environmental Protection in Clausthal, Germany. From 1991 he was also Chairman of the Working Group Forum, Clausthal. In 1996 he became Chairman of the Academic Advisory Board of Cutec Institute, Clausthal, Germany.

Professor Jischa is the author of *Konvektiver Impuls-Warme und Stoffasutausch* and *Herausforderung Zukunft*.