Background information on sustainable development

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Summary

Sustainable Development has become the leading concept of the 21. century [1]. It describes a development, which agrees with the needs of the present generation but does not endanger the chances of the coming generations to satisfy also their needs. In Europe the term has its origin from forestry; now "sustainable development" has become an important general goal for all fields of life like economy, ecology and social balance.

The development and shaping of our future has been discussed internationally like on the summits of the Conferences in Rio and in Johannesburg. But this is also a topic on national base in various countries. E.g. in Germany the Enquete- Commission of the 13th German Bundestag has founded the legislative act "Protection of Man and Environment" to investigate and work on the needs of sustainable development. In the final report of this commission four or five rules have been defined, which are regarded as necessary for sustainable development in Germany. This concept has also been accepted by leading authorities in various fields of economy and politics. But for putting these principles to practice, now companies also need consultants as advisors, who are competent to apply the rules of sustainable development in their special fields.

Therefore, the application of a new model of sustainable development in education is necessary. Although the concept of sustainable development has been generally accepted, there are still problems how to achieve and evaluate this general goal. For example, it is clear that the definitions about the prime needs vary from man to man, from country to country and from continent to continent.

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What is the meaning of sustainable development?

Sustainable Development, also called persistent, durable, intense or efficient development [1] was first defined in 1987 by the World Commission on Environment and Develpment, headed by Gro Harlem Brundtland, who was the Norwegian prime minister at that time. In the final report of the commission entitled "Our Common Future", also called Brundtland-Report [2] sustainable development is defined as a:

> Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. ...

In other words, development is essential to satisfy human needs and improve the quality of human life. At the same time development must be based on the efficient and environmentally responsible use of all of society's scarce resources: natural, human, and economic resources.

The history of sustainable development

Today's idea of sustainable development dates back to modern times. The consideration of the needs of coming generations is, however, quite old. First documented indications have been found in the history of Irokeses tribes in Northern America. Their chieftains were expected to consider the demands of future generations [3, 4].

In Europe, the idea of sustainable development first developed in forestry. As early as in the 13th century, there have been ordinances about the sustainable use of wood (forest ordinance of Nuremberg from 1294) [5]. The problem of extensive clear cutting without considering reforestation has been discussed by Carlowitz, a nobleman from Saxony in his paper: "Sylvicultura Oeconomica- instruction for a natural cultivation of wild trees" (1713). Carlowitz requested to study the "world's book of nature". He demands that man must investigate the rules of nature, and always, continuously and "perpetuirlich". Carlowitz pleads in his book for several measures in house construction like the improvement of isolation against heat and cold, he pleads for the use of energy-saving melting furnaces and stoves and for scheduled reforestation by sowing and planting. Finally, he demands for "surrogata" of wood [6].

Based on these ideas Georg Ludwig Hartig published the paper in 1795, "Instructions for the taxation and characterization of forests" to use the woods as efficiently, as possible, but to consider also the needs of future generations [7, 8]. The idea of sustainable development was born. However, it's aim was mostly of economic and social nature. The protection of the environment and nature was beyond the scope of these days. That concept to the decrease of primeval forests yielded in a preference for monocultures of trees, mostly fast growing conifers. These early principles of sustainable development were restricted only to forestry and were not extended to other areas.

The term sustainability in the context of protecting nature and the world's biosphere was first used in the 1980s in the global program of the world nature protection for Conservation of Nature (IUCN) and the World Wide Fund for Nature (WWF). Its meaning and object was to use an existing biological system without changing its essential characteristics [9].

The idea of this concept was further extended by the use of the term "sustainable development". Economic aspects were added to the former ecological and social aspects as expressed by the Brundtlandt Report in 1987. From this origin on the term and idea has been used and elaborated. A further milestone was set at the United Nations's Conference on Environment and Development (UNCED) held 1992 in Rio de Janeiro. About 170 nations signed the Agenda 21 with "sustainable development" as a global object [10]. Because of the global character of the Agenda it is not quite clear in some of its aspects. It describes only the general goals but not the ways to obtain them. Therefore, the "spirit" of the Agenda 21 seems more important than the words of the document: only a global partnership and cooperation between all states can solve the most important ecological and social problems of the world. In 1996 the German Enquete-Commission on "Protection of Man and Environment" of the German Bundestag has suggested regulations on how to obtain that general goal. In its final report "Concept Sustainability, from Theory to Application" general rules have been defined [11].

The commission declares the "securing and improvement of ecological, economic and social goods" as prime goals of sustainable development. It points to the model of the three equal columns of sustainability resting on ecology, economy and society. The report also defines practical actions and means on how to obtain the goal of sustainability. In June 2001, members of the EU met in Goetheburg, Sweden to discuss Europe's future and consider general guidelines, to its policy with the following result:

> Sustainable development means fulfilling the needs of the present generation without endangering the needs of future generations. Therefore, it is necessary to develop the politics of economy, ecology and social demands by a synergistic way that they are strengthened by each other. If it is not possible to stop tendencies which threaten the future quality of life, the cost demands of societies will dramatically increase and negative tendencies will become irreversible. The European Council welcomes the announcement of the Commission on Sustainable Development with its important solutions to stop the negative tendencies.

The European policy agrees to go a common way of sustainable development and to establish the general conditions for this way. The coming years will show how well the defined model can be realized. This is the main task for politics, but other subjects like non governmental organizations (NGO) and associations of industry and organizations for the protection of nature play also an important part to develop the model of sustainable development.

Economic rules

The above-mentioned Enquete Commission of the 13th German Bundestag (house of Parliament) [11] proposed the following economical rules for sustainable development:

1. The economic system should satisfy efficiently the individual and social needs. For this purpose, the economic order has to be shaped in a way that it promotes personal initiative (own responsibility) and that the individual interest serves the common interest (common responsibility) for the sake of securing the well-being of present and future

population. It has to be organized in a way that private and common interests are reconciled with each other. Each member of the society gets benefits from the social systems; according to personal payments put into the social systems and according to special needs.

2. Prices must always serve an essential guidance function of the market. They should reflect the availability of resources, production, goods and services.

3. The boundary conditions for competition need to allow well functioning markets to be created and maintained, that innovations are stimulated, that long term decisions will be beneficiary and that social improvements will be promoted leading to adjustment to future needs.

4. The economic efficiency of a society and the base of production, of social and human relationships should be sustained during all times. They should increase not only in quantity but also be improved in quality.

In a feature article (German) the economic requirements for a sustainable development from the prespective of chemical industry are described.

Ecological rules

The Enquete Commission entitled "Protection of Man and Environment" of the 13th German Bundestag (house of Parliament) in 1997 has defined sustainable development as central goal for maintaining and improving ecological, economic and social achievements [11]. It is relating to the model of three equal columns for sustainability of ecology, economy and social demands.

The German Enquete Commission mentioned above proposed the following ecological rules for a sustainable development:

1. The rate of the use of renewable resources should not exceed the rate of regeneration of resources. This corresponds to demanding the sustainment of ecological performanc, i.e. (at least) a sustainment of an ecological capital defined by its functions.

2. Emissions to the environment should not exceed the capacity of the individual ecosystems.

3. The timeframe of anthropogenic impacts on the environment must be in a balanced relation to the timeframe of the reaction ability of the relevant natural processes in the environment.

4. Dangers and risks for human health resulting from anthropogenic activities have to be minimized.

Social rules

Finally, the above-mentioned Enquete Comission proposed the following social rules for sustainability:

1. The social constitutional state should sustain and promote the dignity of man and the free development of human personality for present and future generations, in order to keep social peace.
2. Each member of the society gets benefits from the solidary community: according to former contributions to the social security systems but also in the case of neediness.
3. Each member of the society has to pay a solidary contribution to the community according his or her capability.
4. Social security systems can only grow to the same extent as economic standards.
5. The potential of productivity of the whole society and its branches should be maintained also for future generations.

Sustainability in chemistry

Chemistry in the context of sustainable development is at the same time a chance and a risk. The risks are high, as demonstrated by the accidents at Seveso in Italy, Bophal in India and at Sandoz Corp. in Basle, Switzerland. Also, seemingly less important effects like the ubiquitous emission and accumulation of POPs (persistent organic pollutants), have their origin in the chemical industry.

Besides these dangers, chemistry offers great potentials for sustainable development [12]. The chemical industry can support the development towards a more sustainable lifestyle of society according to its competence in the field of transformation of products and materials.

The production of insulation material for public and private buildings is a good example of the contributions chemistry has made in this process. The energy necessary for the production of these materials is conserved within the first year of operation by reduced heating needs [13]. A long-term reduction of the energy used for heating buildings has become possible. Another example is the development of catalytic converters for motor vehicles, which led to a great reduction in emissions. This in turn has lead to a significant improvement of environmental air quality. In the following chapters, the stands and statements of trade unions and of chemical industry regarding the issue of sustainable development will be discussed.

Perspective of the environmental organzations

Today, there are detailed regulations imposed by the legislation of most modern states regarding environmental issues like the handling of chemical compounds and maintenance of chemical plants. These regulations are the result of the controversial discussions in the 1980s about the role of chemistry. The former social explosiveness expressed, e.g. by reports like

"Seveso ist überall" (Seveso is everywhere) [14] has cooled down. In addition, environmental NGOs have increasingly become involved in political decisions regarding chemical issues. Instead of discussion on chemistry and nuclear power, other topics of controversy now play a more important role. Among today's hot issues are genetic engineering and non-ionizing radiation from cellular telephones. A cooperation between environmental organizations and chemical industry has been developed, resulting in publications like "Sustainable Development - Vom Leitbild zum Werkzeug" (from concept to a tool) by the former Hoechst company [15]. This cooperation yielded the tool "Product Sustainability Assessment" (PROSA), which was applied to various fields as a model. A similar cooperation came about with the topic "PVC und Nachhaltigkeit" (PVC and Sustainability) [16].

The final and groundbreaking aim in either model study was to integrate various aspects, especially economic, social, and ecological perspectives, to reach a holistic consideration of chemical products.

Views of federations and companies

Accidents in chemical plants, increasing environmental sensitivity of citizens, and increasing political pressure have led companies and organizations of chemical industries to think globally about their activities. This reasoning resulted in the general concept of "responsible care" in the late 1980s; chemical industry took the voluntary obligation to improve their activities for safety, health, and environmental protection, independent of legislative regulations. Significant improvements have been achieved by the basis of this concept during the last few years, especially in the field of environmental protection. For example, emissions of climate affecting gases in the chemical industry have been significantly reduced by combined heat and power (cogeneration) [17]. However, the demands of the model of "sustainable development" exceed the measures of the concept "responsible care".

National and international organizations of the chemical industry [18, 19, 1] as well as several associated companies [20, 21, 22] discuss these demands and recognize the principles of sustainable development. However, they request not only national but international regulations to promote sustainable development on a global level [1]. More than 100 global companies have united to form the World Business Council of Sustainable Development (WBCSD). This organization develops new sustainable concepts and approaches for chemical companies, e.g. in the fields of eco-effectiveness or renewable resources [23].

Sustainability in chemical education

The challenges of a sustainable development for chemistry cover all three areas of sustainability. Not all questions can be answered by scientists of one discipline because of the complexity of the questions. Therefore, scientists of different fields are needed. The main task from a scientific standpoint is the development of ecologically sustainable processes and procedures. A process can be regarded as ecologically sustainable if the use of resources (the input, condi-

tions of production and the resulting loads) is close to the defined minima[2] [24]. That does not mean that other approaches and solutions may not exist, which can be considered more sustainable.

For the development of these processes, scientists with fundamental knowledge in the field of transformation of materials are needed. In addition, they should also have an understanding of new demands such as the following:

- Application of energetically benign and environmentally friendly alternative reaction conditions by the use of catalytic and enzymatic reactions
- Application of alternative techniques to thermal reactions such as photochemical and electrochemical reactions, microwave and solar techniques
- Application of modern chemo-, regio-, and stereoselective reactions
- Use of resource conserving starting materials and intermediates, and use of renewable resources
- Use of environmentally benign solvents
- Recycling of auxiliary compounds and of solvents

The demands for chemists are summarized by a paper of Eissen et al. "10 years after Rio-concepts for contribution of Chemistry towards sustainable development" [25].

A virtual institute has developed interesting concepts that utilize the principles of green chemistry. These have been codified in twelve general principles [26]:

1. It is better to prevent waste than to treat or clean up waste after it is formed.
2. Synthetic methods should be designed to maximize the incorporation of all materials used in the process to the final product.
3. Whenever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. Chemical methods should be designed to preserve efficacy of function while reducing toxicity.
5. The use of auxiliary substances (e.g. solvents, separation agents, etc.) should be made unnecessary whenever possible and, innocuous when used.
6. Energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.

[2] If the (optimized) resulting expenses and environmental burdens are considered to high by a majority of actors, the process has to be replaced by a newly developed, better process or the products of the process have to be done without.

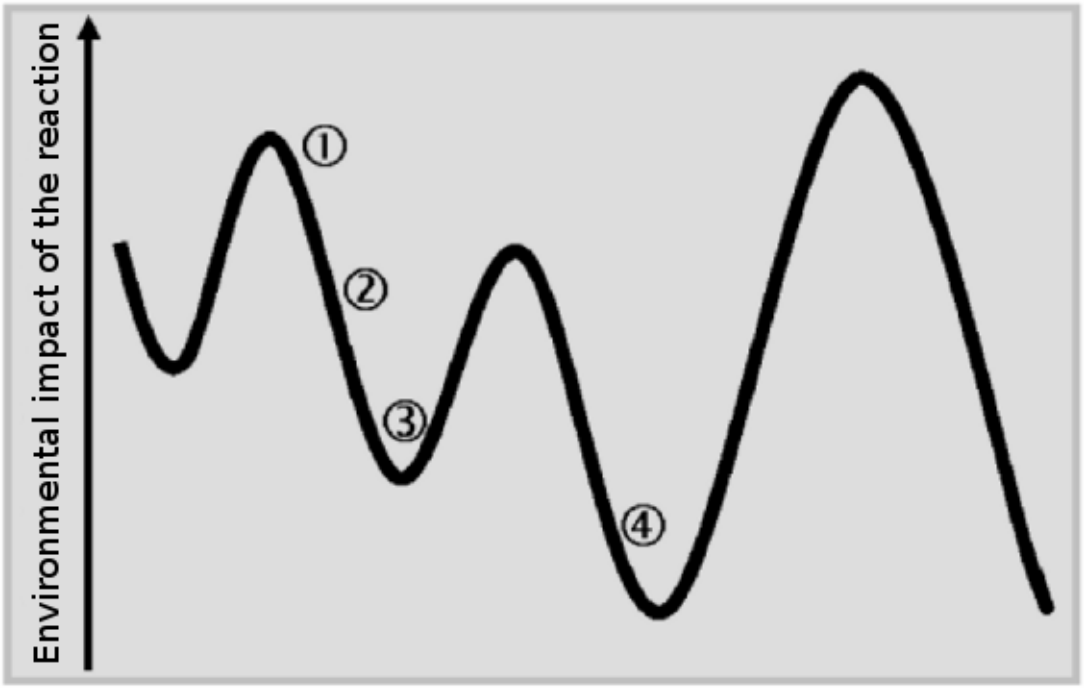

Figure 1: Possible states of environmental impacts of reactions

7. A raw material or feedstock should be renewable rather than depleting wherever technically and economically practicable.

8. Unnecessary derivatization (blocking group, protection/deprotection, temporary modification of physical/chemical processes) should be avoided whenever possible.

9. Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.

10. Chemical products should be designed so that at the end of their function they do not persist in the environment and break down into innocuous degradation products.

11. Analytical methods needed to be further developed to allow for real time, in process monitoring and control prior to the formation of hazardous substances.

12. Substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires.

Besides the demands mentioned herein, an understanding of integrated considerations is necessary. Only by this approach can environmental loads of a reaction be optimized to their minimum. The following figure will specify and explain this approach:

The effect of a reaction on the environment, like human toxicity, eco-toxicity, eutrophication, and climate change will be influenced by many factors. The environmental impact of a

reaction is determined by not only the reagents and auxiliary compounds used, but also by the energy required for the process. The resulting sum of the effects of a given reaction will be described by state 1. A step-wise approach can be used for reaching reaction conditions with minimized environmental impact. When one plans a reaction using an integrated approach, consideration must be given to many factors: the pre-equilibrium steps of educts, the energy of intermediate products, and possible changes to the reaction conditions if the solvents are harmful to the environment. By this kind of optimization, the preferable state 2, rather than state 1, is obtained. When all parameters of the given reaction have been optimized, state 3 is reached because of the optimization efforts. Now principal changes of the reaction conditions are necessary for improvement to obtain a better eco-efficiency, i.e. to reach state 4. An essential improvement could be the use of a special catalyst or the application of other starting materials to yield the same reaction product.

References

[1] Sustainable Development: Wegweiser für die Zukunft. Technical report, Verband der Chemischen Industrie e.V., Frankfurt, 1999.

[2] World Commission on Environment and Development. *Our Common Future*. Oxford University Press, Oxford, 1987.

[3] W. Sachs. Das Kyoto-Protokoll: Lohnt sich seine Rettung? *Blaetter für deutsche und internationale Politik*, Juli 2001, 2001.

[4] T. Mergelsberg. *Nachhaltigkeit - Was ist eigentlich Nachhaltigkeit*. Mergelsberg, 2000.

[5] M. Held. Geschichte der Nachhaltigkeit. *Natur und Kultur*, 1(1):17–31, 2000.

[6] U. Grober. Der Erfinder der Nachhaltigkeit. *Die Zeit*, 25.11.99:98, 1999.

[7] F. Greis. *Wörterbuch zur lokalen Agenda 21*. Universität Mainz, 1997.

[8] M. Krott. Sonderdruck Zukunft Holz - Die Wurzeln des Prinzips der Nachhaltigkeit. *Die Welt*, 17.10.2001:S. 16.

[9] Nachhaltiges Deutschland, Wege zu einer dauerhaft umweltgerechten Entwicklung. Technical report, Umweltbundesamt, Berlin, 1997.

[10] Report of the United Nations Conference on Environment and Development, Rio de Janeiro. Technical report, United Nations, 1992.

[11] Konzept Nachhaltigkeit - Vom Leitbild zur Umsetzung. Technical report, Deutscher Bundestag, Enquete-Kommission Schutz des Menschen und der Umwelt des 13. Deutschen Bundestages, Berlin, 1998.

[12] S. Böschen, D. Lenoir, and M. Scheringer. Sustainable chemistry: starting points and prospects. *Naturwissenschaften*, 90(3):93 – 102, 2003.

[13] Kunststoff ist Klimaschutz. Energiesparen, Ressourcen schonen. Technical report, Verband Kunststofferzeugende Industrie (VKE), Frankfurt, 2001.

[14] E.R. Koch and F. Vahrenholt. *Seveso ist überall - Die tödlichen Risiken der Chemie*. Fischer, Frankfurt, 1980.

[15] C. Ewen, F. Ebinger, C.-O. Gensch, R. GrieSShammer, C. Hochfeld, and V. Wollny. *Hoechst Nachhaltig*. Öko-Institut Verlag, Freiburg, 1997.

[16] Steuerungsgruppe zum Dialogprojekt PVC und Nachhaltigkeit und Arbeitsgemeinschaft PVC und Umwelt e.V., editor. *PVC und Nachhaltigkeit: Systemstabilität als Massstab. Ausgewählte Produktsysteme im Vergleich*. Deutscher Instituts-Verlag, Köln, 1999.

[17] Responsible Care Bericht 2001. Daten der chemischen Industrie zu Sicherheit, Gesundheit, Umweltschutz. Technical report, Verband der Chemischen Industrie e.V., Frankfurt a.M., 2001.

[18] The ICCA Chemical Sector Report to UNEP for the World Summit on Sustainable Development. Technical report, International Council of Chemical Associations, 2002.

[19] CEFIC Statement on an integrated approach towards Sustainable development. Technical report, European Chemical Industry Council (CEFIC), Brüssel, 2000.

[20] Sustainable Development Report 2001. Technical report, Bayer AG, Leverkusen, 2001.

[21] Konzern-Umweltbericht. Technical report, Schering AG, Berlin, 2000.

[22] Umweltbericht 2000. Technical report, BASF AG, Ludwigshafen, 2000.

[23] Case Studies. Technical report, World Buisness Council of Sustainable Development, Genf, 2002.

[24] G. Kreisel and A. Diehlmann. Definition einer ökologisch nachhaltigen Chemie. *unveröffentlicht*, 2002.

[25] M. Eissen, J.O. Metzger, E. Schmidt, and U. Schneidewind. 10 Jahre nach Rio - Konzepte zum Beitrag der Chemie zu einer nachhaltigen Entwicklung. *Angew. Chemie*, 114(3):402–425, 2002.

[26] P.T. Anastas and J.C. Warner. *Green Chemistry: Theory and Practice*. Oxford University Press, Oxford, 1998.

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