CONSIDERATIONS REGARDING ENVIRONMENTAL IMPACTS OF DIFFERENT TECHNOLOGICAL APPLICATIONS

Assoc.-Prof. Dr.-Ing. habil. ILDIKO TULBURE
University "1 Decembrie 1918" Alba Iulia

ABSTRACT: *All economic activities, especially industrial activities have the direct goal to help increasing the quality of life of our society. Beside positive direct and desired effects of industrial activities these have also negative, undesired and sometimes unthinkable effects on the environment and society. After the Conference for Environment in Stockholm in 1972 it was understood that besides wanted effects of technological progress, undesired negative effects can appear. After this time the environmental awareness in the western world began changing. The discussions in 1992 during the Rio-Conference for Environment and Development, especially for establishing the Agenda 21 activities, succeeded in emphasizing the necessity of taking into account the environmental impacts of human activities. Nowadays we confront us with a series of global problems, not only environmental ones, which have been collected by the Club of Rome under the concept of the "World Problematique".*

Keywords: *industrial activities, effects on the environment, global problems.*

The concept of sustainable development of our society has been defined for the first time in the year 1987 in the Brundtland-Report and is nowadays very much discussed on different levels. With regard to sustainability goals of humanity the chances and risks of technological applications have to be carefully analysed and evaluated. Considering the sustainability of our society it is necessary to evaluate industrial processes or generally economic activities not only from economic and technological points of view but from environmental ones as well. There are several methods and instruments used in this regard. Presently the most discussed ones on international level are life cycle assessments (LCA), environmental management systems, eco-audits and ecobalances.

1. The Concept of Sustainable Development

After the Conference for Environment in Stockholm in 1972 and the first report of the Club of Rome „The Limits of the Growth" published in 1972 [10] it was understood that besides wanted effects of technological progress, undesired and negative effects can appear. Nowadays we confront us with a series of global problems, which can be grouped in three categories: world population growth, growth of the energy and natural resources consumption and environmental pollution, see also www.clubofrome.org. They can be called "old" problems. Other issues have arisen in the last years and they can be called "new" global problems. For instance issues related to the use of ICTs can be mentioned in this category [8, 15].

In the Brundtland Report published in the year 1987 for the first time the concept of *sustainable development* has been defined and accepted as a possible solution for the global complex ecological, economical and social problems [6].

This concept was very large discussed on the Conference for Environment and Development in Rio de Janeiro 1992 as well as approached in the closing document „Agenda 21" [4] and during the Johannesburg Conference in 2002.

Many actions after this time emphasise that the evolution of technical, social and ecological systems has to be analysed in synergetic relation [15].

The general Brundtland definition was worldwide accepted, but alone does not deliver a concept, that can be applied to the real concrete situations.

The operationalisation of the concept of sustainable development means the transformation or translation of its goals in political measures and controlling instruments [15]. A general methodology in order to operationalise sustainable development can be materialized in the following steps:

- defining the sustainability problem;
- establishing the space and time scales;
- systemic approach of the region by modelling the interactions;
- establishing concrete aims for the studied case;
- developing concepts and measures by establishing priorities;
- developing evaluation and control instruments, indicators;
- verifying the possible results, which could be obtained after introducing the proposed measures, comparing different scenarios;
- applying in the practice the developed concept.

The operationalisation is only possible, when for an individual problem-case concrete aims are established and from these aims concepts to achieve them are developed. Sustainability is to be for each different case newly defined. The space and time scales are to be established for each case.

There are several levels to apply the concept of sustainable development. On a global level this means to define general goals for the whole world, things which happened more or less with the Rio-Conference. On a national level this means to define goals paying attention to the specific conditions of a country. On regional or local level concrete measures represent the content of the Local Agendas 21. But what about applying sustainable development on the level of companies, of industrial processes or of products? In this field it is very important to use instruments or tools for assessing the environmental impacts of different technological applications [7]

Part of what engineers do is to evaluate developments in technology. Their evaluation has up to now been focused almost without exception on technical aspects and on economic aspects following legal and financial boundary conditions. With respect to sustainability more criteria have to be considered like: environmental quality, social and human values, quality of life [7]. This means, the activities of engineers when evaluating technologies can be sustained by Technology Assessment (TA) [5].

Although in the last 20 years it was a lot of progress in the field of technology assessment especially due to several studies which have been carried out in USA, Japan, Germany and other European countries, there is still a need for developing integrative methods for Technology Assessment [1, 7, 9, 16].

2. Technology Assessment (TA)

Technology Assessment TA means after [17] the methodical, systematic, organised process of:

- analysing a technology and its developmental possibilities,
- assessing the direct and indirect technical, economic, health, ecological, human, social and other impacts of this technology and possible alternatives,
- judging these impacts according to defined goals and values, or also demanding further desirable developments,
- deriving possibilities for action and design from this and elaborating these, so that well-founded decisions are possible and can be made and implemented by suitable institutions if need be.

When going through the given methodology for operationalising sustainable development one can recognize that many steps can be also identified in the phases distinguished in technology assessment [1, 3, 5]. Very often a concrete sustainability problem especially related to a technological issue is to be solved by doing a TA-study. Or a TA-study has as a goal to research if a

technology has negative effects on different domains, this means if the effects of a technology application do not conflict with the goals of sustainable development.

Operationalisation of sustainable development with technology assessment TA means analysing the complex dynamic environmental, economic and social systems in order to try to discover developments which lead to instabilities [7, 15]. The concept of technology assessment equally how it is named, if Technology Evaluation, Innovation Research, System Analysis or others, brings together almost all of the scientific disciplines with the goal of clarifying how sustainability can be operationalised [5, 7].

Technology assessment tries to give an answer to the question: Which are the technologies that we need, how are these technologies to be developed and how do they integrate into environment and society?

These questions are in the present conditions of the Eastern European countries from dominant importance, in the process of modernisation of old technologies and implementation of new technologies [1]. Technology assessment is the concept, which tries to answer exactly such questions. From this reason technology assessment has to play a central role in the next technological, economic, environmental and social development of these countries.

3. Tools for Environmental Impact Assessment

In order to assess the possible effects of human activities, especially of industrial processes on the environment, several tools, so-called instruments of technology assessment can be applied with respect to the question which has to be answered (fig. 1). Here are listed the most used and important ones [2, 7, 16]:

- % Environmental management systems;
- % Life-cycle-assessment;
- % Eco-Audit;
- % Ecobalances.

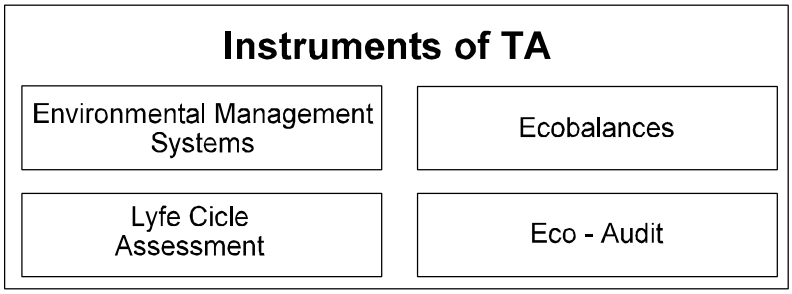

Fig. 1. Instruments for environmental impact assessment

The most important one is the Life-Cycle-Analysis. The other tools are also very often used depending on the concrete situation on company level, local or regional level.

The legislative framework for environmental impact assessment exists from 1985 in the countries of the European Community [16]. In Germany for example the law concerning the examination of different public or private projects was promulgated 1990. In Romania there is a legislative regulation from 1994 through the Ordinance of the Minister for Water, Forests and Environmental Protection regarding the examination of potential impacts on the environment of economic and social activities [11]. The analysis of the environmental impacts has as a goal the assurance of activities which have as minimal

impacts as possible on the environment. Going into details the followings have to be taken into account:

- the possible results and consequences of a project have to be searched, described and evaluated and
- the results of the analyses have to be delivered to the authorities which have to decide basing on the results.

In order to carry out such an analysis the project which has to be certified must contain information about the project itself, proposed measures to diminish the negative effects, other alternatives etc. The application domain for these studies is represented by big projects or public projects.

The requirements with respect to the environmental impact assessment EIA of a project are the following:

- the assessments have to be transparent,
- public,
- the methods used are to be unified, and
- the results have to be comparable.

3.1. Eco-Audit

The Eco-Audit is a management tool for systematic, documented, periodic, objective evaluation of the environmental management in a company. The environmental management in a company as stated in the norms DIN-ISO 14000 represents the whole measures directed to organize and lead the activities in the company related to environmental protection including installations for environmental protection and for environmental monitoring.

The Eco-Audit is an instrument which works preventively with respect to environmental protection. By Eco-Audit the actual situation in a company is emphasized. The results state the degree with which the company respects the legislative measures and decrees in the field of environmental protection as well as the goal of the company. Taking into account the results it improves the environmental protection program of the company.

It is remarkable that in this case it is aimed that companies take voluntarily part in, with the conviction of gaining at the end economic advantages. It is to be mentioned that a big problem constitutes the data-base, that means collecting, processing and evaluating data and information from the company.

3.2. Ecobalance

The ecobalance or environmental performance evaluation represents an instrument for systematic analysis of products, processes or even companies or regions regarding environmental impacts [2]. The ecobalance can be performed as a singular study or as a comparative study. The ecobalance registers material and energetic flows when producing something, or within a process or within a company or a region.

An ecobalance is to be done in 4 steps [2]: definition of goal and scope; inventory analysis; impact assessment; and interpretation of results.

3.3. Life Cycle Assessment (LCA)

The LCA is an analysis which registers all the effects on the environment of a product during its life "from the cradle to the grave", from the production to the consumption and recycling. The general life cycle of a product is presented in fig. 2. We can observe that including production and consumption processes also transport processes are to be taken into consideration. With T are indicated the transport processes within the life cycle of a product. The life-cycle-analyses is appropriate to improve the production lines of products, to compare different products and to ecologically optimize the life-cycle of products. The LCA is in fact an ecobalance which can be performed as a singular study or as a comparative study. The ecobalance registers material and energetical flows when producing something, or within a process or within a company or a region. Such an analysis needs several steps [2]:

a) definition of goal and scope;
b) inventory analysis;
c) impact assessment;
d) interpretation of results.

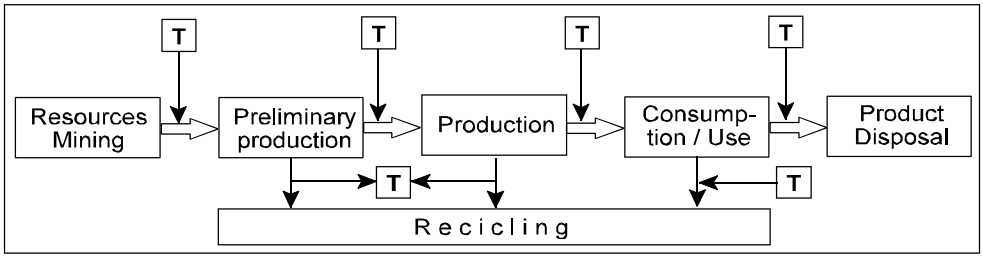

Fig. 2. General life-cycle of products

a) Definition of goal and scope - The goal shall unambiguously state the intended application, the reasons for carrying out the study and the intended audience, i.e. to whom the results of the study are intended to be communicated. In defining the scope of an LCA study, the following items shall be considered and clearly described: the functions of the product, the functional unit, the system boundaries, methodology of impact assessment, data requirements, assumptions, limitations.

b) Inventory analysis - It involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system. These inputs and outputs may include the use of resources and releases to air, water and land associated with the analysed system.

c) Impact assessment - It is aimed at evaluating the significance of potential environmental impacts using the results of the inventory analyses. The impact assessment may include elements as: assigning of inventory data to impact categories, modelling of the inventory data within impact categories and possibly aggregating the results in very specific cases. It is to be mentioned that the methodological and scientific framework for impact assessment is nowadays still being developed [7]. Very often in the step of assessment aggregated indicators are used in order to allow a transparent evaluation [16].

d) Interpretation of results - in this phase the findings from the inventory analysis and the impact assessment are combined together. The interpretation takes the form of conclusions and recommendations to decision-makers, consistent with the goal of the study.

With respect to the LCA a difficult step is represented by getting on relevant data and information about the products and production processes. To compare different life cycle stations of a product from the point of view of environmental impacts, an appropriate evaluation has to be done. An evaluation method, that quantifies different pollutants emissions, has been developed at the Clausthal University of Technology [7, 9, 16].

4. Conclusions

For industry and engineers the operationalisation of sustainable development could mean to analyse the environmental impacts of technological applications. The heightened awareness of the importance of environmental protection and the possible impacts associated with products has increased the interest in the development of methods to better comprehend these impacts.

The concept of sustainable development has begun to find its important place from global to local levels. On the other side several companies in Western Europe having practiced environmental optimisation of production processes recognised that by these means also economic advantages can be achieved. This gives example to companies in Eastern Europe as well and can arise the interest for environmental impact assessments also in this part of the world.

There are several tools in order to evaluate environmental impacts of industrial activities like life cycle assessments (LCA), eco-audits, ecobalances or environmental management systems. Life cycle assessments (LCA) are

presently world wide used to assess environmental effects of products during their life cycle, but the evaluation questions are still not clarified.

The evaluation problem has been debated in different circles of scientists and the necessity of using assessment methods based on aggregated indicators has been pointed out several times with the goal of delivering relevant results regarding the environmental impacts of technological applications.

REFERENCES

[1] G. Banse (Hrsg.): *Technological and Environmental Policy – Studies in Eastern Europe*, Edition Sigma, Gesellschaft – Technik – Umwelt, Neue Folge 6, Berlin, 2007

[2] U. Beck: *Ökobilanzierung im betrieblichen Management* (Ecobalances in the Companies Management), Vogel, Würzburg, 1993

[3] H.-J. Bullinger (Hrsg.): *Technikfolgenabschätzung* (Technology Assessment), Teubner, Stuttgart, 1994.

[4] W. Engelhardt and H. Weinzierl: Der Erdgipfel (World Summit). *Economica*, Bonn, 1993

[5] A. Grunwald: Technikfolgenabschätzung - *Eine Einführung* (Technology Assessment – An Introduction). Edition Sigma, Berlin, 2002

[6] V. Hauff (Ed): *Our Common Future. The Brundtland Report of the World Commission on Environment and Development.* Oxford Univ. Press, Oxford, 1987

[7] M. F. Jischa: *Herausforderung Zukunft (Challenging the Future).* 2. Auflage. Spektrum Akademischer Verlag, Heidelberg, 2005

[8] T. Lengsfeld, I. Tulbure, A. Vali: *Exploring a worthwhile future for all*. Spanish Chapter of the Club of Rome, 2003

[9] B. Ludwig and I. Tulbure: *Möglichkeiten zur ganzheitlichen Erfassung und Bewertung von Umweltinformationen für automobile Verkehrssysteme*. In: VDI Berichte. Nr. 1307 (Ganzheitliche Betrachtungen im Automobilbau). S. 257-283, 1996

[10] D. and D. Meadows: *The Limits to Growth*; Universe Book, New York, 1972

[11] Ministry of Water, *Forests and Environmental Protection*: Ordin pentru aprobarea Procedurii de reglementare a activitatilor economice si sociale cu impact asupra mediului inconjurator (Reglementation for Environmental Impact Assessment of Economic and Social Activities). In: Monitorul Oficial al Romaniei, Nr. 73, Part I, Bucharest, 11.04.1994

[12} National Centre for Sustainable Development: *National Sustainable Development Strategy for Romania*, NSDS 2013-2020-2030, Bucharest, 2008.

[13] I. Tulbure: *Zustandsbeschreibung und Dynamik umweltrelevanter Systeme (State description and Dynamics of Environmental Systems).* Doctoral thesis, TU Clausthal; Germany, Papierflieger, CUTEC nr. 25, 1997

[14] I. Tulbure and B. Ludwig: *Umweltindikatoren – Schlüssel zu Sustainable Development (Environmental Indicators – Key to Sustainable Development).* Umwelt, Springer VDI, Nr. 4-5, pp.45-49, 2000

[15] I. Tulbure: *Integrative Modellierung zur Beschreibung von Transformationsprozessen (Integrative Modelling for Describing Transformation Proceses).* Habilitationsschrift, TU Clausthal, Germany, VDI-Fortschrittsberichte, Reihe 16, Nr. 154, VDI-Verlag, Düsseldorf, 2003

[16] I. Tulbure: *Technology Assessment. Vorlesungsskript*. Course at the Clausthal University of Technology. Clausthal-Zellerfeld, Germany, 2011

[17] VDI-Richtlinie 3780: *Technikbewertung* - Begriffe und Grundlagen (Technology Assessment – concepts and basic notions), new edition, 2000.