# CONSIDERATONS REGARDING ENVIRONMENTAL IMPACT ASSESSMENT OF DIFFERENT TECHNOLOGICAL APPLICATIONS

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**Abstract**

Having the goal to actually increase the quality of life of our society, several industrial activities and applications have been developed in different fields. But in the meantime it has been very clear that these industrial activities and applications can have beside positive direct and desired effects, also negative, undesired and sometimes unthinkable effects on the environment and society.

In this context the concept of sustainable development of our society is nowadays very much discussed on different levels. Taking into account 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 and social ones as well.

In the last years the new discipline called Technology Assessment grew up. The discipline bases on several instruments and methods to carry out technology assessment studies but especially for assessing environmental impacts of industrial activities. For such environmental impact assessment studies scientists often use analytical methods and instruments. There are several methods and instruments used in this regard. Presently the most discussed one on an international level is the life cycle assessment (LCA). In the present paper some general notions regarding these tools and application possibilities will be presented. The energetic use of biomass in the form of different bioenergy concepts is a newer technological application. Possible concepts in this regard can be biogas plants, which are operated by electric service providers or a single biogas plant owned by one farmer.

## 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" 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 [7].

They can be called "old" problems: growth of world population, increase of energy consumption and environmental pollution. 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 [7, 15].

In the Brundtland Report 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 [5]. 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" [6] 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 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: global, national, regional or local level. But what about applying sustainable development on the level of companies, of industrial processes or of products? In this field the operationalisation of sustainable development means to use instruments or tools of the pretty new discipline called Technology Assessment TA.

Part of what engineers do is to evaluate developments in technology. Their evaluation has up to now almost without exception been focused 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. This means, the activities of engineers when evaluating technologies can be sustained by Technology Assessment (TA) [7, 16].

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 need in developing integrative methods for Technology Assessment [8, 9, 15].

## 2. Technology Assessment (TA)

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 sustainable development one can recognize that many steps can be also identified in the phases distinguished in technology assessment [8, 15]. 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 [9]. 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 question of how sustainability can be operationalised [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 East European countries from dominant importance, in the process of modernisation of old technologies and implementation of new technologies. 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.

Assessments for technological decisions are usually important and far-reaching, yet only rarely applicable to methodical solutions. Thus, it is the aim of an assessment to determine a scaling value of an alternative that represents its advantages in only a single expression. The solution of this problem of selection will be especially difficult, if the following conditions hold:

- Many objectives are to be considered.
- Different assessment scales emerge.
- Objectives are weighted differently.
- Information is uncertain and may be subject to doubt.
- Problem is time-dependent.
- Many are to participate in decision making process.
- No unique criterion exists for decision making.

Therefore, a multidimensional assessment problem can be considered as a logical measurement operation [8]. Consequently, one usually has to deal with complex and nonlinear systems, where many non-measurable qualities occur and interactions are at least partially uncertain.

## 3. Tools for Environmental Impact Assessment

In order to assess the possible effects of human activities, especially industrial processes on environment, several tools, so-called instruments of technology assessment can be applied with respect to the question which has to be answered (Figure 1). Here are listed the most used and important ones [2, 6, 8, 16]:

- Environmental management systems
- Life-cycle-assessment
- Eco-Audit
- Ecobalances

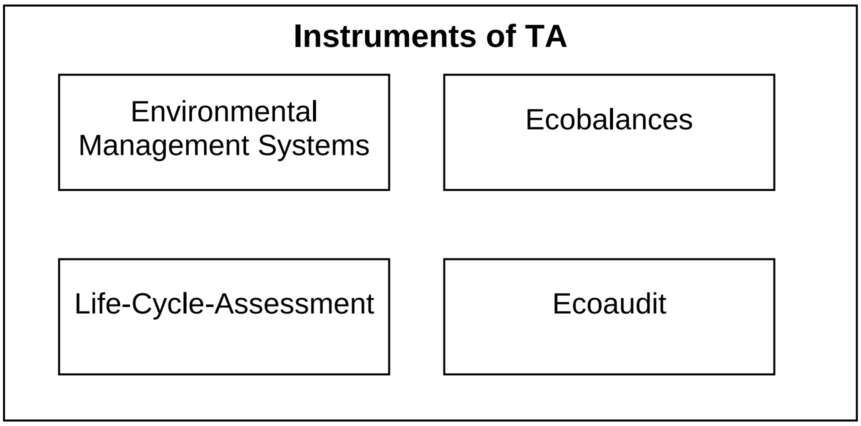


**Figure 1:** Instruments for environmental impact assessment.

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 1996 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 effects 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 realize 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 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. Ecoaudit

The Eco-Audit is a management tool for systematical, 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 with 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.

### 3.2. 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

Figure 2. We see that besides production and consumption processes also transport processes T are taken into consideration.

The life-cycle-analyse 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 [1]:

*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.

*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.

*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 still being developed.

*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.

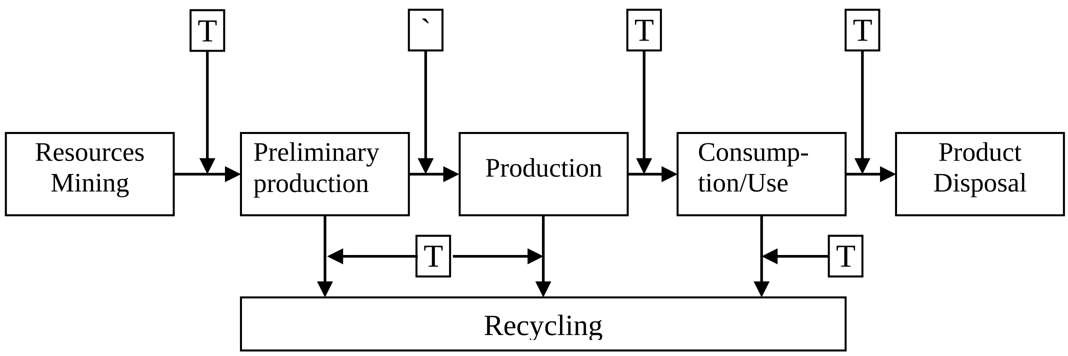


**Figure 2:** General life-cycle of products.

With respect to the LCA a difficult step is represented by getting on data and information about the products and production processes. To compare different life cycle stations of a product from the point of view of pollutants emissions a method has been developed at the Technical University of Clausthal [8, 9, 15, 16]. For instance when taking into account the life-cycle of a car, the results obtained emphasize that in the using phase of a car much more pollutants are emitted compared with the fabrication phase. It is to be mentioned that transport processes have not been taken into account because of lack of data. Comparisons can be made among different life cycle stations and with other products too, allowing in this way assessments of different products. Dangerous and unsafe points in the production lines can be found and measures to improve production processes can be established. The results may emphasize that this methodology can be successfully applied.

## 4. Different bioenergy concepts

A newer technological application is represented by the energetic use of biomass in the form of different bioenergy concepts. Possible concepts can be biogas plants, which are operated by electric service providers or a single biogas plant owned by one farmer, or bioenergy villages owned by a village cooperative (Eigner-Thiel, Schmehl, Ibendorf, Geldermann 2011). The necessity in the future is the development of suitable ecologic, economic, social and technical criteria, in order to assess the sustainability of different biomass use concepts. More interesting in this regard are the so-called "bioenergy villages", owned by a village cooperative, which do represent a new concept in the assurance of energy for the population, having new concepts by using the biomass. In this regard it is required the adaption of existing indicator systems (Tulbure 2003) to the special requirements of sustainable biomass use for energy.

In order to assess the sustainable use of biomass and the sustainability of different bioenergy concepts, it is suitable to use the Life-Cycle-Analysis for carrying out the environmental impact assessment of the biomass use. Other environmental assessment tools regarding different bioenergy concepts can be also used depending on the concrete situation on company level, local or regional level, when

## 5. Conclusions

For industry and engineers the operationalisation of sustainable development could mean to lead technology assessment studies especially environmental assessments. The heightened awareness of the importance of environmental protection and the possible impacts associated with products manufactured and consumed 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 arises the interest for environmental assessments.

There are several tools in order to evaluate environmental impacts of industrial activities like life cycle assessments (LCA), ecoaudit, ecobalances or environmental management systems. Life cycle assessments (LCA) are presently world wide used to assess environmental effects of products, but the evaluation questions are still not clarified. In this paper these several instruments have been presented.

The new possibility of biomass usage in the form of different bioenergy concepts has been emphasized. The evaluation question has also been debated. The application way of different instruments used for technology assessment, like the LCA, in the case of different bioenergy concepts is a very promising method.

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