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SOME ASPECTS REGARDING TRAFFIC RELATED ENVIRONMENTAL POLLUTION

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ABSTRACT: *The developments in the last time did show that beside positive desired effects of human economic activities, also negative undesired effects on environment and society can appear. Therefore it is impetuous necessary to analyse and evaluate these unwanted impacts of technological applications, not only on the environment, but also on the society. On a global level there is presently a huge debate related to environmental impact assessment of different economic activities and for such an assessment different tools can be used. In the present article general remarks about Life Cycle Assessment (LCA) will be presented, emphasing the emergence of this concept, as well as its usage possibilities in the context of different industrial applications. Concretely it will be mentioned that LCA has to be carried out in different stages and for different phases in the life cycle of a product. Regarding traffic engineering several transport means will be chosen and the pollutants emissions in their using phase will be assessed and compared. Conclusions regarding the traffic related environmental impacts will be drawn as well as measures to reduce these impacts will be emphasised.*

Keywords: *environmental impact assessment; traffic environmental pollution; life cycle assessment;*

1. Introduction

Starting with the '70 years the world began to realize the dangers and undesired effects of human activities, especially industrial ones. After the Conference for Environment in Stockholm in 1972 and the first report to the Club of Rome „The Limits of the Growth" [7] was understood that besides wanted effects of technological progress, undesired and negative effects can appear. After this time the environmental awareness in the Western world began changing [3]. It was clear that the created regional and global environmental problems are very serious and need to be solved. Nowadays we confront us with a series of global problems known as the „trilemma" of our society: world population growth, growth of the energy and natural resources consumption and environmental pollution [4].

Worldwide began discussions on political, scientific and social levels in order to find solutions for the problems shown above. The Brundtland Report of the World Council on Environment and Development represented a result of these worldwide political discussions. The concept of sustainable development was for the first time defined in the Brundtland Report [8] and accepted as a possible solution for the global complex ecological, economical and social problems. The concept of sustainable development was very large discussed on the Conference for Environment and Development in Rio de Janeiro 1992, as in the conference closing document „Agenda 21". Many actions after this time emphasize that the evolution of technical, social and ecological systems has to be analysed in synergetic relation [6, 12].

In order to make this concept more understandable rules, strategies and principles of sustainable development have been defined [14]. The general Brundtland definition was worldwide accepted, but together with the rules, strategies and principles, it does not deliver a concept, which is able to be applied to the real concrete situations.

2. Tools for Environmental Impact Assessment

In order to assess possible impacts of human activities, especially industrial ones on the environment, several tools technology assessment can be used and applied [14, 16]. The most frequent used ones, as presented in Figure 1, are the followings [11, 14]:

- Environmental Impact Assessment;
- Life-Cycle-Assessment;
- Ecoaudit;
- Ecobalances .

2.1. Environmental Impact Assessment (EIA)

The legislative framework exists since 1985 in the countries of the European Community. In Germany for example the law concerning the examination of different public or private projects was promulgated 1990. In Romania there is a legislative reglementation 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 [9]. The analysis of environmental effects has as a goal that only such activities are allowed to be carried out, which have as minimal impacts as possible on the environment [4]. 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 analysis have to be delivered to the authorities which have to decide basing on the results.

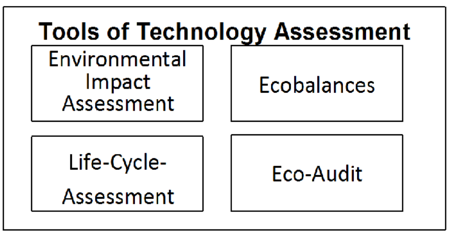

Fig. 1. Instruments of Technology Assessment, TA

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, as well as other possible alternatives. The application domain for such studies is represented generally by public projects. The requirements of a project with respect to EIA are followings: assessments have to be transparent and public, the methods used are to be unified, and the results have to be comparable. [13].

2.2. 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 production to the consumption and recycling [17]. In Figure 2 the most relevant phases in the general life-cycle of a product are presented [14]. It can be observed that in the general life-cycle of a product, besides production and consumption processes also transport processes are taken into account. By ”T” are stated transport processes within the life-cycle of a product [5, 10].

As a tool of technology assessment, LCA is appropriate to improve the production lines of products, to compare different products and to ecologically optimise 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 [5]. The ecobalance registers material and energetic flows when producing something, or within a process, company or a region. Such an analysis needs several steps [5, 14]:

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

Going into details regarding the relevance of each of these steps in carrying out a life-cycle analysis or an ecobalance, one can remark that each step has its importance at a certain stage in the development phase of the life-cycle assessment of a certain product [5].

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 already in this first step [2]:

- the functions of the product;
- the functional unit;
- the system boundaries;
- the used methodology for the impact assessment;
- what are the data requirements;
- which kind of assumptions are made;
- which limitations have to be considered.

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 also pollutants emissions by the system.

c) Impact assessment - It is aimed at evaluating the potential environmental impacts using the results of the inventory analysis. The impact assessment may include elements as assigning of inventory data to impact categories, modeling inventory data within impact categories and possibly aggregating the results. It is to be mentioned that the methodological and scientific framework for impact assessment is still in the development phase. Very often in the step of assessment aggregated indicators are used for allowing a transparent evaluation [14].

d) Interpretation of results - In this phase the findings from the inventory analysis and the impact assessment are combined together. The interpretation should take the form of conclusions and recommendations to decision-makers [15].

With respect to LCA a difficult step is represented by gaining specific relevant data and information about products and production processes [5]. On the other side in order to compare different life-cycle stations of a product from the point of view of pollutants emissions there is a need to use different environmental indicators, depending on the intended goal of the study regarding the LCA of a certain product, if the results are to be interpreted on a sectoral, local or regional level. [5, 12, 14]. This

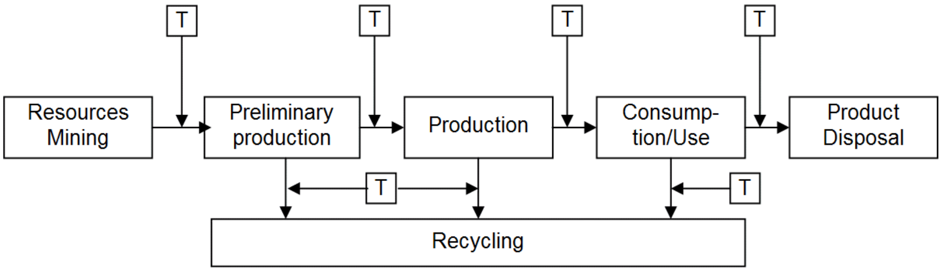

Fig. 2. General life-cycle of products

process of developing appropriate environ-mental indicators depending on the considered area is currently still in development [4].

The life-cycle of a product takes into account relevant steps in the existence and use of a product, as shown in Figure 2, starting with the extraction of mineral resources used to manufacture the product and ending with the disposal of the product [5, 10, 14].

Going into details regarding the most important steps in the life-cycle of a product it can be recognised that there are the following ones [5, 10]:

- Resources mining: this phase is referring to the extraction of mineral resources, that will become the raw material used to manufacture the respective product;
- Preliminary production: this phase is including the manufacture of components that will be assembled during production to get the desired final product;
- Production: in this phase the components are assembled, resulting the product in its final form;
- Consumption/Use: this phase is referring to the happenings after the sale of the product, because thereafter it is entering in the stage of use;
- Product Disposal: after the usage phase of a certain product, the product disposal phase is following, that is actually the last stage in its life-cycle, where the used product should be directed to the phase of reuse or recycling or, if no other possibilty, it will be transformed into waste and will come to the waste processing stage.

2.3. 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 standard family DIN-ISO 14000, is actually representing the totality of measures directed to organise and to lead the activities in a company related to environmental protection, also including installations and plants for environmental monitoring and protection [17].

The Eco-Audit is an instrument which works in a preventive way with respect to environmental protection. Carrying out an Eco-Audit in a certain company or institution is supporting to monitor and to emphasise the actual situation in the respective company.

The results are stating the potential impact of the production processes or other activities in the considered company or institution with respect to the environmental quality.

On the other side an Eco-Audit carried out for a company does inform about the interest of the respective company to respect legislative measures and decrees in the field of environmental protection as well as about the actual goal of the company related to possible impacts on the environment [14]. Taking into account the results of the Eco-Audit it is possible for a company or an institution to improve its environmental protection program by reorganising certain production processes or certain production related activities in the company.

The general aim is represented by the fact that companies are actually voluntarily taking part in this process with the conviction of gaining in the end economic advantages.

It is to be mentioned that for successfully carrying out an Eco-Audit also a lot of environmental data should be available, which means that a difficult task could be represented by shaping an appropriate database [17]. With this goal the steps of collecting, processing and evaluating data and information from the company are relevant, especially regarding production and environment related data [13].

2.4. Ecobalance

The ecobalance or environmental performance evaluation represents an instrument for systematically analysis of products, processes or even companies or regions regarding environmental impacts [1, 17] (Figure 3). The ecobalance can be performed as a singular study or as a comparative study of different processes, products.or even companies The ecobalance registers material and energetic flows in different production processes developed in a company or within a company or a region.

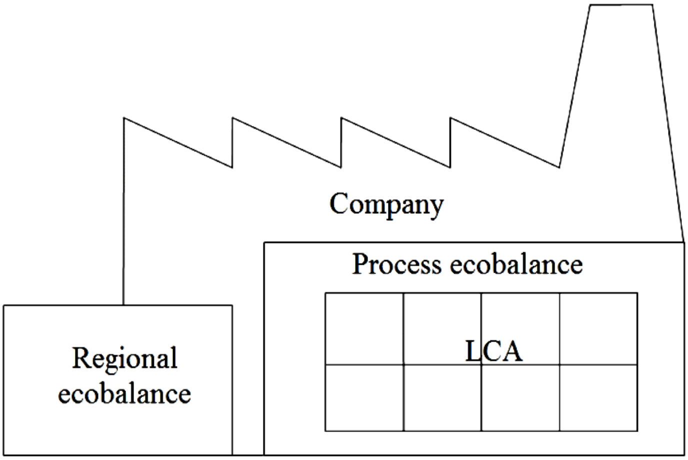

Fig. 3. Different types of ecobalances

As generally stated in the literature an ecobalance is to be carried out in 4 relevant steps [1].

-a) definition of goal and scope;

- b) inventory analysis;
- c) impact assessment;
- d) interpretation of results.

Ecobalances and life-cycle assessments (LCA) are both of them representing instruments used for assessing potential environmental impacts, the difference between them being emphasised by the system boundaries [14]. LCA is referring to the life-cycle of products, whilst ecobalances are used to assess environmental performances of processes, of companies or even of cities [4, 13, 14].

3. Application Example in the field of Assessing. Traffic related Environmental Pollution

In order to emphasise the usage possibilities of the presented tools for assessing environmental impacts along the life-cycle of products, it is possible to analyse different steps in the life-cycle of a certain product or to compare the same step in the life-cycles of different products [5].

The field of evaluating traffic related environmental pollution came in a newer time into the attention of scientists and is representing a much debated field not least because of the necessary fossil fuels for operating the Diesel or Otto engines of the vehicles.

By considering the consumption/usage phase of different transport means, it is possible to analyse the environmental impact of the transport field, by calculating the CO_2 emissions in the usage phase of the vehicles. Taking into account the made calculations and the resulting CO_2 emissions, conclusions can be drawn regarding environmental impacts of different vehicles as well as which transport mean is the most „environmentally friendly” one [15].

The considered transport means are the following ones:

a. Car
b. Coach
c. Train
d. Airplane

In order to emphasise the possible impacts on the environment of these different transport means, the same travelling distance between the same two cities has been considered, cities which also have airports nearby, as Bucharest and Cluj Napoca, just to make possible the consideration of flights between the two cities. All four transport means have been taken into account, the airplane transport as well, in order to assess their environmental impacts in the usage phase of them.

Concretely the pollutants emissions have been calculated for the distance between the International Airport ”Henri Coanda” in Bucharest and the Interna-tional Airport ”Avram Iancu” in Cluj Napoca. It follows that the considered distance is of 442 km [11, 18].

When taken into account the four mentioned transport means, it is important to know their specific fossil fuel consumption related to each 100 km. Some appropriate data will be presented below and have been found in the literature, by mentioning also the number of transported passengers, as follows:

a. car: Skoda Fabia with 5 passengers – consumption of 5.09 l per 100 km [19, 20];
b. coach: Mercedes Benz Tourismo with 5 passengers – consumption of 25.1 l per 100 km [21, 22];
c. train: with 480 passengers (from the assumption of 5 wagons, 96 passengers/wagon) - considered motor: 060 DA – consummption of 230.7 l/100 km [23];
d. airplane: Boeing 747 - 400 with 416 passengers – consumption of 1 610 l/100km [24].

By using these data and by knowing the fossil fuel consumption of each transport mean it is possible to calculate the fossil fuel consumption for the whole travelled distance between the two cities, Bucuresti and Cluj Napoca, results given below, in Table 1.

Table 1. Fossil fuel consumption of different transport means for the considered distance

Transport means	Number of passen-gers	Fossil fuel consumption l/100 km	Total fossil fuel consum-ption (l)
Car	5	5.09	22.49
Coach	51	25.1	110.94
Train	480	230.7	1 019.69
Airplane	416	1610	7 116.2

In order to calculate the respective CO_2 emissions when travelling by car, coach or train on the considered distance and for a person, it is necessary to know the carbon content of diesel, Cc, which is 87 % [25]. With this information the mass of carbon, mc, in a volume V=1 m3 diesel can be calculated when knowing the Diesel density, ρDiesel = 832 kg/m^3:

$$m_c = C_c \times V \times \rho_{Diesel} = 723\ kg \qquad (1)$$

In order to calculate the CO_2 emissions resulted when burning the volume of 1 l Diesel, the corresponding chemical reaction is necessary, $C+O_2 \rightarrow CO_2$.

It follows that the mass of the CO_2 emissions is calculated with the formula:

$$m_{CO_2} = m_C \times \frac{M_{CO_2}}{M_C} \qquad (2)$$

where:

MC –molar mass of carbon; MC = 12 kg/kmol

MCO_2 – molar mass of carbon dioxide; MCO_2 = 44 kg/kmol

mC – the mass of carbon entering in the reaction (kg)

mCO_2 – CO_2 mass emissions (kg)

This means that when burning a volume of 1l Diesel, the CO_2 emissions are ?

$$m_{CO_2} = 0.723 \times \frac{44}{12} = 2.65\ kg\ from\ burning\ 1\ l\ diesel$$

When considering the travel by airplane between the two cities, from the literature data is known that an airplane is emitting 2.76 kg CO_2 for each liter kerosene [26].

Considering the already meantioned different transport means, by knowing the CO_2 emissions when burning a volume of 1l fossil fuel as well as knowing the total fossil fuel consumption for the considered travelled distance (Tabel 1), it is possible to calculate the total CO_2 emissions for each transport mean when travelling the whole distance between Bucharest and Cluj Napoca, data presented in Table 2. By using the data from the literature regarding the passenger numbers for each transport mean, data already presented above, it is possible to calculate the CO_2 emissions per passenger. The corresponding results are presented in Table 2 and in Figure 4.

Table 2. CO_2 emissions/passenger for different transport means for the distance from Bucharest to Cluj Napoca

Transport means	CO_2 emissions when burning 1 l fossil fuel (kg)	Total CO_2 emissions (kg)	CO_2 emissions/ passenger (kg)
Car	2.65	59.59	11.91
Coach	2.65	293.99	5.76
Train	2.65	2 702.17	5.62
Airplane	2.76	19 640.71	47.21

The beams in the diagram from Figure 4 are presenting in a concise form the calculation results regarding the CO_2 emissions for different transport means for the considered distance between Bucharest and Cluj Napoca.

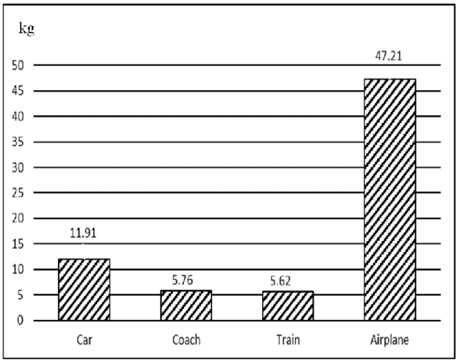

Fig. 4. Emissions of CO_2 for different transport means

4. Conclusions

There are several tools in order to evaluate environmental impacts of human activites, one of them have been discussed in this paper. An assessment method based on an emission indicator has been presented and applied in the transport field [18]. Results emphasise the significance of the presented method, because it is possible to compare environmental impacts of different transport means by calculating the CO_2 emissions in the utilisation phase of each of them. By considering the fossil fuel consumption and the number of passengers, the made calculations are emphasising that the most „environmentally friendly" transport mean is the train and the most „unfriendly" transport mean is the airplane, the other two transport means, car and coach, being between the other two ones. It is possible to consider several measures in order to reduce environ-mental impacts, especially technical measures for redu-cing the fossil fuel consumption. Other measures could be of organisational manner for a better travel planning or ones acting in the social field, where first of all mentality changes regarding travel necessities are requested.

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