



Circular economy – the role of the Environmental Life Cycle Assessment, opportunities, barriers and challenges

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Abstract: Environmental Life Cycle Assessment (LCA) is an environmental management technique which, because of its potential, can be applied in many different areas. Its key role in increasing the efficiency of waste management is emphasised in the literature on the subject. This paper intends to make a contribution to the discussion on this subject and its primary goals are to present LCA in the context of implementation of circular economy and to assess the chances of popularisation of this concept in Poland. Based on own survey results, it was demonstrated that while the vast majority of respondents assured of their sense of environmental awareness, a little over 60% of respondents stated that they systematically segregate municipal waste. Thus making the transition towards a circular economy in Poland requires the increase in public's involvement and adequate education in this field.

Introduction

In line with the waste hierarchy adopted by the European Union, the first thing to do is to prevent waste generation. In the case when the generation of waste is unavoidable, the aim is to minimise and eliminate waste “at source” as well as support the efficient use of natural resources allowing for their re-use, in particular recovery and recycling [3]. In view of the above, it can be concluded that over time and at constant costs a well-functioning waste management system is characterised by a reduction of the amount of formation and disposal of waste and an increase in the amount of recovered and recycled waste. Selective collection of as many fractions of waste suitable for recovery and recycling as possible is extremely important in this system. The published in July 2014 European Commission Communication *Towards a Circular Economy: “A Zero Waste Programme for Europe”* aims at increasing the efficiency of waste management through an increase in the amount of recovered and recycled waste and decrease in the amount

of landfilled waste to the necessary minimum [4, 9]. The Environmental Life Cycle Assessment that is more and more often used in various fields of economy is supposed to support the achievement of the objectives of the “zero waste Europe” [2]. This paper intends to make a contribution to the discussion on this subject. Its primary purpose is to present the concept of a circular economy and the potential of LCA in this context. The chances of building a circular economy in our country were assessed on the basis of own research regarding environmental awareness of the Polish society.

Environmental Life Cycle Assessment in Poland

Environmental Life Cycle Assessment is an environmental management technique, which involves “compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle” [20]. The above-cited definition emphasises two

main features of the LCA, namely the assessment of the environmental aspects through the prism of the “input” and “output” elements, which make the LCA an ecological balance and recognition of these aspects within the whole lifecycle of the product that is from the extraction and processing of raw materials until their final disposal. All of these issues make the environmental life cycle assessment applicable in many areas ranging from the public sphere, through sectorial analyses to the use at a level of a single organisation [15].

The history of the LCA studies in Poland is relatively short, and dates back to the 90s of the last century. The first Polish book on this subject written by Zbigniew Kłos was published in 1990. After 9 years, at Poznań University of Technology the first doctoral thesis in the field of LCA was written [7]. The level of popularity of the LCA research on the Polish market is steadily growing, as evidenced by the scope of the research, including:

- coal mining processes – Central Mining Institute, Katowice;
- processes of extraction and processing of metals and chemical processes and compounds – Mineral and Energy Economy Research Institute of the Polish Academy of Sciences, Kraków;
- municipal waste management – Wrocław University of Technology, University of Zielona Góra;
- packaging – Packaging Research Institute, Warsaw;
- wood processing – Wood Technology Institute, Poznań;
- technical facilities – Poznań University of Technology;
- building materials, energetic processes – different scientific centres;
- areas of environmental management and the use of LCA in corporate processes – Kraków University of Economics, Poznań University of Economics.

The subject of LCA is also reflected in official national documents [1, 8, 10], and moreover, it is also becoming a subject of interest of business practice. The most important factors that could potentially determine the popularity of LCA are greening of public procurement, the increase of the relevance of the study of carbon footprint for products and technologies as well as changes in the requirements of ISO 14001:2015 promoting the eco-design of environmental management systems, and establishing effective communication on environmental issues [6, 13 18]. The popularity of LCA among enterprises may also be influenced by the projects financed by the Polish Agency for Enterprise Development, for example the *Development and implementation of pro-innovation optimisation services for SMEs based on an integrated expert system*, realised by the Wielkopolska Quality Institute in Poznań [14, 16]. It is also worth noting that the Polish Research Centre for LCA (PCLCA) was appointed in 2009, and it aims at boosting competitiveness by means of popularisation of the Life Cycle Management techniques in decision-making processes of companies [11].

The concept of a circular economy

The concept of circular economy is the opposite of the prevailing linear model of economy. This model relied on the assumption that the abundance and availabil-

ity of resources allowed for their free use, production of goods, and when used – they could be easily thrown out. This concept, functioning for many years, contributed to a significant waste of materials and irrational exploitation of natural resources. Changes in this area were happening slowly. According to the literature the first demands to “close the loop”, “loop the economy” were put forward in the 70s by W. Stahel and G. Reday in the European Commission report “*The potential for substituting manpower for energy*” (1976) and by M. Braungart and W. McDonough who promoted material recycling and treated waste as a potential raw materials [5].

The more than thirty-year period between the first works commenced in this field and the European Commission's Communication *Towards a Circular Economy: “A Zero Waste Programme for Europe”* published in July 2014, was filled with documentation calling for: resource efficiency, rational, sustainable use of natural resources, etc. The concept of circular economy is a holistic approach to product management aimed at creating a system of product that is free from waste in accordance with the idea of “*from cradle to cradle*.” This assumption is based on [8, 9]:

- reducing the amount of materials required for the provision of a particular service (reducing weight);
- reducing energy and material consumption in the phases of production and use (efficiency);
- restricting the use of materials that are hazardous or difficult to recycle in products and production processes (substitution);
- designing products that are easier to maintain, repair, modernise, recover and recycle (eco-design).”

The role of the Environmental Life Cycle Assessment in a circular economy

The environmental policy of the European Union predisposes the implementation of the LCA in waste management, emphasising the need to “*develop waste prevention programmes concentrating on the key environmental impacts and taking into account the whole life-cycle of products and materials*” [12]. The concept of circular economy presupposes the minimisation of waste at the stage of product design, and then covers the subsequent phases of the life cycle, until the phase of reworking of the product or eventually recycling. So the postulate for the use of LCA in this regard is well-founded. The potential of LCA in the analysed context manifests itself in the fact that this technique allows for:

- determination of the environmental burdens of products or groups of products and selection of the ones that are most environmentally friendly, e.g. least resource- and energy-intensive;
- assessment of the environmental consequences of alternative ways of implementing the same function by various product systems;
- comparison of manufacturing processes from the point of view of the used production factors and their substitutes (raw materials, production materials including hazardous substances, etc.);
- presentation of the environmental impacts of selected waste disposal operations and comparing them with the

assumption of a single functional unit;

- presentation of the ratio of burdens and environmental benefits, e.g. energy intensity of installation used to recover non-renewable resources to the level of recovery;
- indirect elimination of wastage, reduction of the amount of waste produced, decrease of the operating costs and external costs.

The fact that the discussed environmental problems will be presented in a comprehensive manner (including impact and damage categories) and in numeric form (e.g. cumulative weighted ecofactor) is worth emphasising, especially that it will facilitate the interpretation of environmental impacts and their presentation to the parties concerned.

Generalising to a large extent, it can be concluded that the use of LCA techniques by entrepreneurs will contribute to the implementation of the policy of responsibility for putting products on the market and using recycled raw materials.

The popularisation of a circular economy in Poland - opportunities and challenges

The implementation of a circular economy is determined by many factors. From the point of view of the national waste management system, the EU's plans in this regard are very ambitious. The currently functioning national waste management system has some barriers that are very controversial and in the short term, may prove to be insurmountable, for example [1, 17]:

- 1) low quality of recyclate – toxic substances and components are often used in products which results in significant impoverishment of the quality of the recyclate (e.g. PVC); the majority of the population declares recycling “at source,” but waste collected is still contaminated and mixed; recyclate from mechanical-biological treatment is of lower quality than the one derived “at source” [19];
- 2) equipping the mechanical-biological treatment line with proper technical infrastructure – the MBT installations should be retrofitted so that they can provide a much higher level of separation of waste for recycling, as a complement to the selective collection and recovery of energy;
- 3) out-dated technologies for thermal neutralisation of waste – six modern and large municipal waste incinerators are currently under construction, but they may run out of waste of sufficient quality and calorific value; moreover the incinerators are intended to destroy waste that potentially are used resources suitable for reuse (recycling);
- 4) lack of kitchen and garden bio-waste treatment installations.

In conclusion, the currently functioning waste management model requires changes in the financing of the national system, organisational and legal changes relating to waste and the need to organise an appropriate waste segregation system for recovery and recycling at the municipal level. The authors wish to emphasise, what is also visible in the abovementioned four barriers of the system, the importance of the citizen – consumer as the first link in waste generation process. Therefore, as reported by D. Matlak “to ensure that expected by the waste processors the quality of

waste, it is necessary to increase the range and quality of selective collection of municipal waste “at source,” which includes not only raw material waste (paper, plastic, glass, metal), but also bio-waste from households, waste electric and electronic equipment as well as waste batteries and accumulators (in the so-called recycling outlets, municipal waste collection points and on the basis of direct collection of bulky waste from residents)” [17]. Therefore the support of actions encouraging consumers to reduce the amount of waste generated and to segregate waste properly is of utmost importance in the process of building a circular economy.

In order to obtain the answer to the question – what is the attitude of the Polish society towards the selective collection of municipal waste “at source,” and to identify how well Polish people are informed about changes in the field of waste management, a nationwide survey was carried out in 2015 by means of mixed techniques of PAPI and CAWI. The study involved 1,067 people from all over Poland aged above 18. A portion of the results is presented below.

The survey - chosen results

As shown in Figure 1, more than 82% of citizens surveyed consider themselves to be environmentally conscious; the group consisted of 55% women and 45% men. When asked about proecological behaviour in one's everyday lives almost 77% of respondents indicated *segregation of waste “at source”* (Fig. 2). However, only 61.4% stated that they do it *always*, 19.2% responded that they do it *sometimes* and 9.5% admitted that they do it *rarely*. The rest of the respondents does not sort waste. Another example of environmentally conscious behaviour affecting waste management is *the use of eco-bags or reusable* rather than disposable bags, which was ranked fourth in this classification. Nearly 65% of the respondents declared that they do that.

Are you environmentally conscious?

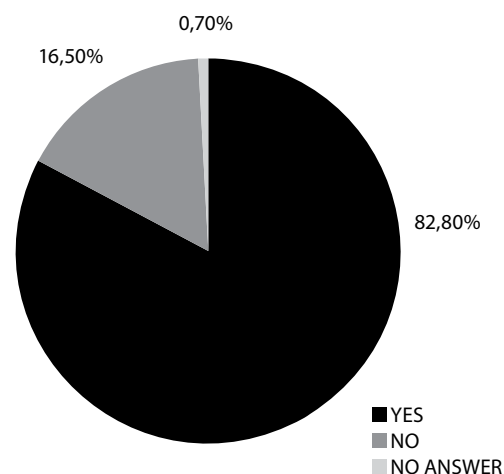


Fig. 1 Subjective feelings of the respondents about being an environmentally conscious citizen
SOURCE: own elaboration.

What proecological behaviour do you undertake in your everyday life?

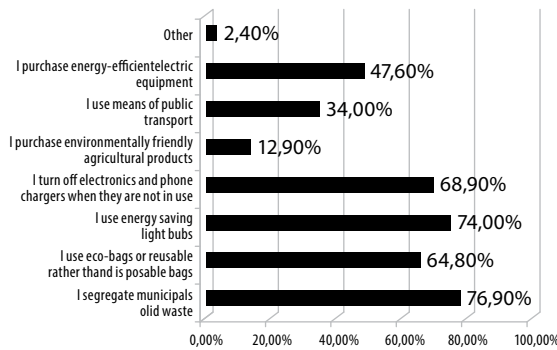


Fig. 2 Type of proecological behaviour undertaken by the respondents
SOURCE: own elaboration.

The question: *In your opinion did the bodies responsible for waste management inform the society in a proper manner about the introduced legal changes relating to the necessity of segregation of waste* was answered negatively by 41.8% of the respondents, 21.8% said I don't know which may indicate total lack of interest and attention paid to the importance of the issue of waste and segregation. On the other hand 35.9% of respondents stated that they were adequately informed about the changes in waste management (Fig. 3).

Did the bodies responsible for waste management inform the society in a proper manner about the introduced legal changes relating to the necessity of segregation of waste?

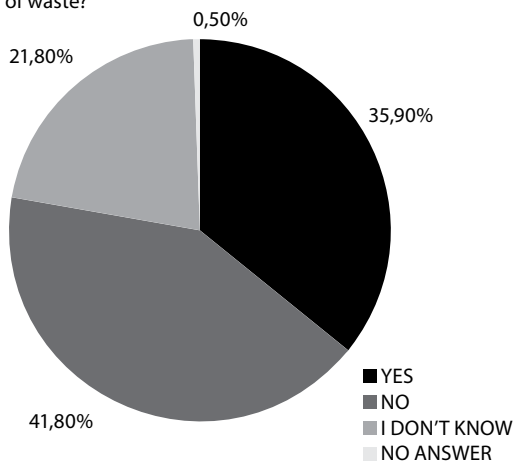


Fig. 3 The respondents' level of knowledge about the changes in the waste management system
SOURCE: own elaboration.

Based on the survey results, it can be concluded that the vast majority of respondents assures of their sense of ecological awareness. This is an optimistic prognosis, but further conclusions raise some concerns. It is hard to talk about building a circular economy in Poland, which is based on segregation "at source," when only 61.4% of the surveyed citizens declare that they segregate waste systematically. It is also alarming that more than 64% of respondents are not prepared to meet the objectives the new Act on waste. Such a small percentage of respondents (35.9%) conscious of the changes that occurred after June 1, 2013 shows major shortcomings, but at the same time it shows the possibilities and the need for continuous public

education on the subject of the changing rules of municipal waste management.

Conclusions

The Environmental Life Cycle Assessment (LCA) is one of many techniques supporting environmental management in an enterprise, but because it is a universal technique it can also be successfully applied to economic systems. Its use in the implementation of a circular economy is desirable, especially in terms of increasing responsibility for the product that is put on the market, but it will be insufficient without the apparent social commitment. An additional element is the question of the financing of the system, organisational and legal changes relating to waste and the need to organise an appropriate waste segregation system for recovery and recycling at the municipal level. As the survey shows, the respondents themselves indicate a significant unreadiness of the system visible in the lack of adequate education, information and containers labelling. The question is, however, how to convince the public to become more involved in the implementation of the objectives of the revised waste management system in Poland in order to put all that into practice? ■

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