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THE IMPACT OF PRODUCING DEVICES FOR RECYCLING ON THE ENVIRONMENT

Abstract: *Generally usage of devices for recycling on the environment has positive effect. On the other side is negative impact of production of its devices on environment. Where is trade-off between them? It is the subject of this paper. The goal is to find optimal solution using appropriate methods, techniques and tools. The paper is arranged on following kind. After introduction is presented literature review in chapter two. In chapter three is presented methodology for assessing the impact on the environment. In chapter four are presented results of analysis and in last chapter are presented conclusions.*

Keywords: *Production, Devices, Recycling impact, Environment*

1. INTRODUCTION

Quality of life (QoL) has many faces. One of them is related to environment and energy consumption. For enhancing QoL in each state and on global level are established systems for recycling different waste. A motor vehicle is now viewed not only as transport system but as system with high negative impact on environment. It is because for producing motor vehicles producer in supply chains spent en energy, billion tons of raw material, etc.

Each product in addition to the basic functions of use has some impact on the environment. Devices for recycling have a double impact as follows: (1) the impact that follows from their creation and use, and (2) the impact due to the recycling of products on the environment.

Methods for assessing the impact are numerous, based on the different phases of the life cycle of a product (in this case the device for the Environment) and certain aspects of the environmental impact. These methods can complement other methods of group decision-making methods of science, econometric methods, quality, ICT methods, etc.

In accordance with the objectives and scope of the project TR35033 as the base method was chosen LCA method, which is the basis for the development of methodology for assessing the impact of device for recycling components of the ELV on the environment. Through the work on this project are especially manufactured (design and technological) effects device for vehicles detoxification and recycling cables.

The result is a methodology with a sufficient level of generality or, more importantly, sufficient level of applicability in order to assess the impact of defined goals of this project.

This work is structured in four chapters. After introduction there is second chapter which presents the basics of LCA methods, and the third chapter presents model of impact of devices for recycling ELV components of the environment. Fourth chapter presents the conclusions which highlight the advantages of this methodology.

2. LITERATURE REVIEW

LCA method is the result of changes of various methods and procedures at the end of the twentieth century and standards, in particular standards from the group ISO 1404X at the beginning of this century. Today it is practically involved in these standards in four phases (Figure 1) and:

1. the definition of the objective and subject of analysis,
2. the inventory analysis (LCI),
3. impact assessment (LCUA) i
4. interpretation.

The first phase of LCA method is critical because it defines the objective, scope and field of application. Table 1 shows the types of LCA studies depending on the system's boundary.

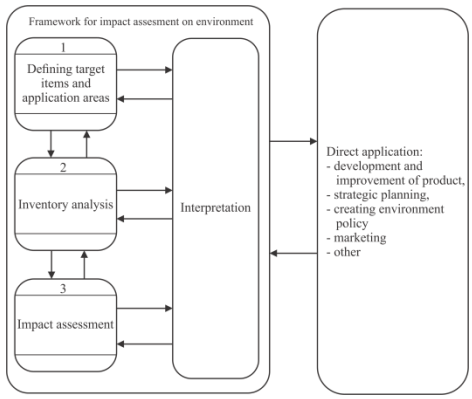

Fig. 1. Basic phases of LCA according to ISO 14040

Table 1. *Types of LCA studies depending on the system's boundary*

Vrsta LCA metoda	Opis
cradle-to-grave	covers the entire life cycle
cradle-to-gate	It covers the life cycle from raw material to output of production
gate-to-gate	It includes only one process, from one to other border
cradle-to-cradle	It covers the last phase of the life cycle or disposal of the product through the recycling process and the beginning (to cradle)

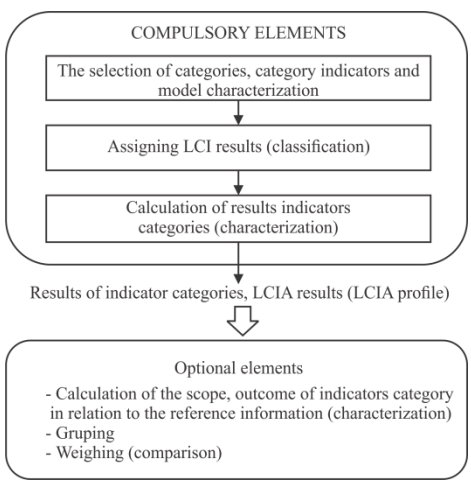

Fig.2. Basic elements of LCIA **[2]**

Phase of results interpretation occupies the central place in the interpretation (Figure 3).

Interpretation of the results consistently represent the LCA, in accordance with the defined goal, subject and the scope of the implementation.

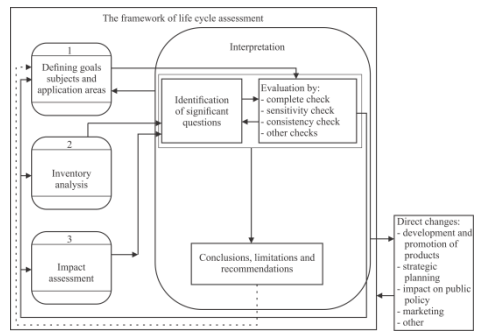

Fig. 3. The basic elements of the interpretation phase and the relationship with other phases of LCA

It should be noted that this interpretation is also an iterative process, and therefore input and output are connected with dotted line.

3. MODEL OF INFLUENCE OF RECYCLING DEVICE ON ENVIRONMENT

Devices for the recycling of ELV components have influence on the environment in three ways:

1. use of materials and energy for the production of components and devices in general,
2. consumption of resources during the life cycle of the device for recycling, and
3. recycling of the ELV components (fig. 4)

The first process (P1) refers to the procurement of the material and energy for production of devices for recycling components of the ELV. In relation R5 are defined the amount of material and energy for the preparation of devices for recycling, obtained on the basis of assessment of a relation through R8. This process (P1) is connected by the relation R1 with the process P3, which relates to connection between devices for recycling and the ELV components that can be recycled. Feedback relation R2 refers to the correlation between the quantity of types of materials, depending on recycling capacity and the type of material components of the ELV.

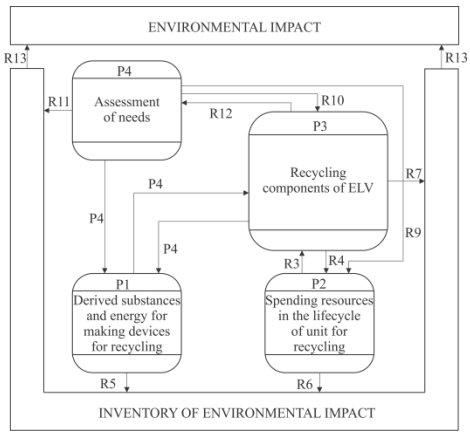

Fig. 4. The basic model of environmental impact

The second process (P2) refers to the use of resources over the life cycle of devices for recycling. This process P2 is associated with the process P3 relation R3, pertaining to the intensity of use of device for recycling in the recycling process, as well as consumption of other resources during the life of devices for recycling. Feedback relation R4 refers to the intensity of the components of the recycling ELV.

In addition to this relation, there is a relation R9 which based on needs affects the consumption of resources during the life cycle of devices for recycling. Relation R6 defines inventory of environmental impact.

A third process P3 refers to the recycling of components of the ELV, on the basis of estimated need (the relation R10). Relation of this process with other processes is described above. R7 gives the inventory process on the environment, and the relation R12 adjustment based on the condition of recycling ELV components.

Fourth process (P4) is evaluation of the needs for recycling, which is made based on the needs of society and other stakeholders (producers, investors, importers, markets, materials and parts, etc.). This process also consumes resources, which results in a impact on the environment (relation 11).

The next step, on the basis of resource waste, determines the inventory of the environmental impact, and later, in a subsequent step, the impact on the environment (RB). A more detailed description of relations will be given in the next chapter.

To model the impact of devices for recycling elements ELV on the environment as a basis is used LCA (Life Cycle Assessment) method defined by the ISO 1404X. The framework for the assessment of environmental impact is shown in figure 5.

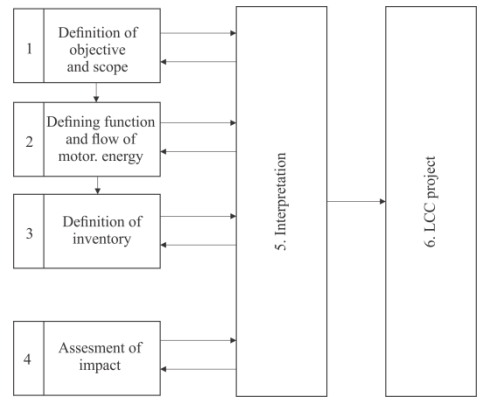

Fig. 5. Management Procedure LCA / LCC projects

The scope of the LCA study is in accordance with the objectives of the project TR 35033 defined in the territory of Serbia and refers to two types of devices, as follows:

- devices for detoxification and ELV
- devices for recycling ELV cables

In the next (second) phase of the use of LCA with Fig.5, is carried out the ascertaining of the function, the function unit, the reference and alternative flows of materials and energy. This is accomplished through the following steps:

1: identify all the functions, components and functional units of the ELV, which can be recycled,

2: define key parameters for the functions and functional units,

3: define the unit of measurement for the amount of functions and functional units,

4: define a reference system for making functions,

5: define alternative system for making functions,

6: define reference flow of materials and energy for function and functional unit

Based on the above, the analysis of the inventory is performed (the third stage in FIG. 5), through the following steps:

-1: delimitation of the eco-economic system,

-2: making flowchart,
-3: determine the format and data categories,
-4: quality assurance data,
-5: data collection and data connection for unit processes,
-6: data validation,
-7: shortened method for determination of data,
-8: determining and allocating multifunctionality and
-9: determination and application of the budget method.

In the fourth stage of the implementation of LCA project carried out assessment of environmental impact, through the following steps:
-1: selection of impact categories,
-2: choice of methods for characterization, ie. Indicator category, model characterization,
-3: assessment of exhaustion of non-living resources,
-4: assessment of exhaustion of living resources,
-5: assessment of the competitiveness of land,
-6: assessment of biodiversity loss,
-7: assessment of vital functions loss,
-8: drying estimation,
-9: assessment of climate change,
-10: assessment of ozone level in stratosphere,
-11: evaluation of toxicity to humans,
-12: score of eco-toxicity of the ports,
-13: score of eco-toxicity on land,
-14: evaluation of the eco-toxicity in fresh water on the sediments,
-15: evaluation of eco-toxicity of sediment in harbors,
-16: evaluation of oxide formation,
-17: acidity raiting,
-18: assessment of eutrophication,
-19: assessment of waste heat,
-20: rating of malodours water,
-21: rating of malodours air,
-22: noise,
-23: evaluation of ionizing radiation impact,
-24: assessment of other causes,
-25: evaluation of the missing interventions,
-26: economic flows that do not follow the boundaries of the system,
-27: classification,
-28: characterization,
-29: normalization,
-30: grouping and
-31: determining weighting factors.

In the fifth stage, the interpretation of the results is done through the following steps:
-1: consistency check,
-2: verification of competence,
-3: analysis of contributions,
-4: analysis of disorders,
-5: sensitivity analysis and uncertainty,
-6: conclusions and recommendations

Sixth stage carries out using the cost determination LCC method.

• Methodology for assessing the impact of recycling ELV components (URKELV) on the environment.

Starting from the established model, given in Chapter 3, the methodology for assessing the influence of device for recycling ELV components in the environment comprising the following steps:

1. Analysis of the recycling process (P1-P4), including the relations between them,
2. Each introduced process is determined by the context, the goal and the application range of LCA,
3. Each is defined by function, the service unit and the flows of materials and energy, by
4. applying methods and tools,
5. Each process are performed with the inventory assessment of the environmental impact by suitable methods and tools,
6. For each of the process are performed interpretation of results of assessment of the environmental impact, by suitable methods and tools,
7. Assessment of the effects of recycling apparatus in terms of the use of other resources (human, economic, social, etc.).

- methods and tools:
    - General research methods,
    - Quality methods and tools (histograms, correlations, trend analysis, cause and effect, Pareto analysis,

etc.),
- Prediction methods (Delphi, econometric methods, nominal group, etc.),
- Simulation methods,
- Methods of systems theory,
- Methods of operational research, etc.
- The methods in the field of information systems, etc.

Methodology also includes:

- Procedures:
  - For assessing the suitability of the model for the purposes of applying the LCC method.
  - For the evaluation of the interpretation of results of LCA methods,
  - For the assessment of environmental impact,
  - For evaluation of the inventory of environmental impact,
  - To optimize the process,
  - For modeling and analysis of the process,
- Organizational framework for the implementation of the methodology, comprising:
  - Organization of project
  - Organization of the process
- Procedures P1-P4 for process management:
  - Responsibility for the procedure for the assessment of environmental impact
  - Organizational framework to the meso and macro levels

Based on the above, the methodology for assessing the impact of devices for recycling ELV components of the environment is shown in Fig. 6.

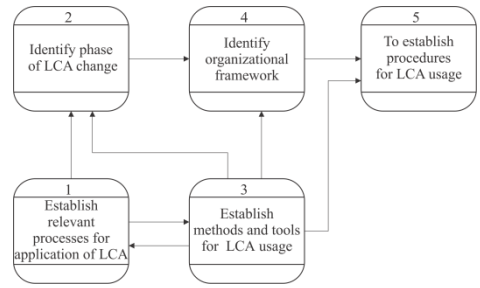

Fig. 6 The methodological basis for evaluating impact of equipment for recycling on the environment

4. ANALYSIS OF RECYCLING PROCESSES

Rating of URKELV impact on the environment is determined separately for each phase of the life cycle. With regard to the objectives of the project and the significance of application URKELV, decision on the applied method is carried out on the notional group, consisting of the members of the project team (Fig. 7).

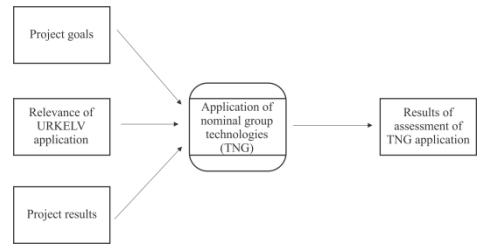

Fig. 7. The method of application of the method

Results of application of TNG are:

The starting point is the current situation (fig. 8):

- consumption of resources in the design of the device is small (fig. 8) so as the impact on the environment
- consumption of resources during the production of prototypes (fig. 9) is slightly larger, but still very low

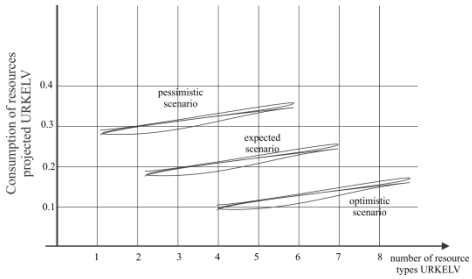

Fig. 8. Assessment of consumption of resources

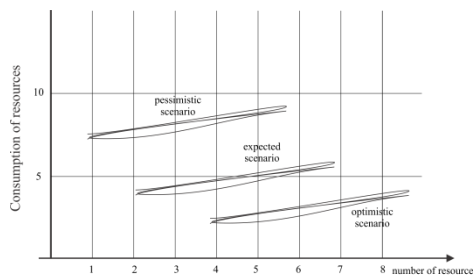

Figure 9. Consumption of resources in the prototype production process

- resource requirements for the regular production and export URKELV depends on demand (Fig. 9), which should be taken into consideration
- recycling resources by applying URKELV has dominant positive effect on the environment (fig. 10).

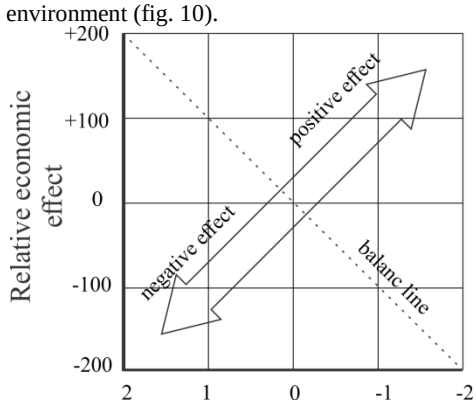

Fig. 10 Relative effects on the environment (Eco Ind. 99 / t)

According to (Bahne R. 2005) the overall impact on the environment is:

$u = \Sigma_t U_j * w_{j,t}$ where is:

- U – the overall impact of the year t,
- Wj,t – the quantity of a waste fraction in tons,
- Uj – environmental impact fractions of waste per ton of waste.

If the calculation include the variable r_i relating to alternative waste treatment, then

$$U = \Sigma_i * \Sigma_t * U_j * r_i * w_{j,t}$$

Eco-efficiency (EE) was determined as the ratio of

$$EE = \frac{\Sigma i \text{ costs}}{\Sigma i \text{ influence } on\ the\ environment}$$

Compared to the existing solution is:

$$\Delta EE = \frac{\Sigma i \text{ costs} - \Sigma i \text{ cost of existing solution}}{\Sigma i \text{ influence on the env.} - \Sigma i \text{ inf.on the env.} and\ existing\ solution}$$

Flow for the assessment of each stage in the life cycle URKELV on the environment is given in fig.11.

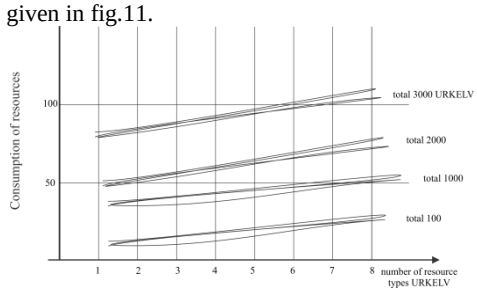

Fig. 11 Consumption of resources for regular production URKELV

5. CONCLUSION

The developed methodology for assessing the impact of devices for recycling ELV components has the following characteristics:

- takes into account the entire life cycle of equipment, from design to recycling the same,
- is based on the use of LCA as defined in ISO 1404X,
- further activation of various methods and techniques in the various phases of use of the method,
- based on the process approach, which is the basis of ISO 9000 series of standards for the quality of the organization,
- due to the inclusion of a process approach, very easily can create specific LCA studies on the impact of certain processes on the environment,

- in view of the above, the methodology has been opened for the application of other methods and approaches, in particular LCC and ICT support.

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