ENVIRONMENTAL ASSESSMENT USING MECO MATRIX – CASE STUDY

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ABSTRACT

The paper deals with the definition of Life Cycle Check, it is very practical and usage tool for environmental assessment of products. In the first part of the paper there is described the instruction on how to proceed step by step. The Life Cycle Check helps to identify where the environmental impacts lie and to identify on which stage of lifecycle we should focus on to reduce the negative environmental impact. To obtain a complete overview of environmental issues of the product system can be used a tool called the MECO matrix. The next part of a paper is demonstrated on practical example that is focused on the life assessment of a fruit dryer. The practical realization was carried out in the computer program CES Edu Pack.

KEYWORDS

Life Cycle Check, environmental impact, lifecycle stage, MECO matrix

1. INTRODUCTION

Nowadays, more and more emphasis is being put on the protection of the environment. The approach of a company to protecting the environment may be determined on the basis of a chosen strategy. Environmental strategy defines environmental aims in terms of the concept of sustainable production and consumption. All products contribute to environmental degradation through their life cycle. On the one hand, there is the consumption of raw materials, energy, on the other hand, the emergence of adverse outputs in the form of waste and emissions. For evaluation of environmental impacts all companies may use voluntary environmental instruments to achieve the reduction. These instruments are preventive and seek new ways to reduce negative impacts on the environment. Implementation of voluntary environmental instruments into the overall management system represents a significant environmental and economic advantage. The Life Cycle Assessment (LCA) represents a useful tool for assessing environmental impacts of a product.

2. LIFE CYCLE ASSESSMENT AND LIFE CYCLE CHECK DESCRIBING

LCA can be defined as a compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout the life cycle. We can say that the Life Cycle consists of four basic steps such as: mining of raw materials, manufacturing (packing and distribution), use and maintenance and disposal of a product. The study of LCA must examine energy and material flows in raw material acquisition, processing and manufacture, distribution and storage (transport, refrigeration, and so forth), use, maintenance and repair, recycling options, and waste management. [2]

The Danish Environmental Protection Agency has initiated activities concerning simplification of LCA to meet a need to simplify the work with LCA. One of the initiatives was the work on how to do a quick Life Cycle Check of a product or service. The aim of the Life Cycle Check is to illustrate the life cycle thinking and to give the company a tool to perform a preliminary LCA. It is a tool, which guide the planning, and optimising of the future work of assessing environmental impacts from the company’s products. The Life Cycle Check consists of next four basic tasks.

2.1. To describe the service provided by the product

The first step in the Life Cycle Check is to define and describe the service provided by the product. The product service can be defined as the benefit of the product provides to the user, or the service of the product gives the user. LCA always address comparisons and this is a reason why it is crucial to define the product’s service. All products cause the use of materials and/or the use of energy, which imply consumption of resources and impacts on the environment. Some products will contain less of materials and consume less energy than others, and they are therefore better for the environment. When we are describing the service of the product, it is necessary to identify the most important product properties. Some product’s properties are called obligatory are the ones which a product must possess to be marketable or which are determined by law. Other properties are called positioning properties. The ones will consumer consider nice to have and which will make the product attractive compared to others products.

The functional unit
When the product service is quantified with respect to volume and time it is called defining the functional unit. The functional unit is made up by quantity, quality and durability.

Secondary service
A product most often also delivers other services or has additional functions to the ones profiling the product. Those services are secondary services and are market irrelevant. A secondary service can be waste heat from energy consuming household appliances like a PC or TV. The waste heat can be a significant contribution to heating a house. It substitutes oil or gas for the central heating system [1].

2.2. To describe the product life cycle

Now we know about the product’s services and it is the time to identify, where the environmental impacts lie. We must start off by getting an overview of the product’s life cycle. This is an overview of all the processes from material extraction and production to the disposal of the product.

The product life cycle has four main stages. These stages are called: materials, manufacturing, use and disposal.

Distribution and transportation are included in and among all the four stages. To get a good overview you must consider and determine [1]:

- the product’s weight and the type of materials, consider whether manufacturing will involve problematic processes or chemicals;
- the product’s life time, for most product the use stage will make up the major part of the total life time (except food products), total time for manufacturing;
- the part of total lifetime spent in the use stage;
- routs of the disposal are the most likely, which materials are likely recycled and which will be disposed of through other processes.

2.3. To do preliminary environmental assessment using MECO Matrix

You have an overview of the parameters. Instead of making a detailed inventory followed by a detailed assessment, you will undertake a screening of the most significant environmental impacts. This is achieved by combining the inventory and assessment in the same procedure. The screening follows the MECO principle. The MECO matrix is a tool to get a concise overview of the environmental problems. The principle of the screening is to evaluate the agents causing environmental problems instead of focusing on the actual environmental impact categories. The principle divides the assessment into four areas in accordance with the underlying causes of the product’s environmental impacts. These areas are Materials, Energy, Chemicals and Others.

Material
Material includes all the materials needed to produce, use and maintenance the product. Material consumption results in use of natural resources and consequent waste problems. Resources are considered scare if they have a short supply horizon. [3] A short supply horizon means that the known reserves only are sufficient for a short period of time given the present extraction rate. Then calculate the consumption of the scarce resource quantitatively by dividing the known content in the product with the known reserve per person. The unit is milli person reserve. It means how much of the reserves left for me and my descendant do I use when consuming this product. Materials that are being reused in the phase of disposal marked with a minus sign.

Energy
Energy includes all energy used during the product's life cycle, including the use of energy during the supply of materials. Energy consumption means use of energy resources and consequent problems as global warming, nutrient enrichment and waste in the form of slag, ashes or radioactive waste. [1] The use of energy should be indicated as primary energy and as use of oil resource. [3] Primary energy is defined as the amount of energy contained in the energy resource when extracted from nature. The energy consumption for a process can be calculated from the power consumption given at the machinery name plate multiplied by production time of this product. This provides a conservative estimate of the process energy. Include product operation and maintenance throughout the life cycle. Operation can be consumption of energy, resources and auxiliaries. Include energy consumption in the disposal stage. It is possible to include the total transportation as a separate stage to evaluate the size of energy consumption for transportation.

Chemicals
The chemical inventory and assessment is the most difficult part of the preliminary environmental assessment performed by the MECO analysis. You do not have all data you need. In the parts list you can find some information about the chemical consumption in manufacturing or some information are available in user manuals. The chemicals are classified as type 1, 2 or 3 according to their environmental hazard level. [3] Chemical consumption results in impacts as toxicity to human and the environment, stratospheric ozone depletion and photochemical ozone formation. [1]

Other
Into this category you can mark other resource and environmental problems, problems with working environment, which have not yet been covered. This can be noise, dust, irradiation or physical impacts on humans and the environment.

2.4. To report of the results

The interpretation should contain the following elements [1]:

- Where in the product life cycle do the most significant resource consumption and environmental impacts seem to be?
- Where are the most significant data shortcomings and uncertainties?
- Which possible changes could be environmentally attractive?

If the company wants to proceed with the environmental assessment and make comparisons to competing products, there are specific requirement in the ISO standards which must be met.

3. PRACTICAL EXAMPLE – USING OF THE CES ECO AND THE MECO MATRIX

3.1. The CES ECO audit tool

The CES Edu software includes an eco – audit tool. On picture 1 you can see how the user interface looks like. It shows the user actions and the consequences. There are five basic steps [2]:

1. Product definition allows entry of a descriptive name.
2. Material, process and end of life allows entry of the bill of materials and processes. The primary shaping process, the mass for each component.

a) The component name is entered in the first box, the material is chosen from the pull-down menu of box 2.
b) Selecting a material from tree-like hierarchy of materials retrieve and store its embodied energy and CO_2 footprint per kg.
c) The primary shaping process is chosen from the pull-down menu of box 3, which lists the processes relevant for the chosen material, the tool retrieves energy and carbon footprint per kg.
d) The box 4 allows the component weight to be entered in kg.
e) The final box 5 allows choice of disposal route at end of life

3. Transport allows the transportation of the product from manufacturing site to point of sale. The tool allows multistage transport (shipping followed by delivery by truck). A transport type is selected from the pull-down menu.

Figure 1 – The CES ECO audit

4. The use phase allows the two different classes of contribution. We have two basic types of contribution: static mode contribution x mobile contribution.
   a) The static mode allows selecting an energy conversion mode causes the tool to retrieve the efficiency and to multiply it by the power and the duty cycle. Entered here as use days per year times hours per day times product life in years.

b) The mobile mode allows selection of the type of transport, listed by fuel and mobility type. On entering daily distance, the tool calculates the energy and CO_2 by multiplying product weight and distance carried by the energy or CO_2 per tonne.km.

5. The final box allows the user to select energy or CO_2 as the measure displaying it as a bar chart and in tabular form – report.

3.2. Life cycle check of a fruit and mushroom dryer

Primary function of the Fruit and Mushroom Dryer is to dry efficiently all kinds of mushroom, fruit, vegetables and herbs with as little energy consumption as possible. During the heating and drying process is using energy to heat the motor with fan. The fan gives a high airflow and low drying temperature. The drying temperature can be regulated with the ventilator on the lid. The used temperature is not less than 50 °C and the highest possible temperature is about 70 °C with closed ventilator. The dryer has a very silent motor with an overheat protection.

The maintenance of the fruit and mushroom dryer is very easy to clean. It is only necessary to wash the dehydrator trays and the lid after each use. We suppose that the duration of this appliance is 10 years.

The user will use this device 50 times per year, average drying temperature is 6.5 hours. For cleaning is needed water and detergent. The consumption of fresh water is estimated about 500 ml and the consumption of detergent about 5 ml for one cleaning.

Among secondary services provided by the Fruit and Mushroom dryer belong the heat loos during the use stage which substitutes room heating, recycling substitute virgin materials and incineration of materials substitute production of energy.

After determination of all properties and the functional unit it is necessary to dismantle the device to determine the material composition of components which the device consists of. In the next step is necessary to consider the weight of all components and compile the list of materials. The list of materials is divided into three main categories such as: plastics, metals and other.

List of Materials		
PLASTICS	2,442	kg
PE	0,04	kg
PS	0,314	kg
ABS	0,059	kg
AS	1,26	kg
PP	0,623	kg
PA	0,146	kg
METALS	1,099	kg
Iron	1,024	kg
Copper	0,075	kg
OTHER MATERIALS	0,751	kg
Carton	0,603	kg
Paper	0,148	kg
TOTAL	4,3	kg

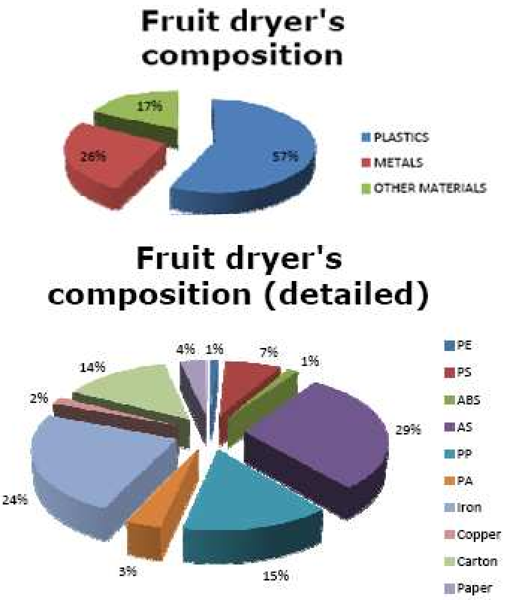

Figure 2 – Material composition of a Fruit Dryer

3.3. MECO Matrix

MECO matrix is a tool to get an overview of the environmental impacts for each life cycle stage and is made by estimation and calculations of the amounts of materials and energy and chemicals. Materials and energy are calculated as consumption of resources. Material unit is milli reserve per person, the unit of energy is MJ. Environmental impacts that do not fit into these categories should be included in category others. For MECO matrix is necessary to use the software named CES Edu Pack. The inputs data represent individual materials and their weight. The outputs were this table and the graphs.

	Materials	Energy	Chemicals	Other
Material Stage	Oil: 1,41 kg ≈ 0,055 mPR Mg: 0,01 kg ≈ 0,067 mPR Iron: 1,014 kg ≈ 0,083 mPR Copper: 0,075 kg ≈ 1,25 mPR Natural gas: 0,846 kg ≈ 0,036 mPR In total: 1,49 mPR ≈ approx. 6,66 kg oil-eq. ≈ approx. 0,26 mPR oil	Plastics: 226,2 MJ PE: 3 MJ PS: 28,3 MJ ABS: 5,6 MJ PP: 49,8 MJ AS: 119,9 MJ PA: 19,6 MJ Metals: 47,75 MJ Copper: 6,75 MJ Steel: 41 MJ In total: 273,95 MJ	The List of Undesirable Substances Copper Emissions: VOC, NO_X, CO_2, HCl, HF, Fluorides, PAH, Ashes' particles, Fe_xO_y, CN^-	Irritation of the nose, mouth and eyes, headaches, stomachaches, dizziness, vomiting and diarrhoea Odor nuisances, respiratory diseases Acid rain, greenhouse gas
Manufacturing Stage	≈ approx. 1,47 kg oil-eq. ≈ approx. 0,057 mPR oil	22 % of Material stage In total: 60,27 MJ	Possible problematic chemicals: Lubricants/grease	
Use Stage	*(Water: 125 L ≈ 6,48*10⁻⁶ mPR)* Detergent: 1,25 L ≈ approx. 81,46 kg oil-eq. ≈ approx. 3,18 mPR oil	In total: 3340 MJ	Nitrates, phosphates, tenseactives	Allergies Eutrophication
Transportation	In total: 13,2 MJ ≈ approx. 0,32 kg oil-eq. ≈ approx. 0,013 mPR oil		Emissions: NO_x, CO_2, particles	Greenhouse gas
Disposal Stage	Recycling: -0,988 kg Paper and carton (72%) -0,54 kg Copper (90%): -0,068 kg ≈ -1,13 mPR Steel (42%): -0,914 kg ≈ -0,031 mPR Incineration: -1,368 kg ≈ approx. -0,696 kg oil-eq. ≈ approx. -0,027 mPR oil	Recycling: -13,175 MJ Incineration: - 27,825 MJ In total: -41 MJ	Incineration: NO_x, CO_2, SO_2, HC's, Halogens Recycling: Lubricants	Greenhouse gas, acidification of water, respiratory diseases

Figure 3 – MECO Matrix

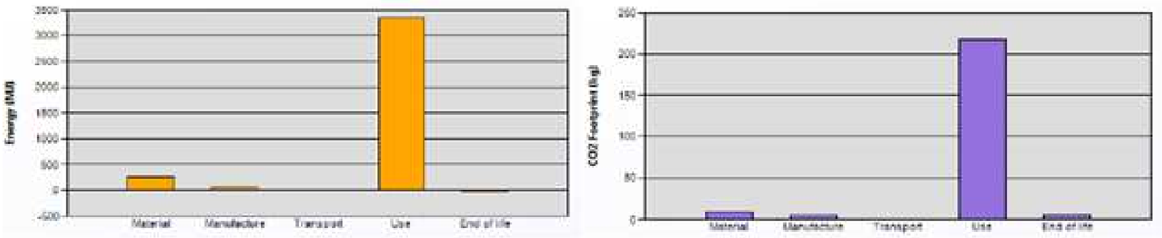

Figure 4 – Energy consumption and CO_2 footprint of each lifecycle stage

The chart shows that the most environmental impact is estimated during the use stage of the life cycle. The reason, why the use-stage column is so great is given by our initial estimates that were no realistic. As is mentioned above we supposed and estimated that the user will use this device 50 times per year and the duration is about 10 years.

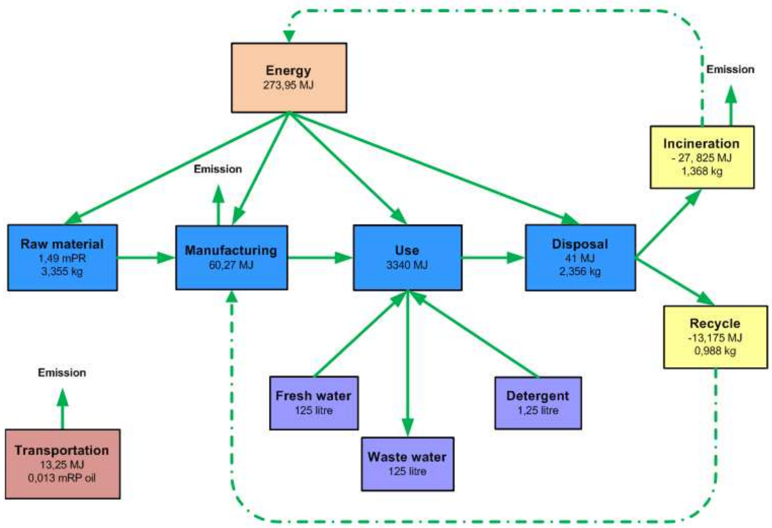

Figure 5 – Life Cycle Check of the Fruit and Mushroom Dryer

4. CONCLUSION

In the first part of the paper is explained the general instruction how to proceed step by step during the life cycle check. For collection input and output data is used a MECO form in order to create an overview of the data collected. In the MECO form, the data are related to the individual stages of the life cycle. The MECO gives a first indication of where the significant environmental impact occurs and shows where the data are lacking. The main difficulty at work of the life cycle check is to obtain information of the product's life cycle which occurs outside the company. For easy processing of data we can use the computer program CES Edu Pack.

In the second part is explained the life cycle check on the practical example – fruit dryer. From the results of the MECO form we can try to find some ways to improve a product's environmental performance or other ways how to reduce the total environmental impacts.

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[5] http://www.mst.dk/

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