

# Progress in the Teaching of Eco-Design in the Electric Engineering Education

<sup>1</sup>Hejatkova E., <sup>2</sup>Reznicek M., <sup>3</sup>Szendiuch I.

Dept. of Microelectronics, Brno University of Technology, Czech Republic,  
hejatka@feec.vutbr.cz <sup>1</sup>, reznicek@feec.vutbr.cz <sup>2</sup>, szend@feec.vutbr.cz <sup>3</sup>

## Abstract

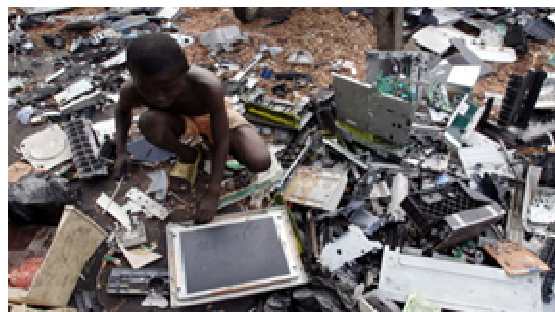
This paper introduces some new approaches in the eco-design teaching, which were obtained during three years experience at Brno University of Technology in the Master study program "Microelectronics". Eco design makes a part of the subject "Modern microelectronics technology" that is teaching in the fourth semester. It is very important part of education of all engineers which concerns ecology activities held worldwide. Base for this matter are EU directives RoHS, WEEE and EuP, but also new applicable tools makes powerful output. This paper is presenting the educational concept of Eco-design in general approach, which can be presented in various ranges. Basic subject matter in one lecture can be implemented in various courses concerning electronics from different points of view, as for example design, production, applications of circuits, packages, systems etc. The subject can be divided for more lessons or extended in the whole semester. This knowledge can give good support to engineers, especially which are in managing positions, to help for business units to design better products with better economical results and in so doing help protect environment and human health. This paper indicates the basic approach to eco-design application and shows how to make eco-evaluation of electrical products. At last there is suggested the structure of the basic topics that make the framework of eco-design education process.

## 1. Introduction

There is the reality the electronics industry is a major part of the World economy and in more drivers of innovation and new product ideas. In all sectors of electronic/electric production the first step before manufacturing is design. Designers have to make choice of materials, components and corresponding processes, which all need certain material and energy consumption. By contrast new production plants, new processes and new products. Every one new plant is increasing energy consumption together with waste and pollution (Fig.1). The growth of electronics products, their manufacture and disposal are featuring additional threats to the fragile balance of the Earth's eco systems. In other words that all causes environmental impact that cannot be changed after the finishing of products and their introduction on the market participants.



a)



b)

**Figure 1:** Ecological impact of production on environment  
a) plant pollution b) waste

There is reason to educate future engineers for favour to human living environment. Therefore the first step is to give them a basic knowledge about principles and laws that concerning protection of environment. There is nothing to discuss the significant results can come only when this knowledge will be obligatory for each inhabitant of our globe and especially for people in managing positions. The main objective is to have basic overview of electric and electronic products (category) and basic concepts in environmental impact of electric and electronic industry on environment in coincidence with legal compliance in EU, first of all with WEEE, RoHS and EuP regulations.

## 2. Why focus on Eco design

Today eco-design makes a fix part of environmental management which has to be non-separable part of education in management generally. Each engineer working in electric branch takes decision about selection and purchase of materials or products, including some design matters. It stands to reason that each this decision has some impact on environment. That means all engineers can assist in reducing of products or processes influence on environment.

The traditional approach to environmental protection is pollution prevention or waste management, but these strategies only focus on avoiding or minimizing potential environmental impacts without considering the design of products. That means this traditional approach doesn't appear causes of this negative impacts and their elimination. In Fig.2 is designed environmental impact of a product during the whole life cycle. In total, about 80% of all product-related environmental impacts are determined during the product design phase. Eco-design is the integration of environmental considerations at the design phase, considering the whole product life cycle from raw materials acquisition to final disposal.

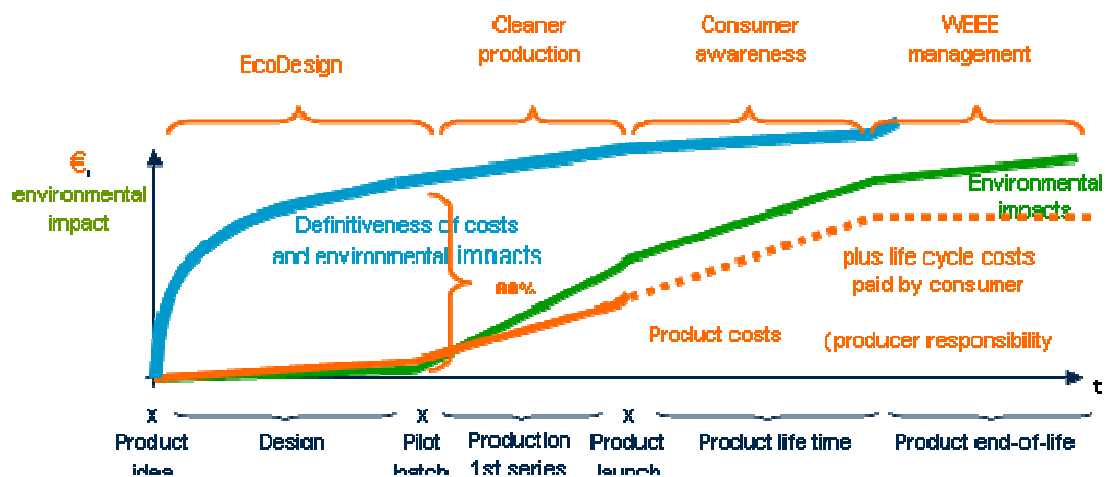


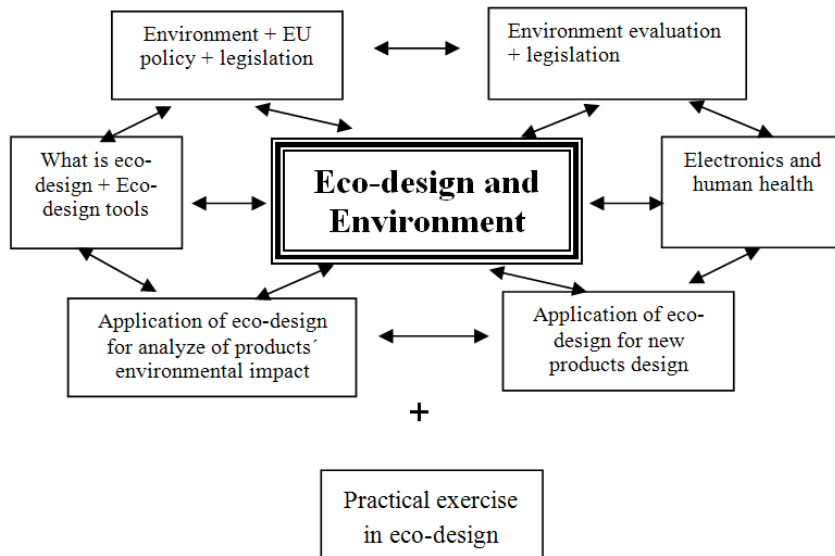
Figure 2: Cost concerning product life cycle and eco-design [2]

Curriculum that is presented in Fig.3 can be supported by practical exercise. As example is shown comparison of three various 2GHz flash memories which have a different package material. These are shown on Figure 4, metal Al/Mg (aluminium/manganese), plastic PMMA (polymethylmethacrylate) and rubber PDMS (polydimethylsiloxane) and principle of exercise is to learn which the environmental impact each of them is.

## 3. Eco design curriculum

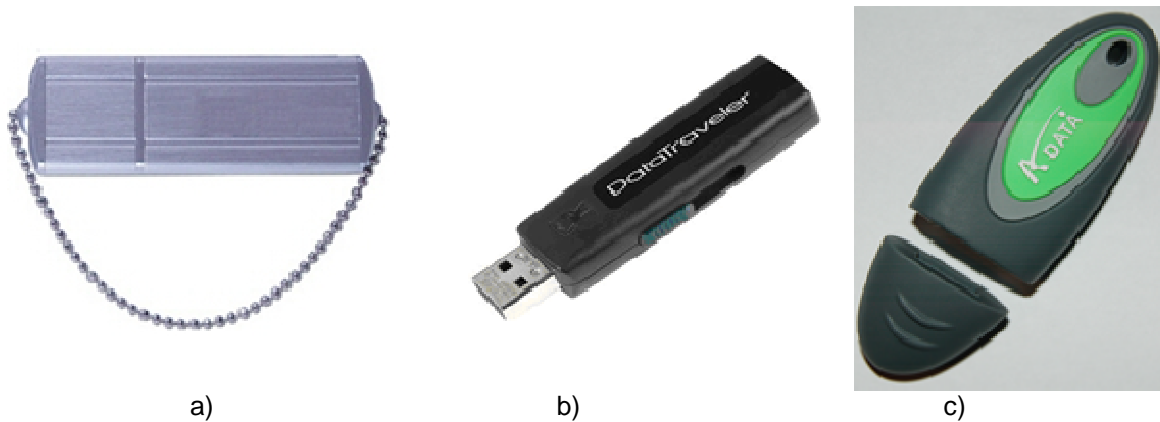
The syllabus for application of eco-design in electric engineering education contains the following main topics:

- Environment and EU policy + legislation (RoHS, WEEE, EuP, CE)
- Environmental evaluation and management
- What is eco-design and how to do eco-design
- Eco-design tools and their use in praxis
- Application of eco-design for investigation of environmental impact of products
- Application of eco-design for design of new products



**Figure 3:** Basic curriculum for eco-design.

Curriculum that is presented in Fig.3 can be supported by practical exercise. As example is shown comparison of three various 2GHz flash memories which have a different package material. These are shown on Figure 4, metal Al/Mg (aluminium/manganese), plastic PMMA (polymethylmethacrylate) and rubber PDMS (polydimethylsiloxane) and principle of exercise is to learn which the environmental impact each of them is.

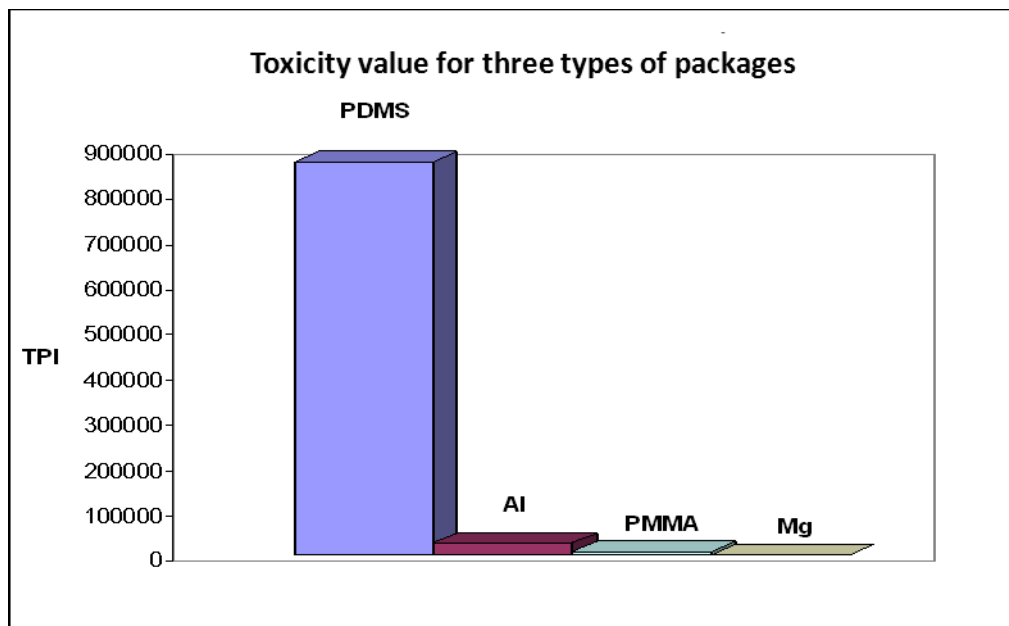


**Figure 4:** Three various flash memories with different package:  
a) metal b) plastic c) rubber

A student makes at first the teardown analyze and after the definition of materials. He has to weigh each package component and through on internet available tools accomplish the evaluation of materials (Bill of materials). For diagnosis of toxically impact of each material is used toxic potential indicator (TPI) [7] that gives for package material the following results shown in Table I. Overview representation is shown in Figure 5.

**Table 1:** Toxicity indicator for single materials:

Package	Weight [g]	Element	% volume	Weight [g]	TPI/mg	TPI
PDMS	14	-	100	14	61,85	865900
PMMA	8	-	100	8	0,78	6240
PS	14	-	100	14	1,63	22820
PVC	14	-	100	14	0,58	8120
AW 5005	11	Al	98,9	10,88	2,21	24044
		Mg	1,1	0,12	0,78	94,38



**Figure 5:** Graf of toxicity find by TPI out.

#### 4. Conclusion

Without knowledge of theoretical rules and ability design application can't be expected any results leading to the environmental improvement. That's reason to implement distinct and objective subject which gives fundamental overview to all electric engineers out of a studios bent. The University promotes the development of interdisciplinary branches such as material science and engineering, industrial design, etc. That's reason to implement for the begin some basic lessons about eco-design and by and by distinct and objective subject which gives fundamental overview to all electric engineers out of a studios bent. In this paper is suggested the structure of the basic eco-design matter that make the framework of eco-design education process.

To establish useful and transparent content of Eco-design basic the following three points have to be enlightened:

- The base for Eco-design – legal compliance
- Introduction on Eco-design strategies
- Tools and Methodologies for Eco-design

This realty asks to start systematically activities to help to control life condition. One of fundamental steps is to involve Eco-design topic in education process, especially where students are involved in research, design and production business including user sector. The human factor and the personal responsibility of each person is the best way to achieve positive results.

There are two basic approaches how to implement Eco-design in education process:

- in one lecture for wide part of students,
- in one subject for engineers who are involved directly in this topic.

Eco-design is currently taught as part of other subjects but it is being proposed as a new subject, involving selected engineering materials from Design for Environment (DfE), through ecological design to end-of life management. To be useful Eco-design must incorporate knowledge from other branches, including Material engineering, Quality management, Knowledge management, Supply-chain management, Information management etc. Eco-design is interdisciplinary as it concerns various fields of the science and engineering.

## 5. Acknowledgements

Funding for this research was obtained through grant project from the Czech Ministry of Education (MSM 0021630503 MIKROSYN „New Trends in Microelectronic Systems and Nanotechnologies”) and the Grant project MSMT FRVS 250/2011 “Innovation of Microelectronics Education Process by Introduction of HIC’s in the Lab Curriculum” and FEKT-S-11-5 “Research of excellent technologies for 3D packaging and interconnection”.

## References

1. Electronics goes Green 2004+, International Congress and Exhibition Proceedings, Fraunhofer IRB Verlag, Stuttgart, September 6-8, 2004, Berlin, Germany
2. “Promoting Eco-Design Activities in the SME’s of Electric/Electronics Sector”, Workshop Series on Eco-Design for small and medium sized enterprises in the electronics sector, EU MAP project ENTR/04/04, 2005, Brussels
3. Schischke, K. and others: Green MST Design from a Designer’s Perspective: How to Base Decisions on Environmental Issues, Report Fraunhofer IZM, Berlin, 2006
4. Tummala, R.: Fundamentals of Microsystem Packaging, McGraw-Hill, New York, 2001
5. Schischke, K., Muller, J., Reichl, H.: EcoDesign in European Small and Medium Sized Enterprises of the Electrical and Electronics Sector
6. Szendiuch, I., Schischke, K.: Eco-design - new part of technological integration, Proceedings of 29<sup>th</sup> International Spring Seminar on Electronics Technology, ISSE2006, Dresden, Verlag Dr. Markus A. Detert, 2006, p. 166 - 169, ISBN 3-934142-23-0
7. Eco indicator, [http://www.pb.izm.fhg.de/ee/070\\_services/75\\_toolbox/index.html](http://www.pb.izm.fhg.de/ee/070_services/75_toolbox/index.html)
8. Szendiuch, I.: Importance of Eco Design Implementation in Engineering Education, 9<sup>th</sup> International Conference on Engineering Education, San Juan, July 23-28, 2006