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ECODESIGN POSSIBILITIES OF FURNITURE

MĒBEĻU EKODIZAINA IESPĒJAS

Jeļena Makejeva, Mg.sc.ing.
Riga Technical University, Faculty of Energy and Electrical Engineering
Institute of Energy Systems and Environment
Address: Kronvalda boulv. 1, Riga, LV-1010
Phone: 371+7089911
e-mail: jelena_makejeva@mail.ru

Gatis Bažbauers, associate professor, Dr.sc.ing.
Riga Technical University, Faculty of Energy and Electrical Engineering
Institute of Energy Systems and Environment
Address: Kronvalda boulv. 1, Riga, LV-1010
Phone: 371+7089911
e-mail: bazbauer@latnet.lv

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Introduction

Improvement of the environmental performance of industrial products and services is a necessity and not a luxury anymore. Solutions driven by ecological considerations are important elements of efficient management and efficient business practice, and it requires an integrated approach. It means that environmental dimension must become an inseparable part of the planning and decision making of companies and industries. Product ecodesign possesses large potential for the improvement of environmental performance while satisfying the needs of consumers and improving economic characteristic of the product at the same time. This is one of the most critical considerations which should motivate producers to implement ecodesign.
The present work is devoted to the following aspects of ecodesign of furniture: assessment of environmental impact (*EI*) of Latvian furniture manufacturing sector by using eco-indicators [1] and proposal of ecodesign recommendations, which is made with help of ECODESIGN PILOT programme [2,3,4]. Implementation of ecodesign in furniture production industry is topical since furniture production companies compose 24% of total industrial sector of wood processing industries [5]. From total number of 397 furniture production enterprises in Latvia during 2003, 258 furniture production enterprises were located in Riga and Riga region.
It has to be taken into account that *EI* of furniture greatly depends on efficient manufacturing technologies and useful life span of furniture. Therefore, the research presented in the paper was addressed for the needs of the designers and producers of furniture. Creativity of designers will be able to prevent a risk of premature ageing of furniture related to insufficient ergonomics, change of fashion trends and other aspects. Efficient production and waste utilisation

technologies provide not only ecologic but also economic benefits, and the present work studies also potential improvement of those aspects from environmental point of view.

Assessment of total life cycle *EI* of furniture, calculation principles and obtained results

Using eco-indicators, *EI* of wooden furniture produced in Latvia during time period from 2000 to 2003 [5] was calculated for life cycle stages of raw material processing, manufacturing of furniture, distribution and end-of-life. Two scenarios were analysed for end-of-life life cycle stage:

1. all used furniture is landfilled, and this scenario corresponds to the existing situation;
2. all used furniture is incinerated with energy recovery. Table 1 shows results of calculations of *EI* for Latvian furniture industry obtained with eco-indicators [1].

Table 1.

Environmental impact at different life cycle stages of furniture for Latvian furniture industry

Year	*EI* of processing of raw wood materials	*EI* of furniture production	*EI* of production waste	*EI* of furniture distribution	*EI* of incineration of used furniture	*EI* of landfill of used furniture
	thous. Pt	thous. Pt	thous. Pt	thous. Pt	thous. Pt	thous. Pt
2000	911	389	20	no data	-1621	36
2001	1086	463	39	1663	-1904	42
2002	1191	508	71	1692	-2036	45
2003	1314	561	103	1860	-2201	48

An equation for calculation of *EI* of furniture for the whole life cycle (1) was worked out based on assessment of *EI* of furniture with eco-indicators. Although the equation (1) is created specifically for the present life cycle conditions of Latvian furniture manufacturing industry on aggregate level, it is of more general purpose, since by using this equation, individual furniture producers interested in sustainable development of their products are able to determine impact of critical aspects of life cycle on total *EI* of their products.

$$\begin{aligned} EI &= M \cdot \left(\rho \cdot e_{w.proc.} + E \cdot e_{el} + k_1 \cdot \rho \cdot e_{w.proc.}\right) \\ &+ M_1 \cdot \rho \cdot \sum_{n=1}^{m} \upsilon_n \cdot \left(L_{rn} \cdot e_r + L_{wn} \cdot e_w + L_{rn} \cdot e_r\right) + , \\ &+ M_1 \cdot \rho \cdot \left(k_2 \cdot e_{inc} + (1 - k_2) \cdot e_{landf}\right) \end{aligned} \quad (1)$$

where *EI* – environmental impact of furniture during whole life cycle [mPt];
M – volume of wood raw material [m^3];
ρ – density of wood [kg/m^3];
$e_{w.proc.}$ – eco-indicator for wood processing [mPt/kg];
E – specific electricity consumption during manufacturing process [kWh/m^3];
e_{el} – eco-indicator for electricity [mPt/kWh];
k_1 – proportion of production waste;
M_1 – volume of wood in produced furniture products [m^3];
v_n – proportion of furniture products exported to country *n*;

L_{rn} – transportation distance covered by road transport [km];
e_r – eco-indicator for road transport [mPt/tkm];
L_{wn} – transportation distance covered by water transport [km];
e_w – eco-indicator for water transport [mPt/tkm];
L_{rn} – transportation distance covered by rail transport [km];
e_r – eco-indicator for rail transport [mPt/tkm];
k_2 – fraction of incinerated furniture at the end of life cycle;
e_{inc} – eco-indicator for wood incineration [mPt/kg];
e_{landf} – eco-indicator for landfill of furniture waste [mPt/kg].

It also has to be noted, that only road transport in distribution of furniture products was considered for calculations of *EI* shown in Table 1.

Sensitivity analysis of *EI* factors

Using equation (1), sensitivity analysis of *EI* factors of furniture life cycle was carried out. Data from Latvian furniture production sector for the year 2003 [5] were used for the base scenario, and the value of total *EI* for the base scenario is 2760 thous. Pt. Fraction of the incinerated furniture waste at the end-of-life stage is 0,5 for the base scenario, and the rest is landfilled. Road transport is considered for the distribution of furniture products. As follows from the obtained results of *EI* calculations (Table 1), the total *EI* of life cycle is most sensitive to changes in amount of raw materials, transportation distance and fraction of incinerated furniture waste at the end-of-life stage (Fig. 1).

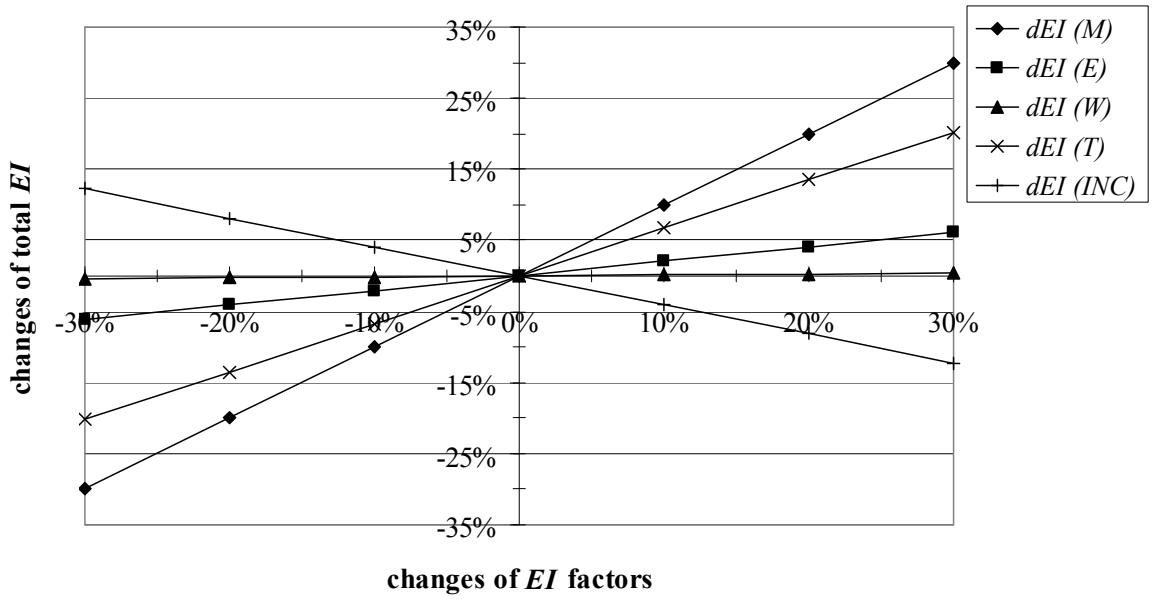

Figure 1. Sensitivity of total *EI* of furniture life cycle to changes of mass of raw materials (*M*), electricity use during production (*E*), amount of waste created during furniture production process (*W*), transportation distance of furniture products (*T*), and fraction of the incinerated furniture at the end-of-life stage (*INC*)

The question which arises is how to consider length of service life *SL* of furniture in *EI* analysis? One way is, instead of looking at total *EI* for the whole life cycle, to look at average annual EI_{SL}

which is EI/SL. Then, the relative change of EI_{SL} depending on relative change of SL can be obtained from the equation (2).

$$\frac{d(EI_{SL})}{EI_{SL}} = -\frac{EI}{SL^2 EI_{SL}} d(SL) \tag{2}$$

However, one would like to have an expression which allows to compare the relative importance of length of service life with other factors of environmental impact on equal conditions. Then, we could introduce a concept which could be called „environmental depreciation" due to its similarity to economic depreciation. Namely, for each year of service life of furniture we have to add $1/SL$ fraction of total EI to the annual average EI_{SL} in order to consider that the furniture will have to be replaced at the end-of-life. Then, the total environmental impact EI_{ED} with added fractions of „environmental depreciation" during chosen base scenario service life SL_{BS} duration used as the comparison base for different scenarios of service life SL can be estimated as follows:

$$EI_{ED} = EI(1 + \frac{SL_{BS}}{SL}), \tag{3}$$

where SL_{BS} - length of service life for the base scenario.

From equation (3) follows, that the total EI doubles for the service life of 10 years if SL_{BS} is 10 years, increases 1,8 times at the same time period if SL is 13 years, and increases 2,4 times during 10 year period if SL is 7 years. Figure 2 shows the sensitivity of EI_{ED} to relative changes of length of furniture service life. It has to be noted, that the total EI remains unchanged when SL changes.

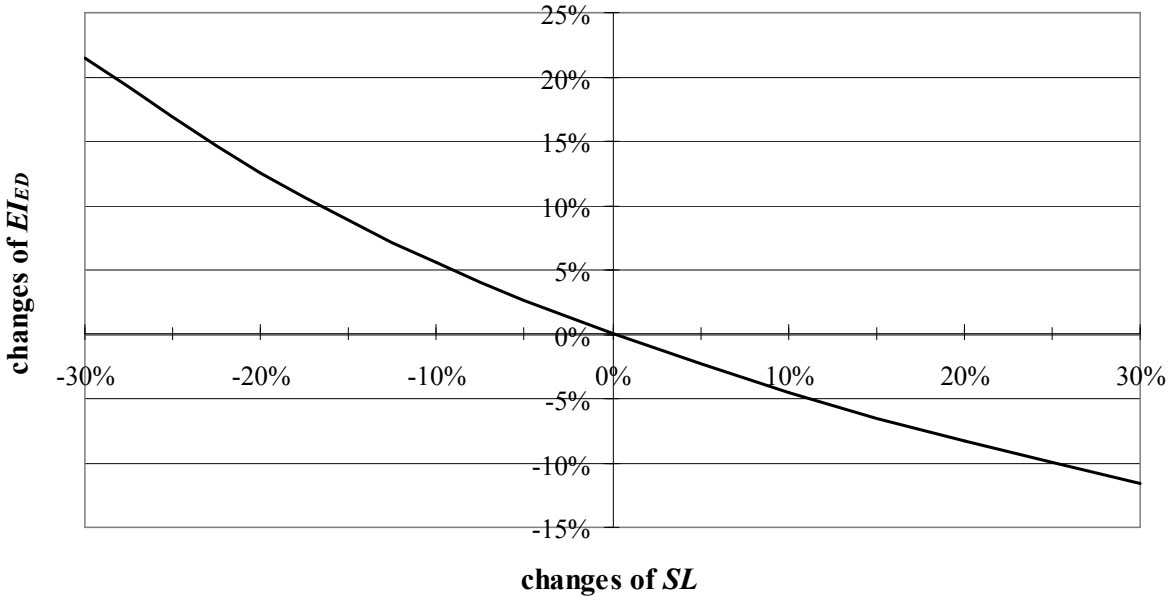

Figure 2. Sensitivity of EI_{ED} of furniture life cycle to changes of duration of furniture service life (SL)

The obtained equations (1-3) help furniture product developers and producers to estimate changes of total EI of their products depending on changes of main environmental impact factors. The

analysis allows identification of potential improvements of the environmental performance of furniture products that provide the highest environmental benefit and fastest economic pay-back.

Recommendations for EcoDesign

The ECODESIGN PILOT programme was used as a tool for the planning of ecodesign strategies for furniture. By using the programme, recommendations for furniture ecodesign were created. The recommendations were evaluated and listed according to potential contribution to the reduction of environmental impact with the help of the evaluation method created in the ECODESIGN PILOT. The most important recommendations, listed according to their potential environmental benefits, are the following:

- use of renewable, recyclable materials;
- avoid use of toxic non-separable materials;
- reduce diversity of materials;
- integrate functions of parts;
- use energy efficient production technologies;
- create closed loops of material flows within production process;
- use strong materials and durable design solutions;
- avoid „weak points" of design, such as insufficient ergonomics, colours and shapes which could quickly fall out of fashion.

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Makejeva J., Bažbauers G. Mēbeļu ekodizaina iespējas.
Darbā ir aplūkoti mēbeļu ekodizaina aspekti – veikts mēbeļu aprites cikla ietekmes uz vidi novērtējums ar ekoindikatoru metodi „The Eco-indicator 99". Darbā izveidotas aprēķina izteiksmes, kas ļauj noteikt ietekmi uz vidi mēbeļu aprites cikla posmos. Aprēķina izteiksmes ir izmantotas, lai noteiktu ietekmi uz vidi, kas rodas mēbeļu aprites cikla posmos, izmantojot datus, kas iegūti par Latvijas mēbeļu ražošanas sektoru laika posmam no 2000. līdz 2003.gadam. Minētās aprēķina izteiksmes ļauj veikt mēbeļu aprites cikla ietekmes uz vidi analīzi arī individuālajiem mēbeļu produktu attīstītājiem un ražotājiem un izstrādāt ekodizaina rekomendācijas. Izpētē arī veikta jutības analīze, kas parāda saistību starp mēbeļu aprites cikla kopējo ietekmi uz vidi un tādiem ietekmes uz vidi faktoriem kā izejmateriālu daudzums, transportēšanas attālumi produktu sadales posmā, ražošanā patērētās elektroenerģijas un radušos atkritumu daudzums, dzīves cikla beigās sadedzināto mēbeļu frakcija, kā arī mēbeļu kalpošanas ilgums. Jutības analīzes rezultāti parāda, ka vislielākā ietekme uz vidi ir izejmateriālu daudzumam, tad seko transportēšanas attālumi, dzīves cikla beigās sadedzināto mēbeļu frakcija, kā arī ražošanā patērētās elektroenerģijas daudzums. Ražošanas atkritumu daudzumam ir relatīvi neliela ietekme. Ietekmes uz vidi aprēķinu rezultāti ļauj izveidot ekodizaina rekomendācijas un tās sarindot pēc to iespējamā snieguma ietekmes uz vidi samazināšanā. Darbā, balstoties uz ietekmes uz vidi aprēķiniem un ECODESIGN PILOT programmu, ir sastādīts ekodizaina rekomendāciju saraksts mēbeļu ražotājiem.

Makejeva J., Bažbauers G., Ecodesign possibilities of furniture.
Work explores aspects of ecodesign of furniture - environmental impact assessment of furniture life cycle is done by applying the eco-indicator method „The Eco-indicator 99". Equations for calculation of environmental impact of furniture in different stages of its life-cycle is developed during the work. The equations are used for determination of environmental impact of furniture life cycle stages with the data obtained from Latvian furniture manufacturing sector for the time period from the year 2000 up to 2003. The given equations allow to carry out analysis of environmental impact of furniture life cycle also for individual developers and producers of furniture, as well as work out ecodesign guidelines. Sensitivity analysis, which shows the relation between total environmental impact of furniture life cycle and such factors of environmental impact as amount of raw materials, transportation distances during distribution stage of furniture products, electricity consumption and amount of waste created during production process, fraction of incinerated furniture waste at the end-of-life stage, as well as duration of service life of furniture, is obtained in the work. Results of the sensitivity analysis show that the largest impact on environment is caused by raw materials, followed by transportation distances, fraction of incinerated furniture products at the end-of-life stage, electricity consumption during production process. Amount of waste plays relatively small role in creating total environmental impact. Results of environmental impact assessment allow to work out ecodesign guidelines and put these in priority order depending on environmental benefit which could be provided. Paper presents list of ecodesign guidelines created for furniture producers which are created by using ECODESIGN PILOT and calculations of environmental impact.

Макеева Е., Бажбауэр Г., Возможности применения экодизайна в производстве мебели.
В работе рассмотрены следующие аспекты экодизайна мебели: оценка влияния жизненного цикла мебели на окружающую среду с помощью эко-индикаторов метода „The Eco-indicator 99". В работе также представлены формулы расчета влияния на окружающую среду, которое создаётся в разных ступенях жизненного цикла мебели. Формулы расчета использованы для оценки влияния жизненного цикла мебели на окружающую среду учитывая данные о секторе мебельного производства Латвии для периода времени с 2000 по 2003 года. . Описанная в работе модель расчета влияния на окружающую среду поможет производителям оценить влияние своей продукции на окружающую среду и, используя результаты анализа чувствительности факторов влияния на среду, определить приоритетность мероприятий оптимизации этапов жизненного цикла продукта и создать рекомендации по экодизайну. Результаты анализа чувствительности показывают что наибольшее влияние на окружающую среду имеет количество материалов, последующими факторами являются расстояния транспортировки готовой продукции, доля мусора мебели, которое в конце жизненного цикла сжигаются, потребление электричество во время производства мебели. Объем производственных отходов имеет сравнительно небольшое влияние. Опираясь на результаты расчетов и программу ECODESIGN PILOT, в работе создан перечень рекомендации по экодизайну для производителей мебели.