Aplinkos tyrimai, inžinerija ir vadyba, 2010. Nr. 4(54), P. 54-61 *ISSN 2029-2139*
Environmental Research, Engineering and Management, 2010. No.4(54), P. 54-61 *(On-line)*

Application of Life Cycle Measures to Increase Efficiency of Domestic Cooling Appliances

Erika Elijošiūtė, Visvaldas Varžinskas
Institute of Environmental Engineering, Kaunas University of Technology, Lithuania

(received in June, 2010, accepted in December, 2010)

Eco-design refers to systematic incorporation of environmental factors into the product design and development with the aim to reduce environmental impact of products throughout their whole life cycle. Electric power consumption of electrical and electronic equipment is one of the principal environmental aspects throughout the product exploitation time. The objective of this study is the application of eco-design methodology for development of improvement of domestic cooling appliances. Refrigeration systems as energy using products have a negative impact on the environment: emissions to air (including greenhouse gases), soil, water, and energy consumption on the whole. Reduction in energy consumption in product use phase is a very important issue due to both environmental impact when equipment operates and to costs of electricity. The accomplished analysis demonstrates the way how global problems related to refrigeration systems could be resolved using the life cycle assessment (LCA) as a measure for finding out significant environmental impact during all product life time.

Key words: *eco-design, refrigeration system, energy using products.*

1. Introduction

The greatest impact of energy-using products is energy consumption and waste generation at the end of product life cycle. With a view to achieving free movement of energy-using goods contributing to sustainable development through energy efficiency and environmental protection, a great task for Lithuanian company ”Snaigė” stock company producing domestic cold appliances is compliance with the requirements of EuP Directive 2005/32/EC. Eco-design is based on a precautionary approach that leads to changes in the early stages of product development and helps avoid environmental problems at the remote stages of the life cycle. Proper implementation of the Directive will provide an opportunity for Lithuanian industrial companies to ensure competitiveness and free movement of goods within the EU market.

Therefore it is essential that manufacturers would have enough information about the Directive and its implementing measures, and would be able to apply them to product development (design) process.

With reference to the integrated product policy approach, on 6 July, 2005 the EU enacted the European Parliament and Council Directive 2005/32/EC laying down eco-design requirements for energy-using products. The Directive aims to improve the environmental performance of the product during its entire life cycle, its systematic integration of environmental aspects in the earliest stage of its development. In Lithuania, like in other EU Member States, the requirements of the Directive were transferred into national legislation. Directive 2005/32/EC has highlighted the fact that energy-using products consume a large proportion of natural resources and energy. It is also noted that the vast majority of product categories available in the market have very different effects on the environment, although they have similar functional performance (Directive 2005/32/EC laying down ecodesign requirements for energy-using products and amending Council Directive 92/42EEB, and the European Parliament and Council Directives 96/57/EC and 2000/55/EC). The requirements in the Directive are fleshed out in the measures which are set for individual product groups. First is implementation of the measures for products that have a significant

impact on the environment (major impacts being those of climate change) and home market. They are released in large quantities and have a high potential for improvement (Staniškis, J. K., Varžinskas, V., Gurauskienė, I., Kruopienė, J. 2007). Directive 2005/32/EC aims at a high level of environmental protection by reducing the potential environmental impacts of energy-using products to the advantage of consumers other end users. Sustainable development also requires proper consideration of the expected impact on health, social and economic effects. The increasing energy efficiency of products contributes to a greater reliability of energy supply which is the basis for rational economic activity thus - for sustainable development (Directive 2005/32/EC amending Council Directive 92/42EEB and the European Parliament and Council Directives 96/57/EC and 2000/55/EC, Staniškis, J. K., Varžinskas, V., Uselytė, R. 2005). The European Commission is preparing an eco-design implementation measure drafts in accordance with separate groups of energy-using products and having ratified these drafts energy-using products will use less electricity, less raw material will be used to manufacture them; at the end of life of energy-using products there must be a potentiality to reprocess them easier, to dispose of or to reuse their separate parts. Currently, the a Regulatory Committee has approved the implementation of four measures: for the equipment of a public lighting sector; for the power consumption of devices operating in standby and off mode; for eco-design requirements for digital television appendage; for eco-design requirements for power supplies (supply units) (Staniškis, J. K., Varžinskas, V., Gurauskienė, I., Kruopienė, J. 2008).

Eco-design which means the integration of environmental protection aspects in the design phase, is the best way to improve the performance of goods in terms of the environmental protection. This measure will stimulate optimization of product features, conservation of resources, reduction in waste and pollution generation, and reduction in chemical risks (The latest EuP measure will drastically the energy performance of external power supplies 2008).improve

Refrigerator is a single home appliance that works in 24/7 mode all day. For this reason, high efficiency is essential to save energy and natural environment (Liebherr produce - refrigerators, freezers, refrigeration equipment 2009). Different models of refrigeration appliances available on the Community market differ in electricity consumption despite their similar characteristics and capacity which means these appliances differ in energy efficiency (European Parliament and Council Directive 96/57 /EC on energy efficiency requirements for household electric refrigerators, freezers and their combinations). Cooling systems have a negative impact on the environment (emissions to air, soil, water, resource use) (Varžinskas, V., Gurauskienė, I., Pipinytė, L. 2007).

The EU has implemented the energy efficiency labelling system which provides users the option to neutrally compare the efficiency of different refrigerators, freezers, and refrigerator/freezer models. Energy efficiency class accuracy (A-F) is based on the energy efficiency index (EEI). “I”, energy efficiency index, (percentage) is cold appliance energy consumption per year divided by the standard cold appliance energy consumption per year (Domestic Refrigerators and Freezers (LOT 13), Economic and market analysis Task 2. Final Draft. 2007).

The regulation implementing the European Parliament and Council Directive 2005/32/EC sets eco-design requirements applicable to the household refrigeration appliances which get electricity from the mains including devices that are sold for non-domestic use or not to refrigerate foods. The regulation also applies the mains operated household appliances which can operate with batteries.

2. General and specific requirements for eco-design.

From 1 July, 2010 the producer’s manuals for wine refrigerators contain the following information: ”This device is intended only for wine store”. The instructions for household appliances made by manufacturers must include the information about the combination of drawers, baskets and shelves in order to achieve the most efficient use of energy and to find opportunities to reduce energy consumption of domestic refrigeration appliance during its operation.

Starting 1 July, 2013 freezers and freezer compartments for fast freezing or any other similar functions performing installation whose temperature is regulated by changing the thermostat setting will be activated by end-users according to the manufacturer's instructions. Their temperature will automatically return to its previous normal storage temperature conditions of not longer than 72 hours. This requirement does not apply to refrigerator/freezer with one thermostat and one compressor having an electromechanical control panel. A refrigerator/freezer with one thermostat and one compressor having an electronic control panel in accordance to the manufacturer's instructions may be used at an ambient temperature below + 16 ° C. and with any winter-mode switch setting or similar function which ensures adequate frozen food storage temperature it will function automatically under ambient conditions. Domestic cooling appliances with a payload capacity of less than 10 litres, being empty, automatically switch to a working mode, at which the maximum period of one hour consumes 0.00 watt of power. The presence of the switch is not sufficient to meet this requirement.

Domestic cooling appliances covered by this Regulation and whose payload capacity is 10 liters or more must comply with the energy efficiency ratio limit set in Tables 1 and 2 (Commission Regulation (EC). 643/2009 in which the European Parliament and

Council Directive 2005/32/EC sets requirements for eco-design of household appliances).

"Snaigė" stock company is the only company manufacturing domestic cooling appliances in Lithuania. Refrigerators carrying "Snaigė" brand represent more than 62% of overall company sales, the part is produced under a special order of "Whirlpool", "Fagor", "Severin" and other Western European companies. ,"Snaigė" produces refrigerators to the largest trading networks of home appliances containing their brands.

Table 1. Compression refrigeration appliances (21; p.191/59)

Date of application	Energy efficiency index (EEI)
2010 July 1st	EEI < 55
2012 July 1st	EEI < 44
2014 July 1st	EEI < 42

The company "Snaigė" has advanced technologies that help increase production capacity, satisfy environmental requirements, improve product quality and working conditions, reduce production costs and labor intensity, save electricity.

Refrigerators produced by "Snaigė" are made of supreme quality materials supplied by famous manufacturers: BASF, "Climate Control" (Germany), ACC, Marcegalia (Italy), and Danfoss (Denmark). Almost all parts used in the manufacturing process are purchased in Western Europe.

Table 2. Absorption and other types refrigeration appliances (21; p.191/60)

Date of application	Energy efficiency index (EEI)
2010 July 1st	EEI < 150
2012 July 1st	EEI < 125
2015 July 1st	EEI < 110

In 2006 "Snaigė" implemented the EC Directive 2002/95/EC on the restriction of use of hazardous substances in electrical and electronic equipment.

Each of the plastic parts of refrigerator is marked (under ISO), which allows to re-use it, recycle and produce materials and/or energy from waste, according to Directive 2002/96/EC on the electrical and electronic equipment, which was also implemented in 2006.

One of the main criterions of eco-design is to increase energy efficiency of products. For several years "Snaigė" has been producing A+ class energy efficiency products that consume up to 58% less energy compared to standard models ("Snaigė". 2010).

3. Research methodology

The goal of Directive 2005/32/EC is complete promotion of sustainable development in pursuance of free movement of energy-using product within the EU market, greater environmental performance and greater energy efficiency of energy-using product. With regard to the fact that, in the design stage, it is possible to reduce the environmental impact of products through the all-product life-cycle up to 80 %, well-run implementation of the Directive 2005/32/EC will provide significant environmental benefits and contribute to sustainable industrial development (Staniškis, J. K., Varžinskas, V., Gurauskienė, I., Kruopienė, J. 2008). Studies on application of life cycle assessment tools to increase the energy efficiency of domestic cooling appliances in Lithuania have not been carried out. Therefore as a research object refrigerator/freezer RF34SM manufactured by "Snaigė" has been chosen. The aim of this study has been to perform environmental impact assessment of this domestic cooling appliance produced in Lithuania using life-cycle assessment tools and to offer recommendations for improvement of its energy efficiency.

The following goals have been proposed to achieve the aim of this study: to analyze the problem of electric power using products and its legal regulation, to assess the refrigerator market and energy efficiency; using life cycle assessment tools to evaluate the environmental impact of the refrigerator/freezer RF34SM manufactured by "Snaigė" throughout its life cycle and identify some significant aspects; under the equivalent capacity calculation methodology to calculate the energy efficiency index (EEI) of the refrigerator/freezer RF34SM and to assess its conformity to the legal requirements in effect from 1 July, 2010; in accordance with results of the study to submit recommendations to increase energy efficiency of the refrigerator/freezer RF34SM with the aim to conform to even more stringent product environmental and energy efficiency requirements in the EU Directives.

In order to make the assessment of the environmental impact of energy-using product easier, the life cycle assessment methodology and software ,,EuP EcoReport" have been used To determine an environmental impact of the product this program identifies the following environmental impact categories:

- Consumption of raw materials (recyclable and non-recyclable);
- The total amount of energy consumed, the quantity of electricity;
- Generation of waste (hazardous and non hazardous);
- Water consumption (for production and cooling);
- Climate change, ozone depletion, acidification, potential of eutrophication;
- Volatile organic compounds, particulate matter emissions;
- Persistent organic pollutants, heavy metals emissions;
- Quantity of polycyclic aromatic hydrocarbons in emissions (MEEUP Methodology Report.

Methodology Study Eco-design of Energy-using Products. 2005).

Equivalent capacity calculation methodology was used to calculate the Energy Efficiency Index (EEI). The equivalent capacity of domestic cooling appliances is the sum of equivalent capacity of all cameras. It is calculated in litres and is rounded to the nearest integer number (see Eq. 1) (Commission Regulation (EC). 643/2009, in which the European Parliament and Council Directive 2005/32/EC sets requirements for the eco-design of household appliances. 2009, Staniškis, J. K., Varžinskas, V., Uselytė, R. 2005).

$$V_{eq} = \left[\sum_{n=1}^{c=n} V_c \times \frac{25 - T_c}{20} \times FF_c^{\int} \times CC \times BI \right] \quad (1)$$

where:

n – number of compartments;

V_c – payload capacity of compartment (s);

T_c – nominal temperature of compartment(s);

$\frac{25 - T_c}{20}$ – thermodynamic coefficient;

FF_c , CC ir BI – capacity correction coefficient.

To calculate EEI of a particular domestic cooling appliance the energy consumption per year of a household appliance is compared to its standard energy consumption per year (Eq. 2).

$$EEI = \frac{AE_c}{SAE_c} \times 100 \quad (2)$$

where:

AE_c - energy consumption of a domestic cooling appliance per year (Eq. 3);

SAE_c - standard energy consumption of a domestic cooling appliance per year (Eq.4).

$$AE_c = E_{24h} \times 365 \quad (3)$$

where

E_{24h} - energy consumption of a domestic cooling appliance over 24 kW.h, rounded to three decimal places.

$$SAE_c = V_c \times M + N + CH \quad (4)$$

where:

V_{eq} – equivalent capacity of a domestic cooling appliance;

CH - coefficient of domestic cooling appliances with a cooling chamber and 15 litres of net capacity at least is 50 kW.h per year;

M and N values of each domestic cooling appliance category are given in the Commission Regulation (EC). 643/2009 Annex 5. (Commission Regulation (EC). 643/2009, in which the European Parliament and Council Directive 2005/32/EC sets requirements for the eco-design of domestic appliances, 2009).

4. Results

The main aim of this study was to estimate the environmental impacts of the refrigerator/freezer RF34SM ("ICE LOGIC") throughout the product life cycle. The tasks of the study were to identify the most significant environmental aspects of the refrigerator/freezer in the production, consumption, and disposal stages, depending on obtained results to offer recommendations on the product design changes in order to satisfy the increasingly more stringent EU requirements in the future, herewith reducing product environmental impact.

During the study the product system and the functional unit were described. Refrigerator/freezer RF34SM is a refrigerating device with a heat insulated chamber and a built-in refrigeration aggregate, which is intended for chilling or freezing of food and beverages. This is a compressor type "N" class device for use at 16 to 32 degrees Celsius.

The functional unit of the study is one unit of the refrigerator/freezer (including the package) in the production, use and disposal stages. In other words, LCA research of this product includes the manufacture of the product, operation and disposal phases.

The framework of the study system (within the confined facilities) reaches the start of the chain of production – processing of the blanks. The life cycle is completed by the refrigerator/freezer waste created at the end of product life. Waste management and recycling are included in the system model. 2010 production data were used for the description of production processes.

During the exploitation of the refrigerator, including the amount of energy needed for product manufacture and disposal, energy consumption is 48205 MJ (87% is electricity). The maximum amount of electricity is consumed in the use phase, the electricity rate is 39688 MJ (97% of the total energy consumption during the use phase) (see Fig. 1).

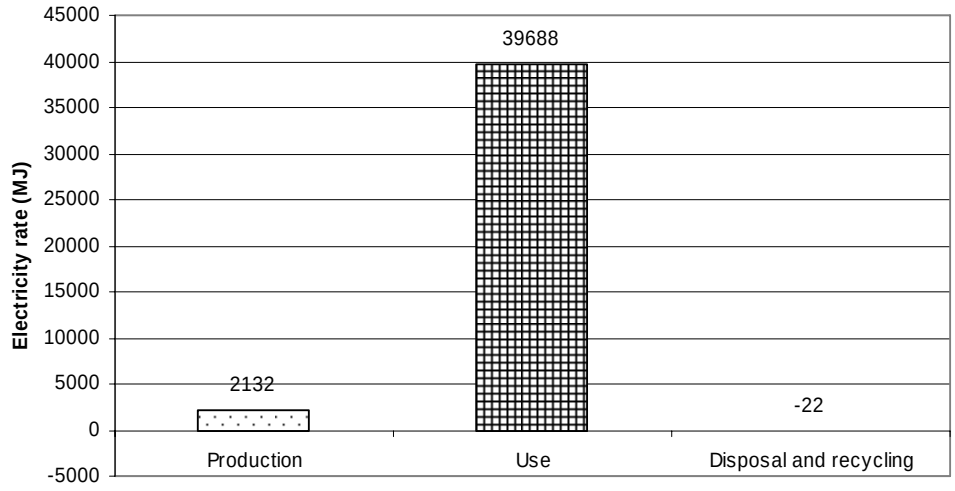

Fig. 1. Electricity consumption during the overall refrigerator/freezer life-cycle

Table 3 shows that the environmental impact is the most serious in the use phase and 100 % relates to emissions into the air. 5 significant environmental impact categories are identified: greenhouse gases, acidifying gases, volatile organic compounds, heavy metals and solid particles emissions into the air. According to the environmental impact categories the impact of the refrigerator/freezer RF34SM during the production phase is slightly lower, although the number of categories of environmental impact to the air and waste water are similar.

Table 3. The environmental impact of all refrigerator/freezer RF34SM life cycle stages according to environmental impact categories

Environmental impact category	Unit	Production	Distribution	Use	The end of life cycle
Emissions (Air)					
Greenhouse Gasses in GWP100	kg CO_2 eq.	302	60	**1827**	50
Acidification emmisions	g SO_2 eq.	1730	182	**10324**	158
Volatile Organic Compaunds (VOC)	g	19	14	**35**	3
Persistent Organic Pollutants (POP)	ng i-T eq.	**514**	3	265	31
Heavy Metals	mg Ni eq.	259	25	**943**	514
PAHs	mg Ni eq.	**2424**	33	362	-2
Particular Matter (PM, dust)	g	182	2353	**4630**	2466
Emissions (Water)					
Heavy Metals	mg Hg/20	**1055**	1	266	152
Eutrophication	g PO_4	**21**	0	1	9

Estimated EEI of refrigerator/freezer "ICE LOGIC" is 40.8. According to the company "Snaigė", the real EEI of this refrigerator model is 42 (see Fig. 2), because of possible deviations from the theoretical value up to 10 %. Since the 1st of July, 2010 refrigerators which would not satisfy EEI <55 will be removed from the market. From 1 July, 2010 this EEI requirement will become even stronger. Presently the EEI of the "ICE LOGIC" is significantly higher compared to the standard, but in the period up to 1 July, 2014 this refrigerator will satisfy the specific eco-design requirements. Despite the conformance to the EU requirements valid until 1 July, 2014 while designing new products that appear on the market now, professionals of the company "Snaigė" will have to take the eco-design measures after several years and make decisions to satisfy legal requirements in the future.

According to the study results eco-design guidelines associated with vacuum and gas-filled panel technologies, forced convection heat meter and linear compressors were offered alongside with air distribution and temperature management in order to increase energy efficiency.

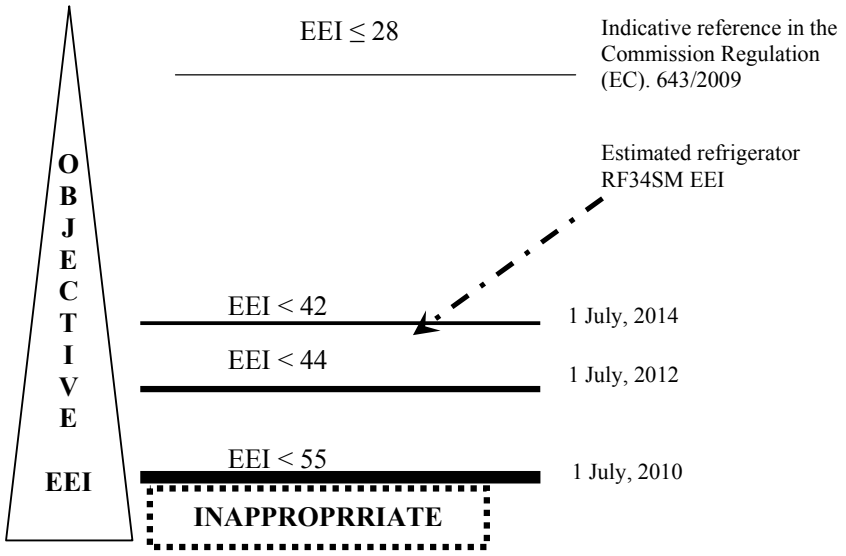

Fig. 2. Legal requirements for energy efficiency (EEI) and the refrigerator/freezer RF34SM EEI

5. Summary and conclusions

After the assessment of refrigerator/freezer RF34SM life-cycle using "Eup EcoReport" software, it was identified that the major impact on the environment is during the use phase. Electricity consumption during the use stage is 97 % of the total amount of electricity consumed throughout the life cycle.

According to the LCA results, it can be concluded that the refrigerator/freezer RF34SM in accordance with Commission Regulation (EC) 643/2009, starting 1 July, 2010 will satisfy the energy efficiency index levels (implementation of Directive 2005/32/EC), but in the period until 1 July, 2014 specialists of the company must adopt eco-design solutions in order to reach conformance to the legal requirements and maintain the product market in the EU.

1. After the assessment of the life cycle of the refrigerator/freezer RF34SM it was identified that the serious negative impact of the product on the environment is in the use phase when electricity is used to operate the refrigerator. The electricity rate over the life cycle is 87 % of the total energy consumption. In the use phase, the largest quantity of greenhouse and acidifying gases, volatile organic compounds, heavy metals and solid particles emissions into the air were estimated. Persistent organic pollutants and polycyclic aromatic hydrocarbons quantities in the air are the biggest in the production phase, as well as the largest quantity of heavy metals and eutrophication causing contaminants in the water are likewise observed in the production phase.
2. The estimated product EEI calculated in the study satisfies the EuP Directive specific eco-design requirements of the product group only until 1 July, 2014. By then the company will have to apply the proposed eco-design solutions to a new product development process to ensure the conformance to the legal requirements and opportunities to continue the product delivery to the EU market.
3. In order to increase the energy efficiency, according to the research results seven eco-design guidelines were offered associated with: vacuum and gas-filled panels technologies; air distribution and temperature management; forced convection heat meter and linear compressors which reduce energy consumption by 20 percent, compared to a conventional compressor. The introduction of the proposed guidelines significantly increases energy efficiency which will allow the company to satisfy the requirements of Directive 2005/32/EC in the future.

References

Staniškis, J. K., Varžinskas, V., Gurauskienė, I., Kruopienė, J. 2007. European Parliament and Council Directive 2005/32/EC laying down ecodesign requirements for energy-using products, the implementation of the Programme in Lithuania studio. (Lithuanian Ministry of Economy). Vilnius: "Centre for Sustainable Industrial Development".

Staniškis, J. K., Varžinskas, V., Gurauskienė, I., Kruopienė, J. 2008. Eco-design Directive (2005/32/EC), implementing for various product groups. (Lithuanian Ministry of Economy). Vilnius: "Centre for Sustainable Industrial Development".

Staniškis, J. K., Varžinskas, V., Uselytė, R. 2005. Product eco-design. Monograph. Kaunas, Technologija. p. 132. p.p. 28-45.

Varžinskas, V., Gurauskienė, I., Pipinytė, L. Improvement in Enviromental Performance of Vapour Compression Refrigeration System by the Model for Environmental Product Development. Environmental

Research, Engineering and Management, 2007. No.2(40), P. 59-69.Kaunas, Technologija. ISSN 1392-1649.

Azapagic A. (1999). Life cycle assessment and its application to process selection, design and optimization. *Chemical Engineering Journal*, 73, p. 1-21.

Bertoldi P., Ricci A., Almeida A. (ed., 2001). Energy Efficiency in Household Appliances and Lighting. Germany: Springer.

Curran M. A. (1996). The history of LCA. Environmental life-cycle assessment. *The International Journal of Life Cycle Assessment,* 1, p. 179-192

Khan F. I., Natrajan B. R., Revathi P. (2001). GreenPro: a new methodology for cleaner and greener process design. *Journal of Loss Prevention in the Process Industries*, 14, p. 307-328

Hyun K., Chul-gi R., Jong-kwon K., *et al*. (2009). An experimental and numerical study on dynamic characteristic of linear compressor in refrigeration system. *International Journal of Refrigeration, 7*, p. 1536-1543.

Lewis H., Gertsakis J., Grant T. et al. (2001). Design+ environment: a global guide to designing greener goods. UK: Greenleaf publishing.

Petek J., Glavic P. (1996). An integral approach to waste minimization in process industries. *Resources, Conservation and Recycling*, 17, p. 169-188.

Staniškis J. K., Stasiškienė Ž., Kliopova I. (2004). Subalansuotos pramonės plėtros strategija: teorija ir praktika. Kaunas: Technologija.

Uselytė R., Karaliūnaitė I. (2003). Aplinkosauginio gaminių projektavimo galimybės Baltijos šalių pramonėje. *Aplinkos tyrimai, inžinerija ir vadyba,* 1(23), p. 76-78.

Gurauskienė I., Varžinskas V. Eco-design methodology for electrical and electronic equipment industry. Environmental research, engineering and management=Aplinkos tyrimai, inžinerija ir vadyba. 2006, Vol. 37, No. 3, pp. 43-51 Kaunas: Technologija ISSN 1392-1649 [INSPEC; CAB Abstracts].

Rebitzer, G., Ekvall, T., Frischknecht, R., Hunkeler, D., Norris, G., Rydberg, T., Schmidt, W.-P., Suh, S., Weidema, B.P., Pennington, D.W. (2004) Review. Life cycle assessment. Part 1: Framework, goal and scope definition, inventory analysis, and applications. Environment international, 30, p. 701– 720

AB „Snaigė". 2010. Activity data. Alytus.

Commission Regulation (EC). 643/2009, in which the European Parliament and Council Directive 2005/32/EC sets household appliances eco-design requirements. 2009. [2010-02-10]: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:191:0053:0068:LT:PDF.

Domestic Refrigerators and Freezers (LOT 13), Economic and market analysis Task 2. Final Draft. 2007. [2010-02-19]: http://www.cfsd.org.uk/seeba/EuP/eup.htm.

European Parliament and Council Directive 2005/32/EC laying down ecodesign requirements for energy-using products and amending Council Directive 92/42EEB and the European Parliament and Council Directives 96/57/EC and 2000/55/EC. Brussels 2005 6 July http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:191:0029:0058:lt:PDF.

European Parliament and Council Directive 96/57/EC on energy efficiency requirements for household electric refrigerators, freezers and their combinations. 1996 3 September. [2010-02-19]: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0057:LT:NOT.

MEEUP Methodology Report. Methodology Study Eco-design of Energy-using Products. 2005. (European Commission). Netherlands. VHK (*Van Holsteijn en Kemna*).

Dr. Visvaldas Varžinskas, researcher at the Institute of Environmental Engineering, Kaunas University of Technology.
Main research areas: sustainable production and consumption, eco-design, life cycle assessment (LCA).
Address: K. Donelaičio str. 20, LT-44239 Kaunas, Lithuania
Fax: +370-37- 209372,
Tel.: +370-37-209372,
E-mail: visvaldas@apini.lt

Erika Elijošiutė, MSc. student at the Institute of Environmental Engineering, Kaunas University of Technology.
E-mail: elijosiute.erika@gmail.com

Būvio ciklo įvertinimo priemonių taikymas, didinant buitinių šaldymo aparatų energijos vartojimo efektyvumą

Erika Elijošiūtė, Visvaldas Varžinskas
Aplinkos inžinerijos institutas, Kauno technologijos universitetas

(gauta 2010 m. birželio mėn.; atiduota spaudai 2010 m. gruodžio mėn.)

Ekologiškai projektuojant gaminius, aplinkosauginiai aspektai sistemingai naudojami kuriant, plėtojant gaminius tam, kad būtų sumažintas poveikis aplinkai per visą gaminio būvio ciklą. Elektros energijos vartojimas elektros ir elektroninėje įrangoje yra vienas iš svarbiausių aplinkosauginių aspektų per visą gaminio naudojimo laiką. Šiame straipsnyje pateikiamas gaminio aplinkosauginių savybių gerinimo pavyzdys, pritaikant energiją vartojančių gaminių (EVG) tyrimo ir ekologinio projektavimo metodiką. Pavyzdiniu gaminiu pasirinktas buitinis šaldymo aparatas – šaldytuvas ir šaldiklis, kurie daro didelį poveikį aplinkai dėl suvartojamos elektros energijos kiekio ir išlakų bei jų daromos žalos aplinkai. Šaldymo sistemos, kurios plačiai naudojamos ne tik versle, bet ir buityje, daro didelę įtaką globalioms problemoms: klimato kaitai ir ozono sluoksnio irimui. Šiame straipsnyje pateikiamos gaminio tobulinimo galimybės, naudojant sisteminį aplinkosauginio gaminių kūrimo modelį, ir įvertinama gaminio atitiktis įsigaliosiantiems ES teisės aktams, reglamentuojantiems buitinės šaldymo įrangos energetinio efektyvumo parametrus.