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elni REVIEW

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We believe that these five issues encapsulate the most relevant questions and provide a broad framework upon which further discussions for a successful legislative process can be based on. So far, there is not much relevant research to answer these questions, especially in the context of emerging economies. Therefore, these questions also provide a research agenda for further investigation on e-waste legislation.

Challenges for eco-design, energy efficiency and waste treatment of electrical and electronic products against the background of requests for exemptions following requirements of Article 5 (1) (b) RoHS Directive

Stéphanie Zangl and Carl-Otto Gensch

Abstract

The EU Directive 2002/96/EC on restriction of use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) stipulates that from 1st July 2006 onwards new electrical and electronic equipment put on the market will not contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl ethers (PBDE). This restriction shall not apply to applications listed in the Directive's Annex.

Article 5 (1) (b) contains criteria for exempting materials and components from the above-mentioned restriction in order to adapt the Annex to scientific and technical progress. Stakeholders have been invited to apply for exemptions from restriction of use according to the criteria in Article 5 (1) (b) against the background of adaptation of the Annex to scientific and technical progress. Prior to an amendment of the Annex, a public stakeholder consultation has to take place.

Öko-Institut e.V. (the Institute for Applied Ecology) and Fraunhofer IZM (the Institute for Reliability and Microintegration) have been appointed by the European Commission to review the requests. The experience gained during this work will be introduced in this paper, i.e. it will be outlined how the requirements of the RoHS Directive affect eco-design, energy efficiency and waste treatment of domestic appliances and lighting (DAL) and what opportunities and drawbacks could arise as a consequence thereof.

1 The RoHS Directive and its implications on DAL

Domestic appliances and lighting equipment are part of the product category headed "electrical and electronic equipment (EEE)". This product category has been the subject of recently-implemented environmental EU legislation: on the one hand, the framework for dealing with these products at their end-of-life has been set by the so-called WEEE Directive[1]. On the other hand, the use of certain substances in these products has been restricted by the so-called RoHS Directive[2].

The WEEE Directive is valid for products that are part of one of the 10 product categories listed in its Annexes I A and B. Domestic appliances fall under the following categories "1). Large household appliances", "2). Small household appliances", "3). IT and telecommunications equipment" and "4). Consumer equipment". Lighting equipment is accorded its own product category (no. 5). The RoHS Directive is also valid for these product categories, but specifies that its regulations on lighting equipment only apply to electric light bulbs and luminaries in households.

The RoHS legal framework outlined above carries the following implications for DAL:

1 Directive 2002/96/EC of 27 January 2003 on waste electrical and electronic equipment, OJ L 37/24.

2 Directive 2002/95/EC of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, OJ L 37/19.

- From 1st July 2006, new DAL put on the market are not allowed to contain lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB) or polybrominated diphenyl eth11ers (PBDE);
- As a result, manufacturers had to commence research and development efforts some time ago, either in order to find substitute materials for those substances or to eliminate those substances or find other technical solutions which do not make use of restricted substances for their applications.
- The Annex to the RoHS Directive contains certain specific exemptions from the requirements of the Directive. Stakeholders in the area of DAL can, in the process of the adaptation of the Annex to scientific and technical progress, apply for further exemptions to be taken into consideration.

By means of one specific example this paper will focus on the implications of the RoHS Directive on the eco-design, waste treatment and, partly, the energy efficiency of DAL against the background of requests for exemptions according to the requirements of Article 5 (1) (b) of the RoHS Directive.

2 The critical review process of requests for exemption

In the period between August 2005 and July 2006, about 80 requests for exemption from the RoHS Directive were evaluated by the Öko-Institut and Fraunhofer IZM. All of these requests were sent to the European Commission, who subsequently had to carry out a stakeholder consultation. In total, 4-5 stakeholder consultations were undertaken during the period of the critical review process.

Once the consultation had been concluded and comments were gathered from stakeholders with regard to certain requests, the critical review process began, taking the following procedural steps:

- Check requests regarding completeness / consistency
- Check whether applications fall under scope of RoHS
- Analyse whether requests use justification in line with Art. 5 (1) (b)
- Check stakeholder comments regarding relevance for single requests
- Contact applicant / stakeholder / external expert to clarify open questions
- Assess the gathered information
- Make final recommendations to Commission including the wording of exemption in monthly reports

During the course of this work, several challenges needed to be met. First of all, the level of quality of the exemption requests was very varied – as much regarding the justification argumentation that was employed, as regarding supporting documentation. This led to the fact that, in order to reach a uniform level of the documents to be evaluated, applicants sometimes needed to be asked repeatedly for further information. Secondly, the response from the stakeholders was poor in many instances, especially when looking at possibilities of outlining existing RoHS compliant alternatives to requested exemptions. This was particularly difficult since knowledge on existing alternatives and substitute materials is not always widespread, nor available to public. Hence, with an eye to a sound review process, it was sometimes difficult to assess in depth whether an alternative was available on the market and the granting of an exemption would therefore not be justified.

Furthermore, the regulation in Article 5 (1) (b) of the RoHS Directive, which explicitly refers to technical / scientific or environmental argumentation that can be used to justify an exemption request, leaves room for interpretation. For example, the non-availability of components in the supply chain can be regarded as an economic argument (rendering it therefore invalid), or can be regarded as a technical issue hindering substitution (constituting thereby a valid argument). Hence, in many cases, it needed to be assessed in a rather general way whether substitution was actually feasible in (technical) practice.

Even though the above-mentioned challenges had to be taken into account, it should be clearly stated that, in consequence of the review process, many substitute materials and alternatives exist for applications in EEE. Only in very specific applications, might an exemption be necessary in order to guarantee technical functionality. For the broad range of DAL applications and products, efforts were made to find substitutions, which were put into practice before 1st July 2006. This can also be deduced from the fact that only a small number of the requested exemptions come from the area of domestic appliances and lighting equipment.

3 Exemption request for discharge lamps

In the course of the review process of requests put forward for exemptions from the RoHs Directive, some requests did refer to DAL. This section will illustrate one example in order to better appreciate the implications of the RoHS Directive's requirements on specific applications, i.e. for which applications the granting or refusing of exemptions would ensure successful eco-design, high energy efficiency and environmentally-sound waste treat-

ment. The example will also elaborate what viable substitutes/alternative technologies are at hand that allow progress in eco-design, energy efficiency and environmentally-sound waste treatment.

3.1 Discharge lamps containing lead in the form of amalgam

The request has been put forward for the use of lead in the form of PbBiSn-Hg and PbInSn-Hg in specific compositions such as amalgam, and in the form of PbSn-Hg as auxiliary amalgam in very compact Energy Saving Lamps (ESL). These substances control the mercury vapour pressure inside small compact fluorescent lamps (especially the types with a closed cover), stabilising the light output and lamp efficacy over a wide ambient temperature range. This makes it possible for incandescent lamps to be replaced by energy saving lamps in a wide range of applications, both indoor and outdoor. ESL can only be made in GLS (General Lighting Service) dimensions and shape (corresponding to a common light bulb; see figure 2) when Pb-containing amalgam can be applied.

Light output versus temperature of ESL

Lamps with amalgam+Pb (blue curve) have a superior performance across a wide range of ambient temperatures, hence do not suffer from light losses in very compact lamp designs

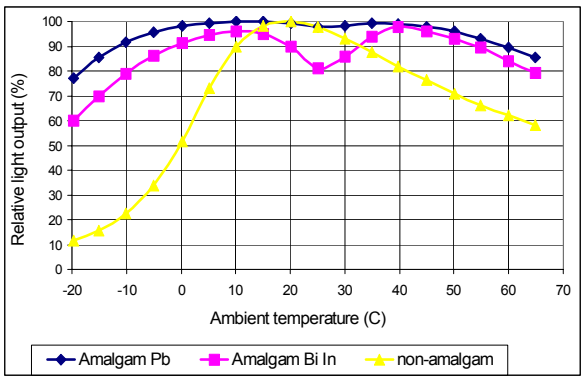

Fig. 1: Light output versus temperature of ESL [source: ELCF]

In the context of this exemption request, the necessity of studying every single specific use of certain substances in corresponding applications in a differentiated fashion is evident. Lead is used here so that an ESL can be placed on the market as a substitute for small GLS lamps, bringing about in turn energy savings in the use of lighting equipment. Existing lead-free alternatives are not able to create optimum mercury pressure in ESLs with GLS-equivalent dimensions. Consequently, either the light output will be slighter when maintaining GLS dimensions, or the product size will be significantly larger in order to maintain the light output.

According to the European Lamp Companies Federation (ELCF), the penetration threshold in the percentage of users of 1 or more compact fluorescent lamp lies at 50%, even in developed markets. The annual European market (Western Europe and Eastern Europe) is 2.5 billion for GLS and 0.15 billion for compact fluorescent lamps (CFL). According to ELCF documentation, consumers do not use CFL due to dissatisfaction with price, size and the 'odd' shape (compared to reference incandescent lamps).

As the market for classic ESL is already well developed, this new market of smaller energy-saving lighting equipment constitutes an important target, supported by overall environmental policy. However, it does need to be examined whether the energy saved by the 1:1 substitution of GSL lamps with small ESL engenders a higher environmental benefit than the damage that lead causes: this is due to the fact that energy production brings about mercury and lead emissions and that lead production requires a certain amount of energy for its production. Both alternatives have, therefore, a negative environmental impact, which need to be weighed up in order to identify the less harmful option environmentally. Former studies and research on the

comparison of conventional incandescent lamps and energy saving lamps[1] concluded that approximately 95% or 90%, as the case may be, of the environmental impact is generated in the use phase. Hence, the production phase does not have a significant environmental impact. The ELCF states that substitution by products not containing lead would bring about increased mercury (Hg) and lead (Pb) emissions during electricity generation, estimated at 900 kg Pb/a[2] and 20 kg Hg/a[3] for 15 million ESL. ELCF quantifies the total potential energy savings as follows: assuming a 10% increase in ESL usage (150 million current market volume + 10%), the annual power consumption would be reduced by 765 million kWh (=15 million x 60 W x 850 hours[4]), which equals the emission of approximately 320.000 tons of CO_2[5].

Thus, even though there are differences between the different European countries, it is believed that within the EU the overall benefit of substituting small GSL with ESL is assured.

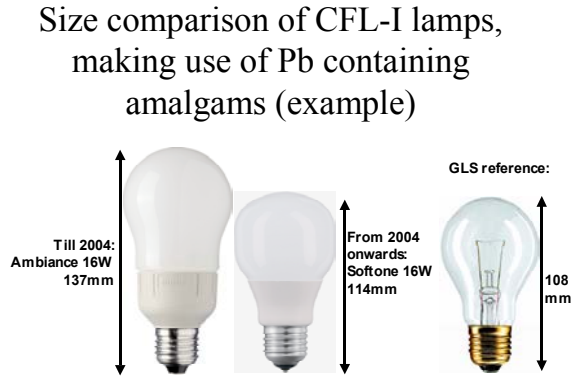

Fig. 2: Size comparison of very compact Energy Saving Lamps with GLS [source: ELCF]

Furthermore, the use of lead as an amalgam in very compact ESL allows these lamps to be made available at a competitive price. This constitutes a further asset in the process of substituting "classic light bulbs".

On the basis of the arguments detailed above, the Öko-Institut recommended that an exemption be granted for this specific application of lead in lighting equipment. In the medium term, however, efforts are being made by manufacturers to substitute lead in very compact ESL. For that reason, it was also recommended that the exemption be limited to the period of time required by these R&D activities. This time period is stated by the ELCF as lasting until 2010. Since the Annex of the RoHS Directive is reviewed every four years, the exemption would in any case be subject to revision by 2010; also, no further time limit has been proposed.

This recommendation was adopted by the Commission in a Draft Decision with an eye to amending the Annex of the RoHS Directive. The so-called TAC (Technical Adaptation Committee) delivered a positive vote on this exemption request. Meanwhile, the Commission has published the exemption in its Decision 2006/310/EC of 21st April 2006 (exemption no. 19).

4 Conclusions

Synthesizing all aspects mentioned in this paper, the following conclusions can be drawn with regard to the impact of the requirements of the RoHS Directive on DAL:

- The restriction on substances in most cases leads to applications and products needing to be re-designed, and to alternatives and substitution possibilities being sought after. This can have an impact on the overall eco-design of DAL. At the least, requirements of the RoHS Directive need to be taken into account during R&D efforts made in the framework of eco-design policies.
- Refraining from using restricted RoHS substances also has an impact on the waste management of DAL when their end-of-life is reached. Since the RoHS Directive was elaborated within the same general environmental policy framework as the WEEE Directive (i.e. enlarging producer responsibility, reducing load of "priority substances[6]" in EEE and thereby reducing contamination of waste, ensuring separate collection of WEEE in order to reduce the amount of hazardous substances in municipal waste stream, ensuring a special treatment of WEEE, taking its particularly high

1 Cf. Pfeiffer, R.; Produktlinienanalyse "Glühlampe versus Energiesparlampe". Öko-Institut e.V., 1994 and AEA Technology Environment. Revising ecolabel criteria for lamps. A report produced for the European Commission DG XI.E.4, March 1999.

2 ELCF estimated 10 ppm lead per ton of coal or 1.2 ppm per kWh for a coal-fired power plant, which in turn engenders solid waste containing lead.

3 ELCF took into account emissions into air of 0.0289 mg per kWh, averaged over existing EU power plants.

4 Average annual burning hours.

5 ELCF used the EU average value of 0.42 kg CO_2 emission per kWh.

6 Meaning those substances identified as being particularly harmful to the environment, especially when used in EEE.

amount of valuable raw material and hazardous substances into account), the desired effect is as follows: when the amount of hazardous substances is reduced at the very beginning of a product's lifetime, the negative impact on the waste stream is also reduced.

- In some cases, though, (as the example on very compact Energy Saving Lamps demonstrated) it appeared that it might be necessary to take a closer look at the sensibility of the restriction of use as regards environmental benefits. Here, an exemption of the requirements of the RoHS Directive enables energy savings to be reached. By making these lamps available on the market (even though they contain lead), conventional light bulbs could be replaced and energy savings in households would thereby be increased.
- Domestic appliances and lighting constitute parts of electrical and electronic equipment which have a particularly high potential to increase energy efficiency. The RoHS Directive may support efforts made in this direction, but does not necessarily wield a direct impact. Companies aware of the challenges set by environmental policy will incorporate the Directive's requirements in their overall environmental product policy development.
- The adaptation of the Directive's Annex to scientific and technical progress gives companies the opportunity to take a closer look at their products: if they are able to argue that continuing to use some of the restricted substances will lead to energy savings which would not have been possible with the use of substitutes, then the chance of being granted an exemption is quite high. Moreover, the requirements of the Directive should be taken as a welcome opportunity to consider a re-design of products.
- In the future, product policy development will probably lead to even more restrictions of use for substances considered to be particularly harmful to the environment. Linking the efforts involving eco-design, increasing energy efficiency and the efforts in developing products containing less harmful substances can only be of long-term benefit for companies.

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The Öko-Institut (Institut für angewandte Ökologie - Institute for Applied Ecology, a registered non-profit-association) was founded in 1977. Its founding was closely connected to the conflict over the building of the nuclear power plant in Wyhl (on the Rhine near the city of Freiburg, the seat of the Institute). The objective of the Institute was and is environmental research independent of government and industry, for the benefit of society. The results of our research are made available of the public.
The institute's mission is to analyse and evaluate current and future environmental problems, to point out risks, and to develop and implement problem-solving strategies and measures. In doing so, the Öko-Institut follows the guiding principle of sustainable development.
The institute's activities are organized in Divisions - Chemistry, Energy & Climate Protection, Genetic Engineering, Sustainable Products & Material Flows, Nuclear Engineering & Plant Safety, and Environmental Law.

The Environmental Law Division of the Öko-Institut:
The Environmental Law Division covers a broad spectrum of environmental law elaborating scientific studies for public and private clients, consulting governments and public authorities, participating in law drafting processes and mediating stakeholder dialogues. Lawyers of the Division work on international, EU and national environmental law, concentrating on waste management, emission control, energy and climate protection, nuclear, aviation and planning law.

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The University of Applied Sciences in Bingen was founded in 1897. It is a practiceorientated academic institution and runs courses in electrical engineering, computer science for engineering, mechanical engineering, business management for engineering, process engineering, biotechnology, agriculture, international agricultural trade and in environmental engineering.

The *Institute for Environmental Studies and Applied Research* (I.E.S.A.R.) was founded in 2003 as an integrated institution of the University of Applied Sciences of Bingen. I.E.S.A.R carries out applied research projects and advisory services mainly in the areas of environmental law and economy, environmental management and international cooperation for development at the University of Applied Sciences and presents itself as an interdisciplinary institution.

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The Society for Institutional Analysis was established in 1998. It is located at the University of Applied Sciences in Darmstadt and the University of Göttingen, both Germany.
The sofia research group aims to support regulatory choice at every level of public legislative bodies (EC, national or regional). It also analyses and improves the strategy of public and private organizations.
The sofia team is multidisciplinary: Lawyers and economists are collaborating with engineers as well as social and natural scientists. The theoretical basis is the interdisciplinary behaviour model of *homo oeconomicus institutionalis*, considering the formal (e.g. laws and contracts) and informal (e.g. rules of fairness) institutional context of individual behaviour.

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In many countries lawyers are working on aspects of environmental law often with environmental initiatives and organisations or as legislators, but have limited contact with other lawyers abroad, although such contact and communication is vital for the successful and effective implementation of environmental law.

In 1990 a group of lawyers from various countries therefore decided to initiate the Environmental Law Network International (elni) to promote international communication and cooperation worldwide. Since then elni has grown to a network of about 350 individuals and organisations from throughout the world.

Since 2005 elni is a registered non-profit association under German Law.

elni coordinates a number of different activities:

Coordinating Bureau

The Coordinating Bureau was originally set up at and financed by the Öko-Institut in Darmstadt, Germany, a non-governmental, non-profit making research institute. The Bureau is currently hosted by the University of Applied Sciences in Bingen. The Bureau acts as an information centre where members can obtain information about others working in certain areas thus promoting the development of international projects and cooperation.

elni Review

The elni Coordinating Bureau produces and sends to each member the elni Review twice a year containing members' reports on projects, legal cases and developments in environmental law. elni therefore encourages its members to submit such articles to be published in the Review in order to allow the exchange and sharing of experiences with other members.

elni Conferences and Fora

elni conferences and Fora are a core element of the network. They provide scientific input and the possibility for discussion on a relevant subject of environmental law and policy for international experts. The aim is to bring together scientists, policy makers and young researches, giving the opportunity to exchange views and information as well as developing new perspectives.

Publication Series

The elni publications series contains 12 volumes on different topics of environmental law.

- Environmental Law and Policy at the Turn to the 21st Century, Liber amicorum, Betty Gebers, Ormond/Führ/ Barth (eds.) Lexxion 2006.
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elni Website: elni.org

The elni website at *http://www.elni.org* contains news about the network and an index of elni articles, gives an overview of elni activities, and informs about elni publications. Internships for young lawyers/law students at the Öko-Instituts environmental law division are also offered on the web.

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