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# Identification and assessment of product's measures to improve resource efficiency: the case-study of an Energy using Product

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The article introduces the "Resource Efficiency Assessment of Products" (REAPro) method to assess and improve the resource efficiency of Energy Using Products, with a special focus to their end-of-life. The method allows to identify product's hot spots relevant for the following criteria: reusability/recyclability/recoverability (in mass and in terms of environmental impacts); recycled content (in mass and in terms of environmental impacts); use of hazardous substances. The method is structured into five steps: characterization of the product; assessment against the selected criteria; identification of product's hot spots; identification of improvement measures (at the product level); assessment of policy measures for resource efficiency (at the 'product group' level). The method includes the calculation of a comprehensive set of lifecycle based indices, including some original indices, as the "Reusability/Recyclability/Recoverability benefits rates" and the "Recycled content benefit rate". The method is applied to a case-study Liquid Cristal Display (LCD) television. Some exemplary measures to improve resource efficiency of television are discussed as: the improvement of products recyclability through the setting of thresholds of the time for dismantling; the setting of a minimum recycled content of large plastic parts; the declaration of the content of indium in the displays. Potential environmental benefits associated to these measures have been estimated. The method also proved to be relevant to current European Union (EU) policies and some of the presented results are being used as input for some on-going policy processes.


## 1. Introduction

Products have important environmental impacts during their life cycle, but "once a product is put on the market, there is relatively little than can be done to improve its environmental characteristics" (EC, 2001). It is therefore necessary to integrate environmental considerations throughout the whole production process, and in particular, during the early phases of product development (ISO, 2002a; Luttropp and Lagerstedt, 2006). "Complex product manufacturers should improve the design of their products more and more in relation to their end-of-life treatment [...]. Recovery activity [...] varies strongly among regions and countries and is quickly evolving. Not only currently available recovery technologies but also promising ones for the future should therefore be considered by manufacturers when designing products" (Mathieux et al., 2008).

The EU Waste Framework Directive (2008/98/EC) underlined the need to identify prevention measures, including "the formulation of a product eco-design policy addressing both the generation of waste and the presence of hazardous substances in waste, with a view to promoting technologies focussing on durable, re-usable and recyclable products" (EU, 2008). In, 2011 the European Commission (EC) published the "Roadmap to a Resource Efficient Europe" identifying the use of waste as one of the European Union (EU) key resources to lower the dependence on imports of raw materials and to lower impacts on the environment (EC, 2011a). Similar concepts related have been also highlighted by the UNEP Resource Panel (UNEP, 2011).

The European roadmap on resource efficiency also set some strategies and milestones for the next future, as the improvement of the quality and quantity of recycling and the progressive limitation of energy recovery and landfilling (EC, 2011a). The EC aims, among the others, to stimulate the secondary materials market and demand for recycled materials through developing end-of-waste criteria as (EC, 2011a): minimum recycled material rates, durability and reusability criteria and extensions of producer responsibility for key products. Furthermore, the improvement of

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recycling rates of materials can be very effective to reduce supply risks, especially for material that are critical for the economies (EC, 2010c).

### 1.1. Criteria for resource efficiency of products

The principles of the EC roadmap and of the waste directive have been already put into practice in several pieces of legislations as, for example, in the setting of minimum recycling and recovery rates (in mass) for Waste of Electrical and Electronic Equipment (WEEE) (EU, 2012) or in the setting of minimum thresholds for some product's criteria as reusability/recyclability/recoverability – RRR – (in mass) for new vehicles (EU, 2005). The objective is the improvement of the product's resource efficiency throughout its whole lifecycle. Principles of the ecodesign have been also applied by the EU to the recent Directive "for the setting of ecodesign requirements for energy-related products (ErP)" (EU, 2009).

Measures for the improvement of the product's resource efficiency can be identified taking into account some of the basic strategies of eco-design (reduction, reuse and recycle, recovery and treatment for disposal) (Cellura et al., 2012). Conscious that the improvement of the product's performances often involves several possible strategies, it is envisaged to develop tools to support designers and policy makers in the assessment of possible ecodesign measures (Ardente et al., 2003; Mathieux et al., 2008; Gehin et al., 2008; Lelah et al., 2011). These should be also evaluated in terms of potential benefits and costs achievable at the product group level, including the assessment of best available technologies in comparison with average products available on the market (VHK, 2011).

The MEErP (Methodology for the Ecodesign of Energy-related Products) (VHK, 2011) has been developed by the EC for the identification of relevant energy-related measures in the European Ecodesign policy context. However, several stakeholders (including associations of consumers, non-governmental organisations and representatives of Member States) recently highlighted the need of more systematic and comprehensive assessments of other resource efficiency aspects, including those related to the end-of-life (EoL) of products (DEFRA, 2011; VHK, 2011; BIOis, 2013). In particular, it is recognised that lack of robust methods is one of the barrier for the integration of resource efficiency issues into product policies (Dalhammar and Machacek, 2013).

The development of methods, standards and tools for the measurement/assessment of resource efficiency criteria is therefore necessary and also encouraged by the legislation as in article 7.4 of the Directive on the EoL of vehicles, which states that the EC "shall promote the preparation of European standards relating to the dismantlability, recoverability and recyclability of vehicles" (EU, 2000). A first method for the calculation of the recyclability/recoverability rates has been illustrated by the standard ISO 22628 (2002b) based on the analysis of the Bill of Materials (BoM) and of the architecture of new vehicles, and on the consideration of proven technologies for the treatments of waste (ISO, 2002b). Recently a similar standard has been developed for the calculation of the RRR rates for Electrical and Electronic Equipment (EEE) (IEC, 2012).

Although these methods represent an important development for the assessment of RRR, some authors criticized the exclusive use of mass-based indicators because insufficient. This concept has been repealed also by the IEC/Technical Report (TR) 62635 (IEC, 2012), which recognized that "the calculation of recyclability rate based on the product mass approach is not the only the criteria to ensure a material efficient design (e.g. for rare materials)". On this issue, Huisman et al. (2003) highlighted that recyclability on weight basis is likely to lead to incorrect decisions. The calculation of the recyclability "should indicate and prioritize from an environmental perspective the avenues for product (re)design for end-of-life treatment" (Huisman et al., 2003). In fact, a material could be not relevant in terms of mass, being relevant in terms of contribution to the lifecycle impacts of the product (Mathieux et al., 2008; Ardente and Mathieux, 2012). Recyclability in environmental terms aims also at increasing the 'recycling quality' meaning the "maximum retention of value from recyclates for producing high quality recycled products with relatively low impact on the environment" (Ravi, 2012).

Another key issue is the promotion of recycled content for the production of certain materials. On this topic the ILCD Handbook (EC, 2010a) concluded that if the amount of a certain material "that is available via reuse/recycling/recovery is higher than the demand, and the market value is accordingly below zero, the main necessity is to increase the demand for the secondary good (i.e. recycled content) and/or its technical quality […], but not the simple recycling rate". Some materials, as for example metals, are largely recycled due to the high value of the recycled material compared to the virgin one (Villalba et al., 2002).

Potential target materials for recycled content measures could be, for example, plastics (Froelich et al., 2007; Hopewell et al., 2009). The increase of recycled content of plastics also produces relevant environmental benefits (Froelich et al., 2007; Ardente et al., 2009). Some examples of measures for the promotion of recycled content of plastics into EEE have been already introduced in the current EU policies, as in the EU Ecolabel (EC, 2011b).

The reduction of use of hazardous substances is also a potential strategy to improve the resource efficiency of products by reducing the production of hazardous waste and improving the RRR of products. Possible related Ecodesign strategies are: the minimization of the use of hazardous substances in product (Donnelly et al., 2006), the identification of alternatives to hazardous substances (Knight and Jenkins, 2008), the reduction of the amount of hazardous waste during production (Wood et al., 2010) or the improvement of EoL treatments of hazardous waste (Ravi, 2012). These strategies have been also applied by some legislation to restrict use of hazardous substances (EU, 2006; EU, 2011) and improve the management of hazardous waste (EU, 2012).

Durability is certainly a key ecodesign aspect since lifecycle impacts of products relate to the lifetime (Ardente et al., 2005). This is particularly relevant for Energy using Products (EuP) or Energy Related Products (ErP), being that an increased lifetime would affect the energy performances of the product, potentially delaying the substitution with more energy efficient solutions, as for example, for energy plants (Ardente et al., 2005) or for buildings and building materials (Ardente et al., 2006, 2011). Methods for the measurement and assessment of product's durability are still an open issue, under debate in the scientific literature (Ardente and Mathieux, 2013). Possible strategies to improve product's durability include: minimum lifetime (measured according to standardized method as (CIE, 2005)), reparability and maintainability (Kostecki, 1998; Brook Lyndhurst, 2011), remanufacturing (Östlin et al., 2009), upgradability (Sundin and Bras, 2005; Brook Lyndhurst, 2011), improved warranties/guarantees (Brook Lyndhurst, 2011). Finally, further ecodesign criteria that have been identified as potentially relevant for the assessment of resource efficiency of products are: design for resource reduction (i.e. dematerialisation (Gottberg et al., 2006)) and design for use of renewable materials (EC, 2001). However, methods to quantitatively assess these criteria are still to be developed.

### 1.2. Aim of the article

The development of method for resource efficiency consists of investigating available ecodesign tools and criteria, analysing their compatibility, adapting/improving the most promising ones and