One step back, two steps forward – resource efficiency requirements within ecodesign

Dr. Moritz-C. Schlegel
BAM Federal Institute for Materials Research and Testing
Rudower Chaussee 11
DE-12489 Berlin
Germany
moritz-caspar.schlegel@bam.de

Dr. Floris Akkerman
BAM Federal Institute for Materials Research and Testing
Rudower Chaussee 11
DE-12489 Berlin
Germany
floris.akkerman@bam.de

Keywords

resources, circular economy, Directive on Eco-design (EuP/ErP), energy policy

Abstract

Resource efficiency is a much discussed topic in terms of improving the sustainability of energy related and energy non-related products. Resource efficiency aspects such as the availability of spare parts, the ability to dismantle, etc. have been included in draft working documents in the revision of several already existing Ecodesign regulations as a first step. However, often these aspects are not consistent with the current technology and design of these products. A possible reason could be a lack of sufficient consultation or of a methodology which is sufficiently tailored for this topic. The established strategies and tools, used by policymakers, such as the Methodology for the Ecodesign of Energy-related Products (MEErP), do not seem to deal with these aspects appropriately. Draft requirements need to be very well developed before being discussed with member states and other related stakeholders, because including resource efficiency parameters could lead to additional, very wide-ranging effects on society. This topic cannot be covered well with legislative tools developed primarily for energy aspects. In this paper, a method is presented which can be used to combine products' properties with crucial resource efficiency indicators. The method can be used to develop a set of draft legislative requirements and to pre-evaluate these requirements by target groups which would be affected by additional legal requirements. These include: market surveillance authorities, standardization organizations, manufacturers and their associations, environmental organizations and research facilities. The method incorporates stakeholders' feedback to identify potential resource efficiency measures for materials and/or products, their impact on the European ecology, economy and society. Based on this it would help to develop legislative requirements which are feasible and desirable. The results can then be fed into the formal legislative process, probably speeding it up.

Introduction

During the few last decades, the efficiency of a series of products on the EU market has significantly improved due to various political initiatives. A major contributor to this has been the decision to develop and adopt the harmonized Ecodesign- and energy efficiency labelling directives which paved the way for boosting cross-border business within the EU market and enhanced the sustainability of energy related products (and could possibly affect non-energy related products in the near future too) (European Commission, 2014b; Schischke et al., 2008; European Union, 2009, 2010, 2017). Energy efficiency labelling in particular helped European citizens to take account of energy and related environmental aspects when buying new products or having the old ones repaired (European Commission, 2012; CSES, 2012). However, in practice the Ecodesign directive and the energy efficiency labelling mainly focus on the use phase of a product. There is an ongoing discussion on whether additional environmental aspects, such as resource and/or material efficiency, should be included, as originally foreseen during the development of the Ecodesign directive (European Commission, 2015b). The advantages and disadvantages are listed in detail in a review study by Dalhammar et al. (Dalhammar et al., 2014). In summary, the major advantage is that the Ecodesign directive has already been established and could introduce resource efficiency requirements on products directly. Moreover, products produced outside and sold inside the EU would be covered as well as those manufactured in the EU. Disadvantages relate to the difficulty of implementation. The authors assume that any additional costs of setting and enforcing resource efficiency requirements will be offset by tax increases or extra charges, which may not be politically acceptable, since this measure would mean an additional cost burden for EU citizens. Finally, Dalhammar et al. state that the implementation of resource efficiency requirements in the Ecodesign directive, as of 2014, was barely being discussed, no final decision had been made. Recent developments show that the European Commission may include resource efficiency requirements in the future (European Commission, 2015a, 2017b). However, resource efficiency potentials have not been quantified. If included, resource efficiency requirements may represent additional challenges for different stakeholders on the market, making their implementation more difficult in the legislative process (European Commission, 2013a).

In addition to the studies mentioned in the section above, two activities can be observed which show that there is still work to be done before it is clear whether a variety of resource requirements can or should implemented in Ecodesign regulations. The first are the mandates issued to European standardization organizations to create standards dealing with basic aspects of resource efficiency such as durability, reusability, reparability, recyclability and the marking of specific materials used in products (European Commission, 2015c; Hughes, 2017). The need for these mandates indicates that a full common understanding of these requirements is currently missing. For example, formally standardized methodologies for calculating the resource efficiency characteristics of a product or its components have yet to be developed (Tecchio et al., 2017).

The second activity are proposals for resource efficiency requirements in preparatory studies and working documents released during the development or revision of several Ecodesign regulations. For instance, in a working document related to a proposed regulation on servers and data storage products, it was suggested that firm gluing should not be used as joining or sealing technique for different components in electronic products. This was meant to increase ease of disassembly. However, firm gluing of microelectronic components (such as CPUs) increases the robustness of electronic products tremendously. The products became more shock-resistant and less susceptible against mechanical stress. Therefore, gluing as fixation technique represents an important contribution to the increase of the durability of portable products, which is finally a valuable contribution to resource efficiency. A general restriction would lead to a higher failure rate and finally have a negative impact on sustainability. Consequently, the actual requirement was set in a technology-neutral way, stating the goal of encouraging repair and reuse and requiring the manufacturer generically to make their product easy to disassemble. Another example can be found in a preparatory study related to the revision of the Ecodesign regulation for PCs. Marking of plastic parts with a specific lower mass limit per part is included in the resource efficiency requirements proposed in the study's conclusions. However, it is not obvious how the lower mass limit is derived and how it is justified. Regulating plastic parts with a specific mass limit would lead to a substantial burden for market surveillance authorities (MSA); they would need to determine the mass of such components to evaluate if a marking is mandatory and then identify the actual material through physical testing. Furthermore, it is unclear how a recycling process would recognize marked components in the case they are covered, or separate them if they are connected to other parts.

Summarized, a comprehensive methodology is missing which includes all indicators necessary to handle a topic with a much broader scope than energy efficiency across a variety of possible regulatory frameworks. The existing methodologies are discussed in the next chapter. In this study, a method is presented which can be used to (i) combine products' properties with crucial resource efficiency indicators, (ii) develop a set of draft legislative requirements and (iii) allow different kinds of stakeholders to pre-evaluate these requirements. Based on this, potential resource efficiency measures for certain products and components and their impact on the ecology, economy and society could be developed. It would allow the identification of the most appropriate requirements and the most suitable legislative framework, be it the Ecodesign directive, the WEEE directive or substance-related legislation like REACH or RoHS. It is not meant to replace the formal legislative process in use under these frameworks, but rather to improve the preparation of policy options.

Existing Methodologies

In many studies, representative indicators and products were identified which may fit the purpose to include resource efficiency requirements into legislation, e.g. within regulations under the Ecodesign directive. Material and resource efficiency should consider all parts of a product's lifecycle (Stevels, 2003). However, almost all studies related to resource and material efficiency to date are based on indicators defined for a specific part of its lifecycle such as the production, end-of-life or the use phase and therefore focus on material content, recyclability or repairability/durability, respectively. Others describe general aspects in monetary values, either in total cost of ownership approaches or through monetarization of impacts that cannot be compared otherwise. We would like to highlight three examples:

The Methodology for the Ecodesign of Energy-related Products (MEErP, see VHK 2013), which represents an established tool in legislation, predominantly considers indicators relevant in the use phase of a product. This arises from the fact that the focus of Ecodesign requirements is in practice mainly on energy consumption and in this aspect the use phase is dominant for most energy-using products which were the first to be regulated. The primary focus on energy is due to the policy priorities (climate goals and 2020 targets) that the Ecodesign directive was meant to help with. Looking at the MEErP, it has a generic system of quantifying other aspects than energy consumption within a set of eco-impacts that are chosen based on the directive itself. However, these calculations are much less detailed than the energy-related parts of the methodology and consequently yield much less precise scenarios. For most of the products that were regulated under the first two working plans in the period 2009 to 2015 the analysis was performed with the MEEuP (VHK 2005), the MEErP's predecessor, which is even more focused on energy aspects. This led policymakers to the conclusion that energy consumption dominates the eco-impacts of the products regulated. This is valid for the energy consumption itself but also for eco-impacts derived from energy use, such as NO_x or SO_2 emissions through combustion of fuels or electricity generation. Another reason for the low quality of resource data apart from energy consumption is the fact that the non-energy-aspects are mostly based on estimates while energy performance is often much more well known through measured values published e.g. because of existing energy labelling legislation.

Another example is a methodology with a focus on the end-of-life phase developed by Ardente, F. and Mathieux, F. (Ardente and Mathieux, 2014). They present definitions of indicators and suggest an assessment procedure to analyze reusability, recyclability and recoverability taking the example of plastic parts in liquid crystal displays. Other studies have a broader scope and include indicators representing aspects of other parts of the lifecycle or even additional natural, social and/or economic indicators (European Commission, 2011a; VHK et al., 2014). However, indicators developed on a national basis are used in these studies as overall, EU-wide indicators without clearly validating this extrapolation. The parameters related to cross-border activities, markets outside the specific country, etc. are not taken into account, even though they could make an important contribution to the final efficiency of a product or component.

An approach to develop a broader methodology was presented and explained in detail by Michwitz et al. (Mickwitz et al., 2006). The authors handled ecological and economic performance equally and analyzed them at three different levels (macro-scale = national, meso-scale = region and micro-scale = company). The authors defined the information needed for this analysis as generally available and therefore transparent for all kinds of stakeholders. However, in reality, information is distributed very heterogeneously and therefore could have different meanings at different scales. For instance, a national indicator such as gross domestic product does not represent the economic development of a company, or a regional indicator such as the production rate of an agricultural product does not have a meaningful impact on the import/export ratio of this product for a member state of the EU.

Methodology – New Approach

The presented methodology represents a tool to develop policy ideas independent from the legislative framework where they may be implemented. The envisioned key aspects to be regulated would be presented in a discussion paper and be pre-assessed by several stakeholder groups, which should lead to a higher acceptance level during the subsequent policy making process. The methodology is based on a five-step procedure (Figure 1). Each subsequent section explains each step and the different stakeholder groups. Only after the steps have been completed, the policy makers identify what exactly should be the content of the proposed regulation and then enter the legislative process with a draft legal text.

FIRST STEP – IDENTIFY AND DEFINE AN OBJECT

An object has to be identified, based on market failures or externalities which are not taken into account by the market. At this stage, the object is not fixed at a specific scale such as product-, component- and/or material level. Combinations are also practical, such as a component in a specific product or a material especially used in a certain component. After the object is defined, specific indicators should be identified in the next step.

SECOND STEP – DETERMINE INDICATORS

After an object is defined, it should be determined what economic, ecological and societal impact can result from the object. Table 1 includes a selection of those parameters in a relatively broad scope (Andersson and Ohlsson, 1999; BioIS 2012; European Commission, 2011a, b, 2013b, 2014a, 2016, 2018; Deike, 2009; Demurtas, 2015; Dooley, 2005; Federal Ministry for the Environment, 2016; GHK, 2006; Mickwitz et al., 2006; Müller and Sturm, 2001; OECD, 2000; Rattanapan et al., 2012; Rosenstrom and Kyllonen, 2007; Rosenström and Lyytimäki, 2006; Roy et al., 2009; Sutton, 2003; UN-ESCAP, 2009; UN, 2004; VHK 2013; Zschieschang et al., 2014). This list of parameters is certainly not complete and should be used as starting point for policy makers. It can be extended by other impacts which have to be taken into account for a specific object if considered necessary.

For each of the applicable parameters, a suitable (set of) specific indicator(s) would be found or developed. As an example, possible indicators for a washing machine would be, amongst others, its reliability (economic indicator), water consumption (ecological indicator) and health effects like hygiene (sociological indicator).

The result of this step is a list of indicators which are relevant for the resource efficiency (in the broadest possible sense) of an object in terms of economic, ecological and societal impacts. This list of indicators helps to identify the appropriate legislative framework where, if feasible, resource efficiency requirements could be drafted (fifth step). The advantage of checking the compatibility of each indicator is that it ensures that all indicators which are needed for an overall characterization of the impact of the object are considered.

THIRD STEP – DRAFT LEGISLATIVE REQUIREMENTS

Key policy ideas for product requirements can now be developed. The requirements could affect a single, a group of, or every identified indicator(s) depending on the actual object considered and the complexity of its impacts. The draft of legislative requirements is a document describing general ideas and strategies. The advantage of following the procedure described in the presented methodology is to develop requirements independent from the legislative framework where they should be implemented. This framework is chosen only in the last step, based on how best to implement the draft requirements. Doing so can overcome the limits placed on policy makers' thinking while the legal frameworks that come in at the last step still ensure that they cannot regulate beyond their competence – splitting sensible requirements between legal instruments if necessary.

FOURTH STEP – STAKEHOLDERS' PRE-ASSESSMENT

In this step, the draft legislative requirements, should be discussed with related stakeholder groups. Based on their responses, the requirements may have to be discarded, modified and discussed again or may accepted in principle. Only when the draft requirements are generally acceptable for all stakeholder groups, can they be used as the starting point for the policy

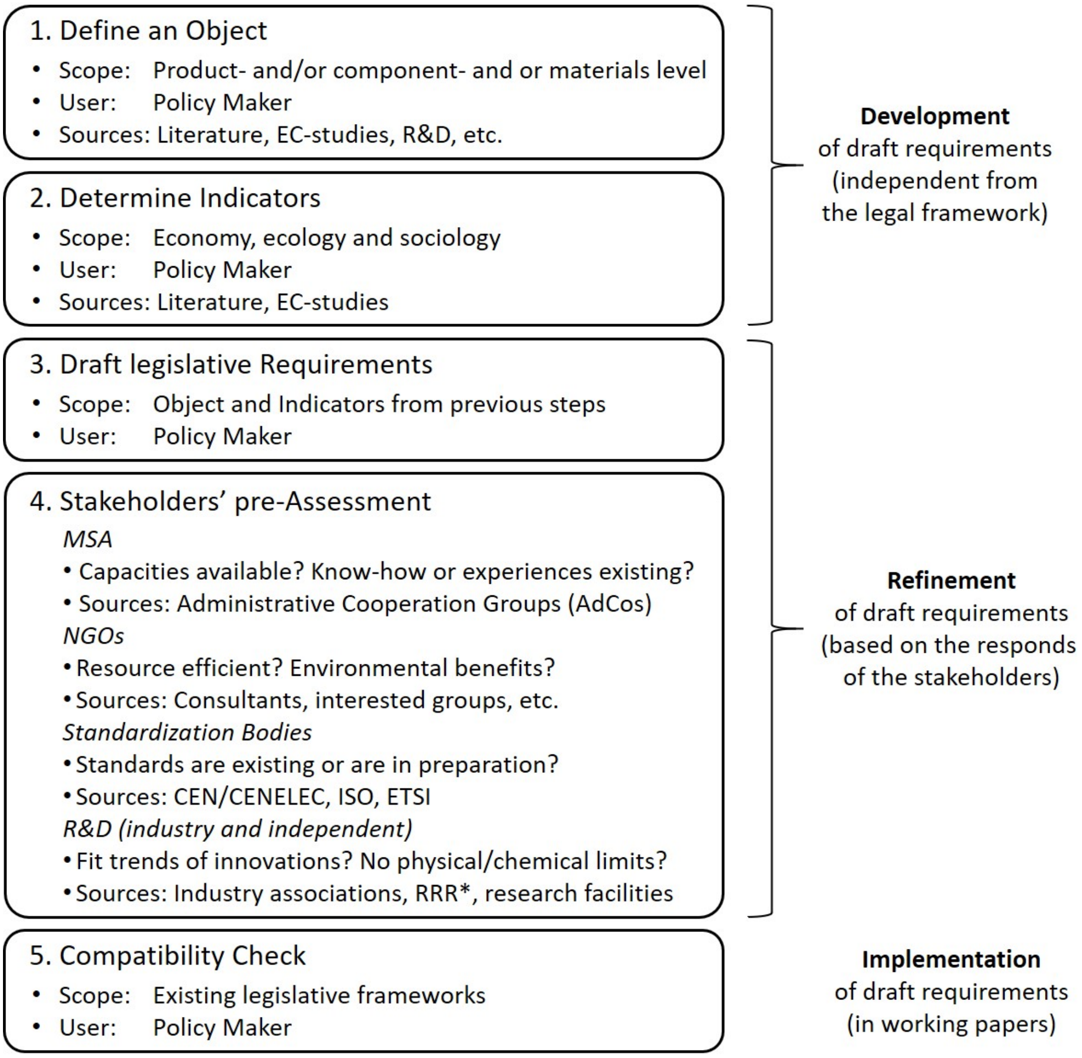

*Figure 1. Overview about the methodology presented in this study. (*RRR = Reusing-, Repairing- and Recycling industry).*

making process. This pre-assessment should guarantee a minimum level of quality of the requirements, which should speed up the policy making process overall.

As an example, a requirement is planned to be implemented to set limits for the content of a specific material. The limits would lead to meaningful improvement of ecological indicators. Hence, environmental non-government organizations agree with the requirements. Manufacturers, represented by industrial organizations, are optimistic that they will find alternatives and research facilities do not see any physical barriers for using another type of material for a specific application. Standardization bodies agree that the planned requirements are still aligned with existing standards or standards can be developed in a reasonable time and effort. However, the market surveillance authorities are not able to agree because of time- and expense of the analysis required to verify if the limits of the specific material are reached or not. As consequence, the draft requirements have to be refined until all stakeholders are able to handle them. In the following, the stakeholder groups are explained more in detail:

NGOs: In the policy making process, consumer and environmental NGOs often act as counterweight to the manufacturers, playing an important role by demanding a high level of ambition for future requirements. Several environmental NGOs concerned with resource efficiency requirements are already part of the policy making process for some forms of EU legislation including Ecodesign. While this may lead to overly ambitious proposals, most NGOs are also pragmatic in the negotiations, they want the requirements to be realistic and enforceable to make a difference. Consumer NGOs can be in an internal conflict of interest, arguing for maximum choice for consumers while trying to protect them from high energy bills or hazardous substances.

Standardization bodies: European standardization organizations can be commissioned by the policy makers to develop standards which should be used to implement certain requirements or – to put it another way – most of the efficiency requirements are only possible by developing related standards in parallel to ensure their measurability. Because this process takes considerable time, it is crucial that representatives of standardization bodies are consulted early on in the draft phase of possible requirements. The European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC), the European Telecommunications Standards Institute (ETSI) and probably the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) could all be

Table 1. List of economic (a) and ecological (b) parameters and parameters with a societal impact (c). In addition, sub-categories are written in capital letters. Each sub-category is separated into different topics of parameters.

a) Economic indicators		
INVENTION, INNOVATION, ALTERNATIVES	**Principal characteristics**	**Taxation, Subsidies**
Innovation/Alternatives	– Understandability	– Implicit tax rate on energy
– Impact on innovation	– Relevance and materiality	– Energy taxes by paying sector – households
– Legal situation	– Reliability	– Shares of environmental and labour taxes
– Ecolabel licenses	– Comparability	– Revenue
– Patents	– Performance	– Environmental taxes
– European Innovation Partnerships (EIPs)	– Conformance	**Type of consumer**
– Replace-ability	– Durability, lifespan	– Behavior
– New resources/materials	– Serviceability	– Consumption
– (Funds for) Research/Technology	– Perceived quality	– Domestic material consumption
– Eco-innovation (index)	– Esthetics	– Generation of (hazardous) waste
– Green Public Procurement	**SALE AND CONSUMPTION**	– Consumption expenditure by purpose
– Labelling, certification	**Marketing and Availability**	**TRANSPORT AND INFRASTRUCTURE**
– Competition, Competitiveness	– Distribution	**Packaging**
PRODUCTION	– Quantity of product	– Volume
Sustainable production	– Market	– Weight
– Generation of waste	– World market	– Material (costs, useable repeatedly)
– Proportion of secondary/primary raw material	– National market	– Stability
Resource-use intensity/costs	– Local market	– Waste generation (costs, disposal)
– Water intensity [m^3/GDP]/water costs	**Sale**	– Transport length, security
– Energy intensity [J/GDP]/energy costs	– Minimize the environmental impact	– Energy consumption of transport
– Land use intensity [km^2/GDP]	– Environmentally friendly way	**Import/export**
– Material intensity [DMI/GDP]	– The energy/water consumption by service	– Material flow between actors
– Waste costs	– Waste generated by service	– Global partnership/network
Manufacturing	– The products/materials used by service	– Free trade agreements (CETA, TTIP, TPP, FTA, etc.)
– Workflow, productivity, production process	– Volume	– Barriers
– Logistics	– Lifetime	**WASTE, RECYCLING, UPCYCLING**
– Qualified employees	**Stock**	**Durability**
– Work contracts	– Volume of product, component or spare part	– Availability of standards
– Location (infrastructure, mobility)	– Number products, components or spare parts	– Dismantling
– Centralized, decentralized	Competition, Competitiveness	– Storage
– Management	– Application of co-product	**Municipal waste generation and treatment**
– Business methods	**Product price**	**Incorporation of used components**
Industry	– BtoB business	– Disassemblility of Products, spare parts
– Kind	– BtoC business	– Reusability
– Structure	– (Net-)value added net sales, turnover	– Recyclability, recycling rate
– Influence on agriculture	– Composition of the price	– Recoverability
– Focus	– Taxation	

The table continues on the next page ... →

Table 1. List of economic (a) and ecological (b) parameters … (continuation).

***b)* Ecological indicators**		
ENVIRONMENTAL INDICATORS	– Wastewater handling	**Biodiversity (38)**
Environmental/ecological footprint	– Waste incineration	– Vegetation
POLLUTION ISSUES	– Recycling, Upcycling	– Species introduction or removal
Climate Change	– Treating waste as a resource	– Biotope, habitat
– CO_2 emissions intensities	**RESOURCES**	– Biomass/human appropriation/net production)
– Global Warming Potential (GWP)	– Resource extraction	– Index of common farmland bird species
– Global and European surface temperature deviation	– Raw material consumption (RMC)	– Livestock density index
– Greenhouse gas emissions per capita	– Resource consumption	– Preserve wildlife corridors
– Carbon footprint	– from renewable sources	– Conservation of nature
Ozone Layer Depletion	– from non-renewable sources	– Agrobiodiversity
– Ozone depletion potential and layer depletion	**Water Resources**	**Energy Resources**
– Photochemical Oxidant Creation Potential	– Water footprint	– Electricity generated from renewable sources
Air Quality	– Water exploitation index (WEI)	– Primary energy consumption
– Air emissions identities:	– Water consumption (Off-stream water use, In-stream water use)	– Energy productivity
– GHG emission (CO_2 equivalents)	– Water productivity	– Energy dependence
– Emissions of Sulphur Oxides (SOx)	– Water scarcity	– Share of renewable energy in gross final energy consumption
– Emissions of nitrogen oxides (NOx)	– Regional or river basin level water stress	– Gross inland energy consumption, by fuel
– Emissions of non-methane volatile organ. comp. (NMVOC)	– Population connected to urban waste water treatment with at least secondary treatment	– Combined heat and power generation
– Emissions of ammonia (NH3)	– Uneven distribution of water resources	– Possibility of chemical and energy recovery
– Emissions of heavy metal (Hma)	**Forest Resources**	– Energy footprint
– Emissions of Polycyclic Aromatic Hydrocarbons	– Forestry	**Mineral Resources**
– Particulate matter (PM)	– Forest increment and fellings	– Industrial minerals/metals
– Total suspended solids (TSS)	**Land and Soil Resources**	– Construction minerals/metals
– POP (Persistent Organic Pollutions)	– Land use	– Ores
Water Qualitiy	– Area under agri-environmental commitment (21)	**Fisheries**
– Water productivity	– Area under organic farming	– Proportion of fish stocks harvested sustainably (38)
– Waste water treatment connection rate	– Expansion of built-up environments	– Fishing fleet, total engine power
– HMw (Heavy Metal and PAH emissions to water	– Artificial landcover	**Others**
– Eutrophication Potential (EP)	– Landscape fragmentation	– Biological oxygen demand (BOD)
– Impact to the ground water pollution	– Fertile soils	– Physical effects (noise, vibration, radiation, electromagnetic fields)
– Global water consumption index	– Rare earth element	– Chemical oxygen demand (COD)
– Water exploitation index	– Soil erosion by water	– Photo-oxidant formation
– Water footprint	– Gross nutrient balance in agricultural land – nitrogen	**Safety and hazardous substances**
– Water consumption, water abstraction	– Gross nutrient balance in agricultural land– phosphorus	– Toxicity (acute, chronic)
Waste	– Land footprint	– Acidity, AP (Acidification Potential)
– Landfill	– Ecosystem quality indicators , e.g. eHANPP, LEAC	– Hazardous Substances (HS), Hazardous waste
– Total waste generation	– Natural capital	– Abiotic depletion
– Generation of radioactive waste (half-life)	– Productivity of built-up areas	– Pesticides
– Generation of hazardous waste	– Built-up areas as a share of total land	– Substances of Very High Concern (SVHC)
– Generation of bio-degradable waste	– Eutrophication potential (EP)	
– Solid waste disposal on land		

The table continues on the next page … →

Table 1. List of economic (a) and ecological (b) parameters … (continuation).

c) **Sociological indicators**		
Development of population	– Physical effects from the environment	– Climate changes
– Population structure	– Job market, green jobs	– Digital connectivity, digitalization
– Social classes	– Health and safety	– Urbanization
– Socio-demography	**Transparency**	**Velocity of modernization**
Human well-being	– Pre-use phase	– Technology adaption and use
– Security	– In-use phase	**Consumption choices**
– Freedom of choice and action	– End-of-life phase	– Interest in sustainability
– Health	**Demand**	– Sustainable acting
– Wealth	– Demand for recycled materials:	– Interest in new and green technologies
Installation, maintenance	– Quality	– Ecological thinking
– Simplicity	– Price	**Education &Media**
– Introduction, assistance	– Alternatives	– Awareness
– Professionals	– Domestic products	– Advertisement
Manufacturing	**Regional development**	**Good governance**
– Working conditions	– Infrastructure	**Green Public Procurement**

appropriate stakeholder for a pre-assessment of resource efficiency requirements. Contacting national standardization bodies should be avoided in order to keep the pre-assessment of draft requirements time-effective (due to the fact that 28 member states would need to be addressed). An exception to this can be justified if some national standards are more advanced in a relevant area and European or global ones have not yet been developed due to lack of agreement. Since 2016, CEN, CENELEC and the European Telecommunication Standards Institute (ETSI) have been working in the framework of the Mandate M/543 on a series of standards which should cover fundamental aspects concerning resource efficiency (European Commission, 2015b). It is planned to develop generic standards within six different working groups aiming on definitions and horizontal calculation methods for durability, upgradeability, reparability, remanufacturing and recyclability of products covered by the Ecodesign directive. In addition, the possibilities of marking the type and probably the amount of specific materials and/or substances (also critical raw materials) are in the scope of the mandate (Hughes, 2017). The outcome of the working groups dealing with the previous mentioned topics could be considered in the pre-assessment of possible resource efficiency requirements and the members of the working group could function as experts for the stakeholder group described in this section.

MSAs: As explained on the website of the European Commission "European cooperation on market surveillance takes place through informal groups of market surveillance authorities, called Administrative Cooperation Groups (AdCos) (European Commission, 2017a). Up to today, 28 groups exist, covering a wide range of products and applications. It is essential that these groups are involved in reviewing draft requirements in order to verify if such requirements are enforceable and if capabilities for compliance tests are available. In Ecodesign, the capabilities of the MSAs have been considered in some preparatory studies and impact assessments, however, the results have often not been taken into account by policy makers in the legislative process before the intervention of member states. This is understandable as the initiative lies with the EU Commission while market surveillance is a member state task.

Other stakeholders: These stakeholders include industry associations, independent research facilities and universities working in the field of reparability, reusability and recyclability. They are the stakeholders with the highest technical knowledge and understanding of the product, component and/or material. These stakeholders should be asked to assess draft requirements in terms of physical limits, market failures and possibilities for innovation and future technologies.

FIFTH STEP – COMPATIBILITY CHECK

As a final step, it is necessary to decide which legislative framework best fits the requirements of the identified impacts. For example it is important to find out if there are intersections with already existing requirements which can be extended or changed in order to widen the scope and/or cover a broader set of requirements or if new legislation is necessary. This may imply regulating different aspects of a product in different frameworks if comprehensive requirements are not possible or nit desirable within a single legal instrument.

After this process, actual legislative work can start, drafting, discussing and voting on legal texts that define in detail and implement in law the actual requirements.

Discussion

The structure of the presented methodology is very similar to the already established procedure practiced during the release or revision of new Ecodesign regulations. However, it is less precise and should be less bureaucratic. It would be conducted before a formal preparatory study, and before draft regulations are forwarded to the EU member states for consultation. It cannot, and is not meant to, replace the formal legislative process.

Is it quicker to take a step back, i.e. introduce a pre-analysis before actually working on legal requirements? This additional step will create some additional work for the policy makers, but only at the beginning. At later stages, e.g. during the consultation of draft documents by stakeholders and EU member states, the more thorough preparation may speed up the development process, due to the need for less discussion and revision. Siderius found in his analysis (Siderius 2014a, b) that technical complexity and political sensitivity are the main factors causing the significant delays experienced in the Ecodesign legislative process. Complexity can be the cause for low quality or inconclusive data which makes it hard to decide on actual requirements. Political sensitivity prevents quick agreement on a regulation as the expected impacts are perceived differently by different stakeholders, e.g. providing resource or energy savings vs. protecting a domestic industry sector with its tax revenues and jobs.

The proposed method may somewhat reduce these two effects, as pre-consultation can identify politically sensitive points and make policy makers aware of the need to deal with them. Considering all relevant indicators without a fixed legislative framework may alleviate complexity by regulating products within a framework they actually fit in. An example of this are the failed attempts to regulate, through Ecodesign, products like industrial furnaces, steam boilers, machine tools or power cables. A thorough pre-consultation would have prevented the selection of these product groups for regulation under Ecodesign as the barriers to doing this would have become apparent before commissioning formal preparatory studies. Another way of avoiding pointless work in preparatory studies would be the approach described in (Hinchliffe 2014), basically performing the analysis described here within the "task 0" of a preparatory study and then taking a step back to decide whether to continue it.

Complexity can also be avoided by taking a step back and finding that the current approach (regulating different aspects of a product in different instruments) may be the correct one. The method proposed here is not a call for a single regulation covering every aspect of a product. There are good reasons to separate legal instruments for e.g. safety requirements from those covering environmental aspects. An example for a requirement that could be implemented in several frameworks is the ban on certain flame retardants. For many products this is done through the RoHS regulation, whereas for electronic displays it will be implemented through a coming Ecodesign regulation.

Summarized, implementing (almost) all comments by the stakeholders during a "pre-consultation" could lead to legislative requirements that are truly fit for purpose, taking full account of the current product's and component's technology and design or the current consumption/application of materials.

So should resource efficiency requirements implemented through the Ecodesign directive? One part of the answer is given in the recitals of the directive itself:

- in recital (3): "Energy-related products account for a large proportion of the consumption of natural resources and energy in the Community. They also have a number of other important environmental impacts. … In the interest of sustainable development, continuous improvement in the overall environmental impact of those products should be encouraged, …",
- recital (10): "… Improving the energy and resource efficiency of products contributes to the security of the energy supply and to the reduction of the demand on natural resources, which are preconditions of sound economic activity and therefore of sustainable development."

This wording indicates that the scope and finally the original idea of the Ecodesign directive is much broader has been practiced to date.

In addition,

- in article 11 the directive also describes the requirements for components and sub-assemblies, which is important in the context of products which are integrated in others: "Implementing measures may require a manufacturer or its authorised representative placing components and sub-assemblies on the market and/or putting them into service to provide the manufacturer of a product covered by implementing measures with relevant information on the material composition and the consumption of energy, materials and/or resources of the components or sub-assemblies."
- The directive mentions key aspects of resource efficacy directly, e.g. in ANNEX I, part 1, point 1.3 (f): "ease for reuse and recycling as expressed through: number of materials and components used, use of standard components, time necessary for disassembly, […];"
- and (i) "extension of lifetime as expressed through: minimum guaranteed lifetime, minimum time for availability of spare parts, modularity, upgradeability, reparability;".

But are the tools (or methods) used in legislation well enough developed to cover a scope which is much broader than the energy efficiency of products? The scope of the MEErP and other studies summarized in section 2 of this study answers this question "no". Without widening the scope and considering economic, ecological and societal aspects with equal attention, (resource efficiency as understood today, European Commission, 2011b; Huysman et al., 2015) this leaves us with legislative tools which are mainly focused on the use-phase of products and are therefore neither feasible nor desirable. Implementing indicators based on the three pillars of the sustainable development (Kloepffer, 2008), could result in draft legislative requirements which may not fit the scope of the Ecodesign directive.

Therefore, resource efficiency requirements need to be developed independently from the type of legislation. The presented method can be a way of achieving this. After draft requirements are developed, based on identifying the key indicators and after consultation with a range of stakeholders, a legislative framework can be found which best fits the purpose, be it Ecodesign or a different instrument.

References

Andersson, K., and Ohlsson, T. (1999). Including Environmental Aspects in Production Development: A Case Study of Tomato Ketchup. LWT - Food Science and Technology *32*, 134–141.

Ardente, F., and Mathieux, F. (2014). Identification and assessment of product's measures to improve resource effi-

ciency: the case-study of an Energy using Product. J Clean Prod 83, 126–141.
BioIS (2012). Assessment of resource efficiency indicators and targets – Final report (BIO Intelligence Service, Institute for Social Ecology and Sustainable Europe Research Institute).
CSES (2012). Evaluation of the Ecodesign Directive (2009/125/EC) – Final Report.
Dalhammar, C., Machacek, E., Bundgaard, A., Overgaard Zacho, K., and Remmen, A. (2014). Adressing resource efficiency through the Ecodesign Directive – A review of oppertunities and barriers, TemaNord, ed.
Deike, S. (2009). Investigations on the resource efficiency of different farming systems with specific emphasis on pesticide use intensity.
Demurtas, A.e.a. (2015). EU Resource Efficiency Scoreboard 2014.
Dooley, E.E. (2005). Millennium ecosystem assessment. Environmental Health Perspectives 113, A591–A591.
European Commission (2011a). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of Regions – Roadmap to a Resource Efficient Europe. *SEC(2011) 1067 final*.
European Commission (2011b). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy. *COM(2011) 21 final*.
European Commission (2012). Consumer Attitudes towards Crossboarder Trade and Consumer Protection. In Flash Eurobarometer.
European Commission (2013a). Communication from the Commission to the European Parliament and the Council – Building the Single Market for Green Products. *COM(2013) 196 final*.
European Commission (2013b). Thirty indicators to measure resource efficiency in the EU. In Resource Efficiency Scoreboard (eurostat newsrelease).
European Commission (2014a). Attitudes of Europeans towards Waste Management and Resource Efficiency. In Flash Eurobarometer.
European Commission (2014b). Communication from the Commission to the European Parliament, the Council and the European Economic and Social Committee – A vision for the internal market for industrial products. *COM(2014)25 final*.
European Commission (2015a). Closing the loop – An EU action plan for the Circular Economy. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions *COM(2015) 614*.
European Commission (2015b). Evalution of the Energy Labelling and Ecodesign Directives. In Commission Staff Working Document.
European Commission (2015c). M/543 Commission Implementing Decidsion C(2015)9096 of 17.12.2015 on a standardisation request to the European standardisation organisations as regards ecodesign requirements on material efficiency aspects for energy-related products in support of the implementation of Directive 2009/125/EC of the European Parliament and of the Council.
European Commission (2016). Buying green! A handbook on green public procurement, 3rd Edition edn.
European Commission (2017a). Administrative Cooperation Groups (AdCos). http://ec.europa.eu/growth/single-market/goods/building-blocks/market-surveillance/organisation/administrative-cooperation-groups_en. Access date 27.11.2018.
European Commission (2017b). Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the implementation of the Circular Economy Action Plan.
European Commission (2018). EU SDG Idicator Set 2018 - Results of the Review in Preparation of the 2018 Edition of the EU SDG Monitoring Report (eurostat).
Federal Ministry for the Environment, N.C., Building and Nuclear Safety (BMUB) (2016). German Resource Efficiency Programme II – Programme for the sustainable use and conservation of natural resources, D.W.I. BMUB, ed. (Berlin, Germany).
GHK (2006). A study to examine the benefits of the End of Life Vehicles Directive and the costs and benefits of a revision of the 2015 targets for recycling, re-use and recovery under the ELV Directive.
Hinchliffe, D., Akkerman, F., et al., (2014). Are Preparatory Studies Flexible Enough for the Ecodesign Directive? Regulation Challenges in Complex Product Groups. Bundesanstalt für Materialforschung und Prüfung (BAM), Berlin.
Hughes, R. (2017). The EU Circular Economy Package – Life Cycle Thinking to Life Cycle Law? Procedia CIRP 61, 10–16.
Huysman, S., Sala, S., Mancini, L., Ardente, F., Alvarenga, R.A.F., De Meester, S., Mathieux, F., and Dewulf, J. (2015). Toward a systematized framework for resource efficiency indicators. Resources, Conservation and Recycling 95, 68–76.
Kloepffer, W. (2008). Life cycle Sustainability assessment of products. Int J Life Cycle Ass 13, 89–94.
Mickwitz, P., Melanen, M., Rosenstrom, U., and Seppala, J. (2006). Regional eco-efficiency indicators - a participatory approach. J Clean Prod 14, 1603–1611.
Müller, K., and Sturm, A. (2001). Standardized Eco-Efficiency Indicators.
OECD (2000). Towards sustainable development: indicators to measure progress; proceedings of the OECD Rome Conference (OECD Publications).
Rattanapan, C., Suksaroj, T.T., and Ounsaneha, W. (2012). Development of Eco-efficiency Indicators for Rubber Glove Product by Material Flow Analysis. In Asia Pacific Business Innovation and Technology Management Society, A.S.F. Chiu, J.M.L. Tseng, and G.K.J. Wu, eds., pp. 99–106.
Rosenstrom, U., and Kyllonen, S. (2007). Impacts of a participatory approach to developing national level sustainable development indicators in Finland. J Environ Manage 84, 282–298.

Rosenström, U., and Lyytimäki, J. (2006). The role of indicators in improving timeliness of international environmental reports. Enviromental Policy and Governance 26, 13.

Roy, P., Nei, D., Orikasa, T., Xu, Q., Okadome, H., Nakamura, N., and Shiina, T. (2009). A review of life cycle assessment (LCA) on some food products. Journal of Food Engineering *90*, 10.

Schischke, K., Nissen, N.F., Stobbe, L., and Reichl, H. (2008). Energy efficiency meets ecodesign – Technology impacts of the European EuP directive. Ieee Int Symp Electr, 394–399.

Siderius, H.P. (2014a), In and out of comitology: Analysing delays in preparing and adopting ecodesign and energy labelling measures. In: Search of European Political Union Conference Proceedings, Utrecht.

Siderius, H.P. (2014b), Increasing effectiveness and efficiency of product energy policy; Dissertation at University of Utrecht.

Stevels, A. (2003). Towards an operationalization of the proposed European Directive on EcoDesign (Design for Environment) of electronic end use products (EuP). 2003 3rd International Symposium on Environmentally Conscious Design and Inverse Manufacturing – Ecodesign '03, 185–191.

Sutton, P.C. (2003). An Empirical Environmental Sustainability Index Derived Solely from Nighttime Satellite Imagery and Ecosystem Service Valuation. Population and Environment 24, 293–311.

Tecchio, P., McAlister, C., Mathieux, F., and Ardente, F. (2017). In search of standards to support circularity in product policies: A systematic approach. J Clean Prod 168, 1533–1546.

United Nations-ESCAP (2009). Eco-efficiency Indicators: Measuring Resource-use Efficiency and the Impact of Economic Activities on the Environment.

United Nations (2004). A Manual for the Preparers and Users of Eco-efficiency Indicators, Vol 1.1.

European Union (2009). Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products. Official Journal of the European Union 52, 26.

European Union (2010). Directive 2010/30/EU of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products (1). Official Journal of the European Union 53, 13.

European Union (2017). Regulation (EU) 2017/1369 of the European Parliament and of the Council of 4 July 2017 setting a framework for energy labelling and repealing Directive 2010/30/EU. Official Journal of the European Union, 23.

VHK (2005). Methodology Study Eco-design of Energy-using Products, Final Report (van Holsteijn and Kemna, Report for the European Commission)

VHK (2013). Material-efficiency Ecodesign Report and Module to the Methodology for the Ecodesign of Energy-related Products (MEErP) – PART 1: Material Efficiency for Ecodesign. (van Holsteijn and Kemna, Report for the European Commission).

VHK, Vito, Maagoe, V., and Wuppertal Institute für Klima, U., Energie (2014). Cold Appliances, Washing Machines, Dishwashers, Washer-Driers, Lighting, Set-top Boxes and Pumps.

Zschieschang, E., Denz, N., Lambrecht, H., and Viere, T. (2014). Resource efficiency-oriented optimization of material flow networks in chemical process engineering. In Proc Cirp, T.K. Lien, ed., pp. 373–378.