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From Waste Management to Resource Efficiency—The Need for Policy Mixes

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Academic Editors: Francesca Montevecchi, Martin Hirschnitz-Garbers, Tomas Ekvall, Martha Bicket and Patrick ten Brink

Received: 2 February 2016; Accepted: 27 June 2016; Published: 1 July 2016

Abstract: Treating waste as a resource and the design of a circular economy have been identified as key approaches for resource efficiency. Despite ambitious targets, policies and instruments that would enable a transition from a conventional waste management to an integrated and comprehensive resource management are still missing. Moreover, this will require innovative policy mixes which do not only address different end-of-pipe approaches but integrate various resource efficiency aspects from product design to patterns of production and consumption. Based on the results of a project funded by the Seventh Framework Programme for Research and Technological Development named "POLFREE—Policy Options for a resource efficient economy", this paper addresses several aspects of the conceptualization of policy mixes with regard to waste as a specific resource efficiency challenge. The guiding research interest of this paper is the combination of policies necessary to create a full circular economy. In a first step, the present waste policy frameworks, institutions and existing incentives at national level are examined in order to disclose regulatory and policy gaps. Based on this, the second part of the paper describes and analyses specific waste-related resource efficiency instruments with regard to their potential impacts under the constraints of various barriers. Based on the assessment of the country analyses and the innovative instruments, the paper draws conclusions on waste policy mixes and political needs.

Keywords: circular economy; waste policy; resource efficiency; policy mixes

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1. Introduction

For centuries, waste management focused on ensuring a cheap, reliable and—since the 1970s—environmentally sound disposal of waste [1]. This view is increasingly being disputed because the idea of a circular economy has attracted growing attention in the public debate, e.g., in the European Commission's Communication on Zero Waste: "Since the industrial revolution, our economies have developed a "take-make-consume and dispose" pattern of growth—a linear model based on the assumption that resources are abundant, available, easy to source and cheap to dispose of. It is increasingly being understood that this threatens the competitiveness of Europe. Moving towards a more circular economy is essential to deliver the resource efficiency agenda established under the Europe 2020 Strategy for smart, sustainable and inclusive growth" [2].

While the roots of the circular economy go back to the 1970s, it is based on principles made known by thinkers and innovators like Walter Stahel and his concept of the performance economy [3], the cradle to cradle model of Michael Braungart, the blue economy concept developed by Gunter Pauli or the circularity concept by the Ellen MacArthur Foundation [4].

Despite several initiatives to transform Europe into a "recycling society", such as the European Commission's Circular Economy Package [1] or the Ellen MacArthur Foundation´s CE 100 initiative [5], the reality shows a different picture. In 2011, the total waste production in the EU amounted to approximately 2.5 billion tons. Only a limited share (40%) of the municipal waste generated in the European Union was recycled, the rest was landfilled (37%) or incinerated (23%). Around 500 million tons of which could have been otherwise recycled or reused. Given that a high quality management of waste depends on ambitious and consistent regulatory frameworks, there is obvious need for innovative mixes of policy instruments that help to transform the conventional waste management structures to a resource efficient circular economy: "This implies full systemic change, and innovation not only in technologies, but also in organisation, society, finance methods and policies" [2].

Against this background, the guiding question of this paper is how to combine effective policies that contribute to develop a full circular economy. It must be taken into consideration that policy measures and the implementation of specific policy mixes do not start at zero. Indeed, there are many policies and institutions in place that exert stronger or weaker, positive or negative influences on the particular field of action. It is therefore essential to examine the institutional frameworks and existing incentives for actors in the first instance.

The paper follows a case study approach. Building theory from case studies is a research strategy to develop theoretical constructs from case-based empirical evidence [6]. Against this background, the structure of this paper is based on the analysis of the existing, mainly end-of-pipe focussed frameworks for waste management in ten countries (Section 3), the description and analysis of innovative instruments for an resource efficiency oriented circular economy policy mix (Section 4) and the discussion of the impacts, the effectiveness and the barriers of this policy mix (Section 5). Following this, the paper draws conclusions on the effectiveness of the instruments and their interactions.

2. Methodological Approach

2.1. Analysis of Existing Frameworks for Waste Management

Ten European Member States were selected as case studies for an in-depth evidence-based country analysis of the current national framework conditions, i.e., the institutional structures and policy frameworks in the area of waste management (Section 3). In order to include pioneers and laggards, countries with a high and a low per capita resource use, new and old Member States, countries from north, south, east and west, the following countries were selected: Austria, Germany, Hungary, Netherlands, Estonia, Finland, Poland, Spain, Sweden, and United Kingdom.

The approach distinguished two pillars: the policy and institutional factors, such as economic incentives and waste programmes assumed to be influencing the technical set-up and infrastructures in the waste sector. Both aspects were analysed with regard to different dimensions and indicators, such as targets (i.e., Municipal Solid Waste (MSW), End-of-Life Vehicles (ELV) targets), the regulatory framework conditions (i.e., the existence of waste prevention programmes, the number of waste management plans or concepts, the existence of specific waste laws, e.g., biogenic waste, the country specific waste charge systems, the Extended Producer Responsibility (EPR) schemes, and potential Waste Prevention Programme (WPP) instruments), the existence of an agency for waste issues, and further relevant policy instruments (i.e., economic recovery programmes addressing waste issues). The technical system was examined by comparing the country specific MSW incineration capacities, the access to separate bio-waste collection systems, the ELV per authorized treatment facilities (ATF), the MSW recycling rates, the biodegradable MSW landfilling rates and the ELV rates.

2.2. Description and Analysis of Specific Instruments for an Innovative Waste Policy Mix

(a) The development of a policy mix for a resource efficient economy requires a systematic identification of resource relevant policy fields as a first step. Based on pertinent literature on Environmentally Extended Input Output assessments [7], policy fields were selected according to their resource intensity [8] and complemented by an assessment of their potential to improve resource efficiency [9–11]. This paper focuses on the policy field waste management, a well-established and often very much end-of-pipe oriented policy field with strong interlinkages to production processes, resource use and the end-of-life phase of materials (see Section 4). Within the scope of waste management, three types of instruments were identified and linked to three pathways [12]: The harvest of low hanging fruits (i.e., an easily implemented instrument with prospective low barriers), the introduction of severe market interventions (i.e., with influences on the market systems), and a systemic transformation of production and consumption patterns.

(b) For the purpose to design a policy mix, the single instruments were examined regarding their essential characteristics based on the policy mix concept developed by Rogge and Reichardt [13] characterizing instruments by their goals, types and design features.

3. Investigation of Present Policy Frameworks, Institutions and Outcomes in the Waste Sectors at a National Scale

In order to develop policy approaches enabling the transformation from waste to resource management, the analysis of the existing waste management systems and the related strengths and weaknesses was considered a necessary first step. The following describes a two-step procedure with a first examination of 10 institutional waste management settings followed by an in-depth analysis of selected countries. The outcomes of the analysis have been used for the selection of policy instruments in Chapter 4.

In order to capture the current status quo of waste management systems in different EU member states, relevant institutional and policy factors are analysed as a first step. This is being done by an in-depth evidence-based country analysis looking at the specific framework conditions, institutional and technical set-ups and incentive systems for waste management.

Ten countries (Austria, Germany, Hungary, the Netherlands, Estonia, Finland, Poland, Spain, Sweden and UK) were selected based on a literature review with the aim to cover a broad range of various waste management performances in Europe. Policy and institutional factors as well as the technical infrastructure system were then explored with regard to different dimensions and indicators as shown in Table 1. The indicators focus on bio-waste, end-of-life vehicles (ELVs) and municipal solid waste (MSW) and cover all steps of the waste hierarchy (from disposal up to waste prevention). The indicators relate to the national level; they exclude however, e.g., regional landfill taxes that clearly influence the development of waste infrastructures.

Following this, countries were assessed according to their fulfilment (e.g., national target is above or below the EU targets) or the value (e.g., low or high incineration capacity) of specific indicators (see Table 1). The classification system ranged from 0 for a low fulfilment or low value to 1 for a high fulfilment or high value. Cells marked in grey are textual evaluated.

The assessment was undertaken mainly based on a review of statistical information reported to the European Commission and discussions with the responsible experts in the countries (interviewing the national reference centres within the European Environment Information and Observation Network (Eionet)). Figures 1–4 illustrate and summarise the results of the country review and show the scores related to waste management targets, policy instruments for waste management, technical infrastructure and outcomes as described in Table 1 for Austria, Germany, Hungary and the Netherlands, thus indicating how different the performances of the dimensions among countries are across Europe.

Table 1. Dimensions and indicators for the analysis of waste policy.

	Dimension	Indicator	Assessment
Institutional set-up and incentives/programmes	Targets	Municipal solid waste (MSW) recycling target	1 if more ambitious than EU target/0 if EU target
		End-of-life vehicle (ELV) recycling target	1 if more ambitious than EU target/0 if EU target
	Regulatory framework	Existence of a waste prevention programme (WPP) in accordance with Art. 29 WFD	
		Number of waste management plans or concepts/Levels of target setting national/regional/local	
		Specific law for biogenic waste	
	Agencies and competences	Existence of an agency for environmental issues including waste issues	
	Policy instruments for waste management	Economic recovery programmes	1 if existent/0 if not existent
		Waste charge systems	1 if exist 3 instruments/0.5 if exist 2 instruments/0 if exist 1 instrument
		Extended producer responsibility (EPR) scheme on end-of-life vehicles (ELV)	1 if existent/0 if not existent
		Waste prevention programme (WPP) instruments	1 if more than 50% regulativ and economic instruments/0.5 if more than 25% regulativ and economic instruments/0 if less than 25% regulativ and economic instruments
Technical set-up	Technical infrastructures	Municipal solid waste (MSW) incineration capacity per capita	1 if above 0.8 quintile/0.75 if above 0.6 quintile/0.5 if above 0.4 quintile/0.25 if above 0.2 quintile/0 if no MSW incineration capacity
		Access separate bio-waste collection	1 if 100%/0.5 if partly implemented/0 if not implemented
		End-of-life vehicles (ELV) treated per authorized treatment facility (ATF)	1 if above 0.8 quintile/0.75 if above 0.6 quintile/0.5 if above 0.4 quintile/0.25 if above 0.2 quintile/0 if no ELV facility
	Outcomes	Municipal solid waste (MSW) recycling rate	1 if above the EU targets/0 if less than EU target
		Biodegradable municipal solid waste (MSW) landfilling rate	1 if 0%/0.5 if less than EU target 2009/0 if above EU target 2009)
		End-of-life vehicles (ELV) recycling rate	1 if above the EU targets/0 if less than EU target

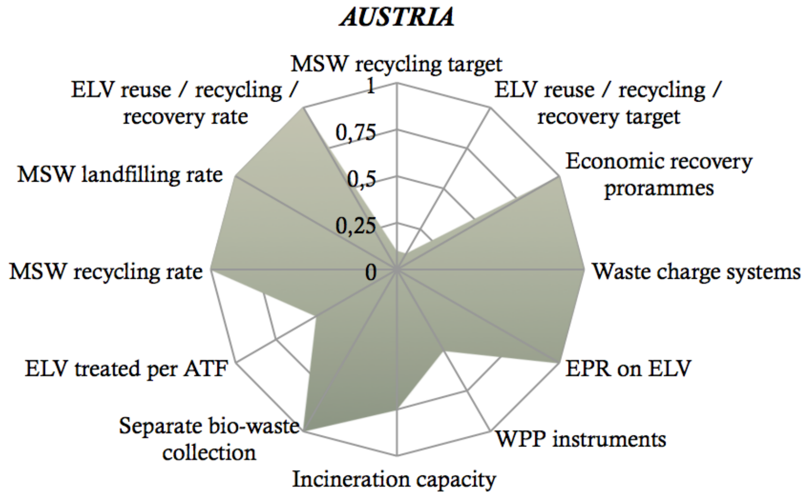

Figure 1. Configurations of waste policies with respect to EU requirements in Austria, 2014.

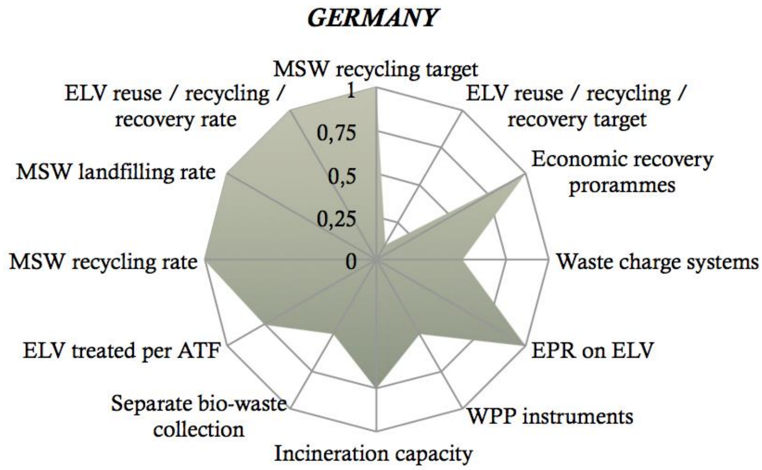

Figure 2. Configurations of waste policies with respect to EU requirements in Germany, 2014.

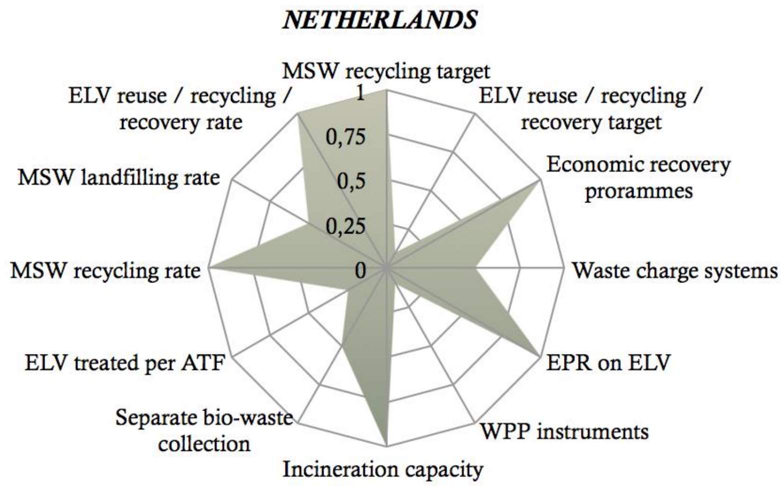

Figure 3. Configurations of waste policies with respect to EU requirements in the Netherlands, 2014.

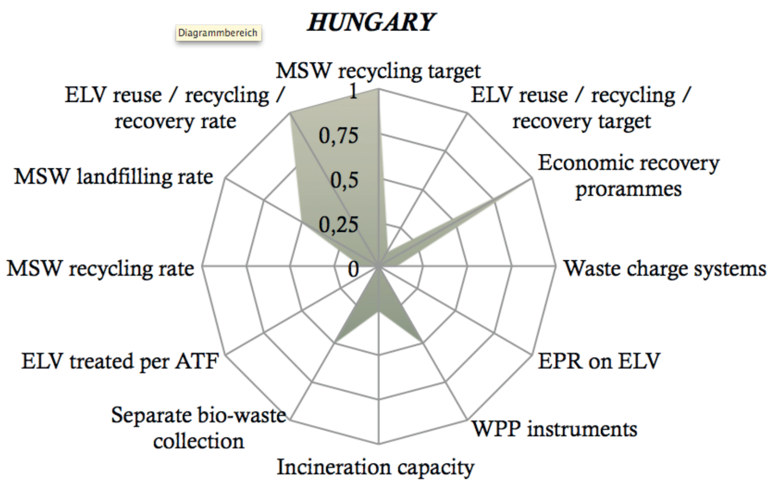

Figure 4. Configurations of waste policies with respect to EU requirements in Hungary, 2014.

Table 2 shows results of the investigation with regard to specific waste prevention programmes, waste management plans and further specific regulations. Cells marked with "→" indicate the existence of such documents for the respective country. The analysis distinguished between different types of documents (e.g., waste prevention programmes as stand-alone publications or included in other documents) as well as different spatial levels (national, regional or local).

The results of the country review showed that the investigated countries have overwhelmingly transposed the EU law into national legislation. All countries have established different kinds of waste management plans and waste prevention programmes (except for Estonia where the programme is still under consideration) but despite the common legal framework (i.e., the Waste Framework Directive), actual recycling rates differ significantly between these countries and waste prevention as well as reuse still play a minor role in all countries.

In terms of contents, ambitions, targets and choice of policy instruments the waste management seems, surprisingly, to be only weakly influenced by the European regulatory framework and varies significantly from country to country. The extent of the various waste prevention programmes varies widely, between few pages (4–6 pages) and elaborate plans (75–80 pages) [14]. In addition, the shares of stringent policy instruments for waste prevention vary substantially between the different countries. Several initiatives highlight the enormous market potentials of waste prevention, reuse or closed loop recycling—without providing answers why companies hesitate to realise these cost savings and market potentials. Some countries clearly see the need to sensitise the market actors, better disseminate research results and lower the transaction costs for data gathering—thus focussing on informative instruments. The underlying rationale in this case is the perception of unexploited market potentials. At the same time, other countries follow a completely different approach and see the necessity for changed legal and market framework conditions in order to avoid that waste generation externalises social costs and waste treatment is organised at the lowest cost level and not from a view point of resource conservation and efficiency. Finland, for example, focuses on regulative and economic instruments (53% of waste prevention instruments), while Sweden has chosen a set of instruments consisting of 90% informative and voluntary agreements [14].

Table 2. Waste Prevention Programmes, Waste Management Plans, and bio-waste regulation applied in selected countries.

	Waste Prevention Programmes			**Waste Management Plans**			**Specific Regulations on Bio-Waste**		
	Stand-Alone Programme	**Incorporated in WMP**	**WPP Not in Place, but Planned**	**National**	**Regional/Provincial**	**Local**	**Ordinance**	**Strategy**	**Covered in WMP**
Austria		→		→	→	→	→		
Germany	→				→	→	→		
Hungary		→		→	→	→		→	
Netherlands	→			→					→
Estonia			→	→		→			→
Finland		→		→	→			→	
Poland		→		→	→	→			→
Spain	→			→	→				→
Sweden	→			→		→			→
UK	→			→	→	→			→

→ means: existence of programme/plan/regulation.

Although the recycling grew in the period 2001–2010 by 29 million tonnes [15] and data on recycling rates shows that waste management is moving up the waste hierarchy and depicts an increase of recycling, the results range from a MSW recycling rate of 20% in Estonia to 63% in Austria in 2010. The analysis of environmental outcomes therefore indicates that—as long as waste management is regarded as expense instead of a valuable "resource"—regulatory instruments seem to be more effective than economic instruments. Austria, for example, has the highest MSW recycling rate in comparison to the remaining countries while having a strong setting with regard to economic and regulatory instruments (e.g., a specific ordinance on bio-waste, a separate bio-waste collection scheme). It achieved the EU targets in the context of the ELV recycling, and does not landfill any biodegradable MSW (see figure above).

A lack of proper treatment infrastructures and sufficient capacities for the municipal waste that is generated is a crucial barrier to environmentally sound waste management as shown by the example of Poland, which still landfills 84% of biodegradable MSW. In contrast, Sweden highlights that even a well-established infrastructure bears risks: In Sweden, the total amount of annually generated waste would not be enough to fill all incineration capacities [16]. These capacities might be used to incinerate waste from non-municipal sources by using imports. As a consequence, capacities that are far exceeding the amount of generated municipal waste indicate a potential competition between the filling of the incineration capacities and the strive for achieving the 50% recycling target of the 2008 Waste Framework Directive, not to speak of the objectives of the EU's 7th Environmental Action Programme to further move towards a circular economy, limit energy recovery to non-recyclable material and reduce the generation of waste.

4. Instruments for an Innovative Resource Efficiency Oriented Circular Economy Policy Mix

Based on the analysis of present national waste policy frameworks and institutions (see Section 3), innovative policy instruments enabling Europe to radically increase the resource efficiency were identified, specified and analysed. Two instruments focus on the aspect of information flows. The third instrument focuses on waste targets which would strengthen the link to resource efficiency. The selection of those instruments was, in addition, based on the resource efficiency potentials and the economic saving potentials [17,18].

4.1. Instrument 1: Waste Targets for Resource Efficiency

Waste management is a policy field that has always been mainly driven by framework conditions such as regulations for collection and waste treatment. In particular, targets play a crucial role for the emergence and diffusion of innovations—as stated in the Zero Waste Communication: "Strong policy signals are needed to create longer-term predictability for investment and change so that materials, such as plastics, glass, metals, paper, wood, rubber and other recyclables, re-enter the economy as secondary raw materials at competitive prices" [2]. As pointed out in Section 3, a specific barrier for resource efficiency is constituted by the fact that concreteness and ambition of targets and policy signals differ significantly alongside the waste hierarchy: Recycling and disposal are regulated by binding and quantitative targets, reuse and waste prevention lack such targets. Also the Roadmap for a Resource Efficient Europe [19] (p. 8) describes the need for innovative targets as a specific regulative policy instrument: "Member States should ensure full implementation of the EU waste acquis including minimum targets through their national waste prevention and management strategies (continuous)" (and) assess the introduction of minimum recycled material rates. From a resource efficiency point of view this could be achieved by amending the Waste Framework Directive with the following two targets: A mandatory recycled content target, as well as quantified waste prevention targets.

Specific waste prevention targets such as recycling targets should be legally binding in order to strengthen waste prevention, as top priority of the European waste hierarchy. According to article 29 of the WFD, Member States are obligated to develop waste prevention programmes—but only 11 of 20 analysed waste prevention programmes include any kind of quantitative target for waste prevention at all [20]. Spain, Scotland and Wales, for instance, have set targets for total waste based on absolute amounts. Most programmes cover targets for different streams in absolute terms, only Italy has introduced reduction targets related to the gross domestic product (GDP). Maximum targets for future waste are another way of setting targets. Latvia, for example, has not implemented a reduction target, but an upper limit for the amount of municipal waste per capita of 400 kg/capita in 2020, which is considerably higher than the waste Latvia generates today—approx. 301 kg/capita in 2012 [20]. The Netherlands has set a maximum target for total waste generation of 68 Mt in 2015, and 73 Mt in 2021 (in 2006 the amount was 60 Mt) [20]. Targets for municipal waste reduction are the most popular. They are put into effect in Italy, Finland, Latvia, Portugal, and Wales.

The establishment of mandatory recycling quotas has been the classic approach of waste management activities for a long time—particularly regulating the treatment of waste and avoiding environmentally harmful waste disposal. A recycling and reuse rate of at least 50% by mass is currently implemented in the Waste Framework Directive for paper, metal, plastic and glass for the year 2010. For construction and demolition waste, a rate of 70% will have to be achieved by 2020. Although mass-based product-specific or waste stream-specific quotas ensure material recycling of these two categories, they do not allow a monitoring of recycled materials contained in new products. As a start, a mandatory recycled content target could be introduced especially for plastics. This would be an essential prerequisite for the recovery of secondary plastics, a waste stream that has been in the focus of many waste and recycling related discussions since the publication of the Green Book on plastic waste by the European Commission. The favourable initial conditions for plastic incineration compared to plastic recycling presently results in extremely low recycling quotas, for example, in the case of electrical goods: Plastic contained in electrical or electronic equipment (devices) is currently almost entirely incinerated [21].

With a specification of minimum recycled content quotas for plastic-containing products, the demand for high-quality secondary raw materials would rise significantly and thus provide incentives to capture a greater share of separated plastic wastes (i.e., in the sense of high-quality recycling), which will be recycled and not utilised for thermal recovery. Experiences with minimum recycling quotas have been made in the case of packaging in the 1980s, in particular as it became clear that the recycling sector needed support. The most stringent regulation is being applied in California: According to the Rigid Plastic Packaging Container Law (RPPC) manufacturers have to reduce resource consumption by design changes (−10% material input or a minimum use of 5 times), a 45% recycling rate, or through a 25% share of secondary resources. The law has received a lot of criticism for its bureaucratic burdens and the associated administrative costs and monitoring problems but has led to a significant stabilisation, especially in the market for high density polyethylen (HDPE) product waste [22].

The introduction of minimum recycled content quotas would allow for direct controlling the use of secondary raw materials and mechanical recycling. Instead of defining technological standards, this approach would be based on market considerations how these standards can be met at the lowest cost level. Particularly the construction sector offers good conditions for the introduction of a secondary plastic quota because many of the employed products are used in the "non-visible range", which means that the oft-quoted problems of colour fidelity of secondary plastics only play a minor role [23]. Since this instrument supports a reliable demand for high quality secondary plastics and thus promotes additional investments in the needed infrastructures it may also be employed on a temporary basis. The underlying rationale is that secondary plastics should have gained higher market shares compared to primary plastics after an initial phase of capital-intensive investments, thus making a further market intervention unnecessary. A self-agreement should therefore provide an appropriate evaluation, for example, after five years.

From a resource efficiency perspective, the targets in place show three fundamental weaknesses that fail to steer innovations in the right directions:

(a) Recycling targets refer to the weight of waste and neglect the ecological rucksacks related to them alongside their life cycle. Weight-based targets make sense from the perspective of securing disposal capacities, but they lead to a focus on recycling heavy stuff instead of the environmentally most relevant waste streams.

(b) The current recycling targets focus on the input for waste treatment procedures and do not take into account quality aspects of the resulting secondary raw materials. Based on the legal definitions set out in the Waste Framework Directive, a product or waste stream is "recycled" when it enters a specific waste treatment operation like shredding, incineration, etc. Again, this makes sense for the purpose of reducing waste volumes but it does not indicate how much of the raw materials contained in the waste stream are actually recovered and how it can be fed back into the production processes.

(c) The comparison of targets and their consequences for waste treatment and waste generation clearly shows that waste policy has an impact on recycling but it fails to influence the generation or composition of waste so far—although this should be the top priority of all waste policy and infrastructure planning according to the Waste Framework Directive.

4.2. Instrument 2: Mandatory Ecodesign Standards for Reuse and Repair-Ability

Improved design can make products more durable or easier to repair, upgrade or remanufacture. It can help recyclers to disassemble products in order to recover valuable materials and components. Overall, it can help to save precious resources. However, current market signals appear insufficient to make this happen, in particular because the interests of producers, users and recyclers are not aligned. It is therefore essential to provide incentives for an improved product design, while preserving the single market and competition, and enabling innovation.

The instrument of mandatory ecodesign standards for reuse and repair of selected products aims to encourage producers to take future repair and reuse into account when designing the products. Inter alia, this includes considering issues such as whether the product can easily be dismantled and reassembled, and whether it is set up in such a way that faults can be easily identified. With mandatory ecodesign standards producers will primarily put those products on the market that do not inhibit the reuse and repair of whole products or their components. Taking into account that more than 80% of all product-related environmental impacts are determined in the design phase [24], relevant resource saving potentials can be covered with the implementation of this instrument. To date, there is virtually no experience with standards on reuse and repair, but an analogical instrument has been very successfully implemented in the energy efficiency sector. The Ecodesign Directive (2009/125/EC) [25] introduced mandatory ecodesign standards for energy-related products in order to reduce the energy consumption and other negative environmental impacts of products. The Ecodesign Directive provides a framework but does not include any binding requirements. The obligations for industries are adopted through special requirements, so-called "implementing measures", which are specifically set for each product group. Although the Ecodesign Directive covers a wide range of environmental aspects such as energy, water and other resource consumption, most of the "implementing measures", so far, primarily focus on energy efficiency parameters during the use phase [26].

In this respect, an analysis and assessment of potential impacts of the Ecodesign Directive on GHG emissions in the EU until the year 2020 showed "that the GHG emissions can be reduced by 211 to 265 million tonnes CO2 equivalents compared to business as usual (BAU) development" [27] if all implementing measures were in place. One of the most famous implementing measures within the Ecodesign Directive is the regulation on household lamps which led to the phase-out of incandescent light bulbs between 2009 and 2012 [28]. According to Remmen and Dalhammar [29], the directive has the potential to be also a powerful policy instrument for resource efficiency and the circular economy. Mandatory ecodesign standards for reuse and repair of electrical and electronic equipment can abolish barriers impacting the optimum end-of life management according to the waste hierarchy and push reuse activities for a more sustainable resource management.

However, the implementation of the instrument will require considering several aspects.

(a) Widening the scope of the European Ecodesign directive to reuse- and repair-ability criteria: The implementation of mandatory ecodesign standards for reuse and repair through the existing European Ecodesign directive is proposed by several studies [26,30,31]. Since the directive is already in place the feasibility could be a main reason for applying the directive for promoting reuse and repair on a European level [32]. On the other hand, Oehlmann and Herlédan [33] argue that the agreement procedure of the implementing measures takes too long and runs the risk to be quickly technically out-dated. On average, the procedure takes 55 month while the innovation cycle of electrical and electronic equipment is often shorter. In addition, the data quality is poor, since manufactures are not obliged to provide specific technical or economic information of their products. Also market surveillance is inefficient, due to too few employees, insufficient budgets, inadequate surveillance infrastructures and sanctions. Insufficient cooperation of Member States and within industry and the absence of standardised measuring methods are further reasons for the inefficient market surveillance. Obviously, implementing mandatory ecodesign standards for reuse and repair of electrical and electronic equipment through the existing European Ecodesign directive can be a promising approach but possibly not the most effective, as long as no flanking measures are being implemented.

(b) Measuring of reuse- and repair-ability: Appropriate parameters are required to practically measure the reuse-ability and repair-ability. According to Brünning et al. [34] determining technical criteria for the assessment of the reuse-ability of electrical and electronic equipment are the types and varieties of parts and materials used, suitability for disassembly, cleaning and testing. Ardente and Mathieux [31] have proposed a threshold for the time needed for the disassembly of the products' components under a standardised procedure. Further parameters, for instance, can be a limited number of bolds, the avoidance of glue or welding of parts and the availability of spare parts.

(c) Demand for ecodesigned products: The throw-away culture in which a quick turnover of (often cheap) goods and a low acceptance of reused products (e.g., social stigma, distrust regarding quality and safety) has become a deeply routed barrier on the consumer side. This may contribute to a low demand for even ecodesigned products. According to a 2011 Eurobarometer survey, the most common reasons for not buying second-hand products were related to concerns about product quality and usability (58% of mentions) [35]. However, some best practice examples (e.g., Kringloop in Flandern, Revital in Austria) underpin the fact that repair and reuse can be practiced successfully when there is a strong support of reuse activities (see, e.g., [36]). In this respect, the linking of mandatory product ecodesign standards with a strong support of reuse activities will contribute to a greater cost-effectiveness of repair, but also to awareness rising and growing demand for repair and reuse, thus leading to circularity compliant with the waste hierarchy.

4.3. Instrument 3: Individual Producer Responsibility

Extended Producer Responsibility (EPR) is "an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of a product's life cycle" [37]. EPR implies that producers take over the responsibility for collecting or taking back used goods and for sorting and treating for their eventual recycling. As a policy instrument EPR aims at internalising environmental externalities and should provide an incentive for producers to take into account environmental considerations along the products' life, from the design phase to their end-of-life. EPR could encourage a change in behaviour of all actors involved in the product value chain: product-makers, retailers, consumers-citizens, local authorities, public and private waste management operators, recyclers and social enterprises. EPR is also identified as a key instrument in line with resource efficiency and raw materials strategies promoted at EU level such as the flagship initiative for a resource-efficient Europe [38].

Analysis has shown however that such incentives are often significantly weakened because the responsibility is organized on a sectoral level and the costs for the collection and the recycling are shared among companies, based on the amount of products put on the market. Such an approach helps to reduce costs but it lowers the ambition for the individual companies to develop more circular products: The company would have to bear the costs for design and production changes, while the benefits of the reduced end-of-life costs would be shared with all other companies in the market—a classic prisoners dilemma: "If producers need to take care of discarded products similar to their own irrespective of brand, there are few or no incentives to spend extra resources enhancing their products' design to reduce environmental impacts from end-of-life. If the responsibilities were distributed among the brands without considering the difference of the products' environmental properties, producers who work harder to reduce environmental impacts from their products would end up subsidising the producers who did not make such efforts" [39].

Against this background, an innovative concept such as the "individual producer responsibility" (IPR) could be a promising approach—in such a system companies would only bear the costs caused by the products they put on the market. This instrument would create a direct feedback loop between the design of brand-specific products and their end-of-life management and provide incentives for producers to adapt the product design to easy repair, reuse and end-of-life treatment. Companies systematically considering these aspects in the products' design would benefit from lower end-of-life costs.

The principle of an extended producer responsibility has been implemented in the European Packaging Directive, the Waste Electrical and Electronic Equipment (WEEE) Directive, the ELV Directive and the Batteries Directive. However, it is more or less distinctly interpreted in the different directives. While, for instance, the Battery Directive applies EPR in terms of financial obligations for collecting and treating of batteries, the WEEE Directive "is a step forward in terms of the degree of responsibility placed on producers not only to ensure that products are collected and treated appropriately at their end-of-life but also to influence these products' design to prevent potential impacts from occurring in the first place" [39].

There are a number of essential research reports on IPR, which examine case studies and their impacts [39–41]. These experiences show that IPR can be implemented in various ways, especially based on the value of the products and the producers' ambition to influence their particular downstream supply chain. The need for incentives for ecodesigned products to reduce environmental impacts from end-of-life management exists for some non-durable products just as for some durable products. IPR may not be the appropriate policy instrument to promote ecodesign for non-durable products, e.g., due to the issue how packaging waste could be differentiated by brands. Taken the example of WEEE—products for which the IPR implementation can be particularly meaningful to provide incentives for producers to design their products durable—there are a series of (potentially hampering) factors, which have to be taken into consideration for designing the concrete implementation of IPR.

(a) Responsibilities on national, European and global level: If responsibilities are not directly assigned to the manufacturer, fragmented in the producing company or different from country to country, the effectiveness of the instrument will be hampered. Manufacturers may hesitate to optimise their material choices and the product design as long as such obligations are limited to the national market. Even if manufacturers are the obligated producers, problems may arise due to too little interaction between the managers responsible for the WEEE Directive compliance and those for the product design. Moreover, different national policies for the management of WEEE can result in less effectiveness, as highlighted in the WEEE Directive: "In particular, different national applications of the 'producer responsibility' principle may lead to substantial disparities in the financial burden on economic operators. Having different national policies on the management of WEEE hampers the effectiveness of recycling policies. For that reason, the essential criteria should be laid down at the level of the Union" [42].
(b) Administrative costs vs. maximum incentives for improved design: The costs to producers of the end-of-life phase of their products can be either based on return shares or the producer establishes

an individual handling of the downstream operations. The costs of the discarded products based on return shares can be determined by random sampling or by sorting each product exactly by brand name. In general, administration costs associated with the product identification are often regarded as "expensive", although there is little empirical evidence regarding the actual costs [40]. Likewise, the use of innovative technologies, for example, optical bar codes, chipless tags or radio frequency identification (RFID) [41] used to minimize these costs can be hampered by several factors (e.g., RFID: sensibility regarding grime, reduced readability of RFID because of high amounts of metals, reduction of a person's privacy, high resource use for the RFID tags).

(c) The issue of "orphan products" due to bankruptcy of producers: The incentive for producers with decreasing market sales to leave the financial system before a large portion of the products return (high costs in combination with lower sales) can also restrict the effectiveness of the instrument. The option of the producer's participation in "appropriate schemes" for the financing of the management of WEEE must be defined in such a way that costs do not burden the remaining producers in the market or society in the event of bankruptcy [40], e.g., preventing orphan products by the implementation of financial guarantees.

(d) Unknown future benefits: In the context of the design for end-of-life and EPR programmes, producers may not favour incentive based legislation, as future benefits are uncertain and any current investments would not lead to significant net present value benefits for firms.

5. Conclusions

The analysis of the gaps and barriers to the transition from waste management towards an integrated resource management underlines (a) the context sensitivity of incentives structures and (b) the necessity of policy mixes and (c) the coordination of the policy instruments along frequently transnational value chains leading to the generation of waste.

Present waste policy in the analysed EU Member countries is characterised by partly very different waste management approaches, great diversity in policy choices and a broad spectrum of performances. The analysis depicts that the implementation of current EU legislation into national law is not sufficient as incentive to treat waste as a resource. Most policy approaches do not sufficiently consider the steps of the waste hierarchy and thus do not systematically take into account aspects of resource efficiency and life-cycle thinking. The empirical analysis points to the following barriers to an upward movement of waste treatment in the waste hierarchy:

- The European regulatory framework for waste too weakly influences national waste management planning and institutional setting for pushing waste issues substantially forward and rather leads to a diversion of policy choices, which highlights uncertainty and knowledge deficits in the general transformation from waste to resource.
- The EU targets for waste are transposed into the national regulatory frameworks but the outcomes show that the implementation of EU legislation into national law and the targets themselves (i.e., weight based instead of considering material quality aspects) are not sufficient in order to manage waste as a resource.
- The aim of steering waste onto routes that save most natural and economic resources (waste hierarchy) is not tackled due to a lack of integrated environmental and economic assessments, monitoring and integrated planning with regard to potential detrimental effects on resource efficiency.

With regard to the analysis of the specific policy instruments (chapter 4) that aim to address these barriers and challenges, the paper highlights that—in contrast to technology-focussed end-of-pipe solutions for waste arising—an integrated resource management is much more demanding regarding the vital information of physical material flows as well as the specific interests of economic actors affected by the legal framework conditions. For this reason, the generation, management and diffusion of information will be a key challenge in the context of closing material loops, reducing the need for resources and increasing the efficiency of the EU resource use. Improved flows of information between the production sector (addressed by IPR and ecodesign instruments) and the end-of-life phase actors (waste targets) are absolutely essential to achieve most efficient policy outcomes under the constraints of temporarily low raw material prices and a strong focus on job generation in Europe. The analysis also highlights the need for innovative instruments with a dynamic perspective on the waste hierarchy: Where does it make sense to prevent waste? In which regions and countries are technical waste management infrastructures of such a high quality that recycling might be an even better solution from a resource efficiency perspective? The need to consider all these aspects for the formulation of successful policy instruments clearly underlines the necessity for integrated and consistent policy mixes.

Acknowledgments: The paper is based on a working paper within the scope of a project "Policy Options for a Resource Efficient Economy—POLFREE". This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No. 308371.

Author Contributions: Nadja von Gries analysed the policy frameworks and Henning Wilts wrote the description and analysis of the innovative new instruments as well as the design of the analytical framework for these. Henning Wilts and Nadja von Gries did the barrier analysis in both parts. Bettina Bahn-Walkowiak contributed to the methodological conception for the analyses of the policy frameworks and policy mixes as well as linguistic support and editing. Henning Wilts, Nadja von Gries, and Bettina Bahn-Walkowiak equally wrote the paper.

Conflicts of Interest: The authors declare no conflict of interest.

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