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Challenges of metal recycling and an international covenant as possible instrument of a globally extended producer responsibility

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Title: Challenges of metal recycling and an international covenant as possible instrument of a globally extended producer responsibility

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1 Introduction

Approaches of an extended producer responsibility (EPR) have raised high expectations regarding an evolvement of the present waste management from mainly being focused on disposal safety towards recycling and resource conservation and thus contributing to an integrated product policy (cf. OECD 2004). At least for the key products vehicles and electronic devices, the expected innovatory effects on the management of material flows associated with these products, however, largely failed. Starting point of this paper is to broaden the instrument of EPR to aspects of a global material responsibility from the perspective of a sustainable resource management (SRM). Therefore in section 2 aspiration and reality of EPR are compared regarding different product groups using the example of platinum group metals (PGM). Section 3 derives limits of existing EPR approaches and develops a governance-oriented proposal for an instrumental implementation aiming at systemic innovations. Section 4 draws some preliminary conclusions.

2 Sustainable resource management and worldwide recovery of PGM

Any socio-economic system and any entrepreneurial activity are based on the use of natural resources. Given finite resources and limited carrying capacities of ecosystems and facing the complexity of the relationship between the environmental and the socio-industrial metabolism, the decoupling of resource use and economic performance has become a widely accepted goal (cf. Bringezu 2011). For this purpose, the right balance between dematerialization and re-materialization needs to be found. This article deals with the second strategy, to forward recycling throughout various scales. The use of nonrenewable resources like metals is one of the key challenges of sustainable resource management (Giljum et al. 2008): metals and ecological rucksacks associated with their production (from mining to processing) are one of the three main drivers of the global total material requirement (cf. Bringezu/ Bleischwitz 2009). Also from an economic point of view a more efficient use of metal resources is one of the crucial future tasks:

- For industry, higher material and energy efficiency is a chance to reduce costs and enhance competitiveness. The search for eco-efficient technologies is thought to trigger sustainable innovation (cf. Bleischwitz 2010).
- Companies depend on a secure raw material supply. Germany and the European Union (EU) as regions poor in ores are highly dependent on imports of ores and metals: There is a significant increase of global metal demand, especially in countries like China and India.

While waste regulations have so far mainly focused on the optimization of recycling of mass flows, so-called critical metals have also been attracting interest lately. They are critical insofar as they have low reserve-to-production ratios, high growth rates of demand are expected due to market penetration of new technologies, and economic incentives have not yet been sufficient for the development of appropriate recycling infrastructures. Some metals also show structural shortages as their extraction as by-products is linked to mass metals, so that even significantly increasing prices of the by-products will only lead to no more than a slightly increased production (cf. Buchert et al. 2009). In addition, changes in the geopolitical-economic framework can impact on the supply side which is often characterized by a high level of concentration of the production processes in few countries. Thus many emerging economies pursue industrial development strategies by means of trade, taxation and investment instruments for critical metals in order to reserve their resource base for their exclusive use (cf. European Commission 2010).

As these rare metals have received less attention in technical literature than ferrous and base metals, the availability of knowledge is also relatively limited regarding material losses along their life cycles only recently these knowledge gaps are addressed by distinct studies, for example regarding the environmental relevance of rare metals (Wittmer et al. 2009). In the following, structures and causes of the continuing failure to especially recycle consumer goods will be discussed taking the example of PGM. Technically, a high-grade PGM recycling is not a challenge: For industrial applications, taking for example industry catalysts, recycling rates of more than 90 % are achieved (see Saurat/ Bringezu 2008). In contrast, the recycling rates of consumer goods are significantly lower. For example, the portion of recycling for the supply of PGM in automobile catalysts was of about only 26 % in 2010 (cf. JM 2010, p. 36). PGM has been identified as one of 14 critical raw materials by the EU Raw Materials Initiative (cf. *European Commission 2010)*. Table 1 shows the theoretical potential to increase resource productivity which is wasted by missing circular flows: primary production of platinum causes about 78 times more total material requirements (TMR) than secondary production.

Table 1

A fundamental problem for the recycling of PGM are exports of used and waste products into regions where either no recycling infrastructure is available at all or only in form of “backyard recycling” with low recovery rates and severe risks for health and environment (cf. Hagelüken/ Buchert 2010). Taking the example of three of the most important application fields for PGM in Germany (catalytic converters, mobile phones and screens) in a first step the relevance of these exports are described and the resulting PGM-losses are estimated before in a second step the relationship between these losses and existing EPR schemes is analyzed.

Given severe problems with the availability of data - especially regarding exports of used products and qualitative aspects of recycling determining the recovery rates for precious metals - the following case studies are based on a review of the few existing studies on this topic, analysis of sector-specific market developments and export statistics as well as on several expert interviews mainly in order to assess the reliability of different sources for information. Altogether the lack of consistent knowledge about these material flows can be regarded as a major barrier for a sustainable resource management.

Case study catalytic converters

In 2008 only 15 % of a total of 3 Million deregistered cars have been supplied to waste treatment in Germany. Evaluations of EU-databases for the re-registration of vehicles show that 50 % of the cars have been exported as used cars to other EU-countries (mainly the new member states, BMU/UBA 2010). The following illustration shows an update of the export statistics:

Figure 1

Based on the analysis of expert interviews and project workshops, it can be concluded that a significant share of the German intra-EU exports are shipped to Non-EU countries without extensive end-of-life vehicles (ELV) recycling. Table 2 shows the main destinations for used car exports, mainly the former CIS countries and West Africa (in recent years Russia has also been a major importing country, but nowadays, it increasingly establishes import restrictions on used vehicles in order to protect domestic production).

Table 2

These exports cause losses of about 1.6 t PGM for high quality recycling within the ELV regime (Buchert 2010). However, based on various Eastern European country studies, it can be stated that especially catalytic converters used in high-quality vehicles with correspondingly high PGM content are recycled in these countries, but often by hydro-chemical methods with significantly lower recovery rates. Afterwards these amounts often flow back in the PGM market through grey markets (cf. Lucas/ Wilts 2011).

Case study mobile phones

In 2009 approximately 26.9 million mobile phones were sold in Germany (cf. Bitkom 2010). With an average PGM content of 9 mg per device (cf. Hagelüken

2010) this corresponds to an annual PGM demand of approximately 243 kg. From the development of penetration rates in German households it can be concluded that about 80% of these devices replace an old one. A total of 120 million units are stored as hibernating stocks in German drawers and are thus (at the moment) not available for recycling.

Based on figures for the weight-related composition of mixed collection groups published by the German foundation “elektro-altgeräte-register” (register for waste electronic products – ear) and an average weight for mobile phones of 197g it can be concluded that in 2009 about 2.5 million mobile phones have been collected within the redistribution systems in the waste electric and electronic equipment (WEEE) regime (cf. ear 2011). In addition, about 1,5 million devices have been collected by professional recyclers, manufacturers and charitable organizations. About 4 million devices per year are disposed of as household waste so that most of the containing precious metals are lost (cf. Chancerel/ Rotter 2009). Regarding exports the analysis of German foreign trade statistics shows that about 13 million of the remaining units are exported into Non-EU countries (cf. table 3). Assuming that at least 80% of these devices are not recycled in a high-quality way, in 2009 these exports resulted in a loss of PGM of approximately 117kg.

Table 3

Case study screens

Unit sales of screens have increased dramatically on a global scale in the last 10 years. Therefore, especially two key drivers can be identified: On the one hand the growing configuration of households with computers, on the other the replacement of the old cathode ray tube (CRT) devices by flat screens. The total annual demand for PGM in Germany for screens can be estimated at about 360 kg, based on data on PGM contents per unit (cf. Chancerel 2010, 154) and sales figures. In 2009 of the total 18 million screens sold (including notebooks), 1% was allocated to CRT TV, 46% to flat panel displays (LCD and plasma) and 53% to LCD computer monitors (LCD monitors and notebook displays) (cf. GFU 2009).

Taking into account expert assessments and data on the equipment of household configuration with screens, it can be concluded that every year about 7.6 million computer monitors and 7.6 million TV sets are discarded. Based on evaluations of the composition of the relevant collection groups (cf. ear 2011), about 130.000t of screens have been collected within the EAR system in 2009. Assuming an average weight of about 5kg for computer monitors and 12kg for televisions sets, this would correspond to around 10 million data terminals and 6.5 million TVs in 2009. The predominantly illegal export of screen equipment can only be estimated with high uncertainty. Based on current studies by Sander / Schilling (2010) and Janz et al. (2009) an annual export of about 3-5 million units can be supposed. According to the assumptions made regarding PGM contents in CRT and flat screen, this would mean a loss of about 70kg PGM per annum.

Table 4

3 Potentials of a global EPR

EPR is one of the key approaches of waste legislation, which could contribute to sustainable resource management enabling preservation of resources and furtherance of a "recycling society" (European Commission 2011). There is no uniform definition of what is meant by EPR. The OECD (2004) has worded it in a very general way as follows: "an environmental policy approach in which a producer's responsibility, of both, physical and/or financial nature, for a product is extended to the post-consumer stage of a product's life cycle." There is an extensive debate about its concrete specification (e.g. individual vs. collective concepts, cf. van Rossem 2009) aiming at the implementation of this very broad concept. This paper tries to analyze specific incentive structures caused by European EPR concepts for end-of-life vehicles as well as for electronic waste implemented in Germany by the laws on WEEE (ElektroG) and ELVs (AltautoV). Complementary to mandatory take back obligations and related financial responsibility of the producer, the promotion of commodity circulation shall be supported or forced by mandatory recovery rates (cf. Beyer/ Kopytziok 2005, p. 20):

- According to the ElektroG since 2006 4kg per capita of WEEE have to be collected and recovered, for IT equipment and consumer electronics the recovery rate has to amount to at least 75% (at least 65% re-use and recycling). The collection costs have to be born by the local authorities in Germany, the producers have to take the responsibility for the recycling.
- According to the AltautoV for end-of-life vehicles the producers have to enable a free return for the last owner of a car. During initial treatment, a

removal of catalytic converters is required, a total of at least 80% of the average vehicle weight (85% from 2015) has to be recycled.

3.1 Limitations of existing EPR approaches

Against the background of these case studies in the following different conceptual gaps of existing EPR schemes shall be analyzed taking into account the collection and recycling of used products.

Objective differentiation

In contrast to most environmental regulations, EPR approaches refer to a concrete product, not to the actual production process or to the resulting waste. The ecological rucksacks associated with the different products usually make up a multiple volume of the actual product in order to but remain hidden from the very beginning. As a reference point for the producer's responsibility only the product itself remains whose configuration and composition shall be influenced in terms of eco-friendly design. Given the increasing complexity of products with a variety of production steps and materials used, the question arises who actually would take responsibility for the fate of these substances. As there is and will be no single person or institution who owns processes and products throughout the whole cycle of extraction, production, consumption, recycling, and disposal, the question is how responsibility for a systems-wide sustainable management can be attributed to the actors along that chain in a way that favours the sustainable management of the substances involved. With regard to global redistribution systems and recycling there seems to be a "responsibility gap" which leads to somehow open ends of waste flows and a loss or down-cycling of potential secondary resources.

For the mass-based collection targets, the tiny amounts of precious metals in small electrical appliances or the catalytic converters are not a relevant issue (cf. Chancerel 2010). Referring to the high mass-based recycling targets, its environmental compliance costs and other relevant costs (e.g. labour costs) lead to high costs for the entire system which average out at about 5.6 billion Euros for the collection and recycling of WEEE (cf. European Commission 2008). These costs, as well as the high global demand for used products have created incentives for legal second-hand goods exports, grey markets and illegal waste shipments. From the perspective of sustainable resource management, it will be necessary to augment EPR to aspects of material stewardship, not only including the directly controllable aspects of the production process, but also taking responsibility for the materials used in their use and end of life phase (cf. OECD 2010, p. 15). The mere obligation to take back a product does not determine a recycling of the materials contained. Even mandatory recycling rates usually refer to the total weight of a product and thus provide no incentives for the recovery of precious metals. The producer will always select the cheapest disposal according to economic criteria (cf. Beyer/ Kopytziok 2005). Even if products in principle could be recovered profitably, transaction costs lead to the preferability of primary raw materials, due to the spatially and temporally distributed generation of secondary raw materials. Also the European Commission demands in its "Thematic Strategy on Waste Prevention and Recycling" (2005, p. 20) a more material specific concept of producer responsibility.

Spatial differentiation

As an approach of direct control based on regulatory law, EPR is limited to a German or at least European regulatory space. At the same time, it can be observed that, however, material and waste streams are increasingly globalized. The analysis of the physical material flows shows that in the course of globalisation the EU has increasingly replaced domestic resource extraction by the import of products or semi-finished products, which has led to a reduction of the local environment burden and added additional damages especially to developing and emerging countries (cf. Bringezu/ Bleischwitz 2009, p. 59). At the same time, used and waste products are still exported (illegally, as well as legally as used products) from Europe into developing and emerging countries. Analysing the incentive structures established by the WEEE and the ELV directive, it is obvious that the existing institutional framework is not suitable to promote the circulation of PGM for a high-quality recycling. Without ambitious collection targets it rather provides additional incentives for export and thus promotes PGM losses (cf. de Bruijn/ Norberg-Bohm 2005). One reason for this development are the increasingly stringent European environmental standards in the waste legislation reducing the environmental pressures in Europe on the one hand, and, on the other hand, leading to a burden shifting into emerging and developing countries: for example, the prescribed removal standards in the end-of-life vehicle or WEEE directive lead to significant incidental costs, so that it is often cheaper to export products to Asia or Africa and dispose of there. For ELV, the removal of pollutants and dangerous parts like air bags costs about 260 Euros (cf. UBA 2002). For screens, investigations have shown that the proper treatment in Germany costs about 4 Euros per monitor, by contrast the export to Africa and dumping there only costs about 1.50 Euro (cf. Hagelüken 2007).

The case studies show that from the perspective of sustainable resource management national environmental policies are increasingly limited. A correspondence between spatial extent of the material flows and the "manageable space" as a prerequisite for an efficient regulation is more and more missing. In order to actually set effective incentives for resource conservation and recycling of raw materials by EPR, the manufacturers' responsibility can not be allowed to end at the border. This will require new governance approaches beyond regulatory law, which also have to involve stakeholders in the destination countries of exports.

Differentiation of actor orientation

Generally, the producer is responsible in terms of EPR. The wording suggests that this is the person or institution who actually manufactures products. In fact, the circle of addressees goes far beyond the actual manufacturer. E.g. the ELV defines the concept of "economic operators", which includes producers, distributors, collectors, motor vehicle insurance companies, dismantlers and companies for shredding, recovery, and recycling of end-of life vehicles. Furthermore, also the member states must ensure that vehicles placed on the market are free of certain pollutants (Article 2, Nr. 10). Lauridsen/ Jorgensen (2010) point out that an EPR which is only manufacturer-oriented pursues a too mono-causal explanation approach for innovation. Nowadays, many products are developed in modular networks, each with very different standards and governance structures. If EPR aims not only at incremental innovations for individual production steps but at systemic innovations along the complete value-chain, many other additional stakeholders will have to be involved. This has to take into account that neither a common understanding of the problem, nor a common interest for problem solving can be assumed automatically.

3.2 International covenants as a possible solution approach

In the following, based on the deficits observed and the limits of direct regulation regarding the recycling of exported products within the ambit of EPR schemes, a so called covenant is outlined to enhance material efficiency and resource conservation in this field of action. The covenant could provide a framework to close material flows on an international level: costs and benefits of increased WEEE or ELV recycling could be distributed more efficiently along the complete value chain. Covenants represent a combination of elements of direct governmental regulation and self-regulation by industry. A draft for such an international instrument has been developed for ELV within the project "material efficiency and resource conservation" (cf. Wilts et al. 2010). On principle, covenants may be characterized by the following elements:

- Industrial sectors commit themselves to achieving precisely and verifiably defined long-term goals far beyond the expected "business as usual" scenarios;
- These goals are negotiated in cooperation with the responsible authorities of the public sector;

- In return, the public authorities commit themselves to omitting further direct regulatory measures for the contract period creating a sufficiently long period warranting stable long-term framework conditions for the enterprises involved to ensure amortization of the necessary investments.;
- Covenants are concluded as private law contracts between all parties involved. Such contracts include both sanction mechanisms in case the stipulated goals are not achieved, and options to adapt the terms and conditions in case of changing framework conditions.

In the context of this covenant, specific targets should be defined on three levels:

Completion of industrial material cycles

In addition to the targets fixed by the ELV Directive regarding the recycling of a certain share by weight of an ELV, the covenant should define standards specific to groups of materials and intermediate targets for the completion of industrial material cycles. These should be based on the quantities currently used, establishing high-quality recycling and recovery procedures. The number of potentially relevant materials includes copper and PGMs because both of these mean a decisive contribution to the profitability of ELV recycling. In addition, which applies in particular to copper, they require extensive dismantling of the vehicle, thus automatically creating incentives for a sorted recovery of other material groups. In the context of the covenant, industrial partners would commit themselves to recovering a certain (to be negotiated) percentage of metal fractions contained in these vehicles which would also include the exported vehicles.

Recycling standards

For the recycling industry in the countries of destination, such commitment by the automobile industry would ensure a defined input for treatment facilities in the sector of base metals. Such facilities should be constructed in these countries of destination for the exported vehicles, at least for the first stages of recovery. Regarding the recovery of ELVs, it has to be taken into account that although the recycling of materials will lead to considerable resource savings, the treatment procedures proper will be associated with substantial environmental impact potentials, for example if oil and other operating liquids are directly discharged into sewer systems. This is why the recycling industry should be committed to high environmental standards also in the countries of destination, including for example compliance with the requirements for treatment facilities according to the ELV Directive (e.g. the removal of operating liquids).

Enhanced monitoring and reporting

Precise and binding reporting obligations for the contracting parties involved should be agreed upon in the covenant. This should, on the one hand, improve information exchange between manufacturers, recyclers and public sector authorities in order to identify possible efficiency potentials and promote innovation processes. On the other, publication of the reports is also intended to exert pressure on individual stakeholders in the case of failure to sufficiently meet their obligations. Relevant national and supranational agencies could and should be included into this process in order to support the provision of policy relevant data, e.g. the Environmental Agencies or Data Centres on Waste (Eurostat).

Sanctions

Past experience with regard to covenants has shown a lack of public control and insufficient provisions for discouraging free-rider behaviour of single stakeholders to constitute the critical points of the instrument (cf. Bressers et al. 2009). As a matter of principle, a covenant should therefore include options to impose sanctions for non-compliance by means of civil action to enforce contract penalties. In case of repeated failure to comply with the goals defined, there should be provisions to sanction the contracting parties concerned by means of economic penalties. In case manufacturers fail to meet their obligations, a binding procedure for the settlement of disputes should have been introduced. A possible preliminary stage could for example consist in the option to exclude enterprises or industries from public research funding. Another measure to be considered could consist in a ban on such enterprises or trade associations to participate in the development of binding standards.

Risks, challenges and necessary preconditions

The covenant's approach is based on the existence of sufficient economic incentives for the recycling of such fractions, together with appropriate framework conditions. One should indeed underline a business interest in (1) getting access to these materials and (2) benefiting from a partnership on the issue. On the other hand, the costs for negotiating and monitoring such an agreement as a substitute for direct regulation should not be underestimated. But of course, the question arises why companies should participate voluntarily in the negotiation of such a binding contract which also constitutes a restriction of their entrepreneurial freedom of action: The covenants would have to combine strategic interests on different levels:

- The recycling industry has to face the fact that electronic waste and ELV increasingly arise in emerging and developing countries. This is not only caused by exports of used and waste products, but also by an increasing amount of domestic waste generation. E.g. for China Yu et al. (2010) estimate that by 2013 more domestic than foreign WEEE will be generated. Therefore, the recycling industry will be substantially interested in establishing redistribution and recycling infrastructures in these countries.
- For the manufacturing industry, such a covenant offers the possibility to increase the security of supply for critical metals by the recycling of ELV or WEEE. The necessity to act is not primarily reasoned by geological scarcity but from structural scarcity, i.e. here the concentration of primary deposits in specific countries which start increasingly to take advantage of this monopoly situation (for example the case of export controls on rare earth metals in China).

Of course it would be naïve to neglect the heterogeneity within the different groups of stakeholders where powerful veto players have strong economic incentives to obstruct such a covenant. For this reason a credible "shadow of legislation" (cf. Töller 2008, Bressers/ de Bruijn 2005) by political actors will be crucial to increase the willingness of the parties involved to negotiate and also to put pressure on actors in grey markets. With this in mind developments on the national level of WEEE legislation like in China (cf. Yu et al. 2010) could support the realization of international agreements like a covenant. Furthermore established structures such as the Mobile Phone Partnership Initiative under the Basel Convention should be included in the negotiations in order to ensure the practicality of the to be developed set of rules.

From our point of view, neither too high expectations nor a fundamental scepticism towards covenants would be appropriate. Of course some voluntary environmentally regulations have dramatically failed in the past therefore the instrument should by no means be considered as an isolated measure but as a part of a comprehensive policy mix to increase resource productivity. Depending on the concrete arrangement, a covenant may have the advantage that all key stakeholders are involved in the negotiation process, which forwards an efficient solution on the one hand, and, on the other hand, may increase the willingness of the parties to actually implement its results.

Covenants as niches for innovation

Nevertheless the covenant bears severe practical, political and legal open questions which have to be balanced carefully against the dynamic effects which could be triggered by such a new arena for innovative solutions (e.g. for the unresolved problems of power and politics in such processes cf. Shove/ Walker 2007): From a static point of view, direct regulations clearly lead to more predictable results than covenants in order to improve high-quality recycling of

PGM (cf. Karup 2001). But facing the limitations of such instruments, a "second best-regulation" should particularly consider innovatory effects of an instrument. Dynamic effects on innovation gain in importance especially in environmental policy. Covenants could represent a form of knowledge-generating institutions (cf. Bleischwitz 2005), because they lower the transaction costs of information search by sector-wide co-operations and significantly stimulate learning processes in favour of system innovations. The covenant could form a technological niche in terms of a transition management where radical novelties emerge like new business models for the redistribution and recycling of mobile phones or catalytic converters in developing countries.

4 Conclusions

As shown, the export of used and waste products into developing and emerging countries without adequate recycling infrastructures is a major cause for the lack of recycling of critical metals. The high export rates thus undermine the basic regulatory EPR approach, the extension of the physical, and the financial responsibility on producers to the end-of-life phase of their products. In principle, the EPR aims to set incentives for a recycling-friendly design, if the EOL costs have to be internalized by the producers. These incentives are already significantly weakened by collective collection and financing schemes (cf. Fehling 2010), but if a relevant share of the products is exported and occurs in developing countries, this approach will be completely foiled.

Therefore, one of the key challenges for metals is to forward recycling also across country borders and enhance a more efficient use along the production chain. Europe drains metals with end-of-life products like scrap cars and WEEE, while the supply of metals is largely based on ores and concentrates imported from abroad. High-level recycling needs to be built up within Europe and beyond that, producer responsibility should be advanced to also establish collection and recovery systems abroad, in cooperation with developing countries as well.

Existing product-orientated EPR approaches focusing on mass-based recycling quota do not create adequate incentives to supply containing rare metals to a high-quality recycling and should be amended by aspects of a material stewardship. The large differences between the various product regimes and the resulting different problems point out that for an actor orientation the product as a reference needs to remain an important component. In the long term, product group- and resource group-specific elements have to be involved in an overall concept of global resource management: Policies for economy related sustainable resource management should develop long-term objectives for the production and consumption of critical resources. Such concepts have taken into account different spatial levels: Mass metals like steel or copper can be recycled on regional level, but especially for precious metals, global redistribution systems have to be developed.

The Raw Materials Initiative of the European Commission underlines the need for bilateral and regional trade agreements in order to secure the access to critical metals for European companies (European Commission 2010, p. 8). This approach should not, as hitherto, be limited to primary deposits, but should increasingly be extended to secondary stocks in future. Therefore, a proposal in form of the covenant has been developed aiming at systemic innovations through participation of the entire life cycle chain, but also, at the same time, allocating clear and reliable responsibilities to all parties. A key focus has to be to increase the transparency of material flows. Designing a robust and effective policy framework, key strategies and technologies for sustainable use of natural resources crucially requires improved knowledge on the short- and long-term dynamics of the socio- industrial metabolism.

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References

Beyer, P., Kopytziok, N. (2005) Abfallvermeidung und –verwertung durch das Prinzip der Produzentenverantwortung. Forschungsvorhaben für das Österreichische Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Berlin.

Bitkom (2010) Handy-Absatz soll 2010 wieder zulegen. From Bitkom (2010): http://www.bitkom.org/de/markt_statistik/64086_59451.aspx (Feb 28, 2011)

Bleischwitz, R. (2005) Gemeinschaftsgüter durch Wissen generierende Institutionen. Ein evolutorischer Ansatz für die Wirtschaftspolitik. Marburg

Bleischwitz, R. (2010) International economics of resource productivity: relevance, measurement, empirical trends, innovation, resource policies. International Economics and Economic Policy, 7 (2010), 2 – 3, 227 – 244

BMU/ UBA (Bundesumweltministerium/ Umweltbundesamt) (2010) Altfahrzeug-Verwertungsquoten in Deutschland im Jahr 2008 gemäß Art. 7 Abs. 2 der Altfahrzeug-Richtlinie 2000/53/EG. From BMU (2010): http://www.bmu.de/files/pdfs/allgemein/application/pdf/germany_elv_quota_ qualityreport.pdf (Dec 3., 2010)

Bressers, H. (2003) The use of Covenants in Target Group Policy: Evaluating a Dutch Environmental Policy Innovation. 11th International Conference of Greening of Industry Network, October 12-15 2003, San Francisco

Bressers, H. & De Bruijn, T. (2005) Conditions for the success of negotiated agreements: partnerships for environmental improvement in the Netherlands. Business Strategy and the Environment, Nr. 14(4), 241-254

Bringezu, S. (2011) Key Elements for Economy-wide Sustainable Resource Management. Responsabilité & Environment, Nr. 61, Jan. 2011, 78-87

Bringezu, S., Bleischwitz, R. (2009) Sustainable Resource Management: Trends, Visions and Policies for Europe and the World. Greenleaf Publisher, Sheffield

Buchert, M. (2010) Recycling, Exportproblematik und Reimportchancen? Werthaltige Komponenten am Beispiel des Katalysators. Berliner Recycling- und Rohstoffkonferenz, May 5, 2010, Berlin

Buchert, M., Schüler, D., Bleher, D. (2009) Critical Metals for Sustainable Technologies and their Recycling Potential. Report by UNEP/ Öko-Institut, Bonn

Chancerel, P. (2010) Substance flow analysis of the recycling of small waste electrical and electronic equipment. Institut für Technischen Umweltschutz, ITU-Schriftenreihe 09/2010, Berlin

Chancerel, P., Rotter, V. (2009) Assessing the management of small WEEE through Substance Flow Analysis – The example of gold in Germany and the USA. ISSST 2009, Phoenix

Commission of the European Communities (2011) Report from the Commission on the Thematic Strategy on the Prevention and Recycling of Waste. COM(2011) 0013 final, Brussels

Commission of the European Communities (2010) Report of the Ad-hoc Working Group on defining critical raw materials. From EC (2010): http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report_en.pdf (Feb 28, 2011)

Commission of the European Communities (2008) Commission staff working paper accompanying the proposal for a directive of the European Parliament and of the Council on waste electrical and electronic equipment - Summary of the impact assessment. COM(2008) 810 final, Brussels

Commission of the European Communities (2005) Taking sustainable use of resources forward: A Thematic Strategy on the prevention and recycling of waste. COM (2005) 666 final, Brussels

de Bruijn, T., Norberg-Bohm, V. (2005) Industrial Information. Environmental Policy in the United States and Europe. MIT-Press, Cambridge

ear Stiftung Elektroaltgeräteregister (2011) Zusammensetzung gemischter Sammelgruppen. From ear (2011): http://www.stiftung-ear.de/aktuell/aktuelle_mitteilungen/kennzahlen/zusammensetzung_gemischter_sammelgruppen (Feb 28, 2011)

Eurostat (2011) Außenhandelsstatistik der EG und ihrer Mitgliedstaaten COMEXT. Luxembourg.

Fehling, M. (2010) Innovationsförderung durch Herstellerverantwortung und Optionsmodelle im ElektroG. Natur und Recht, Vol. 32/2010, 323–329.

GFU (Gesellschaft für Unterhaltungs- und Kommunikationselektronik) (2009) Der Markt für Consumer Electronics in Deutschland. From GFU (2011): www.gfu.de/.../de_de_Der%20Markt%20für%20Unterhaltungselektronik%20-%20Deutschland%202009.pdf (Feb 28, 2011)

Giljum, S., Hinterberger, F., Biermann, B., Wallbaum, H., Bleischwitz, R., Bringezu, S., Liedtke, C., Ritthoff, M., Schütz, H. (2008) Errichtung einer internationalen Datenbank zur Ressourcenintensität von Rohstoffen, Halbwaren und Produkten. Kathy Beys Foundation, Aachen

Hagelüken, C. (2007) Ressourcenknappheit bei Edelmetallen und seltenen Metallen? EMPA Akademie Dübendorf, April 12, 2007, Dübendorf

Hagelüken, C., Buchert, M. (2010) Kritische Metalle für Zukunftstechnologien und ihr Recyclingpotenzial. Materialforum Rhein-Main, Jan 18, 2010, Hanau

Janz, A., Prelle, R., Müller, F., Bilitewski, B. (2009) Grenzüberschreitende Ströme von Elektroaltgeräten. Müll und Abfall, Vol. 3/09, 126-132

JM (Johnson Matthey) (2010) Platinum 2010. From: JM (2010) www.platinum.matthey.com/publications/market-data-charts/ (Nov. 11, 2010)

Kemp, R. (2010) The Dutch Transition Approach. International Economics and Economic Policy, No. 2 – 3, 291 – 316

Karup, S. (2001) Can voluntary approaches ever be efficient? Journal of Cleaner Production, 9/2001, 135-144

Lauridsen, E. H., Jorgensen, U. (2010) Sustainable Transition of electronic products through waste policy. Research Policy 39/2010, 486–494

Lucas, R., Wilts, H. (2011) Weltweite Rückgewinnung von PGM. MaRess-Report Summary, Wuppertal

OECD (Organization for Economic Cooperation and Development: Economic) (2004) Aspects of Extended Producer Responsibility. Paris

OECD (Organization for Economic Cooperation and Development: Economic) (2010): Policies for Implementing SMM. Summary Paper 3, OECD Environment Directorate, Paris

Sander, K., Schilling, S. (2010) Optimierung der Steuerung und Kontrolle grenzüberschreitender Stoffströme bei Elektroaltgeräten / Elektroschrott. UBA Texte Nr. 11/2010, Dessau

Saurat, M. Bringezu, S. (2008) Platinum group metal flows of Europe, PART I: Global supply, use in industries and the shift of environmental impacts. Journal of Industrial Ecology, 5/2008, 754–767

Shove, E., Walker G. (2007) CAUTION! Transitions ahead: politics, practice, and sustainable transition management. Environment and Planning, H. Volume 39, 763–770

Töller, A. E. (2008) Kooperation im Schatten der Hierarchie: Dilemmata des Verhandelns zwischen Staat und Wirtschaft, in: Gunnar Folke Schuppert/Michael Zürn (Hrsg.): Governance in einer sich wandelnden Welt, PVS-Sonderheft, Wiesbaden

UBA (Umweltbundesamt) (2002) Beschreibung des Standes der Technik bei der Vorbehandlung, insbesondere der Trockenlegung von Altautos gemäß AltautoV. FKZ 200 33 323, Berlin

Van Rossem, C. (2009) Individual Producer Responsibility - Principle vs. Practical Implementation. Conference on Canadian Stewardship, October 5-7 2009, Montreal.

Wilts, H., Bleischwitz, R., Sanden, J. (2010) Ein Covenant zur Schließung internationaler Stoffkreisläufe im Bereich Altautorecycling. Resourceneffizienz Paper 3.5, Wuppertal

Wittmer, D., Scharp, M., Bringezu, S., Ritthoff, M., Erren, M., Lauwigi, C., Giegrich, J. (2009) Metallische Rohstoffe, PGM und Infrastrukturen: Umweltrelevante metallische Rohstoffe. Zwischenbericht zur Phase I: Auswahl von Metallen zur vertiefenden Untersuchung (unpublished), Wuppertal

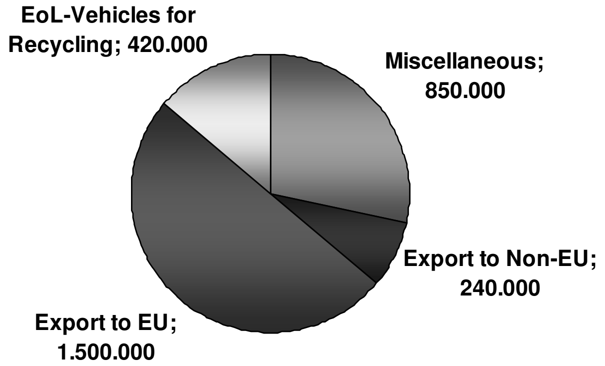
Yu, J., Williams, E., Ju, M., Yang, Y. (2010) Forecasting global generation of obsolete personal computers. Environmental Science & Technology, 9/2010, 3232–3237

Table 1: Comparison of environmental pressures associated with PGM in 2005

Pressure indicator	Platinum
Primary production, TMR in t/t	683,565
Secondary production, TMR in t/t	8,739
Primary production, CO2eq in t/t	39,839
Secondary production, CO2eq in t/t	2,875

Source: Saurat/ Bringezu 2008

Figure 1: Destination of the deregistered cars in Germany in 2008 (numbers rounded)



Source: BMU/UBA 2010

Table 2: Important Non-EU destination countries for used cars out of the EU27 in 2009

Destination	Quantity
Belarus	105902
Benin	73528
Kazakhstan	64930
Angola	49129
Nigeria	38420
Serbia	33585
Bosnia and Herzegovina	27264
Norway	25170
Turkmenistan	23814
Tajikistan	22150
Cameroon	20983
Ghana	16356

Source: Eurostat 2011

Table 3: Losses in the recycling of PGMs in discarded mobile phones in 2009

Life cycle stages	Quantity	PGM
Input: Sold mobile phones	Ca. 27 Mio	243 kg
Discarded mobile phones	Ca. 21,6 Mio.	194,4 kg
- Netto remaining in households	Ca. 0,6 Mio.	5,4 kg
- separetly collected for recycling	Ca. 3 Mio.	27 kg
- separetly collected for reuse	Ca. 1 Mio.	9 kg
- disposed into residual waste	Ca. 4 Mio	36 kg
Losses due to domestic treatment		10,53kg
Export	Ca. 13 Mio.	117 kg

Table 4: Losses for recycling of PGMs in discarded screens in 2009

Life cycle stages	Quantity	PGM
Input: screens sold	Ca. 18 Mio.	355 kg
Discarded screens		
TV sets	Ca 7,6 Mio	135 kg
Computer monitors	Ca. 7,6 Mio	127,5 kg
- Collected for recycling	Ca. 15,2 Mio.	262,5 kg
Losses due to domestic treatment		139,2 kg
Exports	Ca. 3-5 Mio.	52,5-87,5 kg

Title: Challenges of metal recycling and an international covenant as possible instrument of a globally extended producer responsibility

Abstract: As illustrated by the case studies of ELV and WEEE, the approach of an extended producer responsibility is undermined by the exports of used and waste products. This fact causes severe deficits regarding circular flows, especially of critical raw materials like PGM. With regard to global recycling there seems to be a responsibility gap which leads to somehow open ends of waste flows and a loss or down-cycling of potential secondary resources. Existing product-orientated EPR approaches with mass-based recycling quota do not create adequate incentives to supply containing precious metals to a high-quality recycling and should be amended by aspects of a material stewardship.

The paper analyses incentive effects on EPR for the mentioned product groups and metals, resulting from existing regulations in Germany. It develops a proposal for an international covenant on metal recycling as a policy instrument for a governance-oriented framework to initiate systemic innovations along the complete value chain taking into account product group- and resource group-specific aspects on different spatial levels. It aims at the effective implementation of a central idea of EPR, the transition of a waste regime still focusing on safe disposal towards a sustainable management of resources for the complete lifecycle of products.

Key words: EPR, PGM, waste shipments, ELV, WEEE, redistribution, covenant

1 Introduction

Approaches of an extended producer responsibility (EPR) have raised high expectations regarding an evolvement of the present waste management from mainly being focused on disposal safety towards recycling and resource conservation and thus contributing to an integrated product policy (cf. OECD 2004). At least for the key products vehicles and electronic devices, the expected innovatory effects on the management of material flows associated with these products, however, largely failed. Starting point of this paper is to broaden the instrument of EPR to aspects of a global material responsibility from the perspective of a sustainable resource management (SRM). Therefore in section 2 aspiration and reality of EPR are compared regarding different product groups using the example of platinum group metals (PGM). Section 3 derives limits of existing EPR approaches and develops a governance-oriented proposal for an instrumental implementation aiming at systemic innovations. Section 4 draws some preliminary conclusions.

2 Sustainable resource management and worldwide recovery of PGM

Any socio-economic system and any entrepreneurial activity are based on the use of natural resources. Given finite resources and limited carrying capacities of ecosystems and facing the complexity of the relationship between the environmental and the socio-industrial metabolism, the decoupling of resource use and economic performance has become a widely accepted goal (cf. Bringezu 2011). For this purpose, the right balance between dematerialization and re-materialization needs to be found. This article deals with the second strategy, to forward recycling throughout various scales. The use of nonrenewable resources like metals is one of the key challenges of sustainable resource management (Giljum et al. 2008): metals and ecological rucksacks associated with their production (from mining to processing) are one of the three main drivers of the global total material requirement (cf. Bringezu/ Bleischwitz 2009). Also from an economic point of view a more efficient use of metal resources is one of the crucial future tasks:

- For industry, higher material and energy efficiency is a chance to reduce costs and enhance competitiveness. The search for eco-efficient technologies is thought to trigger sustainable innovation (cf. Bleischwitz 2010).
- Companies depend on a secure raw material supply. Germany and the European Union (EU) as regions poor in ores are highly dependent on imports of ores and metals: There is a significant increase of global metal demand, especially in countries like China and India.

While waste regulations have so far mainly focused on the optimization of recycling of mass flows, so-called critical metals have also been attracting interest lately. They are critical insofar as they have low reserve-to-production ratios, high growth rates of demand are expected due to market penetration of new technologies, and economic incentives have not yet been sufficient for the development of appropriate recycling infrastructures. Some metals also show structural shortages as their extraction as by-products is linked to mass metals, so that even significantly increasing prices of the by-products will only lead to no more than a slightly increased production (cf. Buchert et al. 2009). In addition, changes in the geopolitical-economic framework can impact on the supply side which is often characterized by a high level of concentration of the production processes in few countries. Thus many emerging economies pursue industrial development strategies by means of trade, taxation and investment instruments for critical metals in order to reserve their resource base for their exclusive use (cf. European Commission 2010).

As these rare metals have received less attention in technical literature than ferrous and base metals, the availability of knowledge is also relatively limited regarding material losses along their life cycles only recently these knowledge gaps are addressed by distinct studies, for example regarding the environmental relevance of rare metals (Wittmer et al. 2009). In the following, structures and causes of the continuing failure to especially recycle consumer goods will be discussed taking the example of PGM. Technically, a high-grade PGM recycling is not a challenge: For industrial applications, taking for example industry catalysts, recycling rates of more than 90 % are achieved (see Saurat/ Bringezu 2008). In contrast, the recycling rates of consumer goods are significantly lower. For example, the portion of recycling for the supply of PGM in automobile catalysts was of about only 26 % in 2010 (cf. JM 2010, p. 36). PGM has been identified as one of 14 critical raw materials by the EU Raw Materials Initiative (cf. *European Commission 2010)*. Table 1 shows the theoretical potential to increase resource productivity which is wasted by missing circular flows: primary production of platinum causes about 78 times more total material requirements (TMR) than secondary production.

Table 1

A fundamental problem for the recycling of PGM are exports of used and waste products into regions where either no recycling infrastructure is available at all or only in form of “backyard recycling” with low recovery rates and severe risks for health and environment (cf. Hagelüken/ Buchert 2010). Taking the example of three of the most important application fields for PGM in Germany (catalytic converters, mobile phones and screens) in a first step the relevance of these exports are described and the resulting PGM-losses are estimated before in a second step the relationship between these losses and existing EPR schemes is analyzed.

Given severe problems with the availability of data - especially regarding exports of used products and qualitative aspects of recycling determining the recovery rates for precious metals - the following case studies are based on a review of the few existing studies on this topic, analysis of sector-specific market developments and export statistics as well as on several expert interviews mainly in order to assess the reliability of different sources for information. Altogether the lack of consistent knowledge about these material flows can be regarded as a major barrier for a sustainable resource management.

Case study catalytic converters

In 2008 only 15 % of a total of 3 Million deregistered cars have been supplied to waste treatment in Germany. Evaluations of EU-databases for the re-registration of vehicles show that 50 % of the cars have been exported as used cars to other EU-countries (mainly the new member states, BMU/UBA 2010). The following illustration shows an update of the export statistics:

Figure 1

Based on the analysis of expert interviews and project workshops, it can be concluded that a significant share of the German intra-EU exports are shipped to Non-EU countries without extensive end-of-life vehicles (ELV) recycling. Table 2 shows the main destinations for used car exports, mainly the former CIS countries and West Africa (in recent years Russia has also been a major importing country, but nowadays, it increasingly establishes import restrictions on used vehicles in order to protect domestic production).

Table 2

These exports cause losses of about 1.6 t PGM for high quality recycling within the ELV regime (Buchert 2010). However, based on various Eastern European country studies, it can be stated that especially catalytic converters used in high-quality vehicles with correspondingly high PGM content are recycled in these countries, but often by hydro-chemical methods with significantly lower recovery rates. Afterwards these amounts often flow back in the PGM market through grey markets (cf. Lucas/ Wilts 2011).

Case study mobile phones

In 2009 approximately 26.9 million mobile phones were sold in Germany (cf. Bitkom 2010). With an average PGM content of 9 mg per device (cf. Hagelüken

2010) this corresponds to an annual PGM demand of approximately 243 kg. From the development of penetration rates in German households it can be concluded that about 80% of these devices replace an old one. A total of 120 million units are stored as hibernating stocks in German drawers and are thus (at the moment) not available for recycling.

Based on figures for the weight-related composition of mixed collection groups published by the German foundation “elektro-altgeräte-register” (register for waste electronic products – ear) and an average weight for mobile phones of 197g it can be concluded that in 2009 about 2.5 million mobile phones have been collected within the redistribution systems in the waste electric and electronic equipment (WEEE) regime (cf. ear 2011). In addition, about 1,5 million devices have been collected by professional recyclers, manufacturers and charitable organizations. About 4 million devices per year are disposed of as household waste so that most of the containing precious metals are lost (cf. Chancerel/ Rotter 2009). Regarding exports the analysis of German foreign trade statistics shows that about 13 million of the remaining units are exported into Non-EU countries (cf. table 3). Assuming that at least 80% of these devices are not recycled in a high-quality way, in 2009 these exports resulted in a loss of PGM of approximately 117kg.

Table 3

Case study screens

Unit sales of screens have increased dramatically on a global scale in the last 10 years. Therefore, especially two key drivers can be identified: On the one hand the growing configuration of households with computers, on the other the replacement of the old cathode ray tube (CRT) devices by flat screens. The total annual demand for PGM in Germany for screens can be estimated at about 360 kg, based on data on PGM contents per unit (cf. Chancerel 2010, 154) and sales figures. In 2009 of the total 18 million screens sold (including notebooks), 1% was allocated to CRT TV, 46% to flat panel displays (LCD and plasma) and 53% to LCD computer monitors (LCD monitors and notebook displays) (cf. GFU 2009).

Taking into account expert assessments and data on the equipment of household configuration with screens, it can be concluded that every year about 7.6 million computer monitors and 7.6 million TV sets are discarded. Based on evaluations of the composition of the relevant collection groups (cf. ear 2011), about 130.000t of screens have been collected within the EAR system in 2009. Assuming an average weight of about 5kg for computer monitors and 12kg for televisions sets, this would correspond to around 10 million data terminals and 6.5 million TVs in 2009. The predominantly illegal export of screen equipment can only be estimated with high uncertainty. Based on current studies by Sander / Schilling (2010) and Janz et al. (2009) an annual export of about 3-5 million units can be supposed. According to the assumptions made regarding PGM contents in CRT and flat screen, this would mean a loss of about 70kg PGM per annum.

Table 4

3 Potentials of a global EPR

EPR is one of the key approaches of waste legislation, which could contribute to sustainable resource management enabling preservation of resources and furtherance of a "recycling society" (European Commission 2011). There is no uniform definition of what is meant by EPR. The OECD (2004) has worded it in a very general way as follows: "an environmental policy approach in which a producer's responsibility, of both, physical and/or financial nature, for a product is extended to the post-consumer stage of a product's life cycle." There is an extensive debate about its concrete specification (e.g. individual vs. collective concepts, cf. van Rossem 2009) aiming at the implementation of this very broad concept. This paper tries to analyze specific incentive structures caused by European EPR concepts for end-of-life vehicles as well as for electronic waste implemented in Germany by the laws on WEEE (ElektroG) and ELVs (AltautoV). Complementary to mandatory take back obligations and related financial responsibility of the producer, the promotion of commodity circulation shall be supported or forced by mandatory recovery rates (cf. Beyer/ Kopytziok 2005, p. 20):

- According to the ElektroG since 2006 4kg per capita of WEEE have to be collected and recovered, for IT equipment and consumer electronics the recovery rate has to amount to at least 75% (at least 65% re-use and recycling). The collection costs have to be born by the local authorities in Germany, the producers have to take the responsibility for the recycling.
- According to the AltautoV for end-of-life vehicles the producers have to enable a free return for the last owner of a car. During initial treatment, a

removal of catalytic converters is required, a total of at least 80% of the average vehicle weight (85% from 2015) has to be recycled.

3.1 Limitations of existing EPR approaches

Against the background of these case studies in the following different conceptual gaps of existing EPR schemes shall be analyzed taking into account the collection and recycling of used products.

Objective differentiation

In contrast to most environmental regulations, EPR approaches refer to a concrete product, not to the actual production process or to the resulting waste. The ecological rucksacks associated with the different products usually make up a multiple volume of the actual product in order to but remain hidden from the very beginning. As a reference point for the producer's responsibility only the product itself remains whose configuration and composition shall be influenced in terms of eco-friendly design. Given the increasing complexity of products with a variety of production steps and materials used, the question arises who actually would take responsibility for the fate of these substances. As there is and will be no single person or institution who owns processes and products throughout the whole cycle of extraction, production, consumption, recycling, and disposal, the question is how responsibility for a systems-wide sustainable management can be attributed to the actors along that chain in a way that favours the sustainable management of the substances involved. With regard to global redistribution systems and recycling there seems to be a "responsibility gap" which leads to somehow open ends of waste flows and a loss or down-cycling of potential secondary resources.

For the mass-based collection targets, the tiny amounts of precious metals in small electrical appliances or the catalytic converters are not a relevant issue (cf. Chancerel 2010). Referring to the high mass-based recycling targets, its environmental compliance costs and other relevant costs (e.g. labour costs) lead to high costs for the entire system which average out at about 5.6 billion Euros for the collection and recycling of WEEE (cf. European Commission 2008). These costs, as well as the high global demand for used products have created incentives for legal second-hand goods exports, grey markets and illegal waste shipments. From the perspective of sustainable resource management, it will be necessary to augment EPR to aspects of material stewardship, not only including the directly controllable aspects of the production process, but also taking responsibility for the materials used in their use and end of life phase (cf. OECD 2010, p. 15). The mere obligation to take back a product does not determine a recycling of the materials contained. Even mandatory recycling rates usually refer to the total weight of a product and thus provide no incentives for the recovery of precious metals. The producer will always select the cheapest disposal according to economic criteria (cf. Beyer/ Kopytziok 2005). Even if products in principle could be recovered profitably, transaction costs lead to the preferability of primary raw materials, due to the spatially and temporally distributed generation of secondary raw materials. Also the European Commission demands in its “Thematic Strategy on Waste Prevention and Recycling” (2005, p. 20) a more material specific concept of producer responsibility.

Spatial differentiation

As an approach of direct control based on regulatory law, EPR is limited to a German or at least European regulatory space. At the same time, it can be observed that, however, material and waste streams are increasingly globalized. The analysis of the physical material flows shows that in the course of globalisation the EU has increasingly replaced domestic resource extraction by the import of products or semi-finished products, which has led to a reduction of the local environment burden and added additional damages especially to developing and emerging countries (cf. Bringezu/ Bleischwitz 2009, p. 59). At the same time, used and waste products are still exported (illegally, as well as legally as used products) from Europe into developing and emerging countries. Analysing the incentive structures established by the WEEE and the ELV directive, it is obvious that the existing institutional framework is not suitable to promote the circulation of PGM for a high-quality recycling. Without ambitious collection targets it rather provides additional incentives for export and thus promotes PGM losses (cf. de Bruijn/ Norberg-Bohm 2005). One reason for this development are the increasingly stringent European environmental standards in the waste legislation reducing the environmental pressures in Europe on the one hand, and, on the other hand, leading to a burden shifting into emerging and developing countries: for example, the prescribed removal standards in the end-of-life vehicle or WEEE directive lead to significant incidental costs, so that it is often cheaper to export products to Asia or Africa and dispose of there. For ELV, the removal of pollutants and dangerous parts like air bags costs about 260 Euros (cf. UBA 2002). For screens, investigations have shown that the proper treatment in Germany costs about 4 Euros per monitor, by contrast the export to Africa and dumping there only costs about 1.50 Euro (cf. Hagelüken 2007).

The case studies show that from the perspective of sustainable resource management national environmental policies are increasingly limited. A correspondence between spatial extent of the material flows and the "manageable space" as a prerequisite for an efficient regulation is more and more missing. In order to actually set effective incentives for resource conservation and recycling of raw materials by EPR, the manufacturers' responsibility can not be allowed to end at the border. This will require new governance approaches beyond regulatory law, which also have to involve stakeholders in the destination countries of exports.

Differentiation of actor orientation

Generally, the producer is responsible in terms of EPR. The wording suggests that this is the person or institution who actually manufactures products. In fact, the circle of addressees goes far beyond the actual manufacturer. E.g. the ELV defines the concept of "economic operators", which includes producers, distributors, collectors, motor vehicle insurance companies, dismantlers and companies for shredding, recovery, and recycling of end-of life vehicles. Furthermore, also the member states must ensure that vehicles placed on the market are free of certain pollutants (Article 2, Nr. 10). Lauridsen/ Jorgensen (2010) point out that an EPR which is only manufacturer-oriented pursues a too mono-causal explanation approach for innovation. Nowadays, many products are developed in modular networks, each with very different standards and governance structures. If EPR aims not only at incremental innovations for individual production steps but at systemic innovations along the complete value-chain, many other additional stakeholders will have to be involved. This has to take into account that neither a common understanding of the problem, nor a common interest for problem solving can be assumed automatically.

3.2 International covenants as a possible solution approach

In the following, based on the deficits observed and the limits of direct regulation regarding the recycling of exported products within the ambit of EPR schemes, a so called covenant is outlined to enhance material efficiency and resource conservation in this field of action. The covenant could provide a framework to close material flows on an international level: costs and benefits of increased WEEE or ELV recycling could be distributed more efficiently along the complete value chain. Covenants represent a combination of elements of direct governmental regulation and self-regulation by industry. A draft for such an international instrument has been developed for ELV within the project "material efficiency and resource conservation" (cf. Wilts et al. 2010). On principle, covenants may be characterized by the following elements:

- Industrial sectors commit themselves to achieving precisely and verifiably defined long-term goals far beyond the expected "business as usual" scenarios;
- These goals are negotiated in cooperation with the responsible authorities of the public sector;

- In return, the public authorities commit themselves to omitting further direct regulatory measures for the contract period creating a sufficiently long period warranting stable long-term framework conditions for the enterprises involved to ensure amortization of the necessary investments.;
- Covenants are concluded as private law contracts between all parties involved. Such contracts include both sanction mechanisms in case the stipulated goals are not achieved, and options to adapt the terms and conditions in case of changing framework conditions.

In the context of this covenant, specific targets should be defined on three levels:

Completion of industrial material cycles

In addition to the targets fixed by the ELV Directive regarding the recycling of a certain share by weight of an ELV, the covenant should define standards specific to groups of materials and intermediate targets for the completion of industrial material cycles. These should be based on the quantities currently used, establishing high-quality recycling and recovery procedures. The number of potentially relevant materials includes copper and PGMs because both of these mean a decisive contribution to the profitability of ELV recycling. In addition, which applies in particular to copper, they require extensive dismantling of the vehicle, thus automatically creating incentives for a sorted recovery of other material groups. In the context of the covenant, industrial partners would commit themselves to recovering a certain (to be negotiated) percentage of metal fractions contained in these vehicles which would also include the exported vehicles.

Recycling standards

For the recycling industry in the countries of destination, such commitment by the automobile industry would ensure a defined input for treatment facilities in the sector of base metals. Such facilities should be constructed in these countries of destination for the exported vehicles, at least for the first stages of recovery. Regarding the recovery of ELVs, it has to be taken into account that although the recycling of materials will lead to considerable resource savings, the treatment procedures proper will be associated with substantial environmental impact potentials, for example if oil and other operating liquids are directly discharged into sewer systems. This is why the recycling industry should be committed to high environmental standards also in the countries of destination, including for example compliance with the requirements for treatment facilities according to the ELV Directive (e.g. the removal of operating liquids).

Enhanced monitoring and reporting

Precise and binding reporting obligations for the contracting parties involved should be agreed upon in the covenant. This should, on the one hand, improve information exchange between manufacturers, recyclers and public sector authorities in order to identify possible efficiency potentials and promote innovation processes. On the other, publication of the reports is also intended to exert pressure on individual stakeholders in the case of failure to sufficiently meet their obligations. Relevant national and supranational agencies could and should be included into this process in order to support the provision of policy relevant data, e.g. the Environmental Agencies or Data Centres on Waste (Eurostat).

Sanctions

Past experience with regard to covenants has shown a lack of public control and insufficient provisions for discouraging free-rider behaviour of single stakeholders to constitute the critical points of the instrument (cf. Bressers et al. 2009). As a matter of principle, a covenant should therefore include options to impose sanctions for non-compliance by means of civil action to enforce contract penalties. In case of repeated failure to comply with the goals defined, there should be provisions to sanction the contracting parties concerned by means of economic penalties. In case manufacturers fail to meet their obligations, a binding procedure for the settlement of disputes should have been introduced. A possible preliminary stage could for example consist in the option to exclude enterprises or industries from public research funding. Another measure to be considered could consist in a ban on such enterprises or trade associations to participate in the development of binding standards.

Risks, challenges and necessary preconditions

The covenant's approach is based on the existence of sufficient economic incentives for the recycling of such fractions, together with appropriate framework conditions. One should indeed underline a business interest in (1) getting access to these materials and (2) benefiting from a partnership on the issue. On the other hand, the costs for negotiating and monitoring such an agreement as a substitute for direct regulation should not be underestimated. But of course, the question arises why companies should participate voluntarily in the negotiation of such a binding contract which also constitutes a restriction of their entrepreneurial freedom of action: The covenants would have to combine strategic interests on different levels:

- The recycling industry has to face the fact that electronic waste and ELV increasingly arise in emerging and developing countries. This is not only caused by exports of used and waste products, but also by an increasing amount of domestic waste generation. E.g. for China Yu et al. (2010) estimate that by 2013 more domestic than foreign WEEE will be generated. Therefore, the recycling industry will be substantially interested in establishing redistribution and recycling infrastructures in these countries.
- For the manufacturing industry, such a covenant offers the possibility to increase the security of supply for critical metals by the recycling of ELV or WEEE. The necessity to act is not primarily reasoned by geological scarcity but from structural scarcity, i.e. here the concentration of primary deposits in specific countries which start increasingly to take advantage of this monopoly situation (for example the case of export controls on rare earth metals in China).

Of course it would be naïve to neglect the heterogeneity within the different groups of stakeholders where powerful veto players have strong economic incentives to obstruct such a covenant. For this reason a credible “shadow of legislation" (cf. Töller 2008, Bressers/ de Bruijn 2005) by political actors will be crucial to increase the willingness of the parties involved to negotiate and also to put pressure on actors in grey markets. With this in mind developments on the national level of WEEE legislation like in China (cf. Yu et al. 2010) could support the realization of international agreements like a covenant. Furthermore established structures such as the Mobile Phone Partnership Initiative under the Basel Convention should be included in the negotiations in order to ensure the practicality of the to be developed set of rules.

From our point of view, neither too high expectations nor a fundamental scepticism towards covenants would be appropriate. Of course some voluntary environmentally regulations have dramatically failed in the past therefore the instrument should by no means be considered as an isolated measure but as a part of a comprehensive policy mix to increase resource productivity. Depending on the concrete arrangement, a covenant may have the advantage that all key stakeholders are involved in the negotiation process, which forwards an efficient solution on the one hand, and, on the other hand, may increase the willingness of the parties to actually implement its results.

Covenants as niches for innovation

Nevertheless the covenant bears severe practical, political and legal open questions which have to be balanced carefully against the dynamic effects which could be triggered by such a new arena for innovative solutions (e.g. for the unresolved problems of power and politics in such processes cf. Shove/ Walker 2007): From a static point of view, direct regulations clearly lead to more predictable results than covenants in order to improve high-quality recycling of

PGM (cf. Karup 2001). But facing the limitations of such instruments, a "second best-regulation" should particularly consider innovatory effects of an instrument. Dynamic effects on innovation gain in importance especially in environmental policy. Covenants could represent a form of knowledge-generating institutions (cf. Bleischwitz 2005), because they lower the transaction costs of information search by sector-wide co-operations and significantly stimulate learning processes in favour of system innovations. The covenant could form a technological niche in terms of a transition management where radical novelties emerge like new business models for the redistribution and recycling of mobile phones or catalytic converters in developing countries.

4 Conclusions

As shown, the export of used and waste products into developing and emerging countries without adequate recycling infrastructures is a major cause for the lack of recycling of critical metals. The high export rates thus undermine the basic regulatory EPR approach, the extension of the physical, and the financial responsibility on producers to the end-of-life phase of their products. In principle, the EPR aims to set incentives for a recycling-friendly design, if the EOL costs have to be internalized by the producers. These incentives are already significantly weakened by collective collection and financing schemes (cf. Fehling 2010), but if a relevant share of the products is exported and occurs in developing countries, this approach will be completely foiled.

Therefore, one of the key challenges for metals is to forward recycling also across country borders and enhance a more efficient use along the production chain. Europe drains metals with end-of-life products like scrap cars and WEEE, while the supply of metals is largely based on ores and concentrates imported from abroad. High-level recycling needs to be built up within Europe and beyond that, producer responsibility should be advanced to also establish collection and recovery systems abroad, in cooperation with developing countries as well.

Existing product-orientated EPR approaches focusing on mass-based recycling quota do not create adequate incentives to supply containing rare metals to a high-quality recycling and should be amended by aspects of a material stewardship. The large differences between the various product regimes and the resulting different problems point out that for an actor orientation the product as a reference needs to remain an important component. In the long term, product group- and resource group-specific elements have to be involved in an overall concept of global resource management: Policies for economy related sustainable resource management should develop long-term objectives for the production and consumption of critical resources. Such concepts have taken into account different spatial levels: Mass metals like steel or copper can be recycled on regional level, but especially for precious metals, global redistribution systems have to be developed.

The Raw Materials Initiative of the European Commission underlines the need for bilateral and regional trade agreements in order to secure the access to critical metals for European companies (European Commission 2010, p. 8). This approach should not, as hitherto, be limited to primary deposits, but should increasingly be extended to secondary stocks in future. Therefore, a proposal in form of the covenant has been developed aiming at systemic innovations through participation of the entire life cycle chain, but also, at the same time, allocating clear and reliable responsibilities to all parties. A key focus has to be to increase the transparency of material flows. Designing a robust and effective policy framework, key strategies and technologies for sustainable use of natural resources crucially requires improved knowledge on the short- and long-term dynamics of the socio- industrial metabolism.

References

Beyer, P., Kopytziok, N. (2005) Abfallvermeidung und –verwertung durch das Prinzip der Produzentenverantwortung. Forschungsvorhaben für das Österreichische Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, Berlin.

Bitkom (2010) Handy-Absatz soll 2010 wieder zulegen. From Bitkom (2010): http://www.bitkom.org/de/markt_statistik/64086_59451.aspx (Feb 28, 2011)

Bleischwitz, R. (2005) Gemeinschaftsgüter durch Wissen generierende Institutionen. Ein evolutorischer Ansatz für die Wirtschaftspolitik. Marburg

Bleischwitz, R. (2010) International economics of resource productivity: relevance, measurement, empirical trends, innovation, resource policies. International Economics and Economic Policy, 7 (2010), 2 – 3, 227 – 244

BMU/ UBA (Bundesumweltministerium/ Umweltbundesamt) (2010) Altfahrzeug-Verwertungsquoten in Deutschland im Jahr 2008 gemäß Art. 7 Abs. 2 der Altfahrzeug-Richtlinie 2000/53/EG. From BMU (2010): http://www.bmu.de/files/pdfs/allgemein/application/pdf/germany_elv_quota_ qualityreport.pdf (Dec 3., 2010)

Bressers, H. (2003) The use of Covenants in Target Group Policy: Evaluating a Dutch Environmental Policy Innovation. 11th International Conference of Greening of Industry Network, October 12-15 2003, San Francisco

Bressers, H. & De Bruijn, T. (2005) Conditions for the success of negotiated agreements: partnerships for environmental improvement in the Netherlands. Business Strategy and the Environment, Nr. 14(4), 241-254

Bringezu, S. (2011) Key Elements for Economy-wide Sustainable Resource Management. Responsabilité & Environment, Nr. 61, Jan. 2011, 78-87

Bringezu, S., Bleischwitz, R. (2009) Sustainable Resource Management: Trends, Visions and Policies for Europe and the World. Greenleaf Publisher, Sheffield

Buchert, M. (2010) Recycling, Exportproblematik und Reimportchancen? Werthaltige Komponenten am Beispiel des Katalysators. Berliner Recycling- und Rohstoffkonferenz, May 5, 2010, Berlin

Buchert, M., Schüler, D., Bleher, D. (2009) Critical Metals for Sustainable Technologies and their Recycling Potential. Report by UNEP/ Öko-Institut, Bonn

Chancerel, P. (2010) Substance flow analysis of the recycling of small waste electrical and electronic equipment. Institut für Technischen Umweltschutz, ITU-Schriftenreihe 09/2010, Berlin

Chancerel, P., Rotter, V. (2009) Assessing the management of small WEEE through Substance Flow Analysis – The example of gold in Germany and the USA. ISSST 2009, Phoenix

Commission of the European Communities (2011) Report from the Commission on the Thematic Strategy on the Prevention and Recycling of Waste. COM(2011) 0013 final, Brussels

Commission of the European Communities (2010) Report of the Ad-hoc Working Group on defining critical raw materials. From EC (2010): http://ec.europa.eu/enterprise/policies/raw-materials/files/docs/report_en.pdf (Feb 28, 2011)

Commission of the European Communities (2008) Commission staff working paper accompanying the proposal for a directive of the European Parliament and of the Council on waste electrical and electronic equipment - Summary of the impact assessment. COM(2008) 810 final, Brussels

Commission of the European Communities (2005) Taking sustainable use of resources forward: A Thematic Strategy on the prevention and recycling of waste. COM (2005) 666 final, Brussels

de Bruijn, T., Norberg-Bohm, V. (2005) Industrial Information. Environmental Policy in the United States and Europe. MIT-Press, Cambridge

ear Stiftung Elektroaltgeräteregister (2011) Zusammensetzung gemischter Sammelgruppen. From ear (2011): http://www.stiftung-ear.de/aktuell/aktuelle_mitteilungen/kennzahlen/zusammensetzung_gemischter_sammelgruppen (Feb 28, 2011)

Eurostat (2011) Außenhandelsstatistik der EG und ihrer Mitgliedstaaten COMEXT. Luxembourg.

Fehling, M. (2010) Innovationsförderung durch Herstellerverantwortung und Optionsmodelle im ElektroG. Natur und Recht, Vol. 32/2010, 323–329.

GFU (Gesellschaft für Unterhaltungs- und Kommunikationselektronik) (2009) Der Markt für Consumer Electronics in Deutschland. From GFU (2011): www.gfu.de/.../de_de_Der%20Markt%20für%20Unterhaltungselektronik%20-%20Deutschland%202009.pdf (Feb 28, 2011)

Giljum, S., Hinterberger, F., Biermann, B., Wallbaum, H., Bleischwitz, R., Bringezu, S., Liedtke, C., Ritthoff, M., Schütz, H. (2008) Errichtung einer internationalen Datenbank zur Ressourcenintensität von Rohstoffen, Halbwaren und Produkten. Kathy Beys Foundation, Aachen

Hagelüken, C. (2007) Ressourcenknappheit bei Edelmetallen und seltenen Metallen? EMPA Akademie Dübendorf, April 12, 2007, Dübendorf

Hagelüken, C., Buchert, M. (2010) Kritische Metalle für Zukunftstechnologien und ihr Recyclingpotenzial. Materialforum Rhein-Main, Jan 18, 2010, Hanau

Janz, A., Prelle, R., Müller, F., Bilitewski, B. (2009) Grenzüberschreitende Ströme von Elektroaltgeräten. Müll und Abfall, Vol. 3/09, 126-132

JM (Johnson Matthey) (2010) Platinum 2010. From: JM (2010) www.platinum.matthey.com/publications/market-data-charts/ (Nov. 11, 2010)

Kemp, R. (2010) The Dutch Transition Approach. International Economics and Economic Policy, No. 2 – 3, 291 – 316

Karup, S. (2001) Can voluntary approaches ever be efficient? Journal of Cleaner Production, 9/2001, 135-144

Lauridsen, E. H., Jorgensen, U. (2010) Sustainable Transition of electronic products through waste policy. Research Policy 39/2010, 486–494

Lucas, R., Wilts, H. (2011) Weltweite Rückgewinnung von PGM. MaRess-Report Summary, Wuppertal

OECD (Organization for Economic Cooperation and Development: Economic) (2004) Aspects of Extended Producer Responsibility. Paris

OECD (Organization for Economic Cooperation and Development: Economic) (2010): Policies for Implementing SMM. Summary Paper 3, OECD Environment Directorate, Paris

Sander, K., Schilling, S. (2010) Optimierung der Steuerung und Kontrolle grenzüberschreitender Stoffströme bei Elektroaltgeräten / Elektroschrott. UBA Texte Nr. 11/2010, Dessau

Saurat, M. Bringezu, S. (2008) Platinum group metal flows of Europe, PART I: Global supply, use in industries and the shift of environmental impacts. Journal of Industrial Ecology, 5/2008, 754–767

Shove, E., Walker G. (2007) CAUTION! Transitions ahead: politics, practice, and sustainable transition management. Environment and Planning, H. Volume 39, 763–770

Töller, A. E. (2008) Kooperation im Schatten der Hierarchie: Dilemmata des Verhandelns zwischen Staat und Wirtschaft, in: Gunnar Folke Schuppert/Michael Zürn (Hrsg.): Governance in einer sich wandelnden Welt, PVS-Sonderheft, Wiesbaden

UBA (Umweltbundesamt) (2002) Beschreibung des Standes der Technik bei der Vorbehandlung, insbesondere der Trockenlegung von Altautos gemäß AltautoV. FKZ 200 33 323, Berlin

Van Rossem, C. (2009) Individual Producer Responsibility - Principle vs. Practical Implementation. Conference on Canadian Stewardship, October 5-7 2009, Montreal.

Wilts, H., Bleischwitz, R., Sanden, J. (2010) Ein Covenant zur Schließung internationaler Stoffkreisläufe im Bereich Altautorecycling. Resourceneffizienz Paper 3.5, Wuppertal

Wittmer, D., Scharp, M., Bringezu, S., Ritthoff, M., Erren, M., Lauwigi, C., Giegrich, J. (2009) Metallische Rohstoffe, PGM und Infrastrukturen: Umweltrelevante metallische Rohstoffe. Zwischenbericht zur Phase I: Auswahl von Metallen zur vertiefenden Untersuchung (unpublished), Wuppertal

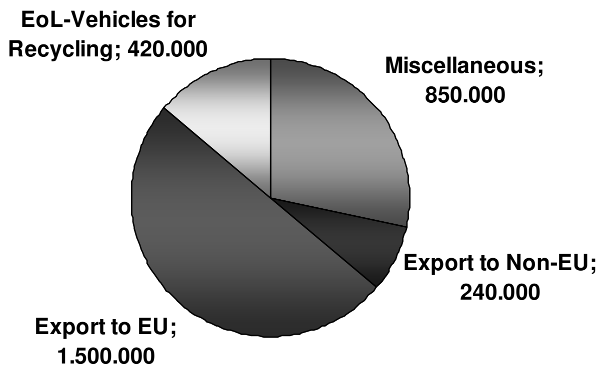
Yu, J., Williams, E., Ju, M., Yang, Y. (2010) Forecasting global generation of obsolete personal computers. Environmental Science & Technology, 9/2010, 3232–3237

Table 1: Comparison of environmental pressures associated with PGM in 2005

Pressure indicator	Platinum
Primary production, TMR in t/t	683,565
Secondary production, TMR in t/t	8,739
Primary production, CO2eq in t/t	39,839
Secondary production, CO2eq in t/t	2,875

Source: Saurat/ Bringezu 2008

Figure 1: Destination of the deregistered cars in Germany in 2008 (numbers rounded)



Source: BMU/UBA 2010

Table 2: Important Non-EU destination countries for used cars out of the EU27 in 2009

Destination	Quantity
Belarus	105902
Benin	73528
Kazakhstan	64930
Angola	49129
Nigeria	38420
Serbia	33585
Bosnia and Herzegovina	27264
Norway	25170
Turkmenistan	23814
Tajikistan	22150
Cameroon	20983
Ghana	16356

Source: Eurostat 2011

Table 3: Losses in the recycling of PGMs in discarded mobile phones in 2009

Life cycle stages	Quantity	PGM
Input: Sold mobile phones	Ca. 27 Mio	243 kg
Discarded mobile phones	Ca. 21,6 Mio.	194,4 kg
- Netto remaining in households	Ca. 0,6 Mio.	5,4 kg
- separetly collected for recycling	Ca. 3 Mio.	27 kg
- separetly collected for reuse	Ca. 1 Mio.	9 kg
- disposed into residual waste	Ca. 4 Mio	36 kg
Losses due to domestic treatment		10,53kg
Export	Ca. 13 Mio.	117 kg

Table 4: Losses for recycling of PGMs in discarded screens in 2009

Life cycle stages	Quantity	PGM
Input: screens sold	Ca. 18 Mio.	355 kg
Discarded screens		
TV sets	Ca 7,6 Mio	135 kg
Computer monitors	Ca. 7,6 Mio	127,5 kg
- Collected for recycling	Ca. 15,2 Mio.	262,5 kg
Losses due to domestic treatment		139,2 kg
Exports	Ca. 3-5 Mio.	52,5-87,5 kg