

**Wuppertal Institut**  
für Klima, Umwelt, Energie  
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# Benefits of resource efficiency in Germany

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## Executive summary

The current utilization of natural resources in German and Europe is not sustainable, as inter alia stated by the German government as well as by the European Commission. At the same time increased resource efficiency could lead to various environmental but also economic benefits. This brief study commissioned by Changing Markets presents developments in the field of resource efficiency policies, analyses the status quo of resource consumption with a special focus on fast moving consumer goods and describes potential effects of resource conservations.

Germany has established particularly strong policy frameworks in the areas of climate, renewable energy and waste, and with the creation of the German Resource Efficiency Programme (ProgRess) it has started to bring resources prominently onto the political agenda. Nevertheless, the primary focus of legislative instruments and eco-innovation support remains on the energy transformation. Further barriers remain in the form of insufficient support and research for radical innovations, perverse subsidies, weak green public procurement levels, a lack of legally binding requirements for resource efficiency, overreliance on information campaigns, etc. Especially for fast moving consumer products there are still only few actions present addressing resource efficiency. Also the links between the circular economy, waste prevention and resource efficiency are still weak and could be improved.

Looking at the total material requirements (TMRs) induced by household consumption of specific product groups in Germany about 37% can be linked to product categories including fast moving consumer goods. The analysis underlines the relevance of food product groups. Almost 60% of the FMCGs related TMR is caused by the production of food products and beverages, products of agriculture add additional 20%. The process of offering these products by the retail sector (processing, logistics etc.) is again another important factor with about 10% of the total material requirements linked to consumption patterns in Germany.

Increasing the resource and material efficiency of fast moving consumer goods is definitely challenging. Nevertheless there are already innovative and smart products on the market that allow to significantly reduce resource requirements, inter alia by resource optimized product designs, reduced packaging, using recycled materials and life time extension by reuse and repair. Based on existing case studies presented in the report a 20% increase of material efficiency in FMCG seems to be an ambitious but reasonable goal. Assuming an absolute reduction of Total Material Requirement in Germany by 20% until 2030, this would lead to significant economic benefits including 683,000 additional jobs compared to a business-as-usual scenario.

# 1 Introduction

Starting point for this study is the increasing evidence that the current utilization of resources, especially non-renewable ones, is not sustainable. In line with such statements, the European Commission states that “continuing our current patterns of resource use is not an option” (European Commission 2011). Thus the European Union has named resource efficiency as one out of seven flagship projects to pursue its so-called *Europe 2020* strategy, which means the EU considers resource efficiency a top policy priority. Nevertheless neither the business tools of integrated environmental management nor classic environmentally policy tools are able to deliver such strategic changes. The key insight is that materials and other resources are economically relevant, both for business and for macro-economic perspectives. But any policy formulation for resource efficiency however is still at a very early stage.

Against this background Changing Markets has commissioned this study that aims to explore potentials to drastically cut unnecessary resource use from the top, i.e. before they enter into our (ultimately circular) economy. The focus is on the material use of consumer goods products, specifically consumer goods sold by supermarket retailers. Retailers hold a very powerful market position both upstream to the producers and downstream to consumers, and can thus leverage genuine change over the whole supply chain. Germany is the biggest EU market for consumer goods products and German retailers have a strategic global position due to their size and market access.

The study is structured as follows: Chapter 2 introduces key concepts of resource efficiency, measurement and policies. Chapter 3 focusses on material use for fast-moving consumer goods in Germany. The final chapter describes the economic and environmental benefits that could be generated from a reduction of this material use.

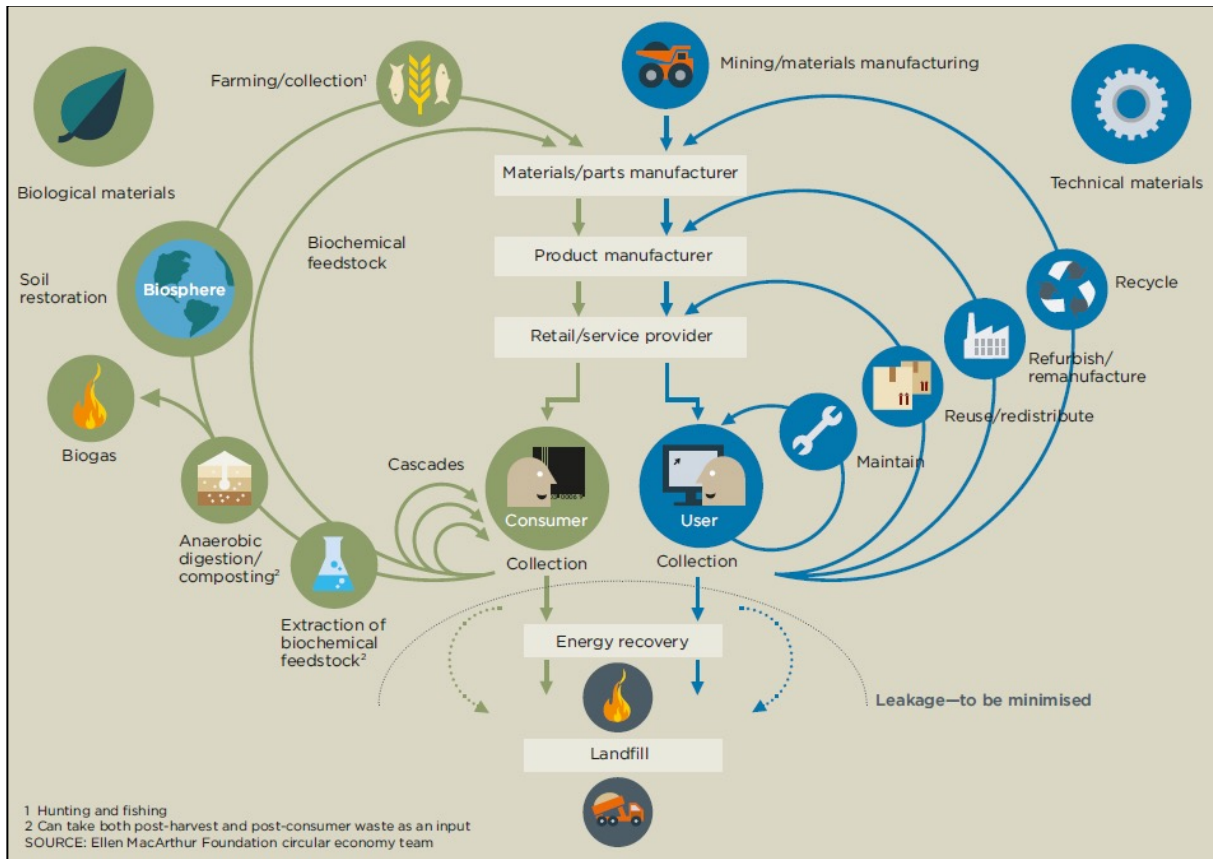
## 2 Resource efficiency in Germany - current state of affairs

### 2.1 Resource efficiency, waste management and the circular economy

Waste management in Germany is undergoing a fundamental transition process: Historically waste infrastructures have been established in order to ensure the disposal of waste in a cheap, reliable and – starting in the 1970s - also environmentally friendly way. Traditionally waste has been seen as a potential threat for the human health and it was regarded as a public task to take care of it – by landfilling it outside of the city walls or in later times by burning it in waste incineration plants (the first ones established in Germany and the UK at the end of the 19<sup>th</sup> century after the last outbreaks of cholera in urban agglomerations in the late nineteenth century). This socio-technical regime of waste disposal with all its technical infrastructures, governance structures and behaviour patterns was and still is focussed on this purpose: To avoid that the society is drowning in waste. In the public opinion large-scale systems based on municipal waste collection schemes and end-of-pipe technologies like waste incineration, shredding or other volume reducing waste treatment procedures seem to literally have minimized these sorrows – in most developed countries and especially in Germany waste seemed to be a „solved problem“.

In principle the main German regulation on waste (“Kreislaufwirtschaftsgesetz”) applies the principles of the waste hierarchy. Nevertheless there are until today no targets for the prevention, or the reuse of waste set in either the German or the European regulations (including the just recently published Circular Economy Package). This status quo is also being reflected in German waste management, where a focus is on recovery of energy from waste or recycling of materials. Only recently status quo has been contested and the idea of a more resource efficient circular economy has raised increasing interest 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“ (European Commission 2014a).

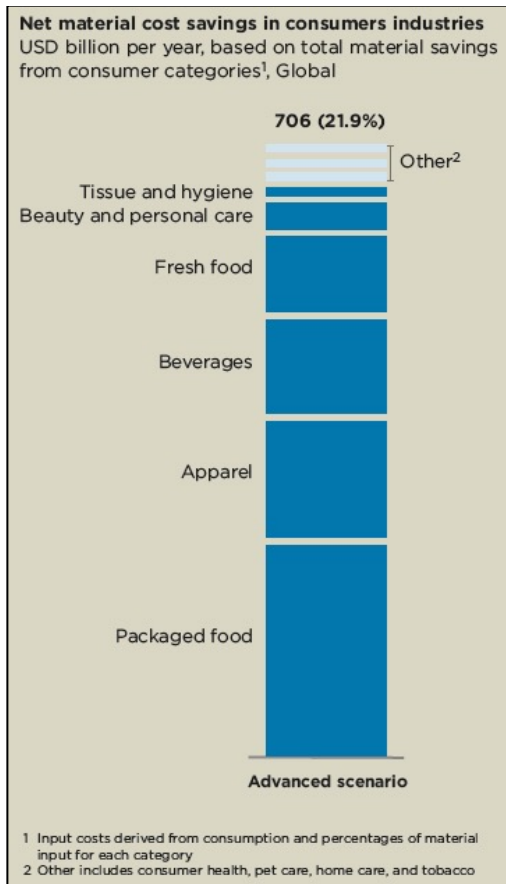




**Figure 1: The Circular Economy (EMF 2012)**

So far no legislation, neither on national or European level was successful to make a shift away from a linear economic model. This is also reflected in the often missing links between waste management and resource efficiency policies (see chapter 1.2). As seen in Figure 1 key to a circular economy are several circles, which are increasing in their process length. Next to maintenance, which could be also seen as a way of reducing or avoiding waste, is the short circle of reuse. This rather easy and logical step is in Germany's consumer market very neglected and only visible in some specific cases like beer bottles or in pre-consumer transport packaging. At first sight it would be expected that reuse of for example packaging is always a better option. Unfortunately due to long transportation routes of food and other consumer products the weight and size of the individual packaging materials have a direct impact on the overall impact. Here it might be necessary to develop either more local circular economies or new, lighter packaging materials, which can be reused better.

More circular business models, including such of reuse cases have not just effects on resilient growth and reduced dependency on resource markets. The circularity has a significant impact on innovation, employment, and capital productivity. In its reports "Towards the Circular Economy" the Ellen MacArthur Foundation, estimates a global annual net material cost saving potential of a rapid scale-up of circular business models up to USD 706 billions globally for fast-moving (with low use spans) consumer goods, as shown in Figure 2 for different categories.



**Figure 2: Adoption of circular setup in relevant fast-moving consumer goods sectors (EMF 2012)**

TNO quantifies in its investigation regarding the Netherlands moving towards a more circular economy the potential impacts on the overall Dutch economy (Bastein et al. 2013). In consideration of the circular economy for metal and electrical products and the use of waste streams from biomass, the total market value of the impacts of increased circularity on the Dutch economy could amount to € 7.3 billion a year. This corresponds, to 1.4% of today's GDP and to approximately 54,000 jobs (given the market value of salaries in all sectors). An adjustment of the TNO calculations according to the considered sectors in the EMF reports shows that the potential is rather lower than the EMF's estimates. Reasons are the assumption of more conservative estimations (e.g. difficulties in estimating radical changes), taking negative effects of the transition into account to the greatest extent possible (e.g. more recycling can result in higher costs in some cases) and the 'frontrunner's handicap' (e.g. initial headstart of Dutch material savings through recycling in comparison to the EU average can turn into a disadvantage in the long term) (ibid.).

However the numbers from both reports stress that a transition to a circular economy will lead to Economies which benefit from substantial material savings as well as drivers for innovation and job creation. Despite this public focus on zero waste, design for recycling and closed material loops the discourse shows a significant disparity between rhetoric's and actual concepts how to initiate, steer or support this transition. Furthermore, while in the policy discourse this transition is seen as a unitary one under the concept of circular economy, it actually includes at least two different paths that can be marked by trade offs. The first path is the closed loop of materials though recycling, recovery and re-use of waste, which results in the substitution and then savings of the corresponding virgin resources. The second path

is waste prevention which, through product and process innovation as well as behavioural innovation, implies the equivalent non-extraction and non-transformation of virgin resources, and the implies an equivalent 100% resource saving since the beginning of the production/consumption cycle for a given consumer satisfaction. Thus this second path is more powerful in terms of material savings but do not provide the materials for a closed loop based on recycling, recovery and reuse. These different paths can be hidden within a circular economy strategy but there can be trade-offs between them that are between waste prevention, which is at the top of the waste hierarchy, and job creation in the recycling/recovery/reuse sector.

## 2.2 Resource efficiency policies in Germany

The German resource efficiency policy can be regarded as based on three pillars: the German Sustainability Strategy, the Raw Materials Strategy and the Resource Efficiency Programme.<sup>1</sup> Resource productivity, as a quantifiable indicator measuring the efficiency of domestic material consumption, has already been embedded in Germany's National Sustainability Strategy since 2002, as well as in the subsequent progress reports in 2004, 2008, and 2012. According to this strategy, the German resource productivity is supposed to double (in comparison to 1994) until 2020. The Federal Government's Raw Materials Strategy (2010) stresses the security of supply of raw materials and emphasises combating trade barriers and the distortion of competition by measurements that diversify the sources of supply. The national Resource Efficiency Programme (ProgRess) aims at a more sustainable extraction and use of natural resources and a reduction of the associated environmental burden. The programme was adopted by the Federal Government in February 2012 (BMU 2012) and also aims to strengthen the efficiency culture as such and thus increase the resilience of the economy. For the 2016 update (see details below) a citizen participation concept was developed, the results were documented in a final report and are supposed to be integrated in the follow-up programme.

In October 2015, the G7 Alliance for Resource Efficiency, co-chaired by the German Federal Ministry for Economic Affairs (BMWi) and Energy and the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) was launched at the initiative of the German federal government by the heads of state and government at their G7 summit in June 2015. The aim is to share best practices on a more efficient use of natural resources and to contribute to the securing of existing and creation of new jobs, "to strengthen the growth of the economies in quantitative and qualitative terms and to improve environmental protection". In addition, the Alliance is to strengthen the pioneering role of the G7 countries in the field of resource efficiency as signal for other countries.

### Institutions and actors

An essential objective of ProgRess I was a nationwide expansion of resource efficiency consultancy for enterprises. In 2009, the Association of German Engineers (VDI) established the

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<sup>1</sup> In Europe, there are presently only three countries that have a dedicated national strategy or action plan for resource efficiency implemented (Austria, Finland and Germany).

Centre for Resource Efficiency (VDI ZRE), which has since developed a number of advice and training services, specifically aimed at small and medium enterprises. Since 2013 VDI ZRE also acts as the agency of the "Network Resource Efficiency" (NeRes), which ensures the integration of the issue into business practice. Based on the experiences gained through consulting services and financial assistance, the VDI ZRE revealed an average material saving potential of about 20% in industry. Hence, the ZRE material efficiency programme aims at the reduction of risks (such as rising material prices), rising competitiveness and security of company locations in Germany.

Further German agencies concerned with resource efficiency at national and regional level, inter alia, are

- German Raw Material Agency (BGR)
- German Material Efficiency Agency (Deutsche Materialeffizienzagentur - demea, now under the auspices of the BMWi and the German Aerospace Center and Project Management Agency (DLR)
- EFA NRW - Efficiency Agency North-Rhine Westphalia (Effizienzagentur NRW)
- Effizienznetz Rheinland-Pfalz
- Agency for Renewable Resources (Fachagentur für Nachwachsende Rohstoffe e.V. - FNR)
- Reconstruction loan corporation ("KfW-Umweltprogramm") and corresponding federal state central banks
- Federal Environment Agency, etc.
- Federal environmental ministries at Bundesländer level

A forum for the exchange between different actors of the advisory landscape is provided by the resource efficiency competence pool, comprising the VDI ZRE, the German Material Efficiency Agency (demea), the DIHK (German Chambers of Industry and Commerce e. V.), the EFA NRW (Efficiency Agency North Rhine-Westphalia), the RKW (Rationalisation and Innovation Centre of the German economy e. V.), the Federal Environment Agency, and the Wuppertal Institute. The aim of these networking activities is the diffusion and promotion of resource efficiency among Small and Medium Sized Enterprises which comprise up to 99% of the manufacturing and retail industry (Dreuw et al. 2011).

### Policies

Germany is highly export-oriented with a strong focus on the manufacturing industry (automotive industry, mechanical industry, etc.) and it also holds a strong position in the field of environmental patents and technologies. At the same time Germany is highly depending on resource imports with only very limited resource reserves in the country - especially with regard to non-energy raw materials<sup>2</sup>. At present, resource efficiency is often still understood as an investment in the cleaner and more efficient production processes. Research pro-

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<sup>2</sup> BGR 2015.

grammes like the High-Tech Strategy, the Master plan on Environmental Technology, and Materials Innovation for Industry and Society (WING) are oriented toward further development of German lead markets and pooling knowledge via network measures such as competence centres, clusters, and science- technology parks. A second focus is on financial or fiscal support for technology adopters (e.g. grants for purchasing new technologies or improving production processes). For example, the BMWi promotes consulting services to increase resource efficiency with the innovation vouchers "go-Inno" within the module "go-efficient". This programme shall be continued.

Germany has established particularly strong policy frameworks in the areas of climate, renewable energy and waste, and with the creation of the German Resource Efficiency Programme (ProgRess) it has started to bring resources prominently onto the political agenda. Nevertheless, the primary focus of legislative instruments and eco-innovation support remains on the energy transformation. Further barriers remain in the form of insufficient support and research for radical innovations, perverse subsidies, weak green public procurement levels, a lack of legally binding requirements for resource efficiency, overreliance on information campaigns, etc. Especially for fast moving consumer products there are still only few actions present addressing resource efficiency, such as activities of the German Federal Environmental Agency (Umweltbundesamt) to have a mandatory charge for plastic bags. Here no legislative approaches to resource efficiency have been put forward, as the main legislative focus for such products is consumer safety and quality.

### Economic sectors

The national **Resource Efficiency Programme (ProgRess)** aims at a sustainable extraction and use of natural resources and a reduction of the associated environmental burden. The programme was adopted by the Cabinet in February 2012 (BMU 2012). ProgRess 2012-2015 describes a total of 20 strategic approaches on the entire value chain (raw material supply, production, consumption, circular economy, and miscellaneous) and presents specific examples of material flows (such as phosphorous) and areas of life and technologies aiming at incrementally improving the raw materials productivity in the German industry (such as sustainable construction or Green IT). The focus is on the input side of natural resources as inputs for the economic and technical system. Quantitative obligations and timelines did not form part of ProgRess 2012 version and against this background and the very broad approach the programme initiated many background papers and policy initiatives – but with rather unclear effects on actual policy development (NABU 2015). The draft update of the programme, however, is under revision and expected to be released in early 2016 – it includes a list of “outcomes” of ProgRess I that is basically a list of identified challenges for ProgRess II. A preliminary draft was published for public and stakeholder consultation in 2015 and available for inspection. The guiding principles remain unchanged in Progress II:

- integrate environmental imperatives with economic opportunities, connect innovation to social responsibility
- global responsibility as a central focus of national resource policy
- make economic and production patterns in Germany gradually independent of primary raw materials, develop and expand the circular economy

- secure sustainable use of resources through social focus on qualitative growth in the long term

The new programme 2016-2019 now encompasses in total 116 different proposals for measures wherein the waste and circular economy policy and construction and urban development related realm was fundamentally and strongly expanded and received the rank of focus areas besides raw material supply, production, consumption, and ICT.

### **German Resource efficiency programme: From ProgRes I (2012) to ProgRes II (2016)**

#### **Focus in ProgRes II : 2012 - 2015**

- **20 strategic approaches – e.g. consumption** – public awareness, resource efficiency as criterion for trade and consumer, certification systems for raw materials, public procurement

#### **Focus in ProgRes II : 2016 – 2019**

- **10 action approaches** – Supply of raw materials, resource-efficient production, resource-efficient products and consumption, resource-efficient circular economy, sustainable construction and sustainable urban development, resource-efficient ICT, overarching instruments, synergies with other policy areas, support of resource policy at local and regional level, strengthening of resource policy at EU and international level,
- **in total 124 qualitative proposals for measures** wherein the waste policy and the construction related programme was expanded.

**Table 1: Development of German Resource efficiency programme**

While ProgRes I focuses on the non-energy raw materials abiotic and biotic raw material use, the scope of ProgRes II has been expanded to the fossil and biotic energy sources. Flow resources such as solar and wind power have also been explicitly included. Details on the approaches and actions of both programmes are summarised in Table 1.

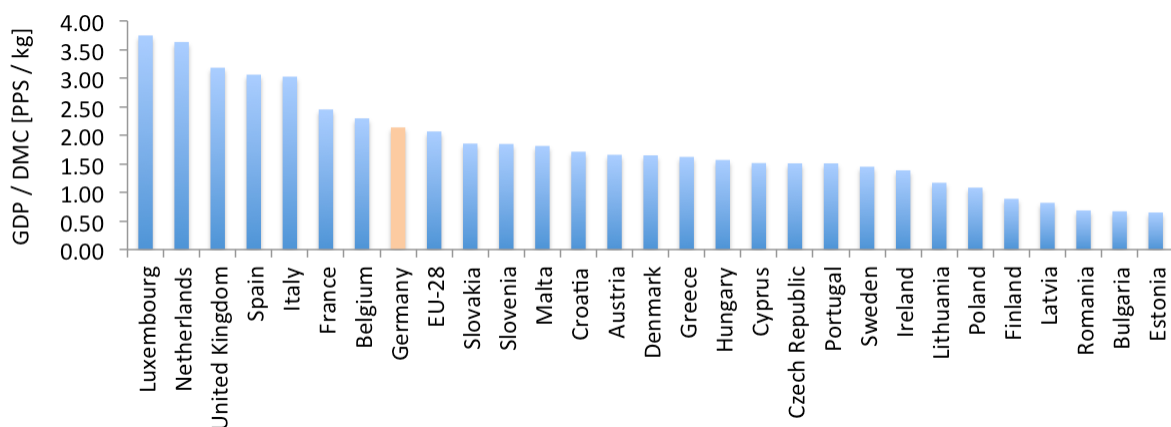
Summarising the above, Germany has an instrumental focus on financial incentives and support programmes for the industry and is one of the pioneers in terms of the programmatic development of resource efficiency agendas/ action plans at the same time. With regard to resource efficiency it can be said that a significant broadening and deepening of the objectives and measures to promote resource efficiency of the German economy has been submitted with the new proposal of ProgRes. The focus is on information tools to enable the key actors to recognize resource efficiency potentials in order to lift them. Concrete targets were not part of ProgRes of 2012 but are under consultation for the ProgRes II programme which is to be released in early 2016. The current draft (as of 17 December 2015), inter alia, includes the goal to continuously increase raw material efficiency and to decrease the raw material consumption per capita – by continuing trends between 2000-2010 until 2030. Although these seem not to be very ambitious targets it will be interesting to see whether these change in the consultation of the draft programme in the cabinet in February 2016. The programme also includes some more waste-related targets but most of them do not go beyond obligatory future EU targets. For the issue of resource efficient fast moving consumer goods

it's interesting to notice that it includes a quite strong statement to support public procurement requirements for resource efficient products.

### 2.3 Deficiencies of Domestic Material Consumption/GDP as an indicator for resource efficiency

The European Statistical Office (Eurostat) monitors resource productivity in the European Union (EU) and its Member States. Resource productivity is measured as gross domestic product (GDP) over direct material consumption (DMC). DMC measures the total amount, in tonnes, of material directly used in an economy, either by businesses, government and other institutions for economic production or by households. DMC is measured in tonnes of extracted natural resources per year. DMC equals the extractions of materials used by producer units in the economy plus imports — called direct material input (DMI) — minus exports (Eurostat 2015a).

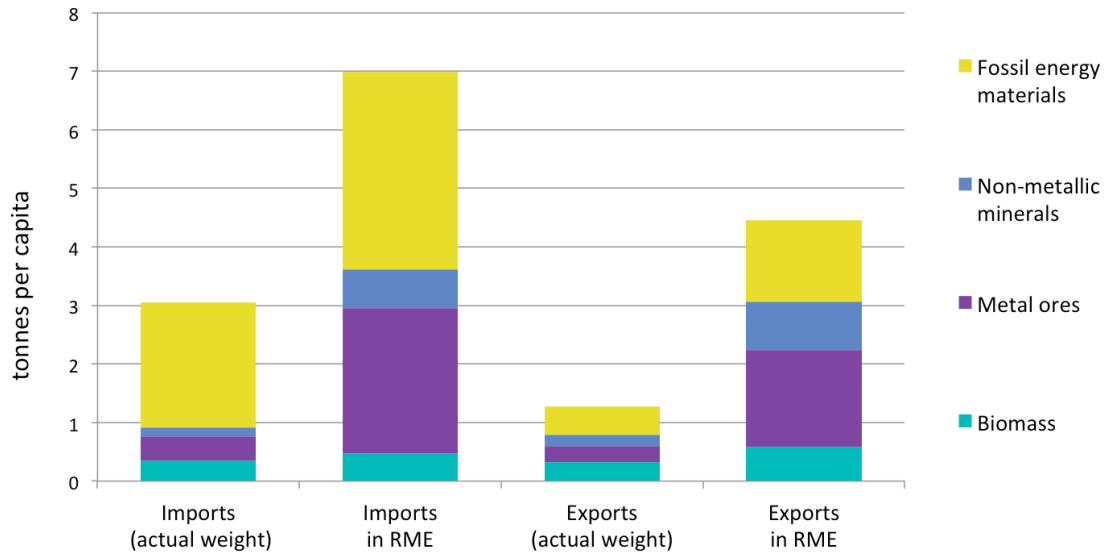
Using this indicator, Germany's economy is the 8th more resource productive in the EU-28 (see Figure 3). Germany's resource productivity lies just 3% above that of the EU28 as a whole. At the two extremes, Luxemburg is 75% more and Estonia 70% less resource productive than Germany.



**Figure 3: Resource productivity in purchasing power standard per kilogram, EU-28 and all Member States, 2014 (Eurostat, online data code: env\_ac\_rp)**

“A resource-efficient Europe” (European Commission 2015) as one of the flagship initiatives of the Europe 2020 strategy does propose to measure resource productivity using GDP/DMC. Eurostat routinely produces the necessary statistics, e.g. DMC as part of the economy-wide material flow accounts (EW-MFA). Those statistics however have shortcomings. They record the international flows of materials differently than the materials extracted from the environment (called domestic extraction in EW-MFA). Imports and exports are recorded in material flow accounts as the actual weight of the traded goods when they cross country borders instead of the weight of materials extracted to produce them. As the former are lower than the latter economy-wide, material flow accounts and the derived DMC underestimate the material flows associated with trade flows (Eurostat 2015b).

To adjust for this, the weight of processed goods traded internationally is converted into the corresponding raw material extractions they induce. Trade flows are then said to be expressed in raw material equivalents (RME). Figure 4 compares trade flows in actual weight and in RME for the EU. Eurostat estimates the raw material equivalents of imports and exports for the aggregated EU economy using a model. These estimates do not yet have the status of official statistics that EW-MFA has.



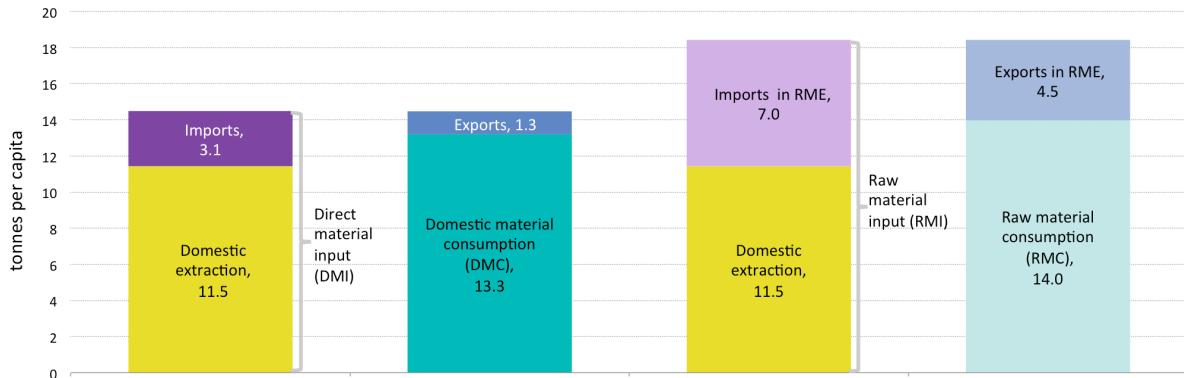
**Figure 4: Comparison of the actual weight of traded goods with trade in raw material equivalents (RME), EU-27 for trade in RME, EU-28 for trade flows in actual weight, 2013 (Eurostat, online data code: env\_ac\_rme, env\_ac\_mfa, demo\_gind)**

Figure 4 shows that the total weight of raw material extractions needed to produce manufactured products is several times greater than the weight of the products themselves. According to the Eurostat estimates, EU imports in 2013 were 2.3 times higher when expressed in RME than imports recorded in EW-MFA. Exports were 3.5 times higher.

Logically, the adjustment of the trade flows from actual weight when crossing the border to RME also impacts the material flow indicators. The main RME-based indicator is raw material consumption (RMC), which mirrors DMC from the EW-MFA. It is also referred to as the EU's material footprint. RMC represents the total amount of extracted raw materials needed to produce the goods and services consumed by residents of the EU (Eurostat 2015b).

Figure 5 shows from left to right how DMC is derived from DMI (subtract exports from domestic extraction plus physical imports) and how RMC is derived from RMI. In the latter case physical trade is converted into RME. The consumption indicators differ only slightly (RMC is 5% higher than DMC) while RMI is 27% higher than DMI.





**Figure 5: Material flow indicators derived from EW-MFA and MFA in RME, EU-27 for trade in RME, EU-28 for physical trade, 2013. Source: Eurostat (online data code: env\_ac\_mfa, env\_ac\_rme, demo\_gind).**

A last group of indicators, total material requirement (TMR) and total material consumption (TMC), expand the material footprint indicators RMI and RMC, respectively. TMR and TMC account for economically unused extraction (e.g. overburden at a mining site) in addition to the raw material flows. These indicators are not supported by Eurostat to date. The European Environmental Agency (EEA) has used these indicators for sustainable production and consumption assessments (EEA 2013). From an environmental point of view it is clear that the more comprehensive indicators TMR and TMC give a more precise picture of the environmental burdens of production and consumption patterns. Nevertheless the data requirements are still challenging and additional efforts will be necessary to update and harmonize the data base as well as to simplify the calculation methods.

## 2.4 Implementation of the waste hierarchy in Europe/ Germany

Europe's state of waste management is as diverse as the continent itself. Even though the European Commission tries to push the continent towards a transformation into a "recycling society", the reality still shows a clearly different picture. In 2011, total waste production in the EU amounted to approximately 2.5 billion tons. In the case of municipal waste during the last two decades, the diversion of municipal solid waste from landfill towards recycling and recovery has been massive and the trend of diversion is well established. However, in spite of this positive process, only a limited share (40%) of waste generated in the Union was recycled, with the rest being landfilled (37%) or incinerated (23%) of which around 500 million tons could have been otherwise recycled or reused. Germany is seen as one of the front-runners in waste management, with 48% recycling, 18% composting, and 34% incineration of waste to recovery energy of municipal waste. Taking into account also other waste streams, the total recycling rate reaches nearly 70% - mainly due to the high rates for construction and demolition waste.

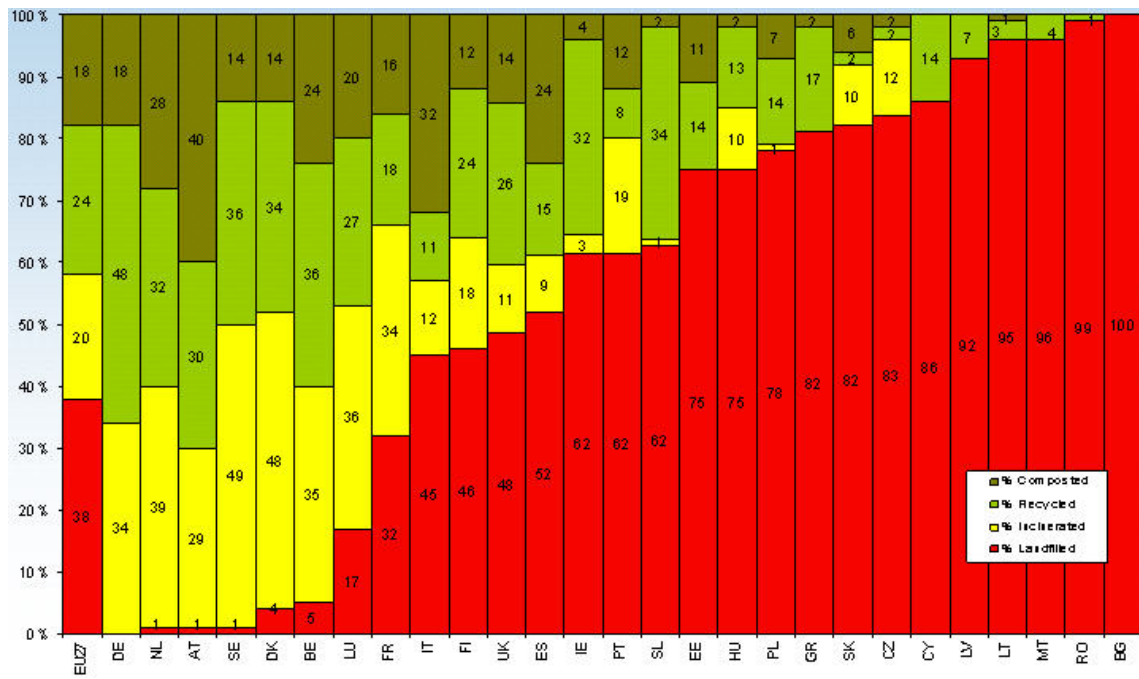


Figure 6: Waste Management composition in EEA countries in 2009. Source: based on Eurostat.

The European Union currently loses a significant amount of potential secondary raw materials contained in waste streams which are not fed into the optimal treatment options: “The Union thus misses out on significant opportunities to improve resource efficiency and create a more circular economy leading to economic growth and jobs which in turn would reduce greenhouse gas emissions and its dependency on imported raw materials.” (European Commission 2014b). While on overall European level there is still a strong concern for the lack of material being fed as input into recycling systems, in Germany the concern is rather about quality.

Further the waste management in Germany is currently facing a new development of framework conditions: On 1 June 2012, the new Closed Cycle Management Act (Kreislaufwirtschaftsgesetz, KrWG) came into force (replacing the Closed Cycle Management Waste Management Act of 1996) with the aim of turning waste into resource management. The core of the Closed Cycle Management Act is represented by the new five stage waste hierarchy (§ 6 KrWG) representing the core of the Closed Cycle Management Act. It determines the fundamental waste treatment prioritisation: Prevention, reuse, recycling and energetic or other recovery and finally, disposal. The best option from the viewpoint of environmental protection is always prioritised but apart from ecological impacts, technical, economic and social consequences have to be considered as well. Mainly for economic reasons, waste incineration is the dominant treatment technology for many waste streams, e.g. plastics.

In order to further improve resource efficiency in waste management, the guidelines for recycling are reinforced in the new Closed Cycle Management Act: In addition to the guidelines of the Waste Framework Directive and the EU Circular Economy Package, a recycling quota of at least 65 % (instead of 50 % as proposed by the EU for paper, metal, plastic and glass) is aimed to be achieved for municipal waste and 70 % for construction and demolition waste (§ 14 KrWG). These quotas are supposed to promote a Circular Economy and give impulses for further progress. The quotas are partly higher than the EU guidelines and consider the recy-

cling level already achieved in Germany as well as the economic feasibility, and create transparency for all stakeholders (BMUB 2012) – nevertheless it has to be noted that the legal definition of “recycled” does not necessarily imply that raw materials contained in specific waste streams or products are actually recovered, they just have been fed into treatment facilities that are listed in the Waste Framework Directive and the KrWG. The share of wastes, which cannot be recovered, has to be consigned to disposal without inflicting harm on the environment or on human health. Organic waste always has to undergo mechanic-biological or thermal treatment to render it inert, thus helping to reduce drainage water leakages and releases of landfill gas. Since June 2005, it is no longer permitted to landfill organic waste without prior treatment. The new Circular Economy Act contains the general obligation to collect organic waste separately with effect from 1. January 2015 (BMUB 2012a). Although more than 100 kg of organic waste per inhabitant are already collected separately today, and Germany ranks among the leaders of separate collection all over the world, there is still potential for optimisation. For example, up to now only half of the German population has access to a bin for biowaste (ibid.).

### Overcapacity of waste incineration

68 waste incineration facilities with a capacity of 19,6 million tonnes were available in 2013 in Germany for the treatment of municipal solid waste (Prognos 2014). Moreover, in 2013, 5.4 million tonnes incineration capacities are available in 35 refuse-derived fuel power plants (ibid.). This leads to total incineration capacity of around 310 kg per German resident. Considering the average generation of municipal solid waste of 617 kg per capita (in 2013, according to Eurostat), this means the available capacity for the treatment option of incineration is 50%. While this considers only the municipal waste, it clearly shows that the capacity is more than 15% over the current rate of incineration treatment shown before (34%). This overcapacity led in the past to dramatic price reductions of gate fees, which have to be paid to dispose-off waste at such facilities. In some cases it can be cheaper to burn waste in a cheap incineration facility rather than use more resource efficient, but costly recycling facilities. In addition these low prices lead to an increasing import of waste streams from other European Member states (in total about 22 Mio tons in 2014), where incineration is more expensive due to newer facilities and a lower overall capacity. Figure 7 shows the price levels for waste incineration in Germany, especially highlighting the low price levels for commercial waste. This situation has been stable for the last few years. For 2016 there will be probably a decrease for public waste combined with an increase for commercial waste due to the re-negotiation of several multi-year contracts with municipalities.

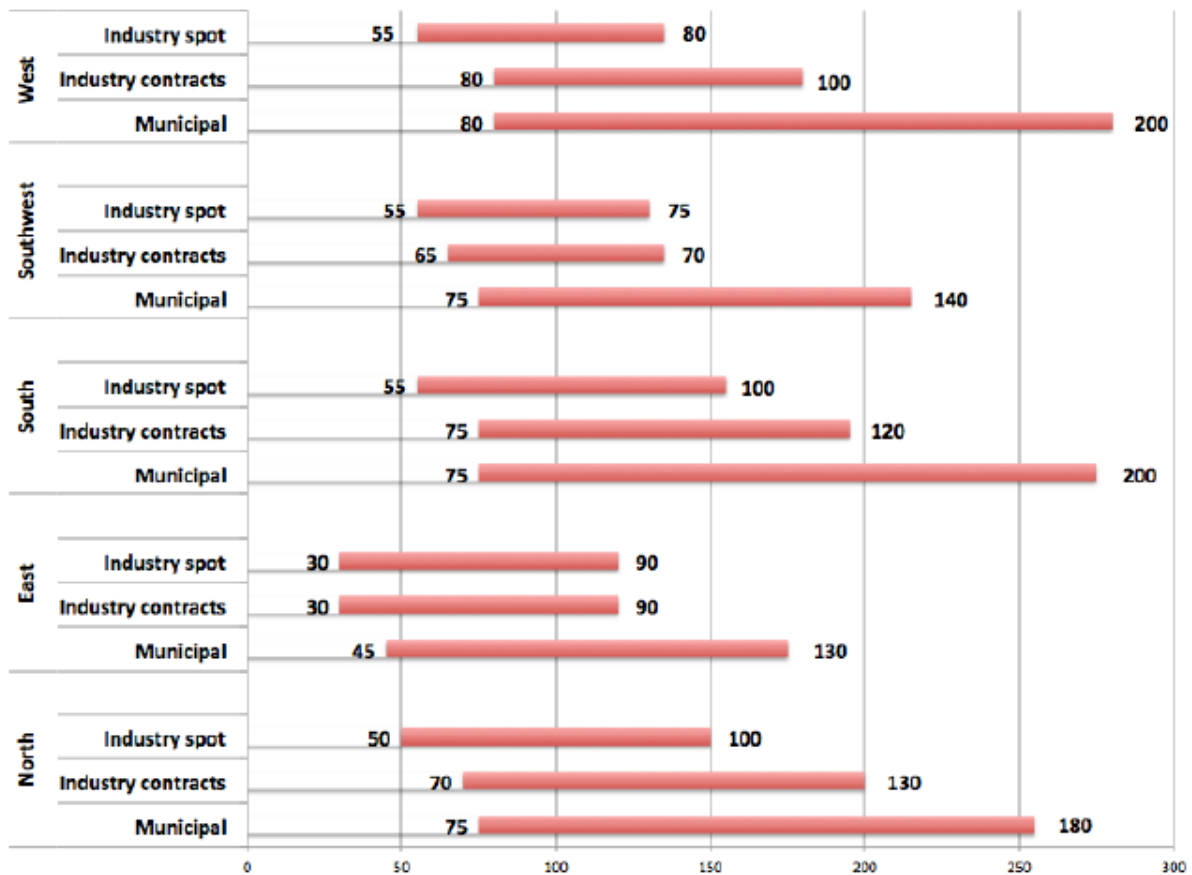


Figure 7: Prices and Fees in Incinerators in Germany Source: Wilts/ v Gries 2014.

The following figures show per capita dedicated municipal waste incineration capacities in Europe and the municipal waste generated – the darker the colours, the higher the ratio. Surprisingly Germany does not belong to the top five countries: Especially Nordic countries like Denmark or Sweden even show much higher figures of up to 800kg per capita. At the same times these countries use their waste incinerators for very efficient districted heating systems – what is rarely the case in Germany<sup>3</sup>. The specific characteristic of the German waste incineration market is the at the same time rather large capacities for commercial incineration: co-incineration e.g. in cement factories and especially large residual fuel driven incineration facilities that produce steam for specific factories or industrial parks. It is this combination of high municipal and at the same time commercial incineration capacities that characterize the German overcapacities (see Wilts/ von Gries 2014).

<sup>3</sup> According to the BDEW, 50% of the energy production in German MSW incineration plants can be counted as renewable energy.

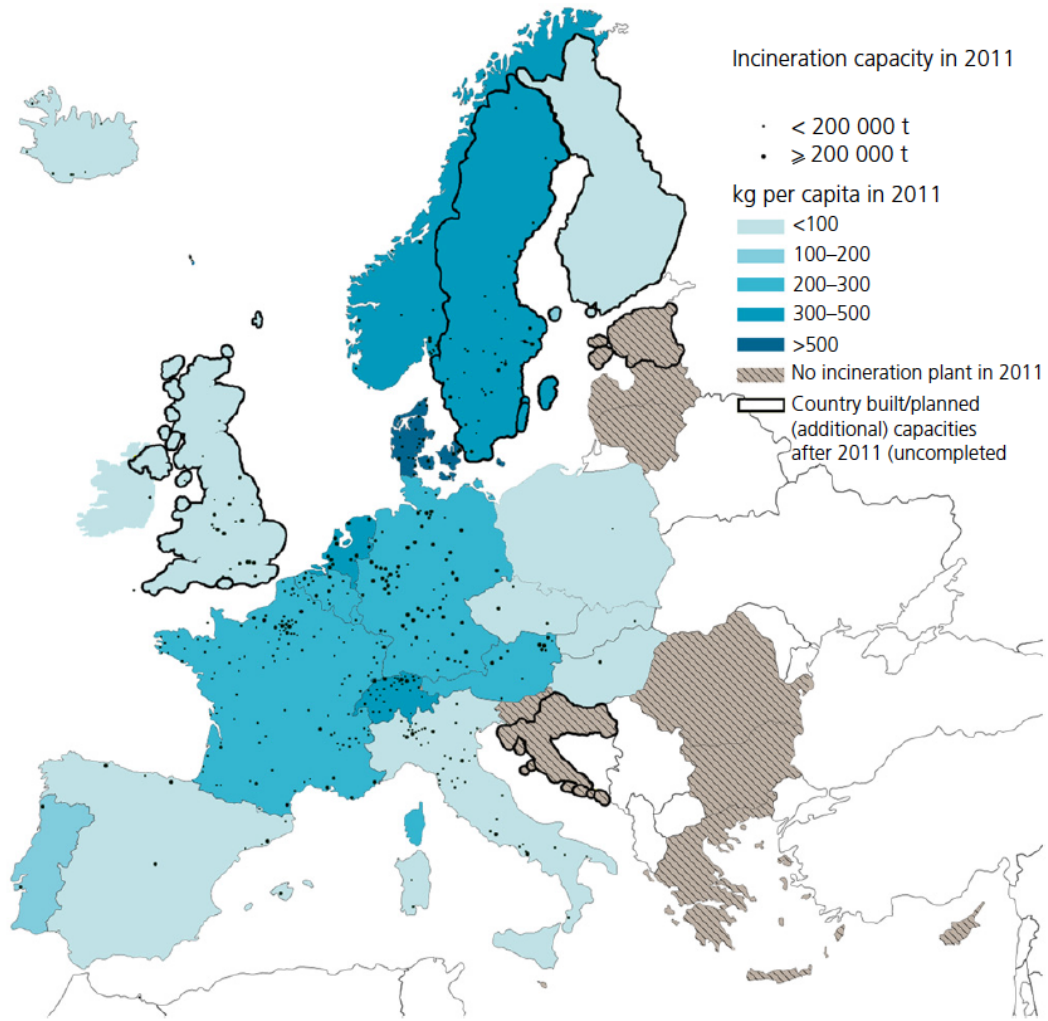
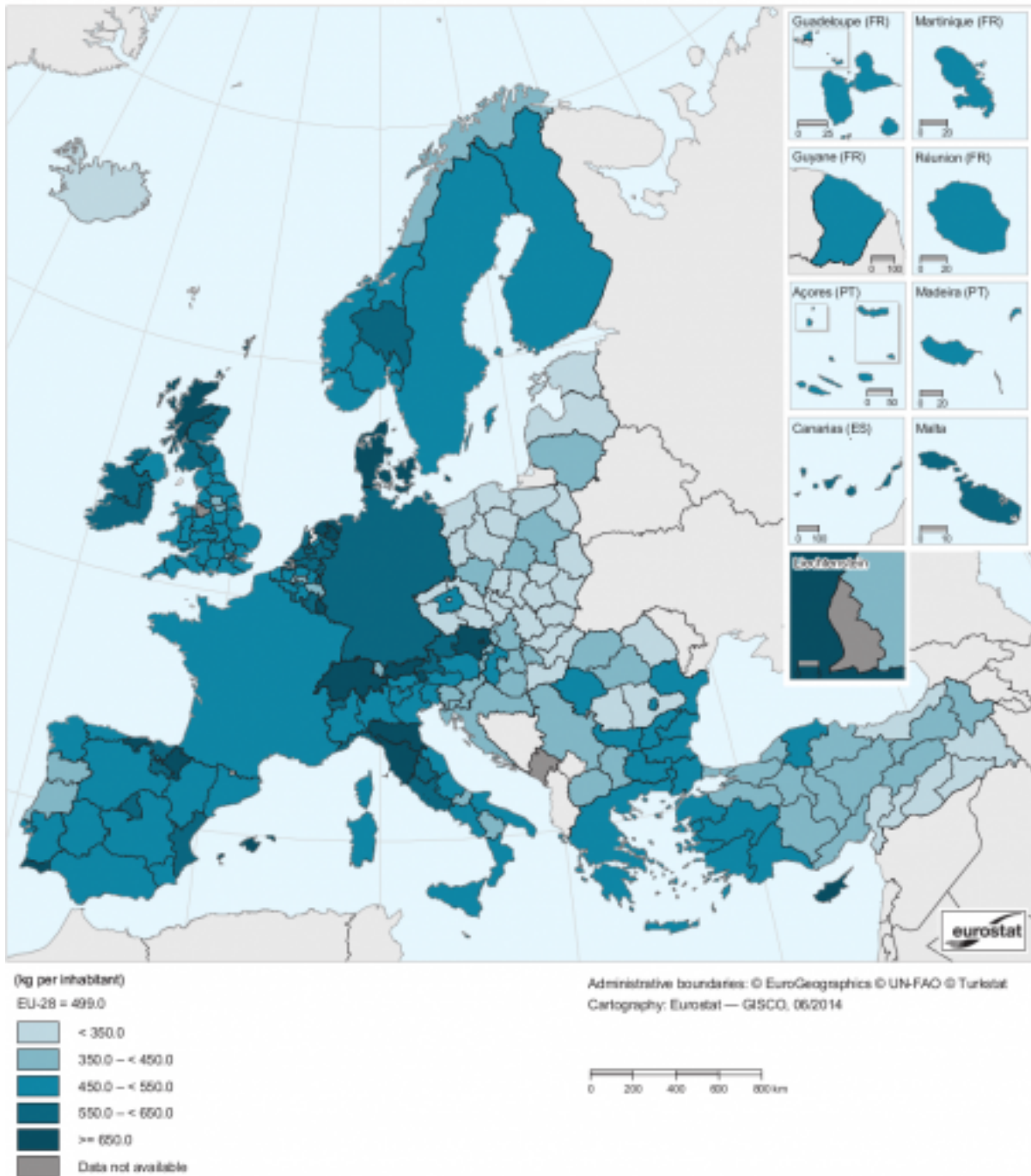


Figure 8: Waste incineration capacities in Europe. Source: Wilts/ von Gries 2015.

Municipal waste generated per inhabitant, by NUTS 2 regions, 2011 (\*)  
(kg per inhabitant)



(\*) Ireland, Italy and Turkey: 2010. Spain and Austria: 2009. Bulgaria and Romania: 2008. Denmark, Germany, Greece, France, Croatia, Finland, Sweden, Switzerland and Serbia: national level.

Source: Eurostat (online data code: [env\\_rwas\\_gen](#) and [demo\\_r\\_d2jan](#))

Figure 8b Waste generation in Europe. Source: Eurostat 2015

## 2.5 Waste reduction & prevention

Like mentioned before over the past decade German waste generation per capita was still above 617 kg (in 2013 according to Eurostat). Yet, Germany has managed to decouple

waste generation from economic growth – thus producing economic output at a lower waste intensity and with significantly reduced environmental impacts, at least domestically. The positive results are partly based on the export of used and waste products, but especially on the industrial flight of waste intensive production processes and sectors: Waste related to German patterns of consumption is increasingly generated abroad, often in countries with much lower environmental standards and less developed waste infrastructures (Wilts 2012).

Against this background the German government has published a national waste prevention programme in 2013 as required by the European Waste Framework Directive. This programme has been developed in cooperation with the German federal states that are responsible for the implementation of waste regulations. It was based on two research projects funded by the German EPA (UBA). The first research project was dedicated to the scientific-technical foundations of a Circular Economy recording more than 300 waste prevention measures in Germany and abroad. A second research project had a focus on the practical implementation and the assessment of specific waste prevention measures. Despite these significant efforts that have been put into the development of the waste prevention programme, it has been criticised for its lack of concrete targets and responsibilities. The programme includes some suggestion for waste prevention indicators but states that they until now lack the scientific basis. Against this background, Germany has chosen a process-oriented approach with several on-going activities exploring innovative waste prevention measures together with consumers, industry and other stakeholders – but with unclear results.

For example in May 2014, the Federal Environment Agency organized a symposium on specific steps for waste prevention in order to promote the realization of the suggestions of the National Waste Prevention Programme, and to facilitate the adoption of its recommendations and the exchange of experiences by different institutions and actors. The event particularly focused on waste preventing product design and product use and aimed to set up a platform for expert dialogue. Current activities and promising approaches were introduced at the conference. Besides this, an intensive exchange on perspectives and boundaries of specific measures was exercised within specific work groups. The following aspects of product-related waste prevention have been discussed (UBA 2014):

#### I. Production – reparable and durable products.

A special significance is assigned to the life cycle stages „design“ and „production“, as these shape the product characteristics „technical lifespan“ and „reparability“. The aim is to make these characteristics equally important design requirements at the design and development stage.

#### II. Reuse – Collect, check, repair, upgrade and ensure quality standards of used products

The practical realization of competitive repair options and functioning upgrade structures has shown several obstacles that prevent existing potentials from being realized. The work group aimed to develop solutions for the installation of sustainable reuse structures.

#### III. Trade with used goods – Effective and sustainable forms

This work group aimed to answer questions about the framework conditions that allow the exploitation of potentials for used goods trade under consideration of ecological, economic and social sustainability aspects.

Another element of waste prevention in Germany is the environmental investment programme that was already introduced in 1979. It was initiated by the Federal Environment Ministry with the objective of financially supporting commercial applications of environment-friendly technologies. It is one of the most successful support programmes for environmental technology in Germany (Moser 2014). Projects are supervised in cooperation with the Federal Environment Agency and the KfW bank group. The programme supports primarily small and medium enterprises with an interest subsidy of up to 70 % of eligible costs or an investment subsidy of up to 30 % of eligible costs with an annual promotional volume of currently 25 M. €. An evaluation report of the programme shows that of the 107 evaluated projects between 1999 and 2008, 37 % of the activities concerned the topic of a circular economy (Struwe 2010). Furthermore, a teaching module was introduced which will integrate sustainable design in already existing education pathways. It aims to give environmental aspects equal significance to 'classical design criteria' as principles in industrial design education (Moser 2014).

Proposals for legal measures are another frequently discussed measure. One legal adaption that is currently being processed is the revision of the Electrical and Electronic Equipment Act (ElektroG). It proposes an aggravation of the regulation on the removability of batteries and accumulators. Batteries are supposed to be removable by consumers if possible or at least by qualified personnel independent from the manufacturer (Odendahl 2014). Legal amendments that are currently researched are the promotion of the preparation for reuse of used electrical equipment (including, among others, the standardisation of additional criteria for reuse institutions) (Schomerus et al. 2014) and amendments in public and civil right that promote sustainable consumption in the area of product use (Salzborn 2014). Research is also being done on the development of an informational basis and strategies against obsolescence (Oehme 2014).

In terms of food waste, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety initiated a campaign in March 2012 whose aim is to achieve a 50 % reduction of unnecessary food waste by 2020. Under the title „Zu gut für die Tonne“ („too good for the bin“), an alliance between experts and stakeholders from industry, trade, gastronomy and agriculture consult with each other about suitable measures for the achievement of that goal. Actions include knowledge transfer, a joint initiative in the parliament, information about ‚best before‘ dates, alliances with the catering sector and hospitals, a student competition for creative ideas and nationwide events and days of action (BMELV 2013).

The German waste prevention programme identifies several specific measures to be analyzed in detail with regard to potential effects and implementation feasibility. There seems to be a special need for action in terms of food waste prevention (Friedrich 2014) in private households and large-scale consumers. The NWPP suggests voluntary agreements and concerted actions, however no specific measures have been undertaken yet. In order to develop a suitable communication strategy for the realization of the measures described in the WPP, the Federal Environment Agency announced the environmental research project „Evaluation and Realization of the Waste Prevention Programme and Development of Appropriate Communication Strategies and Recommendations for Action“ („Bewertung der Umsetzung des Abfallvermeidungsprogramms und Entwicklung geeigneter Kommunikationsstrategien und Handlungsempfehlungen“ (UBA 2014), which aims to support com-



munication and networking between the actors involved in the realization of the Waste Prevention Programme. It focuses on the provision of information and a professional exchange between actors, decision makers and experts and discusses necessary steps and the overcoming of possible obstacles. In order to support a successful realization of measures and improve communication, information bases and guidelines for action will be prepared that also take into account experiences and concepts from other countries. An important building block of the communication strategy will be a topic-related dialogue process with relevant stakeholders and multipliers. Topics include the promotion of reuse/ extending the use phase of products, increasing the usage intensity of products and the promotion of product service systems („using instead of owning“), an improved prevention of food waste and stronger consideration of waste preventing aspects in enterprises.

In conclusion it can be said that waste prevention is already embedded in a variety of ongoing initiatives, legislations and programmes and indeed Germany managed to achieve a relative decoupling of waste generation and economic development. Nevertheless it is clear that the level of waste generation is still quite high and most public waste prevention measures remain on a voluntary, non-binding level (see Wilts 2015). This seems understandable as waste seems to be a technically “solved problem” and many policy makers don’t see the necessity for waste prevention against the background of excellent and often under-utilized end-of-pipe waste management infrastructures (see above). This still very traditional linear thinking can be seen as the key barrier for innovative waste prevention and resource efficiency approaches that could lead to significant cost savings and for future competitiveness necessary for circular business models.

## 3 Material use of fast-moving consumer goods in Germany

In the context of SCP, indicators have proven to be one of the most important drivers for consumers as well as for policy makers. The challenge of measuring the progress towards sustainable and resource efficient consumption has been addressed on the national and international level for more than 20 years (imug Institut 2013) and a variety of indicator systems has been developed and implemented. One of the most challenging aspects is the target operationalization: “Sustainable consumption” is an extremely broad concept, including aspects of intra- and intergenerational justice. But even “resource efficient” products have to take into account complex interdependencies between production, logistics and behavioural aspects (e.g. when it comes to plastic packaging that might reduce the generation of food waste). Comprehensive resource indicators as outlined above go beyond specific materials or concrete impacts and in this way allow giving robust directions which specific consumption patterns might be extremely harmful for the environment.

Approaches (as e.g. developed in the MyEcocost project) could fulfil inter alia the following functions:

- They allow identifying the relevant problems as a starting point for the prioritization of activities by public authorities as well as consumers
- They highlight the key environmental issues in an understandable way and can thus structure and support the public debate
- They allow monitoring actual progress towards more sustainable patterns of consumption

### 3.1 Resource efficiency indicators for consumer goods

First of all, we need to define some important terms. The definitions we use for our particular case are as follows:

- method: set of instructions describing how to calculate a set of indicators.
- indicator: a quantitative or qualitative proxy that informs on performance, result, impact, etc. without actually directly measuring it.

Life cycle assessment (LCA) is a method, for example. It even has its own ISO standard (ISO 14044). LCAs can yield a number of indicators, among which the carbon footprint. A low carbon footprint indicates a low environmental impact for the category climate change, but it does not measure full environmental impact. It only refers to greenhouse gas emissions. Those definitions are by no means “official” but the ones we use in this project to avoid confusion. Many stakeholders in the scientific community, in policy, in the industry etc. indeed

use these terms differently. Methods are applicable and indicators valid only at specific levels. In our case we can distinguish:

- product level
- product group level
- company level
- sectorial level
- national or regional level

Starting from the research question “What is the resource efficiency (with focus on material efficiency) of consumer goods products?” one can short-list relevant indicators and then identify the methods that can yield them at the requested level. The different indicators point out the approach of this study: Instead of focussing on specific products, the emphasis is put on a more aggregated level of product groups.

#### Material efficiency indicator at the product level

*Material Input per Service (MIPS)*, today also referred to as *material footprint*, is a life cycle method to assess the resource efficiency of (consuming) a product or service (Saurat and Ritthoff 2013). The resulting indicators are named after the method. A MIPS value is the sum (in mass unit) of all resources extracted from nature along the life cycle of one service-unit of the studied product. These resource inputs are classified in biotic raw material, abiotic raw material, water, air, and earth movement in agriculture and silviculture. Note that economically unused resource extraction is also accounted for, which makes MIPS comparable to TMR at the macro economic level (see previous task). A MIPS value is a proxy for the environmental impact caused by the whole life cycle of a product relative to the service it provides. The MIPS value of a product minus its own weight is usually referred to as the *ecological backpack* of this product. This indicator allows the assessment of very specific products while the focus in this study is more on product groups.

#### Material efficiency indicator at the product group level

A powerful method called *environmentally extended input-output analysis (EE-IOA)* provides indicators on the environmental pressures resulting from consumption in a country (the domestic final demand). Depending on the level of disaggregation of the input-output tables available the analysis of the impact of consumption can focus on a number of different product groups. The indirect pressures accumulated along the full production cycle of consumed products can then be estimated (i.e. for food — all pressures released and resources used between 'farm and shelf'). Those product groups, which cause the majority of environmental pressures, can then be identified and the eco-intensity (environmental pressure per euro) of different product groups can be compared (EEA 2013). Regarding material efficiency, DMI, RMI or TMR can be used to build eco-intensity indicators that include all relevant natural resources (except for water and air).

This study focuses on goods bought by private households (private final demand) and wants to assess how resource efficient different product groups are. Private final demand is a part

of the domestic final demand and is accessible to the EE-IOA method. The scope of the study makes it a typical case for environmentally extended input-output analysis. Which resource eco-intensity indicators (i.e. DMI, RMI or TMR per euro) can be derived to assess resource efficiency will depend on the input-output tables and environmental extensions available.

### **3.2 Resource indicators as drivers for sustainable consumption and production**

Looking at the development of such indicators, it is increasingly recognised that the current consumption and production patterns of developed countries cannot be transferred to the rest of the world without overstressing global environmental services several times over. One part of the solution to the problem of limited resources and environmental services is to adjust patterns of consumption and production to reduce their demand on these resources. Identifying and encouraging such adjustments are the focus of the policy area of Sustainable Consumption and Production (SCP).

The European Commission's broad vision for 2050 is that of a European economy that respects resource constraints and planetary boundaries. Launched as part of the Europe 2020 Strategy, the Flagship Initiative on a Resource Efficient Europe includes the Roadmap to a Resource Efficient Europe, which lays out milestones on the way to achieving the Commission's vision for resource efficiency. Sustainable Consumption and Production is a holistic perspective on how society and the economy can be better aligned with the goals of sustainability. It is by definition "a holistic approach to minimizing negative environmental impacts from the production-consumption systems in society. SCP aims to maximize the efficiency and effectiveness of products, services, and investments so that the needs of society are met without jeopardizing the ability of future generations to meet their needs" (Norwegian Ministry of Environment, Oslo Symposium, 1994).

Environmentally extended input-output analysis is a method that can aid effective policy and action towards SCP. It can deliver eco-intensity indicators informing on resource efficiency hotspots in European consumption patterns. In particular it can aid actors of the retail sector understand which elements of European consumption—that they help fuel—are the key causes of environmental pressures including resource use and where the greatest environmental gains can be attained.

This study uses available input-output tables and environmental extensions to assess the resource efficiency of the private consumption of selected product groups in Germany and other EU Member States (see subsequent tasks). The data available for calculating resource indicators that go beyond DMI (in this case TMR) and at the same time allow for cross-country comparison goes back ten years. It demonstrates, however, the potential of the tool for answering SCP-question relevant to the retail sector and to private consumption.

Time series of input-output tables up until 2014, more disaggregated regarding product groups, and with global coverage should become available in the first half of 2016. This in-

put-output database is the result of the EU project DESIRE<sup>4</sup>, to which the Wuppertal Institute is a partner. Consequently, more detailed analysis based on recent data should be possible in the near future.

The input-output approach is to date the most appropriate tool for resource efficiency analysis at the product group level. Bottom-up approaches are conceivable in theory, such as aggregating detailed product-level material footprint (MIPS) analyses. A MIPS study of a given product gives access to the contribution of the different product parts (such as packaging) or lifetime phases to the product's overall material footprint. Scaling-up and aggregating such studies to get a grasp on the resource impacts of European private consumption is, however, hardly possible for a number of reasons, including the availability of such studies, their compatibility etc.

Initiatives exist that at monitoring the resource use of products along the value chain, bottom-up, and across the board. One such project is myEcoCost<sup>5</sup> (the Wuppertal Institute is a partner), developing a method and a web-application that harmonizes a global network of resource accounting nodes, measures a product or service's resource efficiency, and can inform all stakeholders (including consumers). This kind of tool is out of the scope of the present study but is potentially interesting to encourage resource use reduction at the product level.

### 3.3 Characteristics of the consumer good market sector in Germany

The market for consumer goods in Germany can be classified in two groups, food and non-food products, such as personal hygiene, cleaning products, etc. The turnover for food products was in Germany Euro 106 billion (Nielsen 2016) and for personal hygiene and cleaning products Euro 17.9 billion (IKW, IRI 2016) in 2014. This amounts to an expenditure of 14% of their consumer spending for food products (Statistisches Bundesamt 2016). German consumers went on average 153 times into stores to buy FMCG for their daily life. The majority of 44% of the trips were to discounters, the remaining were to big convenience stores (19%), smaller convenience stores (15%), supermarkets (12%), and drugstores (10%) (Nielsen 2016).

So far there is no clear trend visible towards a more resource efficient consumption pattern of German consumers. However a main trend in the consumption, especially of food, was and continues to be the growth of organic products. From 2000 to 2014 the market for organic food grew 277% and had in 2014 a turnover of almost Euro 8 billion (BÖLW). While organic products can be more resource efficient, they do not necessarily have to be. Nevertheless it shows an increasing consciousness and interest of consumers towards how products and especially food is produced. Putting this into perspective of the spending of German con-

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<sup>4</sup> <http://fp7desire.eu/>

<sup>5</sup> <http://www.myecocost.eu/>

sumers still shows how small the organic produce market actually is, because only the group of confectionery has a turnover of Euro 14 billion alone (Statistisches Bundesamt 2016).

With a special perspective on waste prevention and resource efficiency one could look at the development of sales for mineral water in Germany. Besides sparkling in the water there is no reason for any consumer to actually buy bottled water. In fact in recent tests the bottled water has shown significant lower quality than tap water (Spiegel online 28.6.2012). Nevertheless the trends in consumption show still a small growth in consumption. From 2010 to 2015 the consumption increased by 10% (Verband Deutscher Mineralbrunnen 2016), nevertheless it has to be stated that at least in Germany packaging of water bottles and drinks normally can be reused or recycled quite easily (e.g. recycling rates of more than 90% are reported for PET bottles<sup>6</sup>). In addition, there is a quickly growing trend in the consumption of single-use coffee capsules, which generate huge amounts of packaging waste. Recent test by a consumer advice centre, showed in fact that some of these capsules contain by weight more packaging than actual coffee. As there is no standard for the different systems, the capsules cannot be recycled most of the time. Basically consumers pay a lot more for such capsules and their packaging, calculated to the per kilo price consumers pay between Euro 33,50 in a discounter to up to Euro 75,00 from a branded group (Verbraucherzentrale Hamburg 2015).

To summarise: there is a clear trend visible that German consumers have an increasing interest in knowing how food and other goods are produced. The share of the population considering sustainable production to be “very important” has increased significantly, especially with increasing age, rising from 32% in the 35 to 49 age group to 40% for those over the age of retirement (GFK 2014). At the same time there is a trend visible that especially goods such as packaged water are being consumed even more, mainly due to lacking awareness of the resulting resource requirements.

### 3.4 Total material requirements for FMCGs in Germany

To focus Resource Efficiency and SCP policy on areas where the greatest environmental gains are possible, policy makers need answers to some key questions:

- Which elements of European consumption and production patterns are the key causes of environmental pressures including resource use?
- Where can the greatest environmental gains be attained?
- And specifically in the context of FMCGs sold in Germany: What are the key basic product groups that should be addressed by the retailer sector?

One tool which has the potential to provide some of the answers to these questions is the analysis of Environmentally-Extended Input-Output Tables (EE-IOTs) whose use and application are described briefly in the following. Environmentally Extended Input Output Analysis

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<sup>6</sup> Foodbev 2015

(EE-IOA), a method applied on Environmentally Extended Input Output Tables, allows the environmental pressures of a whole economy to be viewed according to two complementary perspectives: a production perspective (i.e. which industries are directly causing environmental pressures), and a consumption perspective (i.e. which consumed products directly and indirectly cause environmental pressures).

The production perspective which is drawn directly from EE-IOTs, gives a basic picture of direct pressures arising from economic sectors and their economic output both for domestic consumption and export. The information on resource consumption, direct emissions of greenhouse gases (GHGs) and air pollutants given in EE-IOTs should not be confused with national reported direct resource consumptions, emissions under the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Long-Range Transboundary Air Pollution (CLRTAP)<sup>7</sup>. EE-IOTs use a residency principle for setting a boundary (i.e. includes emissions of all resident citizens and organisations even if they take place in other countries) while the boundary for national emissions inventories is geographic. However, the inclusion of economic data in EE-IOTs allows the environmental intensity (environmental pressure per monetary unit of output) of economic sectors to be compared. It allows success in decoupling of pressures from economic growth to be assessed for countries and for individual sectors. Finally, trends in decoupling at national/regional level can be decomposed into various contributing factors. The focus here is on the consumption perspective that is derived from EE-IOTs using EE-IOA. While the production perspective looks at the question 'what pollutants are being emitted by which industries?', the consumption perspective considers 'what are the consumed products driving these emissions?'. Environmental pressures are re-attributed to the production chains of final products according to the monetary flows between different industries and between industries and final consumption. The products that indirectly cause the majority of environmental pressures can be identified and environmental performance of different product groups compared. Finally, the global pressures attributable to national or EU consumption can be estimated. This is a key piece of analysis in today's global economy where a large proportion of pressures caused by our consumption are being released overseas.

The consumption perspective is of key interest in identifying the drivers of environmental pressures. It provides information critical to SCP policy design complementing the role provided by national emissions inventories. The environmental accounts used were the latest Air Emissions Accounts and Material Flow Accounts (MFA) from Eurostat published in 2011. The MFA accounts were subsequently supplemented with national data on unused extraction of resources. A number of key aggregated pressure categories were assessed: Besides general categories like greenhouse gas emissions, acidifying emissions and emissions of tropospheric ozone precursors from the air emissions accounts, the focus was put on material consumption including domestic extraction used (DEU), direct material input (DMI) and total material requirement (TMR) from the MFA accounts and supplementary data.

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<sup>7</sup> National air emission totals reported under these conventions can differ significantly from those provided by EE-IOTs due to differences in accounting principles and the scope of organisations covered.

Looking at the production side, four economic sectors dominate direct environmental pressures arising within European economies: Agriculture, the electricity industry, transport services and some basic manufacturing industries (refinery and chemical products, non-metallic mineral products, basic metals) together account for 75 % of GHG emissions, 88 % of acidifying emissions and 68 % of emissions of ground ozone precursors arising from European production. Material extraction is dominated by agriculture and forestry (25 %) and mining industries (75 %). Of the four economic sectors contributing most to GHGs and air emissions, only manufacturing shows a comparably large contribution to the EU-25 economy as it does to environmental pressures.

The consumption perspective concentrates on global environmental pressures caused by all the products consumed in a country. Products can be broadly distinguished between material goods and services. In the EU, 60–70 % of total household consumption is made up of services, with material goods accounting for the remaining 30–40 %. Capital formation is dominated by consumption of material goods (~ 80 %), while government consumption is more than 90 % services. A consumption perspective includes imported goods for final consumption but excludes goods produced for the export market. It also excludes goods and semi-finished products which are imported and then re-exported. Pressures caused by consumption include both pressures released directly during the consumption of a final product (mainly fuel combustion in cars and houses) and indirect pressures accumulated during that product's global production and distribution. These indirect 'embodied' pressures comprise more than 3/4 of the total pressures activated by consumption.

### Focus on product groups

In the EU construction works; food products; products of agriculture, forestry and fisheries; and electricity, gas and water services have been identified as the most resource intensive product groups, contributing 42 %, 52 %, 37 % and 57 % to GHG emissions, acidifying emissions, ground ozone precursors and material input, respectively, embodied in all consumed products. At the same time these four groups together represent only 17 % of total consumption expenditure in monetary terms; so the economic relevance is much lower than the environmental relevance. A further seven product groups added a further 30–40 % of environmental pressures embodied in all consumed products:

- wholesale and retail services;
- motor vehicles and other transport equipment;
- hotel and restaurant services;
- transport and auxiliary transport services;
- coke and refined petroleum;
- health and social work;
- public administration, defence and social security services.



Analysis showed large differences in environmental pressure intensities of individual product groups. Emissions of GHGs per Euro spent ranged by a factor of more than 20 between most services at one end of the scale (e.g. education and financial services with very low environmental impacts per Euro spent), and electricity and agricultural products at the other. Material use intensity was even more variable ranging by a factor of more than 150. Due to these differences it is useful to differentiate between the different product groups – for the purpose of this report especially focussing on fast moving consumer goods.

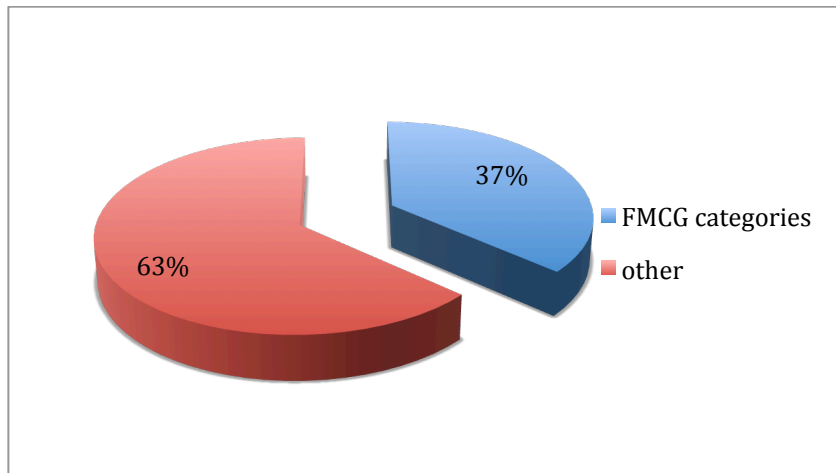
Annex 1 shows the full list of product categories as used by Eurostat. These cover the full range of products consumed by households, companies as well as the public sector. The following categories include fast moving consumer goods and have been taken into account for the further analysis:

<b>CPA_2002_LABEL</b>
<b>Products of agriculture, hunting and related services</b>
<b>Fish and other fishing products; services incidental to fishing</b>
<b>Food products and beverages</b>
<b>Tobacco products</b>
<b>Textiles</b>
<b>Wearing apparel; furs</b>
<b>Leather and leather products</b>
<b>Pulp, paper and paper products</b>
<b>Printed matter and recorded media</b>
<b>Rubber and plastic products</b>
<b>Fabricated metal products, except machinery and equipment</b>
<b>Radio, television and communication equipment and apparatus</b>
<b>Wholesale trade and commission trade services, except of motor vehicles and motorcycles</b>
<b>Retail trade services, except of motor vehicles and motorcycles; repair services of personal</b>
<b>Computer and related services</b>

**Table 2: List of product categories as used by Eurostat**

## Results for Germany

The analysis of TMR that can be linked to these FMCG product categories shows a share of around one third of the total consumption induced material requirements in Germany. It is obvious that the product categories don't sharply differentiate between fast or rather slow moving product groups – some products might be counted under other groups, some of the groups might contain not only fast moving consumer goods. Nevertheless the share of 37% shows the principle importance of this sector.



**Figure 9: Share of FMCG related product groups in relation to the total direct and indirect TMR induced by the final consumption by households of products produced globally in Germany**

The following table shows the detailed results of the analysis for Germany, showing the total material requirements induced by household consumption of specific product groups. The analysis underlines the relevance of food product groups. Almost 60% of the FMCGs related TMR is caused by the production of food products and beverages, products of agriculture add additional 20%. The process of offering these products by the retail sector (processing, logistics etc.) is again another important factor with about 10% of the total material requirements linked to consumption patterns in Germany.

No_Rows	CPA_2002_LABEL	TMR induced by final household consumption
1	Products of agriculture, hunting and related services	177.732.280
3	Fish and other fishing products; services incidental to fishing	315.284
9	Food products and beverages	513.365.517
10	Tobacco products	8.758.723
11	Textiles	7.282.729
12	Wearing apparel; furs	6.810.750
13	Leather and leather products	5.217.212
15	Pulp, paper and paper products	19.600.787

16	Printed matter and recorded media	18.934.510
19	Rubber and plastic products	2.838.647
22	Fabricated metal products, except machinery and equipment	12.312.343
26	Radio, television and communication equipment and apparatus	1.109.614
36	Wholesale trade and commission trade services, except of motor vehicles and motorcycles	13.036.376
37	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods	84.823.827
49	Computer and related services	147.251
	Sum	<b>872.285.849</b>

**Table 3: TMR related to specific product groups in Germany**

### EU comparisons

In order to assess the status quo in Germany, these figures have been compared with other EU countries. For the purpose of this report the following countries have been taken into account: Austria, Czech Republic, Germany, Denmark, France, Italy, The Netherlands, Portugal and Sweden.

Figure 10 shows the relation of TMR per capita for these nine countries. Germany has the second highest rate of total material consumption for the selected FMCGs categories with a level of 10,74 tons of TMR per year and capital. Only The Netherlands show a slightly higher figure. For the Czech Republic it can be assumed that the gap is partly explained by different socio-economic framework conditions, nevertheless the low rate in Sweden (-33%) shows that lower rates can also be achieved in countries with similar per-capita-incomes.

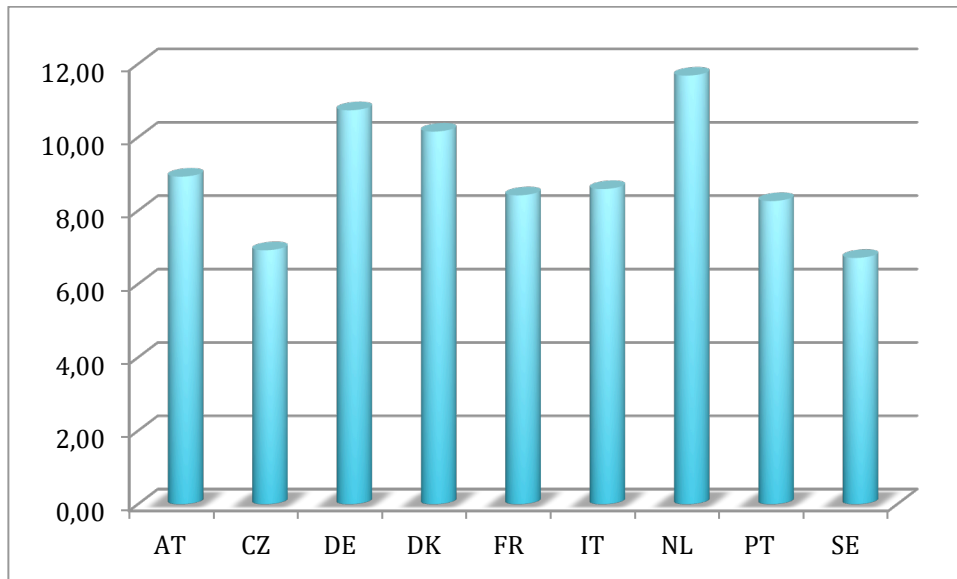


Figure 10: Comparison of TMR in tons per capita and year, own compilation based on Eurostat

A quite different picture is drawn in Figure 11 that compares the relation of TMR and GDP in the selected countries. Obviously the lower-income countries Portugal and the Czech Republic show a higher material intensity for the consumption of the selected product groups. This might be explained by the fact that a larger share of their income goes into basic consumption groups while consumers in the countries with higher per-capita incomes spend larger shares e.g. on travel and transportation. Nevertheless it's again Sweden with the best value in this sample – proving that more material efficiency can be achieved within the product groups analysed for this report.

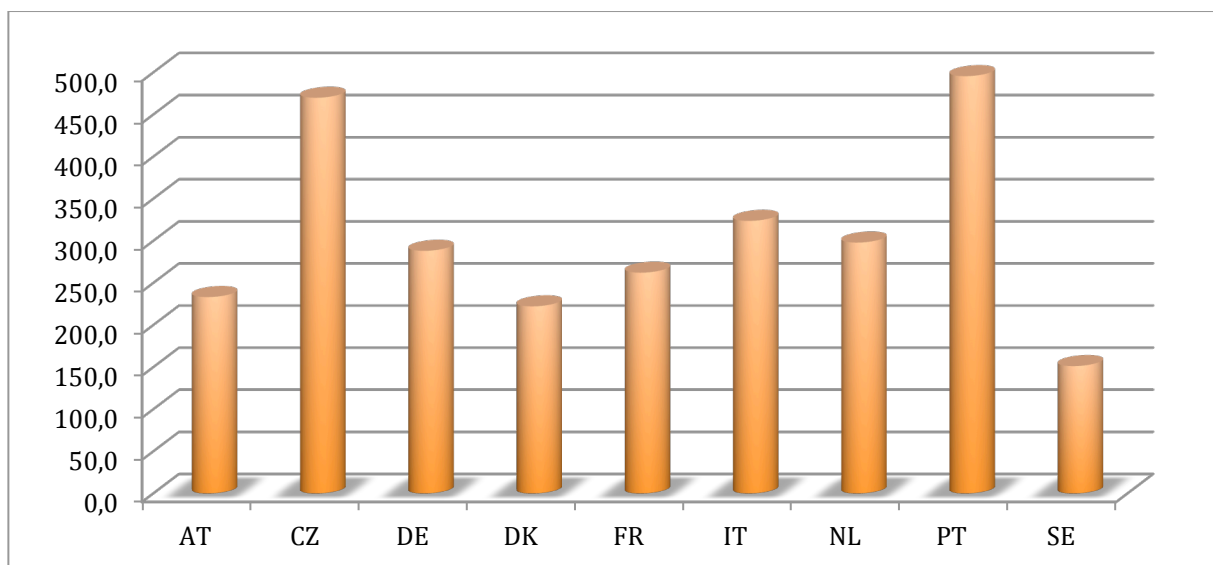


Figure 11: EU comparison TMR in tons/ GDP in Euro. Own compilation based on Eurostat

## Conclusions

The analysis raises the question how relevant the consumption of FMCGs is from an overall perspective and how more resource efficient products could contribute to a globally sustainable level of resource consumption. Unlike to the global climate debate, there is so far no politically accepted goal for total resource consumption. Nevertheless there are several indications and models that highlight the need to drastically reduce the resource consumption: Already in 1994 Schmidt-Bleek suggested a target of 5.6 – 6.1 t/cap TMC, very much based on the precautionary principle. This target has been criticized for being too ambitious, especially considering the recent consumption of about 50 tons per year and capita. Within in the debate around the German resource efficiency programme Bringezu et al. (2014) proposed a target of 10 t per capita and year that can be considered as the global boundary of sustainable resource consumption. Based on the analysis outlined above, this “resource budget” is right now already used up completely for fast moving consumer goods.

Against this background there is an urgent need to reduce resource consumption in all fields, but especially for these product groups. Based on this analysis, two main directions can be identified for reducing environmental pressures caused by European consumption. Firstly, reducing the pressure-intensities of production chains for key product groups (i.e. technology improvements), and secondly, shifting consumption expenditure from pressure-intensive product groups to less-intensive groups — mostly represented by services (i.e. a behavioural change). Decomposition analysis showed that to date most decoupling of environmental pressures from consumption growth has come from technological improvements. To meet the tough challenges ahead in reducing environmental pressures caused by European consumption and production, a combination of technological improvement and behavioural change is going to be necessary. These two factors, and the means by which governments can encourage them, are markedly different. Encouraging technological improvements can be achieved through better regulation, increasing the price of material and energy inputs, encouraging and investing in innovative technologies, etc. Encouraging behavioral change will require an entirely different set of measures including more comprehensive and long-term instruments in the field of incorporating of environmental costs or education for sustainability. While much further research is needed to better understand the interplay of various policy instruments, addressing consumption patterns is critical to achieving the systemic change envisaged in the resource efficiency and green economy initiatives.

## 4 Reduction potentials and related benefits

### 4.1 Product alternatives

Increasing the resource and material efficiency of fast moving consumer goods is definitely challenging. Nevertheless there are already innovative and smart products on the market that allow to significantly reduce resource requirements. The following examples highlight that alternative consumption patterns will not depend only on future technological developments, but mostly on whether or not the market takes up these alternatives.

#### Resource optimized products

A first and obvious approach to increase the resource productivity especially of fast-moving consumer goods is to reduce the resource requirements of the product while at the same keeping or even improving the functionality of the product. There are several existing good practice examples that the environmental and economic benefits e.g. of minimizing approaches.

A striking example are compressed cans for deodorants: They reduced the regular cans from 150 ml to 75 ml. Due to a reengineered spray system, which reduces the amount of gas needed to deliver they have the same level of performance. So they need less of aluminum for the production of the cans, which results less waste for the environment. Furthermore, the cans are recyclable after use. The producer was able to reduce the amount of aluminum by 20% and thereby 555 t of carbon dioxide due to the space-saving in the logistic and less rides by trucks. In addition to the aluminum savings they were able to reduce the amount of gas by 50%. Altogether they lowered their waste balance by 11%<sup>8</sup>. Another example is an innovative ultra-concentrated laundry detergent that is designed to clean clothes with just 1/4th the dose of the leading brand. In this way materials are saved due to less production needed for the same functionality, while also transportation and the amount of product and packaging waste can clearly be reduced<sup>9</sup>. The direct material savings for such ultra-concentrated can reach up to 50%, the total environmental effects of course also depend on the consumer who should use less of the product.

Resource saving potentials: Such solutions like minimization or concentration can be considered as a first and often rather incremental approach to more resource efficient products. Direct material savings are often impressive but sometimes partly compensated by using more resources in the production processes. Looking at the general resource saving potentials, the design of products is often dominated by a variety of other, mainly marketing-oriented factors so that resource potentials are rather incremental and as shown in the examples in the range of 10-15%.

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<sup>8</sup> <http://www.compresseddeodorants.de>

<sup>9</sup> <http://www.c2c-centre.com/product/home-office-supply/8x-laundry-detergent>

### Packaging reduction

Many food and non-food products in the supermarket are sold in plastic and paper packages. Fruits and vegetables, cereals and rice, but also olive oil and laundry detergents, as well as most of the products in supermarkets can be found in complex packaging consisting out of different materials, which hampers recycling and waste sorting in households. Consumers rarely have a choice to buy packaging free products, as packaging offers advantages in transportation, storage and rapid handling at the supermarkets' checkouts. And although buying products without typical plastic packaging requires more planning and flexibility than visiting conventional supermarkets, packaging free supermarkets offer a resource efficient alternative that contributes significantly to waste prevention and reduction. All supermarkets and producers can move in the direction of reducing packaging. Packaging costs is rarely expressed in the final price of the product, but we have seen in numerous countries on the example of plastic bags that charging just a few cents can cause a massive fall in demand. Within the extended producer responsibility scheme of the packaging ordinance, policy-makers could also adopt differentiated tariffs on products that have less packaging – offering them an advantage on the market.

Considering this massive waste production, a solution can be packaging free supermarkets offering a wide range of food and non-food products. The concept aiming to eliminate or at least to reduce packaging waste in all supply chains has been adopted in some supermarkets that can be considered as pilot projects with promising approaches. Especially cereals are often wrapped into several layers of packaging in increasingly small portions – leading to an unnecessary high generation of packaging waste. Packaging free supermarkets encourage their costumers to bring their own containers in order to fill them with cereals and other dry products from larger storage boxes, so-called “bulk bins” in the market, packaging could be reduced by up to 70% (WRAP 2009). The containers do not have to be standardized, but are weighed beforehand in order to calculate the price when they are filled. The amounts of the product can be easily adapted to personal needs of the consumer<sup>10</sup>. Another relevant product groups are fruits and vegetables. A representative survey from NABU (Nature And Biodiversity Conservation Union) showed that 76% of the interviewees prefer packaging free fruits and vegetables (NABU 2014). Retailers often argue that packaging is necessary to provide hygiene, freshness and protection, especially for more sensitive products like fruits. Nevertheless there are various ways to minimize packaging and in this way also to avoid unnecessary costs. In fruits like apples there is ten times more energy and materials locked up in the fruit than in the packaging around them. The UK Waste and Resource Action Programme (WRAP) developed a ‘best-in-class’ packaging weight data database on its website<sup>11</sup> that shows packaging saving potentials for various product groups: If the whole industry would move to the “best in class” solutions, packaging could be reduced by up top 80% as illustrated in the following figure.

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<sup>10</sup> <https://blogs.nabu.de/unverpackt-einkaufen/>

<sup>11</sup> [www.wrap.org.uk/content/uk-packaging-benchmark-database](http://www.wrap.org.uk/content/uk-packaging-benchmark-database)

Product (sold through traditional grocery retailers)	Packaging weight (tonnes)	Reduction if all moved to the Best in Class weight (tonnes)	Potential cost reduction to business (£)	Potential carbon savings (tonnes of CO <sub>2</sub> equivalent)
Wine (bottles)	310,107	106,024	3,150,000	75,000
Champagne & sparkling wine	48,573	19,358	570,000	13,000
Cereals (boxed)	40,686	11,868	830,000	17,000
Carbonated (cans)	47,725	10,816	3,710,000	50,000
Beer (cans)	29,276	10,798	3,700,000	50,000
Fruit juice (cartons)	51,144	10,283	720,000	23,000
Coffee (jars)	36,119	9,492	430,000	6,000
Ketchup table sauce	21,222	7,720	N/A	23,000
Whisky (bottles)	28,347	6,733	320,000	4,000
Eggs (tray & boxed)	12,854	6,697	470,000	10,000

Table 4: Packaging reduction and related cost saving potentials. Source: WRAP 2009.

**Resource saving potentials:** Packaging is often superfluous and causes an unnecessary use of natural resources. Although packaging can in some cases also prevent the generation of food waste, especially the use of plastic could be reduced. Wilts et al. (2015) estimated the overall material saving potentials for plastics at about 10-20% - significantly lower than the theoretical potential calculated by WRAP but taking into account that packaging design is dominated especially by marketing considerations and only in exceptional cases by environmental concerns. Packaging is of course only one element of the product and the total reduction effects per product will thus be lower.

### Using recycled materials

Using recycled, so called “secondary” resources can lead to an often significant reduction of material usage for products: Recycling normally requires less energy, raw materials have not to be extracted from the earth and the generation of waste can be avoided.

A very popular example is toilet paper made of recycled paper. 40% of timber from rainforests is used for the production of toilet paper. The alternative for traditional toilet paper is recycling toilet paper, which doesn't need tropical wood. Recycled toilet paper consists of waste paper. So there is no need to fell more trees, In the production the waste paper is heated with water, which results a pulp. With the help of the so called deink procedure the printing inks can be removed. Recycled paper saves in production up to 60% energy and 70% water and causes less CO<sub>2</sub>, waste and emissions. Buying a single standard 500 DIN A4 sheet package of recycled paper saves up to 4,7 kg wood compared to virgin paper<sup>12</sup>. Fewer chemicals are needed, which results less wastewater contamination. There are several labels like the Blaue Engel that mark recycled papers. Contrary to the private households the majority of businesses use recycled toilet paper. But also for other material types like plastics an increasing variety of good practice examples show the potentials to reduce resource consumption by replacing “primary” plastic materials. Especially thicker plastic

<sup>12</sup> <https://www.econitor.de/>



products like buckets or pipes can be produced with recyclates at the same quality and significantly lower costs (on average about -20%, see BIO IS 2013). Several innovative producers offer plastic buckets that are produced with 100% recyclates and of which more than 50% comes from post-consumer plastics. With specific recyclable inlays there are almost no visible differences to similar products made of virgin plastics but resource savings of about 20% (Ligthart/ Ansems 2012).

Resource saving potentials: The resource savings from using recycled materials obviously differ for different materials: With regard to paper, especially the use of water and wood could be reduced by more than 50%<sup>13</sup>. Producing recycling paper requires about 70% less input materials than virgin paper (and of course uses waste paper instead of fresh wood). For plastics, depending on the specific products and plastic types, resource savings from using recycled materials are in a range between 10-50%. Especially high savings can be achieved by the use of recycled metals with resource reductions up to 80%. On average the resource saving potentials for fast moving consumer goods can be estimated at a range of 20-50%.

### Life time extension by reuse and repair

The role of re-use and preparation for re-use in a circular economy has been significantly strengthened by the five-step waste hierarchy; these concepts are mentioned as two of the key strategies to increase resource efficiency in Europe. Extending the life time of products leads to resource savings in the production phase because less products have to be produced in order to fulfill the same functionality. At the same time the generation of waste can be reduced if products are used for longer periods of time.

A concrete approach in this field is to increase the reparability of laptops or tablets. The reparability of laptops and tablets in many cases is almost impossible due to its complex design: components of the product are impossible to disassemble or there is a high chance to cracking the glass during disassembly. Very often instruction on how to fix a product are also not made publicly available. To guarantee a longer life there are some possibilities: there should be a minimization of ribbon cables and destructive fasteners during the production and a possibility to use updating soft- and hardware for the customer. A focus on possibilities of non-destructive opening of the device while the production would help to increase the chance for repairing as well as the availability of spare parts<sup>14</sup>. There are some product alternatives. Ifixit offers the customer a review of different electrical devices and their reparability<sup>15</sup>. For the rating they test the effort of repair like opening the device, replacement of the battery or the manufacture of the LCD. A high score means that it will be relatively inexpensive to repair

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<sup>13</sup> <http://papiernetz.de/info/nachhaltigkeitsrechner/>

<sup>14</sup> [http://makeresourcescount.eu/wp-content/uploads/2015/07/Durability\\_and\\_reparability-report\\_FINAL.pdf](http://makeresourcescount.eu/wp-content/uploads/2015/07/Durability_and_reparability-report_FINAL.pdf)

<sup>15</sup> <https://www.ifixit.com/tablet-reparability>

because it is easy to disassemble and has a service manual available. Points are awarded for upgradability, use of non-proprietary tools for servicing, and component modularity. Another already very well established example is the use of re-usable glass bottles: The reuse of containers is often thought of as being a step toward more sustainable packaging. Reuse sits high on the waste hierarchy. The container is used many times thus the material per use or per filling cycle is reduced. Many potential factors are involved in environmental comparisons of returnable vs non-returnable systems. Based on life cycle analysis methodologies it can be shown that especially regional systems with limited transportation distances offer significant environmental and economic resource saving potentials. Especially for beverages the environmental benefits of reusable packaging options are well documented. The Öko-Institute published a study that showed material reduction potentials of about 70% for PET bottles and highlighted that a more differentiated taxation could lead to an avoidance of 400.000 t of packaging waste and thus 1,5 Mio. t CO<sub>2</sub> emissions (Dehoust et al. 2009).

Resource saving potentials: Whilst the relative merits of recycling, energy recovery and land-fill are well studied, the wider environmental and economic impacts of re-use, which ranks above these options in the waste hierarchy, are so far less well understood. The existing literature reveals (e.g. Bakker et al. 2014, James 2014) that the benefits are clearly product- and context-specific but nevertheless significant and e.g. for laptops can be estimated at a range of 20-50%. Prakash et al (2012) considers the environmental impacts of replacing a notebook with a more efficient version. The study finds that “the environmental impacts of the production phase of a notebook are so high that they cannot be compensated in realistic time-periods by energy efficiency gains in the use phase”. The most effective strategies for reducing the impact of a notebook were found to be extension of the useful life time of a notebook, and the study recommends that “the focus of mandatory product policy for ICT should be expanded to measures related to possibilities of hardware upgrading, modular construction, recycling-friendly design, availability of spare parts, standardisation of components and minimum warranty periods.” (Prakash et al 2012). For non-electrical savings could be even higher, at the same time re-use rates in Germany are still extremely low and compared to front-runner regions like Flanders, Belgium, could be increased by a factor of 5-10 (see Wilts/ v Gries/ Wolff 2015).

### From products to services

The idea of product-service-systems or a leasing society is a more systemic approach to increase the resource efficiency of fast-moving consumer goods. The concept stands for a society or an economy that is characterized by a new relationship between producers and customers connected with new incentives of how to use resources. Thereby, this new producer customer relation is offering the potential of reducing environmental impacts by diminishing raw material extraction, resource consumption, waste generation and associated environmental impacts—as such, the leasing society has the potential to fundamentally contribute to the societal challenge of increasing resource efficiency and preventing waste. The leasing society is based on two main pillars:

- More innovative and service-oriented business models to fulfil customer needs, focusing on the provision of product use and result of product use, and
- A product ownership staying in the realm of the producer, while the customer either uses the actual product or consumes the actual result of the product use.

The concept has raised a lot of attention over the last years, nevertheless it is not yet broadly applied. Then again there are some good practice examples that highlight the potential benefits if producers and retailers manage to establish the necessary legal framework and infrastructure to offer such services to their clients. One of the most popular examples are Mud jeans: Fashion is the 3rd largest polluting industry in the world, but over 90% of textile waste that ends up in landfills is recyclable. So there is a growing understanding that the traditional linear business model must be reworked for the 21<sup>st</sup>-century. Approximately 32 Kg clothing waste per person comes up per year. There are several options to deal with this: reuse of clothes in charity shops, collection and recycling, but another alternative is also a more circular business model, like a new concept of leasing. The Dutch clothes company, Mud Jeans, developed a concept for customers in which they have to pay a monthly fee for jeans and returning them at the end of the leasing period<sup>16</sup>. After returning Mud Jeans repairs the jeans before it re-leases them or recycles them through its denim manufacturer. The benefit for the customer is the fact that they can update their wardrobe annually without any upfront costs. The benefit for the company is that it retains the ownership of the raw material what helps them to protect themselves from volatile cotton prices. Altogether the company is able to reduce the consumption of resources (Benton et al 2015). Compared to the purchase of a standard jeans, the leasing concept requires about 80% less materials and e.g. only 10% of fresh water. On the one hand Mud Jeans supports a sustainable cotton growing to reduce the risks for the environment and humans. On the other hand the company can save water by using recycled materials. A new technology makes it possible to save water while the production of jeans as well. Another example in the field of fast-moving consumer goods is the idea to replace the light bulb by an "illumination service": New and innovative lighting in industry or private rooms is necessary for energy efficiency- but it is expensive as well. There are several companies, which offer leasing schemes for lighting. For a monthly paid amount the customer can lease the efficient (LED-) technology, which is installed by the leasing company. The offer is especially for big companies but already now medium-sized businesses can benefit as well and offers for private consumers might follow in the future. With the use of modern LED lighting they can save up to 65% of energy, clearly reduce the amount of resources required in the production process and reduce the generation of waste. Looking at the material reductions, also due to the significantly longer use-phase of LED, the savings can be on the order of 60-90%<sup>17</sup>.

Resource saving potentials: Switching from product to services is clearly the most radical potential transformation for fast moving consumer goods and the resource savings and related environmental benefits depend on the specific business models and products. The more the focus switches from products to services within the continuum outlined in Figure 12 and the more property rights are kept by the producer, the higher the theoretical potential for en-

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<sup>16</sup> <http://www.mudjeans.eu/about/>

<sup>17</sup> [http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012\\_led\\_lca-pt2.pdf](http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/2012_led_lca-pt2.pdf)

vironmental improvements (Tukker, Tischner, and Verkuijl 2006, Hockerts 2008) – also meaning that not all these business models necessarily lead to resource savings. On average savings can be estimated at a range of 20-50% (see Tukker 2004).

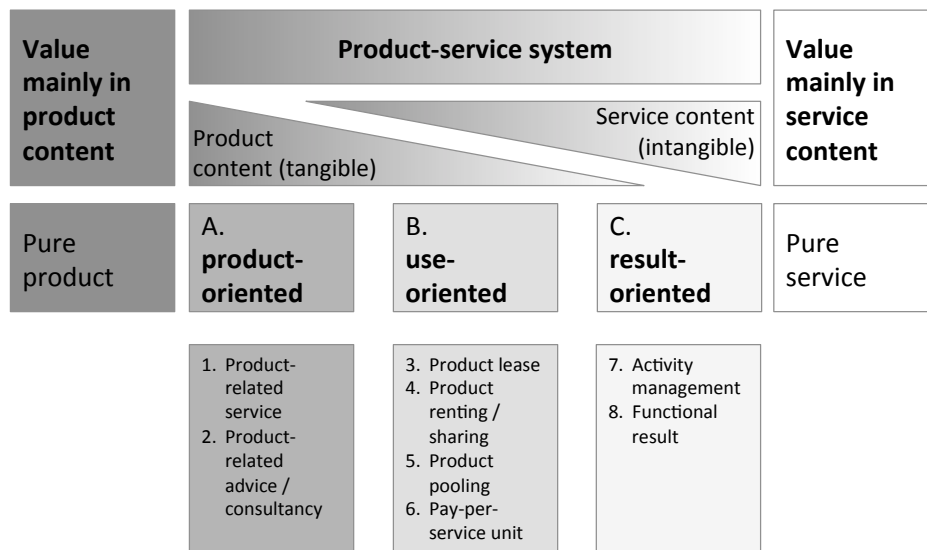


Figure 12: The continuum of product service systems. Source: Tukker et al. 2006

Looking at the different approaches for increasing the resource efficiency of fast moving consumer goods highlights that

- a variety of already existing product alternatives exists with clearly and significant resource requirements;
- the environmental saving potentials differ between products, but also depending on individual behaviour patterns; e.g. the benefits of reuse are often reduced because lower prices for second hand goods lead to the purchase of more products and
- almost all approaches are not purely market-driven but require supporting framework conditions to increase the uptake by relevant market actors, e.g. the retailer sector.

## 4.2 Socio- and macro-economic effects of increased resource efficiency

The following will describe the effects that could be related to an overall reduction of resource consumption in Germany – based on a broad-range and comprehensive increase of resource-efficient products in the German retailers sector. Such an increase is of course impossible to predict but based on the examples given above and other existing studies (e.g. Jungbluth et al. 2012, Wilts et al. 2015, Tukker 2004) on potential resource savings in the fast moving consumer sector it seems reasonable to assume an overall resource reduction of 20%. The report only focussed on fast-moving consumer goods but of course also addressed more general consumption patterns with similar drivers and barriers for more resource efficiency. Taking into account all the related environmental benefits alongside the product value

chains that would imply a reduction of the German material footprint from 50 down to 40 t per capita and year. This will definitely be challenging but the main purpose of the following is to highlight the various benefits that could be related to such a transformation. It is nevertheless clear that such a reduction would require systemic changes that go beyond incremental increases but include innovative concepts of leasing and sharing as well as different patterns of housing, mobility and nutrition.

### Methodological modelling approach

In order to model macroeconomic effects of optimized resource use, the PANTA RHEI model, a macroeconometric simulation and forecasting model for the integrated assessment of environmental and economic impacts inter alia of policy interventions, was used, which is characterized by the bottom-up principle and full integration. The construction principle of bottom-up states that every sector of an economy is modelled very detailed - PANTA RHEI, for example, includes about 600 variables for each one of the 59 sectors – and that macroeconomic variables are formed by explicit aggregation within model interrelations. The construction principle of full integration includes complex and simultaneous modelling, which does not only describe inter-industrial interdependence, but also observes the development and distribution of incomes, energy use, pollutant emissions, the state's redistribution policy, as well as income use of private households for different goods and services. The model shows high levels of endogenization. Besides common cycle interdependencies, PANTA RHEI also depicts quantity-price interdependencies and income-price interference. Regarding the energy and environment sector, physical sizes are included in addition to constant price data (Distelkamp et al. 2010).

### Scenario development

With regard to the evaluation of macroeconomic effects by focusing on resource efficient consumer goods, a comparison between a business-as-usual scenario and a development trajectory assuming changed circumstances (here: reduction of resource use of x% by a significantly increased share of resource efficient consumer goods) is necessary. The business-as-usual scenario was not created in order to give a prognosis in the sense of the most likely future economic development. For this purpose, a more detailed assessment of exogenous variables, e.g. concerning trends in foreign trade, would be required. The scenario is aiming to provide a feasible reference framework to analyse effects of policy measures. Moreover, the alternative scenario does not represent a prediction of the future, but rather clear development trajectories – whereas other development can be seen as no more or less likely.

### BAU scenario

Then what is an adequate reference framework to analyse effects of resource politics in the next decades? Especially guidelines for two areas will be needed, as they will have a decisive impact on resource use and can be considered as exogenous for economic development in Germany. This refers to global economic development and climate change policies chosen by politics. The following statements are based on the so-called “Mit-Maßnahmen-Szenario” (with-measures-scenario) and the “Strukturwandel-Szenario” (Structural change scenario) of Policy Scenarios V, which were developed on behalf of the German Federal Environment Agency (Umweltbundesamt, 2009) by a joint working group of Öko-Institut, For-

schungszentrum Jülich, German Institute for Economic Research, and the Fraunhofer Institute for Systems and Innovation Research ISI. Core elements are, among others, the extension of the European Emissions Trading System, the introduction of a building refurbishment program, and a broad expansion of renewable energies. Within this scenario moderate climate policies as well as a moderate global economic growth are expected (Distelkamp et al. 2010). The following table and figures show key economic and environmental figures that would result from the model under such assumptions.

Year	Development of price-adjusted GDP in the baseline scenario, in billion Euro	Development of final energy consumption in the baseline scenario, in TJ	Development of CO2 emissions in the baseline scenario, in 1000 t	Development of Total Material Requirement in the baseline scenario, in million t
2015	2350	8641931	655526	5900
2020	2440	8374500	631972	6100
2025	2500	8240771	632000	6300
2030	2690	8200200	608418	6500

Table 5: Key elements of the business-as-usual scenario. Based on Distelkamp et al. (2010)

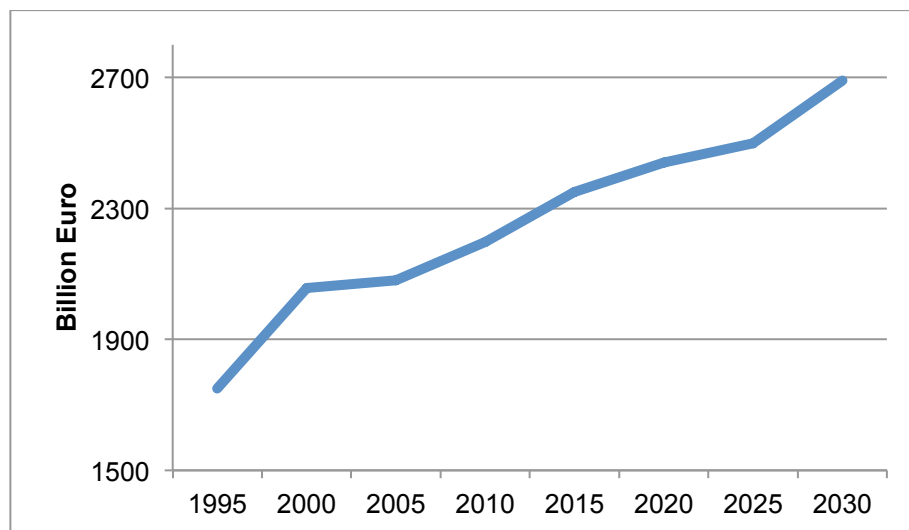


Figure 13: Development of price-adjusted GDP in the BAU scenario. Based on Distelkamp et al. (2010)

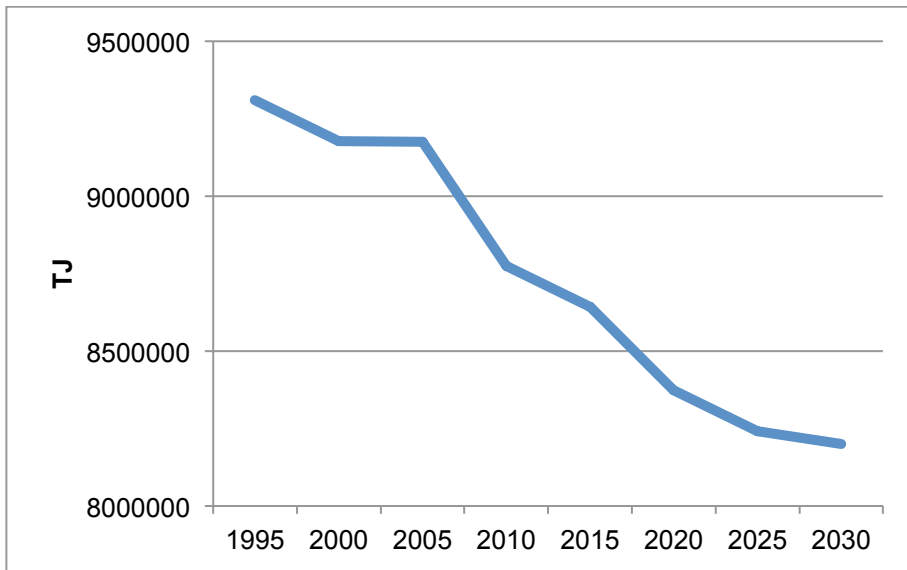


Figure 14: Development of final energy consumption in the BAU scenario. Based on Distelkamp et al. (2010)

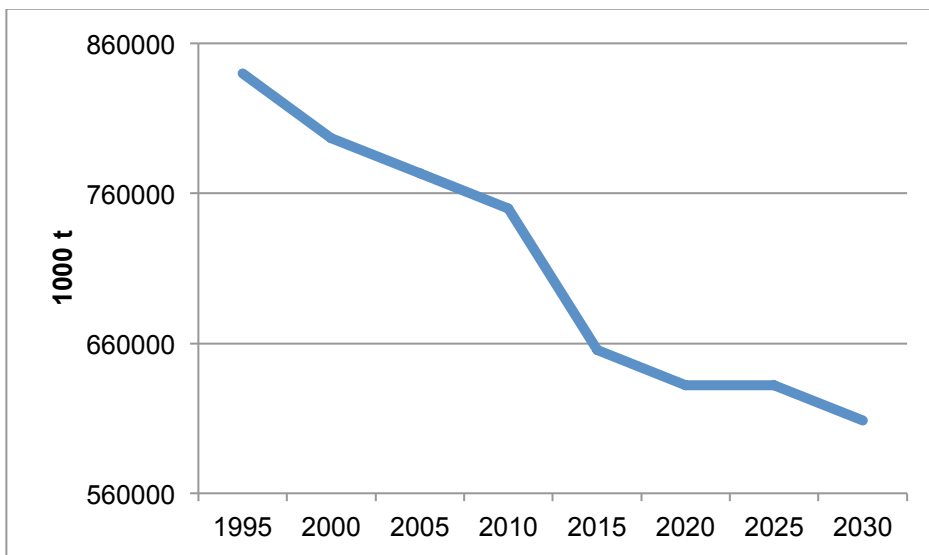
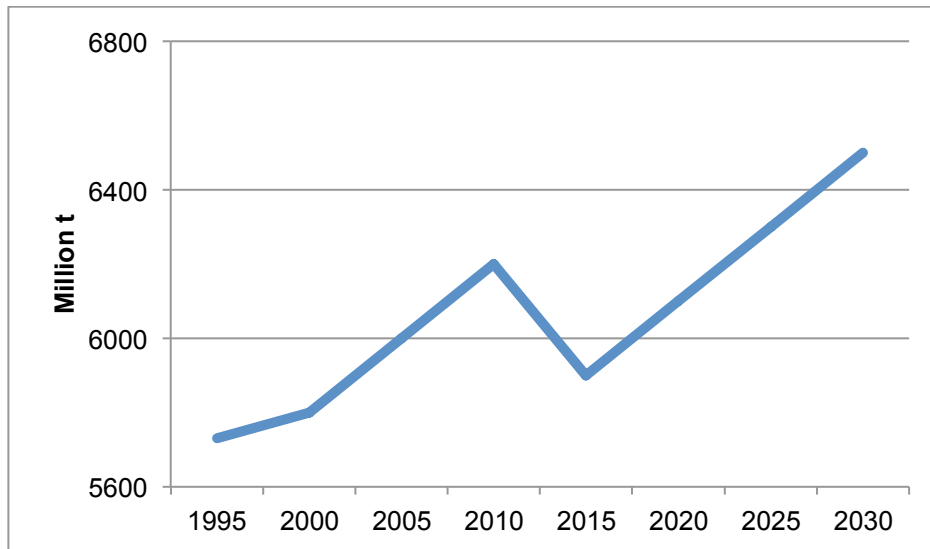


Figure 15: Development of CO2 emissions in the BAU scenario. Based on Distelkamp et al. (2010)



**Figure 16: Development of Total Material Requirement in the BAU scenario. Based on Distelkamp et al. (2010)**

### The alternative scenario

Based on the case studies in chapter 3.1, the following will analyse an alternative reduction scenario that as outlined above assumes an overall reduction of resource consumption in Germany by 20% - initiated by a broad shift towards more resource efficient products. Such a reduction could of course be achieved in many different ways, e.g. by an increase of energy efficiency. The following scenario is more focussed on material efficiency increases and related impacts alongside the value chain, it's based on a scenario developed within the UBA project Material Efficiency and Resource Conservation (MaRess) (Distelkamp et al. 2010).

### Environmental effects

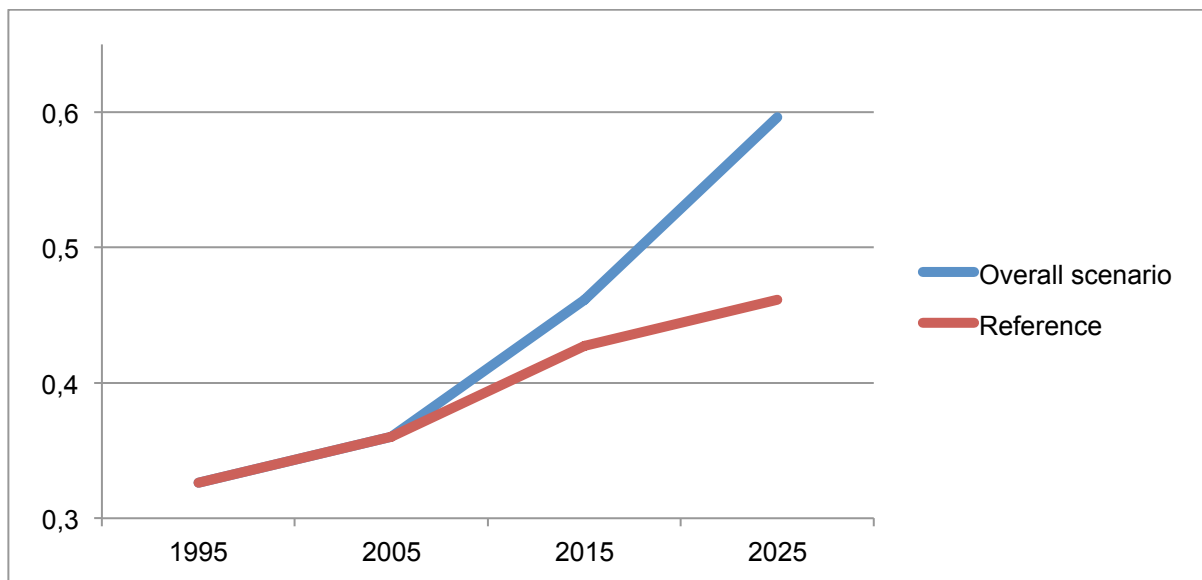
Based on the assumptions of a growing focus on resource-efficient products, the total resource consumption would by assumption be reduced by 20%. This reduction would be achieved despite an on-going economic growth in Germany: resources would be used much more efficiently with also significant economic benefits. In the alternative scenario describing a strongly reduced resource- and material use, it is shown that the level of material productivity in 2030 is about 39,3% above the baseline.

The following table depicts the effects on usage levels according to material types in 2030. The strongest effects result for metals. Especially by using recycled non-ferrous metals a reduction in TMR of about 480 million tonnes, as the related resource demand of imported goods is diminished, i.e. through prevented raw material extraction.



Deviation from the baseline	Energy sources	Metals	Non-metal minerals	Biomass	Others
In %	+0.5	-33.7	-26.6	-8.4	-6.7
In million t	+4.9	-701.3	-143.8	-119.4	-41.0

**Table 6: Effects of an overall scenario on the levels of material use according to material types in 2030. Based on Distelkamp et al. (2010)**



**Figure 17: Effects of overall scenario on material productivity. Based on Distelkamp et al. (2010)**

The increased material productivity would also be linked to reductions of CO<sub>2</sub> emissions: In addition to already existing climate policy measures in the business-as-usual scenario, in this alternative scenario the energy productivity would be increased by 13,7% - leading to a total reduction of emissions of -18,3% in 2030 compared to 2008. Compared to the business-as-usual scenario that already includes some ambitious climate protection policies the total CO<sub>2</sub> reduction would only be about 0,8% higher but at an of course significantly increased GDP.

### Macroeconomic effects

The modelling of a resource reduction by a comprehensive focus on resource-efficient products shows that not only remarkable environmental benefits, but also positive macroeconomic effects are achieved. Growing resource efficiency leads to decreased production costs in manufacturing industries, which contributes to a higher competitiveness on the international market and to a higher domestic value creation. The price index of the gross output will fall about 4.3% in average until 2030, compared to the baseline. The following overview shows

deviations from the business-as-usual scenario for the most important macroeconomic variables.

Deviations from the baseline	Exports in 2030	Imports in 2030	Private consumption in 2030	Public consumption in 2030
In %	+4.6	-10.7	+6.9	+3.0
Billion EUR	+82.2	+171.4	+82.2	+14.1

**Table 7: Effects of an overall scenario on the components of price-adjusted GDP in 2030. Based on Distelkamp et al. (2010)**

Regarding labour market effects, it is important to consider the nominal wages remaining constant, as price reductions and productivity increase compensate each other within their effects on wage agreements. Therefore, real wages increase by the percentage of price reduction. In companies of the manufacturing industry, unit prices will lower significantly due to clear increase of material productivity. The demand raising effects are considerably stronger than the reduction of value creation through less demand in material producing companies. In this context the reduction of raw material imports plays a key role. Growing exports can be traced back to improved competitiveness by low prices of goods that accompany increasing material efficiency in Germany. It has to be considered that price reductions are significantly higher than average in those types of goods that are important for export. Concerning employment, there is an increase of 1.9% or around 683,000 additional jobs – significantly reducing the number of unemployed people in Germany.

Deviations from the baseline	Workforce in hours	Unemployed persons
In %	+1.9	-13.6
Absolute	+683,900	-432,100

**Table 8: Deviations from an overall scenario on the labour market in 2030**

### 4.3 Sustainable consumption and necessary policy interventions

Sustainable consumption and resource efficient products have become a trend: the turnover of “green” products and services is growing constantly with only few exceptions (see UBA 2013). Nevertheless, a growing turnover is yet not to be equaled with growing market shares, as also conventional markets still keep growing. Whereas organic food or public transport

stay under a percentage point, other product categories were significantly higher. Household devices could reach between five and 35 percentage points. They show that “green” products are suitable for the mass market. The willingness to buy is clearly above current market shares, even regarding less demanded products. According to a survey initiated by the German Umweltbundesamt (2013), 12% of the interviewees indicated to currently use or would like to use compensation payments (e.g. offsetting climate gas emissions from air travel) in future, 24% indicated to currently use or would like to use green electricity in the future and 34% highlighted the importance of organic food for their consumption patterns. This does not mean, that a willingness to buy can be turned into real purchasing. Still, it is an important indicator for market as well as employment potentials that are not yet fully exploited.

In all relevant consumption fields, there are diverse sustainable alternatives that belong more and more to the standard range of products. With a view to global environmental problems, we nevertheless have to admit that developing countries are catching up faster to our non-sustainable consumption than the western countries’ pathway to sustainable products and services. Against this background the small growth rates of “green” products will not be sufficient and more radical policy mixes will be necessary to increase a significant resource reduction (Wilts 2015). Specifically with regard to fast moving consumer goods the following elements should be included in such a policy mix:

- environmental costs of products should be reflected in their final prices so that consumers can make rationale decisions, this could be implemented e.g. by resource extraction taxes on virgin raw materials and concepts of extended producer responsibility that set incentives to consider resource saving potentials alongside the whole value chain;
- given the resource saving potentials from an increased use of recycled materials, the aspired transition towards a “circular economy” should be reflected in waste-related targets that focus on the actual recovery of raw materials and clearly favor recycling over incineration;
- with regard to the design of products the Ecodesign Directive should increasingly include also resource and material efficiency aspects, e.g. by including minimal requirements for repairability and recycability. The process for setting binding product standards should be significantly shortened in order to be able to keep up with innovation processes especially in the fast moving consumer good sector.

## 5 Annex 1: Product group categories according to Eurostat

No_Rows	CPA_2002_LABEL
1	Products of agriculture, hunting and related services
2	Products of forestry, logging and related services
3	Fish and other fishing products; services incidental to fishing
4	Coal and lignite; peat
5	Crude petroleum and natural gas; services incidental to oil and gas extraction excluding surveying
6	Uranium and thorium ores
7	Metal ores
8	Other mining and quarrying products
9	Food products and beverages
10	Tobacco products
11	Textiles
12	Wearing apparel; furs
13	Leather and leather products
14	Wood and products of wood and cork (except furniture), articles of straw and plaiting materials
15	Pulp, paper and paper products
16	Printed matter and recorded media
17	Coke, refined petroleum products and nuclear fuel
18	Chemicals, chemical products and man-made fibres
19	Rubber and plastic products

20	Other non-metallic mineral products
21	Basic metals
22	Fabricated metal products, except machinery and equipment
23	Machinery and equipment n.e.c.
24	Office machinery and computers
25	Electrical machinery and apparatus n.e.c.
26	Radio, television and communication equipment and apparatus
27	Medical, precision and optical instruments, watches and clocks
28	Motor vehicles, trailers and semi-trailers
29	Other transport equipment
30	Furniture; other manufactured goods n.e.c.
31	Recovered secondary raw materials
32	Electrical energy, gas, steam and hot water
33	Collected and purified water, distribution services of water
34	Construction work
35	Trade, maintenance and repair services of motor vehicles and motorcycles; retail trade services of automotive fuel
36	Wholesale trade and commission trade services, except of motor vehicles and motorcycles
37	Retail trade services, except of motor vehicles and motorcycles; repair services of personal and household goods
38	Hotel and restaurant services
39	Land transport and transport via pipeline services
40	Water transport services
41	Air transport services

42	Supporting and auxiliary transport services; travel agency services
43	Post and telecommunication services
44	Financial intermediation services, except insurance and pension funding services
45	Insurance and pension funding services, except compulsory social security services
46	Services auxiliary to financial intermediation
47	Real estate services
48	Renting services of machinery and equipment without operator and of personal and household goods
49	Computer and related services
50	Research and development services
51	Other business services
52	Public administration and defence services; compulsory social security services
53	Education services
54	Health and social work services
55	Sewage and refuse disposal services, sanitation and similar services
56	Membership organisation services n.e.c.
57	Recreational, cultural and sporting services
58	Other services
59	Private households with employed persons

## 6 Annex 2: Glossary of key terms and concepts

### **Entkopplung:**

Bezeichnet hier eine im Vergleich zum Wirtschaftswachstum (z.B. BIP) geringer verlaufende Entwicklung von Ressourcennutzung. Bei einer relativen Entkopplung steigt der Ressourcenverbrauch zwar an, aber weniger als das wirtschaftliche Wachstum. Oder der Ressourcenverbrauch bleibt konstant bei gleichzeitigem Wachstum der ökonomischen Leistung. Eine absolute Entkopplung ist dadurch gekennzeichnet, dass der Ressourcenverbrauch bei steigendem Wirtschaftswachstum über die Zeit abnimmt.

### **Decoupling:**

Refers to a reduced development of natural resource use as compared with economic growth (e.g. GDP). Relative decoupling means that resource use may increase, however, at a lower rate than economic growth. Or, resource use remains constant while the economic output increases. Absolute decoupling is achieved when resource use declines over time while the economy grows.

### **Indirekte Materialflüsse:**

Mit indirekten Materialflüssen werden solche bezeichnet, die (i) zur Herstellung eines Produktes erforderlich sind, (ii) in vor gelagerten Stufen des eigentlichen Produktionsprozesses auftraten, und (iii) physisch nicht im Produkt selbst enthalten sind. Indirekte Flüsse werden entlang der lebenszyklusweiten Produktkette erhoben und umfassen sowohl verwertete (genutzte) als auch nicht verwertete (nicht genutzte) Materialien. Bei der ökonomieweiten MFA beziehen sich indirekte Materialflüsse auf die vor gelagerten Materialaufwendungen für importierte und exportierte Güter im Außenhandel.

### **Indirect (material) flows:**

The term "indirect flows" is used to designate the flows of materials that (i) are needed for the production of a product, (ii) have occurred up-stream in the production process, and (iii) are not physically embodied in the product itself. Indirect flows take into account the life-cycle dimension of the production chain, and encompass both used and unused materials. In economy-wide material flow accounting (i.e. Eurostat, 2001) where the national economy is considered as a whole, "indirect flows" refer to upstream flows associated to imports and exports, i.e. flows that indirectly cross the boundary between the domestic economy and the rest of the world economy.

### **Material:**

Allgemeiner Begriff, der sowohl die Rohmaterialien als auch bereits vom Menschen durch physikalische oder chemische Prozesse veränderte Stoffe einschließt. Dabei handelt es sich also praktisch immer um zwar potentiell dienstleistungsfähige, jedoch nicht unbedingt im Gebrauch befindliche Güter. Material wird im Sinne des MIPS-Konzepts verstanden als alle materiellen natürlichen Ressourcen, die entweder direkt der Natur entnommen werden oder darin bewegt werden. Dazu gehören abiotische M., biotische M., Boden- bzw. Erdbewegungen. Materialien sind aber eben auch komplex zusammengesetzte Rohmaterialien, Werkstoffe, Produkte oder Abfallstoffe.

Material:

A general term which comprises raw materials as well as materials processed by humans by physical or chemical processes. In practice, the term refers to potentially service providing goods which, however, are not necessarily in use. Material in the MIPS-concept is understood as all natural material resources which are either directly taken from nature or moved within. This comprises abiotic M., biotic M., moved soil or earth. Materials are also complex raw materials, basic materials, products or waste materials.

### **Materialeffizienz:**

Materialeffizienz bezieht sich allgemein auf das Verhältnis eines erwünschten Outputs eines Prozesses zu dem damit verbundenen Materialaufwand oder -input. Ist der Output eine ökonomische Größe, z.B. Wertschöpfung oder BIP, so spricht man von „Materialproduktivität“. Die Materialeffizienz von Prozessen kann sich jedoch auch auf das Verhältnis von physischen Relationen beziehen, z.B. das Verhältnis von eingesetzter Materialmenge zu hergestelltem Produkt. Materialeffizienz lässt sich beispielsweise durch Verringerung des Ausschusses, durch Reduzierung von Verschnitt oder die Optimierung des Produktdesigns erhöhen. Es können darüber hinaus auch indirekte Materialaufwendungen einbezogen werden.

Material efficiency:

Material efficiency in general refers to the relation of a desired output of a process to the corresponding material requirement or -input. In case the output is an economic measure, e.g. value added or GDP we speak of “material productivity”. Material efficiency of processes can, however, also refer to the relation of physical relations, e.g. the ratio of material used to the resulting product. Material efficiency may for example be achieved through reduced production waste or through improved product design. In addition, unused materials may be included.

### **Materialflussindikatoren: DMI, DMC, TMR, TMC:**



Grundsätzlich sind hier alle aus Materialflussrechnungen ableitbaren Indikatoren gemeint (für eine vollständige Übersicht siehe Eurostat 2001). Im Folgenden werden lediglich die wichtigsten Input- und Verbrauchs-Indikatoren der ökonomieweiten MFA wie folgt angesprochen.

#### Direct Material Input (DMI)

Der DMI bezeichnet die Menge der direkt in die Wirtschaft eines Landes gelangenden Materialien. Der DMI setzt sich einerseits aus den im Inland gewonnenen Rohstoffen zusammen, wie Biomasse, fossile Energieträger und Minerale. Andererseits besteht der DMI aus den Importen von Waren die von Rohstoffen bis Fertigwaren reichen. Der Indikator misst somit die direkt eingesetzten Materialinputs, die zur Weiterverarbeitung oder zum direkten Konsum der jeweiligen Volkswirtschaft dienen, und demnach einen ökonomischen Wert haben.

#### Total Material Requirement (TMR)

Der TMR bezeichnet den globalen (Gesamt-) Materialaufwand (GMA) einer Ökonomie. Der TMR umfasst zusätzlich zum DMI die oftmals als „ökologische Rucksäcke“ bezeichneten Materialaufwendungen. Diese bestehen einerseits aus der nicht verwerteten Entnahme im Inland, z.B. Abraum bei der Gewinnung von Kohle, Erdaushub bei Bautätigkeiten oder Bodenerosion infolge landwirtschaftlicher Bewirtschaftung. Zum anderen umfasst der TMR alle im Ausland lebenszyklusweit aufgewendeten Materialien, genutzt und ungenutzt, die zur Bereitstellung eines importierten Gutes erforderlich waren. Diese werden allgemein als indirekte Materialflüsse bezeichnet. Der TMR ist somit der umfassendste Input-Indikator und misst die gesamtematerielle Basis einer Volkswirtschaft. Der TMR ist damit ein Schätzwert für die Größenordnung der potenziellen Umweltbelastungen durch die Entnahme und Nutzung natürlicher stofflicher Ressourcen.

#### Domestic Material Consumption (DMC)

Der DMC misst den inländischen direkten Materialverbleib eines Wirtschaftssystems. Er ist definiert als DMI minus Ausfuhren.

#### Total Material Consumption (TMC)

Der TMC misst die globale Gesamtmenge der verwendeten Materialien für den inländischen Verbrauch einschließlich indirekter Materialaufwendungen. Er ergibt sich somit aus dem TMR abzüglich der Exporte und deren indirekte Materialflüsse. Der TMC ist ein Maß für alle direkten und indirekten Primärmaterialentnahmen, sowohl im Inland als auch im Ausland, die mit dem inländischen Konsum (apparenter Verbrauch) einer Volkswirtschaft in einem Jahr verbunden sind.

Material Flow Indicators: here only DMI, DMC, TMR, TMC:

In principle this concerns any indicator derived from material flow accounts (see Eurostat 2001 for an overview). Here, only the most important Input- and Consumption-Indicators derived from economy-wide MFA are presented.

#### Direct Material Input (DMI)

Direct Material Input (DMI) refers to the amount of materials directly used in the economy. DMI comprises domestically extracted raw materials like biomass, fossil energy carriers and minerals. DMI further includes imported commodities ranging from raw materials to finished products. The DMI indicator thus measures the directly used materials for further processing or direct consumption within an economy, which thus have an economic value.

#### Total Material Requirement (TMR)

TMR refers to the global total 'material base' of an economic system. In addition to DMI, TMR includes the so called "ecological rucksacks". These consist on the one hand of unused domestic extraction like overburden from coal mining, excavated soil for constructions or soil erosion in agriculture. On the other hand, TMR includes all foreign life-cycle wide required materials, used and unused, which were necessary to provide an imported good. These are in general called indirect material flows. TMR thus constitutes the most comprehensive Input-Indicator and measures the total physical basis of an economy. TMT thus represents an estimation value for the magnitude of potential environmental pressure exerted through the extraction and use of natural resources.

#### Domestic Material Consumption (DMC)

DMC measures the mass (weight) of the materials that are physically used in the domestic economic system. In economy-wide material flow accounting DMC equals DMI minus exports.

#### Total Material Consumption (TMC)

TMC measures the total mass of materials that are associated to the (apparent) material consumption of the domestic economic system. In economy-wide material flow accounting TMC equals TMR minus exports and their indirect flows. TMC is a measure for all direct and indirect primary materials extracted domestically and abroad, which are associated with the domestic use (apparent consumption) of an economy in one year.

#### **Materialproduktivität:**

Die erzielte Wertschöpfung pro Einheit dafür erforderlichem Material, z.B. BIP geteilt durch den gesamten Materialaufwand, Einheit: Euro pro kg. Der Materialverbrauch oder -input

kann auf verschiedene Weise definiert bzw. berechnet werden. Materialproduktivität zeigt die Effizienz der ökonomischen Nutzung von Material an. Siehe auch Materialeffizienz.

Material productivity:

The value added per unit of material required. For example, GDP divided by total material requirement, Unit: Euro per kg. Material productivity indicates the efficiency of the economic use of materials. See also Material efficiency.

### **MIPS – Material Input pro Serviceeinheit:**

MIPS ist die Gesamtheit aller lebenszyklusweiten stofflichen Inputs (MI), die zur Erbringung einer Dienstleistung erforderlich sind. Die Einheit ist kg pro S (Serviceeinheit). Dabei werden fünf Haupt-Input-Kategorien unterschieden: abiotische Rohmaterialien, biotische Rohmaterialien, Bodenbewegungen, Wasser und Luft. Die ersten drei dieser Kategorien können zum TMR-Wert zusammengefasst werden. Ansonsten sind die Kategorien getrennt auszuweisen. MIPS bemisst die Umweltbelastungsintensität von Prozessen und Gütern im Hinblick auf ihren spezifischen Ressourcenverbrauch in allen Lebensphasen. In MIPS werden Inputressourcen als Material und Energie (gemessen in dem zur Energieerzeugung notwendigen Materialinput) in Gewichtseinheiten umgerechnet. Für definierte Prozesse und dienstleistungsfähige Güter ist das Inverse von MIPS ein unmittelbares Maß für ihre Ressourcenproduktivität.

MIPS - Material Input Per Service unit:

MIPS is the total of all life-cycle-wide material inputs (MI) required for the provision of a service. The unit is kg per S (service). Five major input categories are differentiated: abiotic raw materials, biotic raw materials, moved soil, water and air. The first three of these categories can be combined to the TMR-value. Apart from that the categories have to be shown separately. MIPS measures the environmental pressure potential of processes and goods with regards to their specific resource requirements in all life cycle phases. MIPS accounts for all materials and energy (measured as material required to generate energy) in mass units. For defined processes and service providing goods the inverse of MIPS is a measure for resource productivity.

### **Natürliche Ressourcen:**

Natürliche Ressourcen umfassen im weiteren Sinne alle Funktionen des Ökosystems Erde sowie des Sonnensystems, die vom Menschen direkt oder indirekt genutzt werden oder ge-

nutzt werden können bzw. die die Grundlage seines (Über-)Lebens und Wirtschaftens und der Co-Existenz mit der Natur darstellen. Dazu zählen z.B. Funktionen wie die Stabilität des Klimas, der Schutz vor schädlicher Strahlung durch die Ozonschicht, die Aufnahmefähigkeit für Schadstoffe, die Stabilität und Regenerationsfähigkeit natürlicher artenreicher Lebensräume und die Solarstrahlung. Im engeren Sinne versteht man unter n.R. zum einen biotische und abiotische Rohstoffe (Biomasse und Mineralien) und Wasser, die für die verschiedenen sozio-industriellen Zwecke (für Nahrungsmittel, Bau- und Werkstoffe, zur Energiegewinnung usw.) auf Grund ihrer stofflichen oder energetischen Eigenschaften oder technologischer Gegebenheiten der natürlichen Umwelt entnommen werden, und zum anderen das Land, das dafür und darüber hinaus für verschiedene Zwecke und in unterschiedlicher Weise und Intensität genutzt wird (für Siedlungen und Verkehr, Land- und Forstwirtschaft, Abgrabungen, als Erholungsraum und für Naturschutz).

Natural resources:

Natural resources comprise in a broader sense all functions of the ecosystem earth as well as the solar system, which are used by humans directly or indirectly or which can be used resp. represent the basis of human life (and survival) and economic activities and its co-existence with nature. This includes e.g. functions like climate stability, protection by the ozone layer from dangerous radiation, the carrying capacity of ecosystems for pollutants, the stability and capacity for regeneration of natural ecosystems and their biodiversity, and the solar radiation. In a more narrow sense, natural resources are meant to comprise, on the one hand, biotic and abiotic raw materials (biomass and minerals) and water, which are extracted from the environment because of their material or energetic properties or because of technological conditions, to serve for different socio-industrial purposes (for nutrition, construction, manufacturing, energy generation etc.). On the other hand, it is the land which is used for the purpose of extracting or harvesting raw materials, and in addition the land which is used for different other purposes in different ways and with different intensity (for settlements and traffic, for agriculture and forestry, for mining and quarrying, for recreation and for nature protection).

### **Ökologischer Rucksack:**

Der ökologische Rucksack bezeichnet den lebenszyklusweiten Materialinput abzüglich der Eigenmasse und wird gemäß der fünf MI-Kategorien getrennt ausgewiesen. Die Eigenmasse verteilt sich dabei auf die einzelnen MI-Kategorien gemäß ihrer Zusammensetzung bzw. der Herkunft der Stoffe. Der ökologische Rucksack umfasst sowohl verwertete als auch nicht verwertete Materialien. Die Einheit ist kg.

Ecological rucksack:

The ecological rucksack refers to the life-cycle-wide material inputs minus the own mass is shown separately for the five MI-categories. The own mass of a product or good is distributed over the individual MI-categories according to their composition resp. the origin of the

materials. The ecological rucksack comprises both used and unused materials. The unit is kg.

### **Ressourcenproduktivität:**

Die erzielte Wertschöpfung pro Einheit dafür erforderlicher Ressource, z.B. BIP geteilt durch den gesamten Energieverbrauch, Einheit: Euro pro Joule. Der Ressourcenverbrauch oder –input kann auf verschiedene Weise definiert bzw. berechnet werden. Eine geeignete Berechnung ist unabdingbar und hängt von der Zielfragestellung ab. Die berechneten Kategorien müssen zumindest eine gemeinsame Eigenschaft aufweisen (z.B. Primärmaterialien zu sein). Ressourcenproduktivität zeigt die Effizienz der ökonomischen Nutzung von Ressourcen an.

Resource productivity:

The value added per unit of resource required. For example, GDP divided by total energy consumption, Unit: Euro per Joule. Different ways of calculating or defining resource consumption and input are possible. A suitable calculation is vital and depends on the target question; the accounted categories need to have at least one property in common (e.g. being primary materials). Resource productivity indicates the efficiency of the economic use of resources.

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