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Appropriate Evaluation Benchmarks and Indicators for Measuring the Success of Waste Prevention Measures

Final Report

For our Environment

Umwelt Bundesamt

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Appropriate Evaluation Benchmarks and Indicators for Measuring the Success of Waste Prevention Measures

Final Report

by

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Kurzbeschreibung

Das Kreislaufwirtschaftsgesetz (KrWG) verlangt mit Bezug auf das Abfallvermeidungsprogramm (AVP) des Bundes und der Länder die Benennung zweckmäßiger Maßstäbe für festgelegte Abfallvermeidungsmaßnahmen (AVM), anhand derer die erzielten Fortschritte bei der Entkopplung der mit der Abfallerzeugung verbundenen Auswirkungen auf Mensch und Umwelt vom Wirtschaftswachstum erfasst werden können. Das KrWG räumt die Möglichkeit ein, konkrete quantitative oder qualitative Indikatoren zu benennen, was jedoch angesichts der Komplexität und Vielzahl der konkreten AVM, der betroffenen Abfallströme und der involvierten Akteursgruppen auf verschiedenen Ebenen (Bund, Länder, Kommunen) eine besondere Herausforderung darstellt. Hinzu kommt, dass aufgrund struktureller und konjunktureller Entwicklungen der Rückgang der Mengen einzelner Abfallströme nicht direkt der Wirkung von AVM zugeordnet werden kann. Das AVP benennt bereits eine Reihe möglicher Indikatoren für einzelne Maßnahmen, Sektoren oder Stoffströme. Allerdings bestehen erhebliche Wissenslücken, inwieweit diese Indikatoren das Entstehen von Abfällen darstellen oder die Effekte von AVM abbilden können. Vor diesem Hintergrund lautete die Zielsetzung dieses Projektes, mögliche Bewertungsmaßstäbe für die Messung des Abfallvermeidungserfolges vertiefend zu analysieren und diese auf ihre Eignung für die Messung des Erfolges der im AVP etablierten Maßnahmen hin zu prüfen. Basierend auf dem Prüfergebnis wurde ein Set an Indikatoren erarbeitet, um eine kontinuierliche Messung des Erfolges von AVM zu ermöglichen.

Abstract

With reference to the federal Waste Prevention Programme (WPP), the Circular Economy Act stipulates that appropriate standards for defined waste prevention measures must be specified in order to record the progress made in decoupling the effects on people and the environment associated with waste generation from economic growth. The Circular Economy Act provides the possibility of naming concrete quantitative or qualitative indicators, which, however, represents a particular challenge in view of the complexity and variety of concrete waste prevention measures, the affected waste streams and the involved groups of actors at various levels (federal, state and municipal authorities). In addition, the decline in volumes of individual waste streams cannot directly be attributed to the effects of waste prevention measures due to structural and economic developments. The WPP already identifies a number of possible indicators for individual measures, sectors or material flows. However, there are considerable knowledge gaps to which extent these indicators can represent waste generation or effects of waste prevention measures. Against this background, the aim of this project was to analyse possible evaluation criteria for the measurement of waste prevention success in depth and to test their suitability for assessing the success of the measures established in the WPP. Based on the test result, a set of indicators was developed to enable a continuous measurement of the success of waste prevention measures.

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List of Abbreviations

ATV	German Association for Wastewater (German: Abwassertechnische Vereinigung)
BMU	Federal Minister for the Environment, Nature Conservation and Nuclear Safety
BMUB	Federal Minister for the Environment, Nature Conservation, Building and Nuclear Safety
DPSIR	Driving Forces – Pressures – States – Impacts – Responses
DVM	German Association for Materials Research and Testing (German: Deutscher Verband für Materialforschung und -prüfung e.V.)
EEA	European Environment Agency
EEE	Electrical and Electronic Equipment
ElektroG	German Electrical and Electronic Equipment Act (German: Elektrogesetz)
EMAS	Eco-Management and Audit Scheme
EMS	Environmental management system
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FKZ	Project No.
FLW	Food Loss & Waste
GDP	Gross domestic product
GfK	Society for Consumer Research (German: Gesellschaft für Konsumforschung)
GVA	Gross value added
IDA	Index decomposition analysis
KrWG	Circular Economy Act (German: Kreislaufwirtschaftsgesetz)
NPO	Non-Profit Organisation
OECD	Organisation for Economic Co-operation and Development
ProgRess	Resource Efficiency Programme of the Federal Republic of Germany
QuB	Quality Association of Environmentally Conscious Companies
RACER	Relevant – Acceptable – Credible – Easy – Robust
REFOWAS	Reduce Food Waste
REFRESH	Resource Efficient Food and Drink for the Entire Supply Chain

SDG	Sustainable Development Goals
TMR	Total Material Requirement Index
UBA	Federal Environment Agency (German: Umweltbundesamt)
UNEP	United Nations Environment Programme
VDI-RL	Guideline of the Association of German Engineers
WEEE	Waste of Electrical and Electronic Equipment
WFD	Waste Framework Directive
WiRD	Projekt “Re-Use and Repair Centres in Germany”
WPP	Waste Prevention Programme

Summary

Background

The amended European Waste Framework Directive (WFD 2008/98/EC) reaffirmed waste prevention as the top priority of waste management. The introduction of a further level of the waste hierarchy has also strengthened the preparation for reuse as a second priority after prevention. The Waste Framework Directive moreover obligates the Member States to establish waste prevention programmes. These should include objectives and measures to decouple economic growth from the environmental impacts of waste generation. In order to monitor and evaluate the progress of these waste prevention measures, Member States should lay down appropriate and specific standards. These standards can either be of qualitative or quantitative nature.

The European Waste Framework Directive has been transposed into German law in form of the Circular Economy Act (Kreislaufwirtschaftsgesetz – KrWG). The federal government's corresponding Waste Prevention Programme (WPP) under participation of the federal states was adopted in 2013. It already identifies possible indicators for individual measures, sectors or material flows. However, only little is known about the suitability of the proposed indicators to represent waste generation and the effectiveness of waste prevention measures. Challenges in defining the indicators are the complexity and variety of concrete waste prevention measures, the affected waste streams and the involved groups of stakeholders at different levels (federal, state and municipal authorities). Furthermore, the decline in volumes of individual waste streams cannot directly be attributed to the effects of waste prevention measures due to structural and economic developments

Objective of the research project

Against this background, the objective of the project "Appropriate benchmarks and indicators for monitoring the success of waste prevention measures" (UFOPLAN project FKZ 3715343020) was to analyse possible evaluation criteria for the measurement of waste prevention success in depth and to test their suitability for assessing the success of the measures defined in the WPP. Based on the test result, the aim was to develop a suitable set of indicators that would enable continuous measurement of the success of waste prevention measures.

Approach and methodology

The project was divided into five consecutive steps:

First, an analysis of existing indicator systems was carried out with regard to the main objective of the WPP and the operational targets derived from it. The indicators have been systematically classified and reviewed, and appropriate sets of indicators for the main objective, operational targets and subtargets of the WPP have been derived. More than 400 indicators were identified on the basis of a comprehensive literature search and an analysis of European and international waste prevention programmes.

To further systematize the identified indicators, they were structured using the DPSIR impact model. The European Environment Agency (EEA) uses the DPSIR approach for integrated environmental assessment. Through the system-analytical perspective, the focus is on the interactions between environment and socio-economic activities. In a chain of causal links, a distinction is made between driving forces (economic sectors; human activities), pressures (environmental pollution), states (state of soil, water, air; changes in physical, biological or chemical processes), impacts (influence on ecosystems or human health) and responses (socio-political reactions). Indicators can thus be structured in terms of ecological quality and the resulting influence of political decisions (see Figure 1).

Figure 1: DPSIR concept for environmental assessment

Source: Own compilation based on Kristensen (2004)

The entire list of more than 400 indicators identified was subsequently adjusted for duplications, obvious references to recycling instead of waste prevention and country-specific regulations without transferability to Germany. This resulted in a list of 90 waste prevention indicators, which served as a starting point in developing a set of indicators. For the selection of indicators to be subjected to a RACER analysis, this list has been reduced to 25 topics, i.e. different operationalization approaches have been combined, e.g. waste generated per capita, per unit of GDP or per household.

Subsequently, the indicators were subjected to a RACER expert survey in order to systematically identify the challenges in developing indicators for the individual thematic areas. The European Commission's RACER methodology from the Impact Assessment Guidelines[1] was used to assess the suitability of the indicators determined for the main objective and the operational targets of the WPP. Afterwards, all indicators should be "RACER" as far as possible:

- (politically) relevant, i.e. closely linked to the main objective or operational targets to be achieved and therefore appropriate and meaningful in terms of progress,
- acceptable for different stakeholders,
- credible for non-experts, as well as unmistakable, unambiguous and easy to interpret,
- easy to observe, monitor and communicate,
- robust against manipulation and errors, and robust in quality of the data base.

In order to operationalize the RACER methodology, the five criteria were further differentiated.

Since the discussion of individual topics showed that in some areas the data base is not sufficient to form robust and credible indicators, first and second best indicators were formed, which in the first case require a complete data base, and in the second case develop a pragmatic approach in view of limited data availability and, wherever appropriate, try to relate to other indicator sets.

[1] European Commission (2009): Part III – Annexes to the Impact Assessment Guidelines. See also European Commission (2005): Impact Assessment Guidelines. SEC2005 (791/3), with March 2006 update.

On the basis of the evaluation of European and international waste prevention programmes, European Commission programmes and the United Nations Sustainable Development Goals (SGD), target proposals were developed for the indicators (first and second best) and identified which actors would have to be active or at least involved in order to achieve these goals.

In the following step, the measures of the WPP were assigned to specific sub-targets and suitable success indicators for the various areas of activity were developed. The indicator proposals are either accompanied by explanations or it is illustrated, why there is no meaningful indicator in one area or why it would be desirable to use indicators, but not feasible at present. The third step included a decomposition analysis to identify relevant drivers of the different waste streams and to show their effects. The results of the decomposition analysis continued to serve as a basis for developing reference scenarios for the determination of waste prevention effects. Based on this work, a sketch of a data collection concept was drawn up in the fourth step, in which the prospective collection and update effort for the respective indicators is estimated. Finally, in the fifth step, the degree of target achievement for all indicators was analysed, the need for action for individual waste prevention targets was reflected and the set of indicators was finalised.

In addition, a database was created to record the quantities of re-used products in Germany. Strengthening re-use and thus extending the product life cycle in Germany is one aspect of the sub-targets contained in the WPP, but data on quantities of waste products actually re-used and the respective available potential is insufficient. In order to close this gap and create a basis to define indicators for measuring success, a comprehensive survey of re-use facilities in Germany was conducted. This referred on the one hand to the immediate re-use of used products and on the other hand to end-of-life products that have successfully undergone preparation for re-use (end of waste characteristics) and are thus available for re-use. In addition, the potential of quantities of used products traded for re-use via online offers was estimated.

Furthermore, the subject area "Waste prevention indicators for food waste" was examined in depth, as the reduction of food waste is of central importance from an ecological point of view, but there is no sufficient data available regarding the quantification of waste production. Among other things, the current state of debate at national and European level was analysed, European waste prevention programmes were evaluated, Flanders' experience with quantifying food waste was investigated and a process proposal for developing an indicator in Germany was prepared.

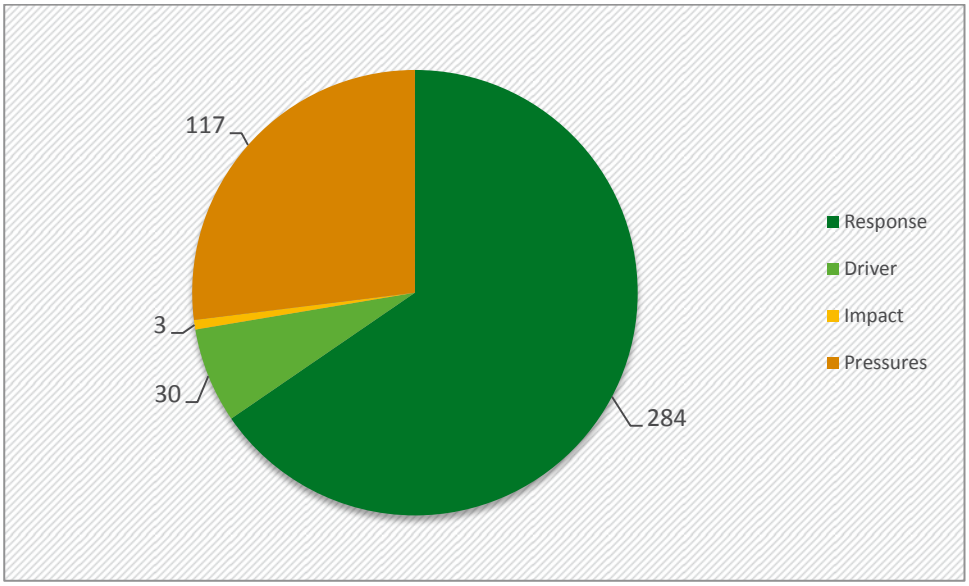
Results

According to Article 29 of the EU Waste Framework Directive, all EU member states are obliged to develop national waste prevention programmes and have the option of specifying suitable waste prevention indicators or benchmarks. For this research project, approaches to the formation of indicators (e.g. with regard to selection criteria and operationalization) from all available European waste prevention programmes have been evaluated that also refer to Article 29 of the Waste Framework Directive. The programmes considered show a broad spectrum of indicators regarding their characteristics, number and feasibility. However, there is little clarity as to which of these indicators should be further investigated and implemented. In addition, some countries have core indicators that are prioritised for monitoring, while for other/possible indicators this is not the case. In addition to the European framework, waste prevention programmes of Australia, Canada, Chile, Israel, Japan, Mexico, New Zealand and Turkey have been evaluated. The number of indicators varies significantly between countries: Some countries define a list of four to ten core indicators, while other countries such as Mexico describe 125 different waste prevention indicators but monitor only three core indicators. The supplementary literature search resulted in a comprehensive list of more than 400 indicators.

After systematizing the indicators according to the DPSIR model described above, it became clear that there are practically no impact or state-related waste prevention indicators (Figure 2). This gap is due

to structural and methodological problems since the direct correlation between waste production and direct environmental impacts depends on so many spatial and temporal factors that it cannot be illustrated by means of national indicators.

Figure 2: Differentiating the identified waste prevention indicators according to DPSIR



Source: Own compilation

Based on the analysis of existing waste prevention indicators, a differentiation of indicators was made for the project, which refers to the DPSIR concept: This first group of indicators follows the question of whether Germany as a whole is making progress in the area of waste prevention. Many of these indicators are based on individual waste streams. A second group of indicators refers to the responses, i.e. concrete measures identified within the framework of the WPP, which in practice often make a very limited spatial contribution to the prevention of waste. This approach addresses the fundamental problem of assessing waste prevention measures, which is that the development of individual waste streams cannot be attributed seriously to concrete waste prevention measures. However, the approach adopted here attempted to map both aspects in a consistent set of indicators.

For the RACER evaluation described above, the list of indicators was adjusted to 90 waste prevention indicators (Annex I). Based on this work, eight sets of indicators have been developed for the main objective, operational targets and sub-targets of the German WPP, which are shown in Table 1 below. In each case, the first and second best indicator for the respective target is named, the feedback from the RACER evaluation is shown and the availability of the data necessary for recording the indicator is described.

Table 1: Indicator sets for the main objective, operational targets and sub-targets of the German Waste Prevention Programme

First Best	Second Best	Feedback RACER	Data availability
Main objective: Decoupling economic growth from waste generation related effects on human and environment **Indicator 1 – Lead indicator:** Waste intensity of net waste volume without construction sector			
Total of the effects on the environment and human health caused by the amount of waste generated in Germany. Problem: Concrete impacts cannot be measured systematically, waste generation also strongly influenced by economic development.	Waste intensity of net waste volume without construction and demolition waste (ratio of waste generated to GDP adjusted for inflation minus GDP in the construction sector)	Since the volume of municipal waste is surveyed – positive assessments, but dependent on individual "dominant" waste streams, especially construction waste	National accounts data on price-adjusted GDP; data by Destatis on net waste generation and construction & demolition waste generation
Operative target: Reduce quantity of waste **Indicator 2:** Construction and demolition waste			
Material input per square metre of new building area	Total volume of construction and demolition waste (hazardous and non-hazardous) relative to gross value added in the construction sector, adjusted for price adjustments	High acceptance, e.g. used by OECD; relevant waste stream; good data availability; would in principle require differentiation between construction and demolition; problem of the time gap	Waste generation by Destatis; gross value added by Statista
Operative target: Reduce quantity of waste **Indicator 3:** Food waste			
Amount of avoidable food waste: Problem definition – especially with regard to points of accumulation and "avoidable".	Per-capita production of food waste according to EU methodology	Extremely relevant waste stream; in particular high environmental relevance; main problem data availability, see e.g. study by Kranert et al. 2012; alternative recording of organic waste bin, but so far no sufficient use to generate reliable data	Not given yet; but has to be recorded soon

First Best	Second Best	Feedback RACER	Data availability
Operative target: Reduce quantity of waste **Indicator 4:** Sectorial waste intensities of the manufacturing sector			
Specific sectorial waste intensities, including their environmental impact	Total waste generated by the manufacturing sector in relation to price-adjusted gross value added for the Manufacturing Sector	Relevant waste stream; manufacturing sector in the focus of the waste prevention debate; established indicator with restrictions on data availability; high dependence on economic development	Waste generation by Destatis; gross value added by Statista
Operative target: Reduce quantity of waste **Indicator 5:** Resource efficiency			
Total use of natural resources along the entire value chain	Total raw material productivity per capita	Input as a relevant variable for waste prevention	Is recorded within the framework of ProgRess II as one of the leading indicators at the national economic level.
Operative target: Reduce hazardous substances in materials and products / substitution of materials hazardous to health and environment **Indicator 6:** Total quantity of hazardous waste			
Total amount of hazardous substances used in production processes and products; overall effects on the environment and human health	Total quantity of hazardous waste according to Circular Economy Act	Relevant waste stream; volume accepted as an indicator for qualitative waste prevention; easy to communicate; good data availability (at least for the total quantity of hazardous waste); problem of robustness, since significant quantity changes can result from re-declarations.	Waste balance by Destatis
Sub-target: Increased product life **Indicator 7:** Increase product use phase			
Average technical useful life of all products placed on the market, weighted with specific environmental impacts.	Initial useful life of selected lead products with focus on electrical and electronic equipment according to Prakash et al. 2016		Fee-based data from the Gesellschaft für Konsumforschung (GfK), analysis in municipal collecting points/recycling facilities, Internet-based consumer survey conducted by the University of Bonn, lifetime test Stiftung Warentest, LCA studies,

First Best	Second Best	Feedback RACER	Data availability
			evaluation www.ifixit.com, expert surveys.
Sub-target: Improving the level of information on waste prevention **Indicator 8:** Improving the level of information			
Share of the population that considers the issue of waste prevention as very important, also against the background of high recycling rates.	–		Refer to the study on "Environmental Awareness in Germany", which is regularly carried out by BMUB/UBA, by supplementing the relevant questions.

Source: Own compilation

At the level of the measures in the German WPP, 12 indicators are proposed. It is currently not possible to propose meaningful indicators for all measure areas. Table 2 shows the recommended indicators for the measure area addressed in each case.

Table 2: Indicators for WPP measures

Area of measures	Proposed indicators
General (horizontal) measures	► Number of federal states that have carried out communication measures (campaign, provision of information, events for the public) in general to avoid waste (period-related) ► Number of federal states that have generally implemented other own activities (working group, events, implementation/awarding of expert opinions) for waste prevention (period-related) ► Number of public authorities who have participated in or initiated actions within the framework of the European Week for Waste Reduction (EWWR)
Waste prevention at operating industrial plants	► Number of branches/sectors for which current (i.e. not older than five years) sub-statutory implementation and handling aids are available on the state of the art for specifying the operator's obligations to avoid waste (as MVV, VDI guideline, ATV/DVM bulletin, etc.)
Waste prevention measures in businesses	► Number of federal states that support waste prevention activities in companies (e.g. information campaign, information or advisory services, exchange of experience) (period-related) ► number of companies that have implemented an environmental management system (EMAS, eco-profit, QuB, ISO 14001 certification)
Re-use of products	► Number of federal states which carry out their own activities in the field of re-use (e.g. information campaign, provision of information for citizens, exchange of information between actors, stocktaking, expert opinions, potential analyses, pilot projects) (period-related)

Area of measures	Proposed indicators
	► Mass and proportion of the mass of waste electrical and electronic equipment which is fed into preparation for reuse
Repair	► Number of federal states which carry out their own repair activities (e.g. information campaign, provision of information for citizens, exchange of information between actors, stocktaking, expert opinions, potential analyses, pilot projects) (period-related)
Product design to eliminate waste	► The number or percentage of eco-design implementing measures setting out eco-design requirements for waste prevention
Prevention of food waste	► Number of federal states that have carried out their own activities for the avoidance of food waste (e.g. information campaign, events, publication of recommendations, establishment of a working group, research project) (period-related)
Public procurement	► Number of federal states that have guidelines for public procurement in which the aspect of waste prevention is explicitly addressed

Source: Own compilation

1 Introduction

1.1 Background and objectives

The waste hierarchy of the amended European Waste Framework Directive (WFD 2008/98/EC) reaffirmed waste prevention as the top priority of waste management and for the development of waste management infrastructure. The introduction of an additional stage also particularly bolstered the preparation for re-use.

In order to support the member states in their efforts to prevent waste, Article 29 WFD provides for the development of national waste prevention programmes in which both existing measures as well as future fields of action for waste prevention are to be described. In 2013, the federal government adopted a national waste prevention programme with the participation of the federal states. The programme recommends implementing various measures "after review of the respective costs and benefits by the respective stakeholder"[2].

In contrast to other EU Member States, Germany is pursuing a conceptual approach that has so far refrained from setting quantified targets (among other things with a view to the existing uncertainties regarding causal relationships between waste volume development and waste prevention measures) and instead relies on a strategic dialogue with stakeholders and actors. This approach was adopted to both motivate stakeholders to take own responsibility for examining and implementing waste prevention measures and to enable them to specifically address waste prevention potentials and their barriers during implementation.

However, the European WFD requires Member States to identify appropriate benchmarks for waste prevention measures and provides for the possibility to identify concrete quantitative or qualitative indicators.[3] At the same time, Article 30 WFD mandates the European Environment Agency to report on the waste prevention efforts of Member States in annual progress reports. With regard to Germany, the chosen conceptual approach which, as outlined above, aims instead at broad, decentralised implementation of waste prevention measures is particularly concerned with presenting the state of implementation of the national waste prevention programme in a "measurable" and thus assessable way.

The requirements of the European WFD were similarly incorporated into the Circular Economy Act.[4] With reference to the Waste Prevention Programme (WPP) of the federal and state governments, the Circular Economy Act thus stipulates that appropriate standards for defined waste prevention measures must be specified in order to record the progress made in decoupling economic growth from waste generation related effects on human and environment. However, identifying concrete quantitative or qualitative indicators poses a particular challenge in view of the complexity and variety of concrete waste prevention measures, the affected waste streams and the groups of stakeholders involved at various levels (federal, state and municipal authorities). In addition, the decline in volumes of individual waste streams cannot directly be attributed to the effects of waste prevention measures due to

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2 BMU (2013): Abfallvermeidungsprogramm des Bundes unter Beteiligung der Länder (Waste prevention programme of the federal government with the participation of the federal states). Bonn; p. 28.

3 Article 29(3) WFD: "Member States shall determine appropriate specific qualitative or quantitative benchmarks for waste prevention measures adopted in order to monitor and assess the progress of the measures and may determine specific qualitative or quantitative targets and indicators, other than those referred to in paragraph 4, for the same purpose."

4 Section 33 (3) No. 4 KrWG: "The waste prevention programme shall set appropriate, specific, qualitative or quantitative benchmarks for established waste prevention measures, against which progress achieved in the measures shall be monitored and evaluated; indicators or other appropriate specific qualitative or quantitative targets may be used as benchmarks."

structural and economic developments. The WPP already identifies a number of possible indicators for individual measures, sectors or material flows. However, there are considerable knowledge gaps to which extent these indicators can represent waste generation or effects of waste prevention measures. Against this background, the aim of this project was to analyse possible evaluation criteria to measure waste prevention success in depth and to test the suitability of the criteria for assessing the success of the measures established in the WPP. Based on the test result, a suitable set of indicators had to be developed to enable continuous measurement of the success of waste prevention measures.

The starting point of the project was the objectives mentioned in the WPP (BMU 2013):

> "The main objective of waste prevention is to decouple economic growth from the human and environmental impacts associated with waste generation.
>
> This main objective is supported by operative targets. However, these targets are relevant only if they actually contribute to achieving the main objective in any specific case. The operative targets take effect at a stage before a substance, material or product has become waste and are geared toward:
>
> - **'Reducing waste volume'**
> - **'Reducing hazardous effects of waste'**
> - **'Reducing hazardous substances in materials and products' through to the substitution of substances hazardous to health and environment**
>
> In order to achieve these operative targets, various sub-targets can be derived such as:
>
> - Maximum reduction of waste volume relative to economic output, number of employees and population;
> - Improving the level of information and thus sensitising the population and the stakeholders involved from industry, trade, commerce and waste management to the necessity to reduce waste volume or hazardous substances in materials, products and waste as well as emissions in the air, water and soil associated with the generation and management of waste;
> - plant internal recycling of materials;
> - Promoting consumer behaviour aimed at purchasing products low in waste and hazardous substances;
> - Low-waste product design;
> - Increased product use phase;
> - Promoting re-use of products;
> - Increasing the intensity of use of products."[5]

1.2 Methodology

In order to analyse whether the pursued targets are achieved through the WPP and to map them using suitable indicators, the project was divided into five content-based work packages:

- An analysis of existing indicator systems was performed in the first work package. Each of the indicators was systematically classified and examined and a suitable set of indicators for the main objective, operative targets and sub-targets of the WPP was derived.
- Subsequently in the second work package, the measures of the WPP were assigned to concrete sub-targets and suitable indicators of success were developed. Additionally, the measurability

[5] BMU (2013); p. 20.

and immeasurability of what had been contributed to the objectives of the various waste prevention measures was examined and justified.

- In the third work package, decomposition analyses were performed to identify relevant drivers of the different waste streams and to demonstrate their effects. Reference scenarios were also developed.
- Based on the previous work, the fourth work package included developing a data collection concept to confirm the success indicators and the evaluation of the survey effort.
- Finally, the need for action for individual waste prevention targets was reflected and the set of indicators was finalised.

1.3 Structure of the report

After the background, objectives and methodology of the project, the results of the analysis of existing waste prevention indicators from European and international waste prevention programmes as well as the literature are outlined in Chapter 2. Chapter 3 clarifies the set of indicators developed for the main objective, the operative targets and the sub-targets of the WPP and Chapter 4 describes the indicators for the waste prevention measures. The results of the decomposition analyses and the reference scenarios are depicted in Chapter 5. Finally, proposals to further develop the WPP are presented in Chapter 6. Annex I contains the 90 waste prevention indicators selected for the RACER evaluation.

2 Survey of existing waste prevention indicators

A first step in the project was to carry out a comprehensive inventory of possible indicators with regard to the main objective of the WPP and the operative targets derived from it. Based on a comprehensive literature search and, most notably, an analysis of EU and international waste prevention programmes, an initial list of possible indicators was drawn up to reflect all currently used waste prevention indicators as comprehensively as possible. More than 400 indicators were identified in total, whereby it should be noted that a more comprehensive understanding of waste prevention can be observed, particularly in the case of some examples outside of Europe, than that underlying the WFD and the KrWG.

The analysis of existing waste prevention indicators also focused on overlapping content regarding resource efficiency, partly because the WPP of the federal government and federal states also highlights this connection: "Resource efficiency policy is intended to help us assume our global responsibility for the ecological and social impacts of the use of resources. The aim must be to reduce the utilisation of raw materials. The waste prevention programme fits into this framework and pursues compatible objectives (...)."[6] Simultaneously, the federal government's resource efficiency programme (ProgRess) also refers to waste prevention as an essential component of an effective resource efficiency policy.[7]

2.1 Preliminary results from the analysis of waste prevention programmes in EU Member States

According to Article 29 of the EU Directive, all EU Member States are obliged to develop national waste prevention programmes and have the opportunity to determine appropriate waste prevention indicators or benchmarks.

For the purpose of this research project, approaches to indicator formation (e.g. with regard to selection criteria and operationalisation) from all available waste prevention programmes were evaluated that also refer to Article 29 of the WFD. Although most of these programmes are only available in the corresponding national language, it was possible to use both the evaluations of the EEA's first progress report and the abstracts of the various programmes written in English that had been fine-tuned and agreed on with the national contact points. Evaluations are now available for 27 programmes which have been examined for possible indicators (Table 3).

6 BMU (2013); p. 28.

7 See BMUB (2016): Deutsches Ressourceneffizienzprogramm II: Programm zur nachhaltigen Nutzung und zum Schutz der natürlichen Ressourcen (German Resource Efficiency Programme II: Programme for the sustainable use and protection of natural resources). Berlin.

Table 3: Overview of the 27 countries and regions whose waste prevention programmes have been analysed

Country / Region				
Austria	Flanders*	Lithuania	Portugal	Austria
Brussels*	France	Luxembourg	Scotland*	Brussels*
Bulgaria	Germany	Malta	Slovakia	Bulgaria
Czech Republic	Hungary	The Netherlands	Spain	Czech Republic
England*	Ireland	Northern Ireland*	Sweden	England*
Estonia	Italy	Norway	Wales*	Estonia

*Refers to individual regions

Source: Own compilation

The programmes considered show a wide range of indicators in terms of their characteristics, number and feasibility, but there is little clarity as to which of these indicators should be further investigated and implemented. Additionally, some countries have their own core indicators prioritised for monitoring, while other/possible indicators are not. For example, Austria describes a set of core indicators and supplementary indicators. The core indicators should be established on a regular basis (annually if possible), whereas the supplementary indicators should only be updated once by 2017. The first update of the Austrian WPP was completed in December 2017.[8]

2.2 Preliminary results from the analysis of further international waste prevention programmes

Waste prevention programmes were also evaluated in countries outside of the European framework. The preliminary results of a study carried out by the Wuppertal Institute for the OECD could be used for this purpose. The information on waste prevention policies presented in this report is mainly based on responses to a survey developed in close cooperation with the OECD and sent to all OECD countries in February 2015.[9] The survey was divided into three parts:

- the policy framework for waste prevention
- specific waste prevention measures
- existing information on the effects of these measures.

The survey contained a total of 18 questions, including aspects related to waste prevention indicators and targets. 22 countries and two regions collected existing information, predominantly from different departments and ministries, and answered the questions so that they could then be analysed. Eight of these countries were non-EU countries, which could be evaluated additionally:

- Australia
- Canada
- Chile
- Israel

8 Ministry of Sustainability and Tourism, Austria (2017): Waste prevention programme 2017, Vienna.

9 Wilts (2017): Waste Prevention: A survey of policies and programmes across the OECD. ENV/EPOC/WPRPW(2015)13/FINAL. OECD. Paris.

- Japan
- Mexico
- New Zealand
- Turkey

The number of indicators varies significantly between these countries as well: Some countries have defined a list of four to ten core indicators, while other countries such as Mexico describe 125 different waste prevention indicators but monitor only three core indicators.

2.3 Preliminary results of the literature search

In a third step, a literature search was carried out to include existing information and expertise on the creation and use of waste prevention indicators. The reports and individual publications evaluated include but are not limited to:

- Bakas, I.; Bøe, E.; Kirkeby, J.; Jørgensen Kjær, B.; Ohls, A.-K.; Sidenmark, J.; Mandrup, M. U. (2011): Assessment of initiatives to prevent waste from building and construction sectors. Nordic Council of Ministers, Copenhagen.
- BioIntelligence Service; Copenhagen Resource Institute; Regional Environmental Center (2011): Preparing a waste prevention programme. Study on behalf of the European Commission, DG Environment, Brussels.
- Cox, J., Giorgi, S., Strange, K., Wilson, DC., Blakey, N. (2010): Household waste prevention – a review of evidence. In: Waste Management and Research (Vol. 23, No.3), pp. 193-219.
- Dehoust, G.; Bringezu, S.; Wilts, H. (2010): Development of scientific and technical foundations for a national waste prevention program. On behalf of the Federal Environment Agency (UBA-Texte 60/2010). Dessau-Roßlau.
- Dehoust, G.; Jepsen, D.; Knappe, F.; Wilts, H. (2013): Inhaltliche Umsetzung von Art. 29 der Richtlinie 2008/98/EG: Wissenschaftlich-technische Grundlagen für ein bundesweites Abfallvermeidungsprogramm (Implementation of Art. 29 of Directive 2008/98/EC: Scientific and technical basis for a nationwide waste prevention programme). On behalf of the Federal Environment Agency (UBA Texte 38/2013). Dessau-Roßlau.
- EEA (2011): Selected Waste Prevention Indicators – A compilation of proposals, EEA workshop on green economy, October 2011, Copenhagen.
- European Commission (2011): Analysis associated with the Roadmap to a Resource Efficient Europe Part II (SEC(2011) 1067 final), Brussels.
- European Commission, DG ENV (2009): Preparation of guidelines on waste prevention programmes according to the revised Waste Framework Directive, including best practices. Final report to the Commission.
- European Commission, DG ENV (2010): Analysis of the evolution of waste reduction and the scope of waste prevention.
- European Commission, DG ENV (2011): Evolution of (bio-) waste generation/prevention and (bio-) waste prevention indicators.
- OECD (2004): Towards waste prevention performance indicators.
- Pre-Waste (2010): Component 4: Build up of shared indicators and web tool–State of the art of waste prevention monitoring.
- Watson, D.; Milios, L.; Bakas, I.; Herczeg, M.; Kjær, B.; Tojo, N. (2013): Proposals for targets and indicators for waste prevention in four waste streams. Report for the Nordic Council of Ministers, Copenhagen.
- Wilts, H. and Rademacher, B. (2014): Potentials and Evaluation of Preventive Measures: A Case Study for Germany. In: International Journal of Waste Resources, 4 (2014).

- Wilts, H.; Dehoust, G.; Jepsen, D.; Knappe, F. (2013): Eco-innovations for waste prevention — Best practices, drivers and barriers. In: Science of The Total Environment, Vol. 461–462, pp. 823–829.

Based on this overall list of over 400 indicators, the next step was to remove duplicates, obvious references to recycling instead of waste prevention and country-specific regulations without transferability to Germany from the list. A resulting list of 90 waste prevention indicators (Annex I) was taken as a first starting point to develop a set of indicators. For the selection of indicators to be subjected to a RACER analysis, this list was reduced to 25 topics, i.e. different operationalisation approaches were combined, e.g. waste generated per capita, per unit of GDP or per household.

2.4 Systematisation of the indicators according to the DPSIR impact model

The identified indicators were further systematised using the DPSIR impact model. The European Environment Agency (EEA) uses the DPSIR concept as an approach for an integrated environmental assessment. The system analytical perspective focuses on the interactions between the environment and socio-economic activities. In a chain of causal links, it distinguishes between driving forces (economic sectors; human actions), pressures (environmental stresses), states (state of soil, water, air; changes in physical, biological or chemical processes), impacts (influence on ecosystems or human health) and responses (socio-political reactions). This allows indicators to be structured in terms of ecological quality and the resulting influence of policy decisions (see Figure 3). The aim is to clearly differentiate waste prevention indicators according to their different approaches, distinguishing between driving forces, environmental impacts caused by them and their specific impacts, the state of individual environmental media and concrete measures aimed at preventing waste.

Figure 3: DPSIR concept as a method for environmental assessment

Source: Own compilation according to Kristensen (2004)

This reveals that social and economic developments exert pressure on the environment, resulting in changes in the environment. This leads to impacts on humans and the environment, which cause social feedback and in turn directly (active action) and indirectly (adaptation) affect drivers, pressures, states and impacts. Although this analytical framework cannot express the complex interactions in real

human-environment systems, a clear and specific definition of the individual factors is needed to describe the relationship between the causes and consequences of environmental problems. These will be examined in more detail below.

Driving Forces

In the DPSIR concept, driving forces are fundamental human, i.e. social, ecological and economic needs such as food, water, protection or mobility, culture and entertainment. These are reflected in social, demographic and economic developments and, accordingly, reflect changes in lifestyles, consumption and patterns of production. The following are some of the driving forces exerting pressure on the environment as a result of this change in production and consumption:

- Population (number, demographics, growth)
- Transport (persons, goods; transport routes and means of transport)
- Energy consumption (fuel types, technology)
- Industry (type, number, age, resources)
- Agriculture (number of animals, types of crops, fertilisers)
- Disposal (landfills, sewage systems)
- Land use.

Pressures

Environmental stresses are caused by human activities resulting from production and consumption processes. These can be divided into three categories: (a) excessive use of natural resources, (b) changes in land use, (c) emissions.

State

Stresses also affect the state of the environment, i.e. the quality of the various environmental fields such as air, water and soil is changed. The quality is a result of the physical, biological and chemical condition of the respective medium.

Impacts

Changes in the state of the environment determine not only the quality of ecosystems, but also human well-being. The ecological state therefore influences the functions of the environment that are central to human beings and, accordingly, health and the economic and social performance of society.

Responses

Undesired effects of environmental stresses trigger responses in society and politics to prevent, offset or adapt to further consequences. Measures may pertain to drivers and pressures as well as to states and impacts:

- number of concrete measures (promoting public transport)
- number of laws passed (CO2 regulations)
- increased efficiency of products and processes
- increased environmental awareness (recycling rates).

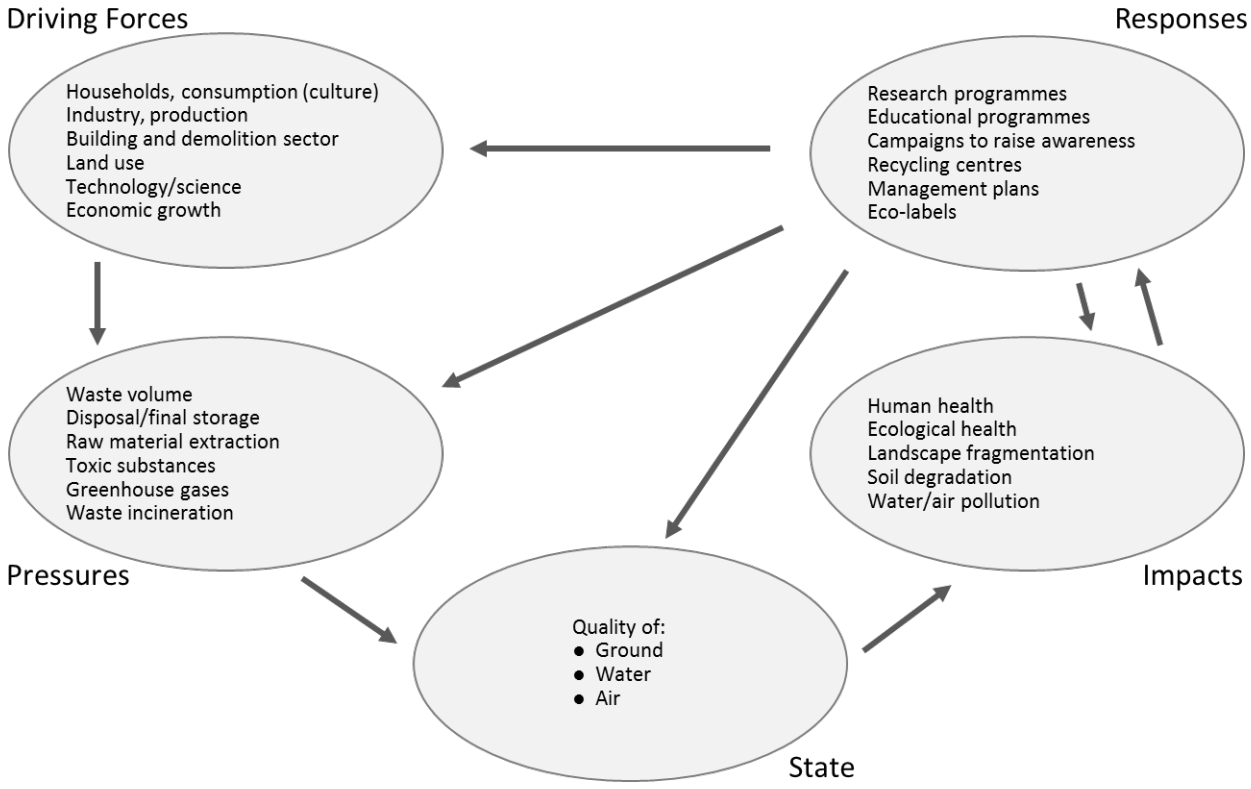
The DPSIR concept can serve as a tool for a descriptive analysis of the relationship between causes and consequences, focusing on the individual economic, social and environmental elements. However, in order to investigate the dynamic interactions, it is imperative to consider the connections between the DPSIR elements. The relationship between drivers and pressures is expressed by eco-efficiency indicators such as waste intensity or emission factors. Increased eco-efficiency means that economic activities can be developed "without an equivalent increase in pressure on the environment"[10].

[10] Gabrielsen and Bosch (2003): Environmental Indicators: Typology and Use in Reporting, Copenhagen; p. 9.

The dynamic between pressures and states is characterised by paths and dispersion models. These indicator relationships reflect the time delay of natural processes ("time bombs", e.g. in the form of landfilled hazardous waste). If the corresponding patterns are known, we can model current and future changes in the state of the environment and its influences. Similar dose-response relationships can also be seen in the interaction between state and impact. These can be used, for example, to predict and quantify health effects or to apply suitable indicators as early-warning systems. Whether society responds to ecological or health consequences depends on how they are perceived and evaluated. Central to this is a risk assessment and a cost-benefit analysis of the planned measures.

The results or the success of social responses depend on the effectiveness, i.e. the relationship between strategies and objectives: "policy-effectiveness indicators generally summarise the relations between the response and targets for expected change in driving forces or pressures and sometimes in responses, state or even impacts".[11] The following figure illustrates these relationships using the example of waste generation and prevention.

Figure 4: DPSIR with waste reference

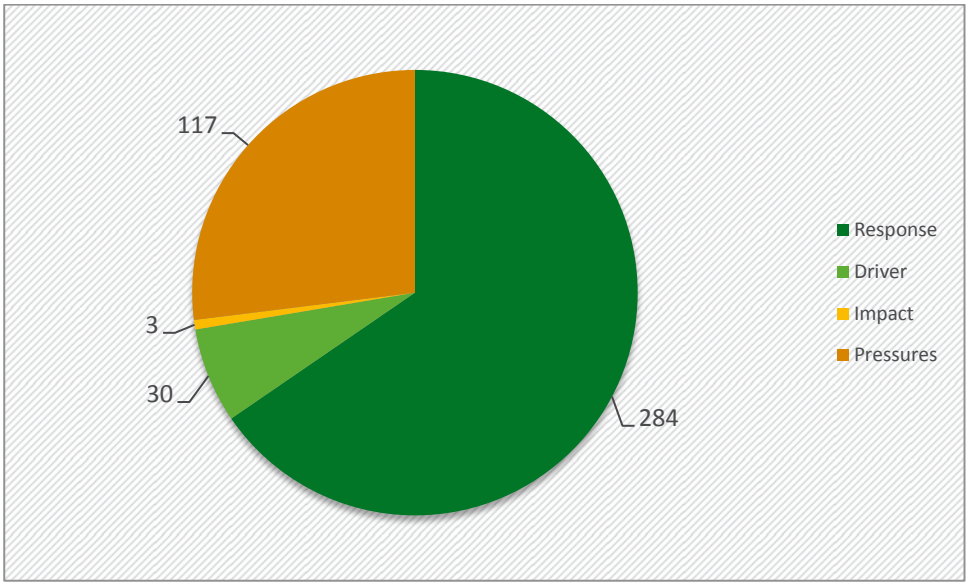


Source: Own compilation according to Kristensen (2004)

A clear result of this differentiation step is that there are virtually no impact or state-related waste prevention indicators, as shown in Figure 5. This gap is due to structural methodological problems, as the direct relationship between waste generation and direct environmental impacts depends on so many spatial and temporal factors that it cannot be mapped using national indicators.

[11] Gabrielsen and Bosch (2003): Environmental Indicators: Typology and Use in Reporting, Copenhagen; p. 9.

Figure 5: Differentiation of the overall identified waste prevention indicators according to DPSIR



Source: Own compilation

Based on the analysis of the existing waste prevention indicators, a differentiation of indicators was developed for the project, which refers to the DPSIR concept described above: This first group of indicators follows the question of whether Germany as a whole is making progress in the field of waste prevention; many of these indicators start with individual waste streams. A second group of indicators pertains to the responses, i.e. concrete measures identified within the framework of the WPP, which in practice often make a very limited contribution to waste prevention. This approach addresses the fundamental problem of measuring waste prevention measures that the development of individual waste streams cannot be seriously traced back to concrete waste prevention measures. However, the approach chosen here is intended to attempt to map both aspects in a consistent set of indicators.

The discussion of individual topics, however, also shows that in some areas the database is simply not sufficient to form robust and credible indicators. First and second best indicators were therefore developed, which in the first case require a complete database, in the second case develop a pragmatic approach in view of limited data availability and, wherever appropriate, attempt to link to other indicator sets in the process.

3 Indicators for main objective, operative targets and sub-targets of the waste prevention programme

The indicator proposals developed for the main objective, the operative targets and the sub-targets of the WPP are presented below. Wherever possible, first and second best indicators were identified for each indicator. Table 4 illustrates the addressed objectives of the WPP.

Table 4: Overview of the addressed objectives of the waste prevention programme

Type of objective	Objectives
1. Main objective	► Decoupling economic growth from waste generation related effects on human and environment
2. Operative targets	► Reducing quantity of waste ► Reducing hazardous substances in materials and products up to and including substitution of materials hazardous to the environment and health
3. Sub-targets	► Increasing the product use phase ► Improving the level of information and thereby raising the awareness of the population and the actors involved from industry, trade, commerce and waste management about the need to reduce waste quantities or the amount of hazardous substances in materials, products and waste as well as emissions in air, water and soil in connection with the generation and management of waste

Source: Own compilation according to BMU 2003.

Furthermore, the results of the RACER expert survey are presented briefly for each indicator, as the RACER methodology has proven to be a valuable approach to systematically highlighting the challenges in developing indicators for the individual topic areas. The European Commission's RACER methodology from the Impact Assessment Guidelines[12] was used to assess the suitability of the indicators identified for the main objective and operative targets of the WPP. According to this, all indicators should be "RACER" when possible:

- (politically) relevant, i.e. closely linked to the main objective or operative targets and therefore appropriate and meaningful in terms of progress or existing gaps between the current and target states with regard to (ideally any of) the objective levels;
- acceptable by various stakeholders, in particular by
  - politics (as indicator users and essential target group of indicator reports),
  - statistical institutions (to calculate and report on indicators),
  - science (to (further) develop indicators),
  - business and civil society (as policy addressees and data providers);
- credible for non-experts, as well as clear, unambiguous and easy to interpret
- easy to observe and monitor (e.g. data collection should be associated with reasonable costs and the required data should be available), and also easy to communicate

[12] European Commission (2009): Part III: Annexes to the Impact Assessment Guidelines. See also European Commission (2005): Impact Assessment Guidelines. SEC2005 (791/3), with March 2006 update.

- ► robust against manipulations and errors (based on robust theoretical principles, avoiding double counting, free of inconsistencies in the units of measurement) as well as robust in the quality of the database.[13]

In order to operationalise the RACER methodology, the five criteria were each further differentiated. An overview of the differentiated RACER matrix is presented below based on studies on resource efficiency and material input indicators[14].

Differentiation of the RACER evaluation procedure

Relevant

Linked to policy objectives • Suitable for progress measurement • Identification of trends • Rebound effect covered

Accepted

Politics • Statistics • Science • Economy • Civil society

Credible

Clear • Transparent

Easy

Data availability • Technical feasibility• Communicability

Robust

Data quality • Reproducibility • Compatibility with official statistical and accounting standards

[13] Supplements based on Best et al. (2008): Potential of the Ecological Footprint for monitoring environmental impacts from natural resource use: Analysis of the potential of the Ecological Footprint and related assessment tools for use in the EU's Thematic Strategy on the Sustainable Use of Natural Resources. Report to the European Commission, DG Environment; and European Commission, DG ENV (2012): Consultation Paper: Options for Resource Efficiency Indicators; and Giljum. et al. (2011): A comprehensive set of resource use indicators from the micro to the macro level, Resources, Conservation and Recycling 55 (3): 300–308.

[14] Bio Intelligence Service; Institute for Social Ecology; Sustainable Europe Research Institute (2012): Assessment of resource efficiency indicators and targets. Final report prepared for the European Commission, DG Environment, Environment, D. G., Brussels; Giljum et al. (2011); Eisenmenger et al. (2014): D4.2 final report on indicator framework. FP7 DESIRE - Development of a System of Indicators for a Resource efficient Europe; Wiedmann (2009): A review of recent multi-region input–output models used for consumption-based emission and resource accounting, Ecological Economics 69 (2), 211–222.

3.1 Main objective

3.1.1 Decoupling economic growth from waste generation related effects on human and environment

Indicator 1 – lead indicator: Waste intensity of net waste volume without construction sector

It is proposed to form a lead indicator for the main objective of the WPP, which in a highly aggregated form can reflect directional progress towards waste prevention. The proposed ratio is between waste production to price-adjusted GDP without construction and demolition waste or GDP[15] in the construction sector, which would otherwise dominate the course of this indicator. This approach would be compatible with the waste intensity indicator as used by the European Environment Agency in the State of the Environment Report[16].

Reference to the objectives of the waste prevention programme:

Decoupling economic growth from waste generation related effects on human and environment

Table 5: Indicator 1 – lead indicator: Waste intensity of net waste volume without construction sector

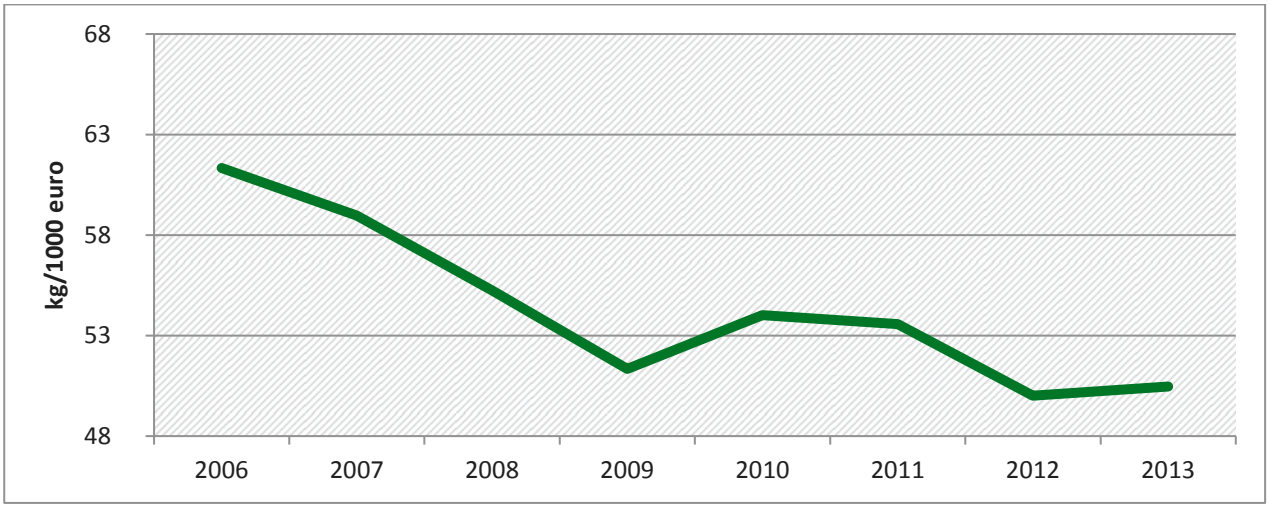
First Best	Second Best	RACER Feedback	Data Availability
Total of the effects on the environment and human health caused by the amount of waste generated in Germany. Problem: Concrete impacts cannot be measured systematically, waste volume also strongly dependent on economic development	Waste intensity of net waste volume without construction and demolition waste (ratio of waste generated to GDP adjusted for inflation minus GDP in the construction sector)	Since the volume of municipal waste is surveyed – positive assessments, but dependent on individual "dominant" waste streams, especially construction waste	National accounts data on price-adjusted GDP; data by Destatis on net waste generation and construction & demolition waste generation

Source: Own compilation

15 With regard to the discussion of a "green GDP", the gross domestic product is definitely not an ideal parameter, since it does not reflect ecological costs such as environmental stresses or resource scarcity (see e.g. van den Bergh and Antal, 2014); established alternatives are however not yet available.

16 EEA (2015a): The European Environment. State and Outlook 2015. Copenhagen.

Figure 6: Development of waste intensity of net waste volume without construction and demolition waste and GDP in the construction sector



Source: Own compilation based on Destatis (2017a).

Various actors confirmed the usefulness of this lead indicator during the project; however, the federal states gave the important information that it could only be presented at the federal level, not at the level of the federal states. Bornträger pointed out in her presentation at the 5th conference on federal state environmental economic accounts that it has not been possible for some time to determine the net amount of waste required for the calculation of this indicator without construction and demolition waste at the level of the federal states: "There are waste balances for all federal states, but the waste balances for municipal waste and the waste that must be proven correctly disposed of only exist at the federal level. The state waste balances therefore do not include the federal state's entire waste generation, it lacks the waste from mineral extraction and treatment, construction and demolition waste as well as other waste."[17]

A plausible alternative at the federal state level would be to focus on the "volume of household and bulky waste"[18] parameter used for the Environmental Economic Accounting (Umweltökonomische Gesamtrechnung), especially since the other relevant parameters of commercial waste and other waste are covered by other indicators in this proposed set. However, the indicator should be established at the federal level as proposed in order to ensure comparability within Europe with the data collected by the EEA (except for all survey quality issues in different EU Member States).

Proposed targets

The German WPP does not contain any concrete objectives for Indicator 1 – "Lead Indicator: Waste intensity of net waste volume without construction sector", and instead refers only to a "maximum reduction of waste quantities in relation to economic output (...)". Possible targets have therefore been identified from national European waste prevention programmes, programmes from the European

17 Statistische Ämter der Länder (Hrsg.) (2016): Umweltökonomische Gesamtrechnungen der Länder (Statistical offices of the federal states (ed.) (2016): Environmental economic accounts of the federal states). Volume 3: Ressourceneffizienz und Kreislaufwirtschaft – den Kreis schließen (Resource efficiency and recycling management - closing the circle). Proceedings of the 5th Congress on the federal state environmental economic accounts on 21 June 2016 in Düsseldorf; p. 80.

18 Statistische Ämter der Länder (2012): Abgabe von Abfällen an die Natur (Statistical offices of the federal states (2012): Waste disposal in nature). In: Statistische Ämter der Länder (Hrsg.) (2012): Umweltökonomische Gesamtrechnungen der Länder – Methodenhandbuch (Statistical offices of the federal states (ed.) (2012): Environmental economic accounts of the federal states – Methodology manual) . Düsseldorf, pp. 53-58.

Commission and the United Nations Sustainable Development Goals. It is important to note the difficulty of developing quantitative targets due to inconsistent requirements.

The United Nations pursues achieving the resolution in the Sustainable Development Goals with the objective 12.5:

- "By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse."[19]

The following objective was drafted in the "Roadmap to a Resource Efficient Europe".

European Commission (2011)[20]:

- Milestone: By 2020, waste is managed as a resource. The per capita volume of waste is falling in absolute figures.

Examples of quantitative limit values and reduction targets from various European countries are presented in Table 6 and Table 7 to provide an overview of what quantitative targets could look like in Germany.

Such objectives may be formulated as follows:

- Reduce quantity of waste / municipal waste by a factor X or to the amount Y (per inhabitant) with GDP continuing to rise or GDP remaining constant

Table 6: Examples of quantitative limit values for waste generation

Country / Region	Quantitative target	Type of waste
Finland	Stabilisation at 2.3 – 2.5 million tonnes per year	Total waste generation
Netherlands	max. 73 megatonnes (2021)	Total waste generation
Estonia	Stabilisation as of 2020, maintain growth rate at less than half of GDP until then	Municipal and household waste
Flanders	max. 560 kg per inhabitant	Municipal and household waste
Latvia	max. 400 kg per inhabitant by 2020	Municipal and household waste
Latvia	max. 650,000 tonnes (total)	Municipal and household waste

Source: Own compilation

[19] Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (2018): Abfall als Thema der Agenda 2030 (Federal Ministry for Economic Cooperation and Development (2018): Waste as a topic of Agenda 2030).

[20] European Commission (2011): Roadmap to a Resource Efficient Europe, COM (2011) 571, Brussels.

Table 7: Examples of waste reduction targets

Country / Region	Reduction by	Type of waste
Portugal	at least 10 per cent by weight (December 2020), based on the audited value in 2012	Total waste generation
Wales	27 % by 2025	Total waste generation
Wales	65 % in 2050, compared to 2007	Total waste generation
Wales	1.2 % per year (18,869 tonnes)	Household waste
Brussels	10 kg per inhabitant per year	Household waste
Brussels	7 kg per inhabitant per year	Paper waste
Brussels	1 kg per inhabitant per year	Disposable nappies
Brussels	12 kg per inhabitant per year	Garden waste
France	7 % (or 10 %) per capita (2020)	Household and commercial waste

Source: Own compilation

Data collection concept

Data are available at the federal level for the indicator “Waste intensity of net waste volume without construction and demolition waste (ratio of waste production to GDP adjusted for inflation minus GDP in the construction sector)”, but are not available for the federal states. The data are collected by the statistical offices and Destatis and are publicly available. They are updated annually and presented in the form of numerical values. No qualitative information is provided. Data quality is reliable due to annual updates, variations due to changes in statistical collection methods are possible. Data collection expenditure is considered to be unproblematic.

Data sources:

- Statistical offices of the federal states (2012)
- Statistical offices of the federal states (2016)
- Destatis (2017a)

3.2 Operative targets

3.2.1 Reduce quantity of waste

With regard to the target "Reduce quantity of waste”, a set of indicators was developed that includes four indicators from construction and demolition waste, food waste, sectorial waste intensities and resource efficiency. This is intended to focus on individual “lead” waste streams based on their environmental and volume relevance as well as their potential for waste prevention.

Indicator 2 – Construction and demolition waste

The first indicator to be considered is the total volume of construction and demolition waste (hazardous and non-hazardous) relative to the price-adjusted gross value added in the construction sector. It would also be possible to consider the absolute quantities for this indicator, but this would primarily reflect the economic development of the construction sector.

Reference to the waste prevention programme:

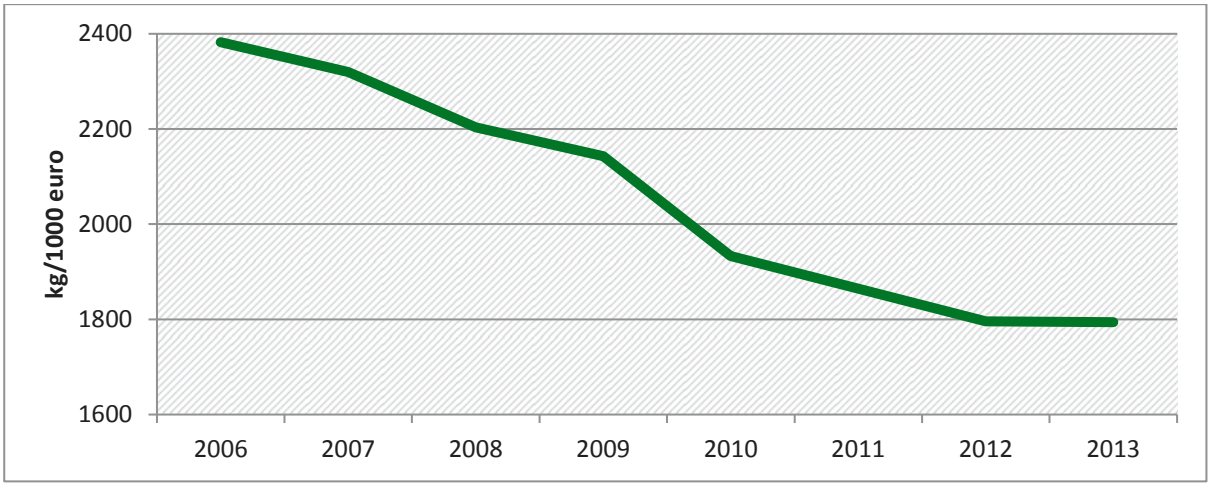
"The construction sector is of particular importance because of its large waste volumes and potential for waste prevention."[21]

Table 8: Indicator 2 – Construction and demolition waste

First Best	Second Best	RACER Feedback	Data Availability
Material input per square metre of new building area	Total volume of construction and demolition waste (hazardous and non-hazardous) as a percentage of gross value added in the construction sector, adjusted for price adjustments	High acceptance, e.g. used by OECD; relevant waste stream; good data availability; would in principle require differentiation between construction and demolition; problem of the time gap	Waste generation according to Destatis; gross value added according to Statista

Source: Own compilation

Figure 7: Development of the total volume of construction and demolition waste as a percentage of the price-adjusted gross value added in the construction sector



Source: Own compilation based on Destatis (2017a).

Similar to the lead indicator presented, this indicator could currently only be depicted at the federal level, since the volume of construction and demolition waste is not shown in the federal state waste

[21] BMU (2013); p. 67.

balances[22]. A possible alternative for this would be to fall back on the variable "Waste disposal in nature by type of waste and federal state" from the Environmental Economic Accounting and restrict it to "Construction and demolition waste including road construction". Both values are in a comparable range (2014: Volume 209.5 million tonnes; disposal in nature 162.9 million tonnes) – although the "volume" indicator would be preferable in view of the significance of the indicator.

Proposed targets

It is also the case for this indicator that the German WPP only provides the qualitative target of reducing waste quantities in relation to economic output, number of employees and population. Presented below are quantitative targets from three EU countries and one from the European Commission. These could be used as starting points for proposed targets for Germany:

- Finland: Use at least 70 % of all construction waste as material and energy in 2016
- Lithuania: By 2020: reduce quantity of waste from manufacturing, construction and other services and ensure that the amount of waste generated does not exceed the EU average
- Wales: Reduce construction and demolition waste by 1.4 % per year

Data collection concept

Data are available at the federal level for the indicator "Total volume of construction and demolition waste (hazardous and non-hazardous) relative to the price-adjusted gross value added in the construction sector", but they are not available for the federal states. The data are collected by the statistical offices and Destatis and are publicly available. They are updated annually and presented in the form of numerical values. No qualitative information is provided. Data quality is reliable due to annual updates, variations due to changes in statistical collection methods are possible. Data collection expenditure is considered to be unproblematic.

Data sources:

- Statistical offices of the federal states (2016)
- Destatis (2017a)

Indicator 3 – Food waste

Preventing food waste is of central importance from an environmental standpoint, therefore it is important to develop an indicator for this flow. However, the result from the European Commission should be anticipated and utilised for this indicator, as a uniform European indicator should be envisaged. In its reflections on indicators, the Commission built on the results of the FUSIONS project[23] completed in 2016. The FUSIONS manual, a guide to quantifying food waste, was developed based on the FUSIONS project. The Commission included these considerations in the sub-groups of the EU Platform on Food Losses and Food Waste.

During the project, all available waste prevention programmes according to Art. 29 WFD were evaluated regarding indicators on food waste as well as the documents currently under discussion within the framework of the EU Platform on Food Losses and Food Waste.

22 Statistical offices of the federal states (2016); p. 80.

23 EU Fusions (2016): EU Fusions Website, https://www.eu-fusions.org.

Reference to the waste prevention programme:

"The aim is to reduce food waste by looking at the entire value chain – not just consumer behaviour – in order to reduce waste."[24]

Table 9: Indicator 3 – Food waste

First Best	Second Best	RACER Feedback	Data Availability
Amount of avoidable food waste: Problem definition – especially with regard to points of accumulation and "avoidable"	Per-capita production of food waste according to EU methodology	Extremely relevant waste stream; in particular high environmental relevance; main problem data availability, see e.g. study by Kranert et al. 2012; alternative recording of organic waste bin, but so far no sufficient use to generate reliable data	Not given yet; but has to be recorded soon

Source: Own compilation

The aim of the project was not to develop a concrete indicator specifically for Germany, but to review the proposals currently being discussed at the EU level with regard to their transferability to Germany. To achieve this, the current state of the discussion at the EU level was presented and the experiences from a first attempt to apply the FUSIONS manual in Flanders were evaluated, among other things.

Proposed targets

By adopting the Sustainable Development Goals, the United Nations has set the goal of cutting per capita global food waste at the retail and consumer levels in half by 2030 and reducing food losses in the production and supply chain. The EU Action Plan for the Circular Economy[25] also outlines this goal and indicates that the EU and its Member States are committed to meeting this target. Austria has included this target in its WPP. Further reduction targets from waste prevention programmes of countries and regions of the European Union can be found in the following table.

[24] BMU (2013); p. 29.

[25] See European Commission (2015a): Closing the Loop – An EU Action Plan for the Circular Economy Action Plan, COM (2015) 614 final, Brussels.

Table 10: Quantitative reduction targets for food waste

Country / Region	Quantitative target
Brussels	6 kg per employee per year 3 kg per pupil per year 5 kg per person per year in households
England	5 % by 2015 in households
Flanders	15 % by 2020 30 % by 2025
Netherlands	20 % from 2009 to 2015

Source: Own compilation

Data collection concept

So far, no specifications and data are available for the indicator "Amount of food waste according to EU methodology per capita". A methodology for collecting data on food waste is currently being developed by the European Commission in collaboration with the members of the EU Platform on Food Losses and Food Waste. This would allow for consistent and comparable quantified figures at the EU level. According to the tentative schedule, the first reporting period is expected to begin in January 2020.
Data on food waste in Germany are not yet collected comprehensively but are instead only collected sporadically based on certain projects. Even in these cases, the database is often unreliable since calculations are often based on estimates due to a lack of data. A comprehensive process with various sectorial working groups and industry participation was conducted to monitor food waste in Flanders, where the FUSIONS manual has already been adopted in a pilot project. To create a comprehensive database in Germany that can be modelled after Flanders' approach, significant coordination and survey efforts will be necessary at the beginning of the quantification process.

The quality of the data will depend heavily on the definition of "food waste" used in the collection process. Some of the data to be collected will be characterised as confidential. The frequency of updates remains to be clarified. Data collection expenditure is considered to be difficult overall.

Pilot experiment for monitoring food waste in Flanders:

- Flemish Food Supply Chain Platform for Food Loss (2017)

Indicator 4 – Sectorial waste intensities of the manufacturing sector

The sectorial waste intensities of the manufacturing sector address another relevant waste stream. Decoupling this parameter from economic growth is again a primary objective. The structural change of the German economy will also have to be taken into account to analyse the indicator over time.

Reference to the waste prevention programme:

"Maximum reduction of waste volume relative to economic output, number of employees and population"[26]

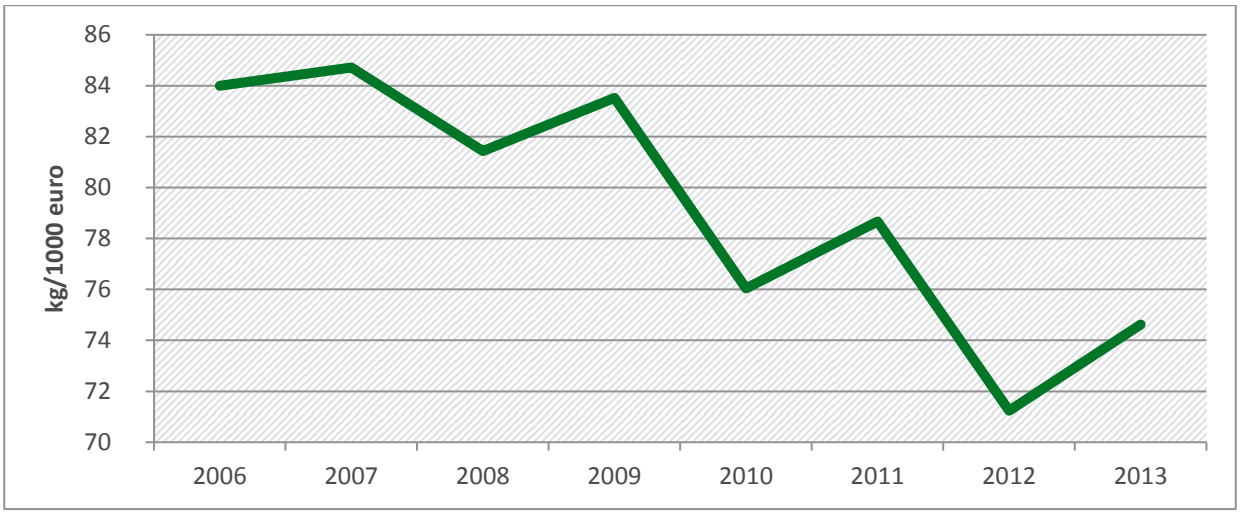
[26] BMU (2013); pp. 20-21.

Table 11: Indicator 4 – Sectorial waste intensities

First Best	Second Best	RACER Feedback	Data Availability
Specific sectorial waste intensities, including their environmental impact	Total waste generated by the manufacturing sector relative to price-adjusted gross value added for the manufacturing sector	Relevant waste stream; manufacturing sector in the focus of the waste prevention debate; established indicator with restrictions on data availability; high dependence on economic development	Waste generation according to Destatis; gross value added according to Statista

Source: Own compilation

Figure 8: Total waste generated by the manufacturing sector relative to price-adjusted gross value added for the manufacturing sector



Source: Own compilation based on Destatis (2017a).

The indicator can also only be presented at the federal level. The alternative for the federal states would again be the "waste disposal in nature" value from the Environmental Economic Accounting with regard to waste from production and business. The significance would however be limited considering the presumably significantly higher proportion of waste shipped between the federal states within Germany.

Proposed targets

Neither Germany nor the European Commission have set quantitative targets for Indicator 4 "Sectorial waste intensities of the manufacturing sector". Lithuania and England have set broad quantitative targets, while the Brussels and Wales regions have set concrete quantitative targets.

- England: The aim is to help companies identify potential savings through improved resource efficiency and waste prevention.

- Lithuania: The aim is to reduce waste generation from manufacturing, construction and other services by 2020, while ensuring that the amount of waste produced does not exceed the EU average.

Table 12: Quantitative targets for the sectorial waste intensities of the manufacturing sector

Country / Region	Reduction by	Type of waste
Brussels	30 kg per employee per year	Paper waste
Brussels	1 kg per employee per year	Packaging waste
Wales	1.4 % per year	Industrial waste
Wales	1.2 % per year	Commercial waste

Source: Own compilation

Data collection concept

Data are available at the federal level for the indicator "Sectorial waste intensities of the manufacturing sector", but they are not available for the federal states. It is necessary to combine data from the waste balance sheet with Statista data, the waste balance sheet only takes into account companies above certain sizes. The confidential data is collected by Destatis. The data are updated annually and presented in the form of numerical values. No qualitative information is provided. The data quality is reliable due to annual updates. Data collection expenditure is considered to be unproblematic.

Data source:

- Destatis (2017a).

Indicator 5 – Resource efficiency

In view of the overlapping content between considering resource efficiency on the input side and preventing waste from the output perspective, the total raw material productivity indicator should be included in the indicator set, as it is now also envisaged as a supplementary value in the Resource Efficiency Programme adopted by the Federal Government of Germany (ProgRess).

Reference to the waste prevention programme:

"Resource efficiency policy is intended to help us assume our global responsibility for the ecological and social consequences of the use of resources. The aim must be to reduce the utilisation of raw materials.
The waste prevention programme fits into this framework and pursues compatible objectives (...)."[27]

Table 13: Indicator 5 – Resource efficiency

First Best	Second Best	RACER Feedback	Data Availability
Total use of natural resources along the entire value chain	Total raw material productivity per capita	Input as a relevant variable for waste prevention	Is recorded within the framework of ProgRess II as one of the lead indicators at the national economic level.

Source: Own compilation

[27] BMU (2013); p. 7.

Figure 9: Development of total raw material productivity in Germany

Index (2000=100)	2000	2008	2009	2010	2011[P]
total raw material productivity in Germany	100	114	119	114	122

P = provisional

Source: own analysis of Federal Statistical Office

Source: Federal Statistical Office, cited in Günther and Golde 2015.

(Total) raw material productivity is an aggregated indicator that does not cover all facets of waste prevention in detail. Nevertheless, the indicator is important with regard to the life cycle approach to waste prevention and also sends a political message that waste prevention is not primarily about waste.

As Günther and Golde (2015) point out, the indicator has limitations to its interpretation: "The direct material input used for the indicator calculations includes both raw materials as well as manufactured and semi-finished products. Raw materials, in turn, are used for the production of these semi-finished and finished products. These raw materials are included in the indicator if the products are manufactured domestically. However, if the products are manufactured internationally, only the weight of the imported semi-finished and finished products is included in the calculation, not the raw materials actually required for production." This can lead to an overestimation of productivity. Overall, this indicator is well established both nationally (within the framework of ProgRess and the German Sustainability Strategy) and at the European level, particularly with regard to data collection/availability.

Proposed targets

In the German WPP, a quantitative target for resource efficiency that has been set in the National Sustainability Strategy (Nationale Nachhaltigkeitsstrategie) and repeatedly confirmed by the German government is to double raw material productivity[28] by 2020 compared to 1994. The following resource efficiency targets are cited in European waste prevention programmes:

- Denmark: Improve resource efficiency of Danish companies; help the construction sector to act in a more resource-efficient manner and to switch to safe and sustainable materials as well improve the exchange of knowledge throughout the sector
- Wales: Help companies use resources more efficiently by promoting eco-design and resource sharing

Data collection concept

Data are available for the "Resource efficiency" indicator. The data are collected by Destatis and are publicly available. They are updated annually and presented in the form of numerical values. No qualitative information is provided. Data quality is reliable as a result of annual updates, variations due to changes in statistical collection methods are possible. Data collection expenditure is considered to be unproblematic. The even more comprehensive TMR (Total Material Requirement Index) could also be used, however the data availability for this indicator is to be regarded as even more challenging.

Data source:

- Günther and Golde (2015)

[28] In this context, raw material productivity is defined as gross domestic product (GDP) in relation to direct material input (DMI).

3.2.2 Reducing hazardous substances in materials and products / substitution of materials hazardous to the environment and health

Indicator 6 – Total hazardous waste generation

The total amount of hazardous substances used in products and production processes and products is considered to be the preferred indicator, as it could be used to derive an overall effect on the environment and human health. Total hazardous waste generation according to Circular Economy Act (KrWG) can be observed as the second best available alternative – even if the total volume says little about the toxicity of the waste.

Reference to the waste prevention programme:

"'Reducing hazardous substances in materials and products' up to and including substitution of materials hazardous to the environment and health"[29]

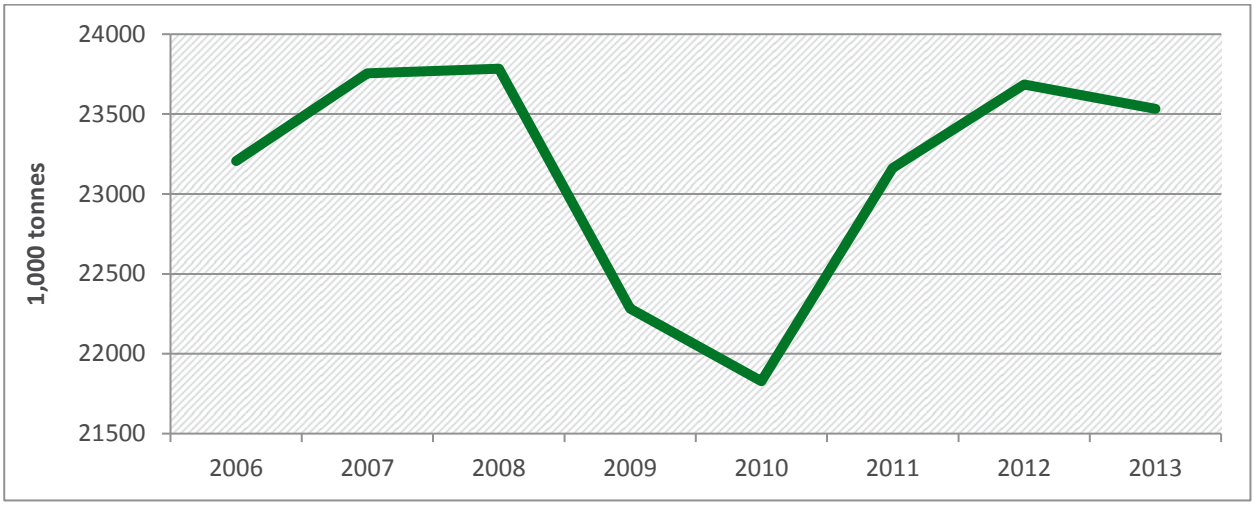
Table 14: Indicator 6 – Total quantity of hazardous waste

First Best	Second Best	RACER Feedback	Data Availability
Total amount of hazardous substances used in production processes and products; overall effects on the environment and human health	Total quantity of hazardous waste according to Circular Economy Act (KrWG)	Relevant waste stream; volume accepted as an indicator for qualitative waste prevention; easy to communicate; good data availability (at least for the total quantity of hazardous waste); problem of robustness, since significant quantity changes can result from re-declarations	Available through waste balance by Destatis

Source: Own compilation

[29] BMU (2013); p. 20.

Figure 10: Total hazardous waste generation



Source: Own illustration based on Destatis (2017a).

The increase in Figure 10 will be mainly due to the robust economic activity, but there has also been a slight but steady growth in the total volume of hazardous waste throughout Europe.[30] The risk of future variation due to changes in classifications is considered to be rather low.

Proposed targets

Germany and other EU countries aim to reduce hazardous substances in materials and products and to substitute substances that are harmful to the environment and health in order to reduce the harmful impacts of waste. Quantitative targets based on the following country targets (Table 15) would be plausible for this purpose.

Table 15: Quantitative reduction targets for hazardous waste

Country / Region	Quantitative target
Bulgaria	The value of the indicator "Hazardous waste per unit of GDP" should be lower than its 2010 value by 2020.
Italy	By 2020: Reduce the ratio of special hazardous waste generated to GDP by 10%
Latvia	Produce no more than 50,000 tonnes of hazardous waste per year by 2020 Recycle 75% of hazardous waste by 2020

Source: Own compilation

Data collection concept

Data are available at the federal level for the indicator "Total hazardous waste generation". The data are collected by Destatis and are publicly available. They are updated annually and presented in the form of numerical values. No qualitative information is provided. The data quality is reliable due to annual updates. Data collection expenditure is considered to be unproblematic.

30 See EEA (2016a): Prevention of hazardous waste in Europe – the status in 2015.

Data source:

- Destatis (2017a):

3.3 Sub-targets

The WPP also designates exemplary sub-targets, some of which can be addressed using indicators representing WPP success, others using indicators for individual activities (see Chapter 4).

3.3.1 Increasing the service life of products

Indicator 7 – Increase product use phase

For the indicator regarding the increase product service life, the initial useful life of selected lead products focusing on electrical and electronic equipment is to be used as a feasible approximation.[31] Please refer to UBA Study FKZ 3713 32 315 "Einfluss der Nutzungsdauer von Produkten auf ihre Umweltwirkung: Schaffung einer Informationsgrundlage und Entwicklung von Strategien gegen ‚Obsoleszenz'" ("Influence of the useful life of products on their environmental impact: Creating an information base and developing strategies against 'obsolescence'") to select possible lead products.

Reference to the waste prevention programme:

"Increasing the service life of products"[32]

Table 16: Indicator 7 – Increase product use phase

First Best	Second Best	RACER Feedback	Data Availability
Average technical useful life of all products placed on the market, weighted with specific environmental impacts	Initial useful life of selected lead products with focus on electrical and electronic equipment according to Prakash et al. 2016		Fee-based data from the Gesellschaft für Konsumforschung (GfK), analysis at municipal collecting points/recycling facilities, Internet-based consumer survey conducted by the University of Bonn, lifetime test Stiftung Warentest, LCA studies, evaluation www.ifixit.com, expert surveys

Source: Own compilation

The first useful life is the period of utilisation only by the first user, which is not to be confused with the technical service life. The measurement would be based on an analysis of the time it takes in private households for a percentage of a product category placed on the market in year X to be disposed of or passed on to a second user. As a result of equating this parameter with the plain household retention time, the utilisation period cannot be distinguished from storage time in households.

The first useful life as a methodological approach neglects the entire topic of repair and re-use. Relating to waste prevention measures, the topic is also regarded using other possible indicators, e.g. federal states promoting re-use (see Chapter 4.2.3). Additionally, the discussion on this topic is still in its infancy and it can generally be regarded as progress if a feasible approach is available.

31 Prakash et al. (2016).

32 BMU (2013); pp. 20-21.

Proposed targets

In addition to Germany, promoting re-use is also a key objective of waste prevention programmes in Greece, Latvia and Wales. Waste prevention efforts in Germany, Denmark, Lithuania, Luxembourg, the Netherlands and Spain also focus on reusing products and extending their service life. However, none of these programmes has set a quantitative target.

Data collection concept

No data are yet available for the indicator "Increase product use phase". The data could be collected through a research project commissioned by the Federal Environment Agency (UBA) based on the GfK data, among other things. The product useful life could be measured by an analysis of private households (first use, second use, etc.). The effort required for this survey is estimated at approximately one person-month. The data collected would be presented in the form of numerical values. Data collection expenditure is considered to be difficult overall.

3.3.2 Improving the level of information on waste prevention

Indicator 8 – Improving the level of information

Improving the level of information is expected to raise the awareness of the population and the actors involved from industry, trade, commerce and waste management about the need to reduce waste quantities or the amount of hazardous substances in materials, products and waste as well as emissions in air, water and soil in connection with the generation and management of waste. For this indicator, we shall use the share of the population that considers the issue of waste prevention as very important (also in the context of high recycling rates, which can contribute to the subjective perception of an apparently lower urgency of waste prevention). With regard to the availability of data, the study on environmental awareness in Germany regularly carried out by BMUB/UBA could be used after supplementing relevant questions. Furthermore, we should take into account the results of the ongoing research project "Identifizierung soziologischer Bestimmungsfaktoren der Abfallvermeidung und Konzipierung einer zielgruppenspezifischen Kommunikation" (Identification of sociological determinants of waste avoidance and conception of target group-specific communication; UFOPLAN research code 3717 34 333 0).

Reference to the waste prevention programme:

"Improving the level of information and thereby raising the awareness of the population and the actors involved from industry, trade, commerce and waste management about the need to reduce waste quantities or the amount of hazardous substances in materials, products and waste as well as emissions in air, water and soil in connection with the generation and management of waste"[33]

[33] BMU (2013); pp. 20-21.

Table 17: Indicator 8 – Improving the level of information

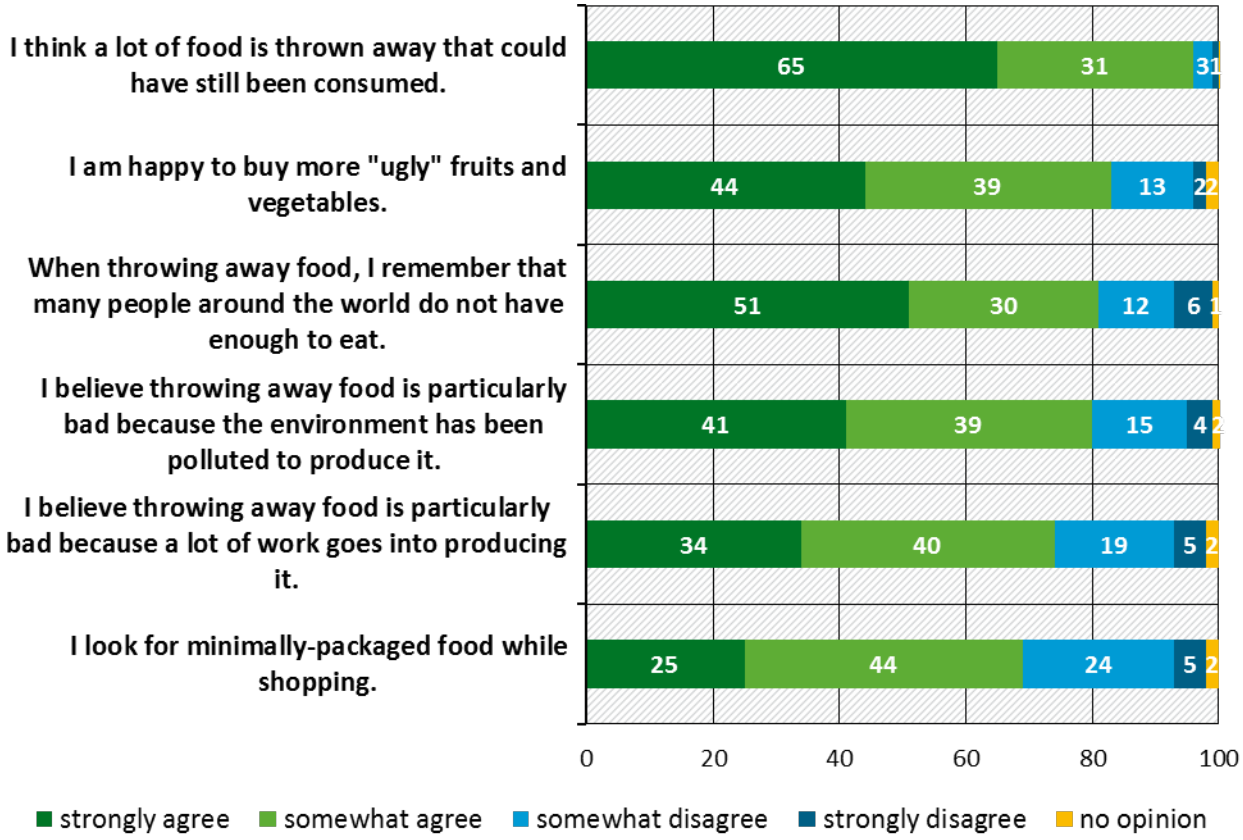
First Best	Second Best	RACER Feedback	Data Availability
Share of the population that considers the issue of waste prevention as very important, even against the background of high recycling rates.	–		Recourse to the study on "Environmental Awareness in Germany", which is regularly carried out by BMUB/UBA, by supplementing the relevant questions.

Source: Own compilation

A possible approach in this direction has already been implemented in the current study on environmental awareness in Germany. The approach focuses on food waste. As the following Figure 11 illustrates, 96 % of respondents "strongly" or "somewhat" agree with the hypothesis that "a lot of food is thrown away that could have still been consumed".[34] The indicator demonstrates extremely high sensitivity within the population and can therefore also be used as an argument for further government measures.

[34] BMUB and UBA (2017): Umweltbewusstsein in Deutschland 2016. Results of a representative population survey; p. 59.

Figure 11: Attitudes toward food waste



Question: About 11 million tonnes of food are wasted every year in Germany. Below you will find some statements on the subject of food waste. Please indicate whether you strongly or somewhat agree or disagree with each statement.

N = 2030, online survey, 1st survey round, sample of individuals 14 years of age and older
(in percent)

Source: BMUB and UBA (2017).

Proposed targets

Germany would like to promote consumer behaviour aimed at purchasing products low in waste and hazardous substances. This can be achieved by improving the level of information and thereby raising the awareness of the population and the actors involved from industry, trade, commerce and waste management about the need to reduce waste quantities or the amount of hazardous substances in materials, products and waste as well as emissions in air, water and soil in connection with the generation and management of waste.

Among the European countries, Belgium's aim is to draw attention to the issue of "waste" by illustrating the relationship between lifestyles and the amount of resources consumed. Additionally, waste-free products and recycled products will be promoted. The European Commission (2011) has set the milestone target of providing citizens and public authorities with the right incentives to choose the most resource-efficient products and services by 2020 through appropriate price signals and clear environmental information.

The waste prevention programmes do not cite quantitative targets.

Data collection concept

No data are yet available for the indicator "Improving the level of information". A possible course of action to collect the relevant data is to supplement the surveys on environmental awareness in Germany conducted by the Federal Environment Ministry and the Federal Environment Agency. The data collected would be presented in the form of numerical values and updated as necessary. Data collection expenditure is considered to be difficult overall.

Study "Environmental Awareness in Germany":

- BMUB and UBA (2017)

4 Indicators for waste prevention programme measures

4.1 General remarks

4.1.1 Reason for structuring in measure areas

The discussions about creating suitable indicators to assess the success of implementing the measures of the German WPP have so far shown that the current comparatively differentiated structuring of Chapter 6 of the WPP would require equally differentiated test indicators. Many of the experts involved from the federal and state governments consider this to be a too detailed and impracticable assessment[35].

Additionally, both observations of actual implementation as well as discussions with real-life actors show that there are additional waste prevention activities beyond those described in the WPP.

The following approach was therefore chosen in this project, similarly to structuring the survey in the parallel project to update the WPP[36]: Measure areas were created in order to monitor success with reference to Chapter 4.1 of the WPP. Each area covers one or more of the measures in the Annex (Chapter 6 of the WPP), while also offering scope for recording further possible activities to achieve the objectives of the WPP. Those individual measures that fall within the respective measure area are listed under "Related waste prevention measures from the Annex" (Chapter 6 WPP). In cases where this is particularly striking, possible need to specify the measure areas will be indicated, including through further individual measures relating to some of the proposed indicators.

4.1.2 Explanatory notes relating to the indicators

Placement in the DPSIR system and type of indicators

The proposed indicators are almost invariably "response" indicators since the task in work package 2 of the project is to develop indicators that build on the WPP measures (or measure areas, as explained above). According to the DPSIR system (see Chapter 2.4), this includes indicators that measure the degree of social reaction to an environmental problem, for example market penetration of a comparatively environmentally-friendly technology or the establishment of certain institutions and policies[37]. The proposed indicators therefore provide information on waste prevention activities.

It is hardly possible to link the measure areas directly to waste streams or to assign them "pressure" indicators (i.e. indicators that measure the release of emissions and the use of resources). However, it makes sense to assign pressure indicators to the WPP objectives and has already been performed as described above in work package 1 of the project (see Chapter 3). Disadvantages to this approach are that no conclusions can be made about the quality or success of the activities just by the information that these activities were carried out and that most of the necessary data are not available in official statistics and would have to be collected specifically for this purpose. The advantage of this type of indicator, however, is that it can be used to demonstrate where measures have been taken and where

35 Personal communication and discussions at an expert discussion during the project on 27 Sept. 2016.

36 Wuppertal Institute et al. (ongoing): Fortschreibung Abfallvermeidungsprogramm: Erarbeitung der Grundlagen für die Fortschreibung des Abfallvermeidungsprogramms auf Basis einer Analyse und Bewertung des Umsetzungsstandes (FKZ 3716 34 328 0) (Updating waste prevention programme: Development of the basis for updating the waste prevention programme based on an analysis and evaluation of the implementation status).

37 One could certainly still make distinctions here, i.e. differentiate between policies and institutions and technological-physical answers (which can be influenced by the former), but this has not yet been done in the DPSIR system.

there are gaps, and where it can stimulate a policy debate on the implementation of the WPP (as well as its proposed measures).

When presenting the indicators for the measure areas, it is proposed across the board for many cases these should not be displayed as individual numerical values due to the small statistical population (e.g. federal states), but instead the pure figures should be supplemented by qualitative information (see the explanations on the individual indicators).

RACER assessment

The RACER analysis carried out differs from the analysis of the indicators for the main objective as well as for the operative targets and sub-targets, in particular in that most of the indicators selected for the waste prevention measures are not yet collected. The analysis was therefore essentially a hypothetical investigation to test the suitability of the proposed indicators related to the waste prevention measures to determine performance based on searches for existing data options and possible availability.

Not all criteria categories of the analysis were applied during this hypothetical RACER analysis – for example, the criterion acceptable was not evaluated because the question of the acceptance of indicators that do not yet exist cannot be meaningfully raised among various stakeholder groups by inferred desktop research. On the other hand, the RACER analysis has revealed a large number of questions relating in particular to the following criteria:

- credible: unclear terminology or vague boundaries (e.g. what must a municipal WPP contain in order to be considered as such and measured accordingly in the indicator for the waste prevention measure 1 "Development of waste prevention concepts and plans by municipalities") can impair the transparency and clarity of the indicators;
- easy: also unclear terminology (e.g. with regard to the definition of product service systems), but also missing, unknown or sporadically available data complicate a final evaluation of data availability, technical feasibility and communicability;
- robust: in conjunction with unclear terminology[38], questions arise regarding both data quality[39] and reproducibility. If data are missing or the quality is unknown, the reproducibility of the results cannot be ensured.

Reference to current WPP

The indicators proposed below refer to the current WPP. Areas not covered in detail in the WPP (e.g. packaging waste, construction and demolition waste) are therefore not covered by the indicators proposed here. However, the project to update the WPP (Wuppertal Institute et al., ongoing, see Chapter 4.1.1) focuses on analyses on further developing the WPP. Indicators have already been proposed in a limited form where aspects appear to be missing from the description or from the measures in the WPP within a measure area. These indicators cover the respective measure area more comprehensively (see the example of repair).

Data availability

It is also often a challenge to ensure data availability for the indicators at the "response" level. Compilations regarding which municipal authorities have taken certain measures are usually not available and the measures to be counted must be precisely defined in order to obtain sufficient data quality. However, building on the survey carried out by the federal states during the current project to update

[38] For example, with regard to what is considered standardisation and from when it can be assumed that it supports product design that avoids waste and conserves resources.

[39] The quality cannot be conclusively assessed as some data are missing or the stocks are unknown.

the WPP (see Wuppertal Institute et al., ongoing), we can create indicators that are backed up with data from this survey. Specific data would need to be collected for some of the proposed indicators, which can be done with limited effort (e.g. in the area of product design: the number of measures to implement eco-design containing waste prevention requirements).

Administrative levels and time-related reference

Some of the proposed indicators are (generally) applicable at different administrative levels – at federal, state and municipal (or public waste management authorities) level. However, most of the indicators currently relate only to the federal state level, as regularly collecting data from municipalities or public waste management authorities does not appear realistic. A particular problem for collecting data from municipalities is that there is often no contact person for waste prevention as no clear responsibility has been assigned regarding the topic. It would be desirable to include information from the municipal level in the measure indicators. However, it is currently not possible to compile comprehensive data.

While some indicators represent a snapshot in time (e.g. the current number of federal states that have a plan or concept for implementing waste prevention), others are period-related, i.e. they survey the activities carried out over a period of time (to be determined) in the area of waste prevention measures. This is indicated in each case with the note "(period-related)" after the indicator.

Proposals and assessment

A total of 12 indicators spread across the various measure areas are proposed below. The proposed indicators are accompanied by explanatory notes or a description is given as to why no indicator would appear to be useful in a certain area or why it would be desirable to map it using indicators but does not currently appear feasible.

Proposed targets

The project also provides for the evaluators to propose target values for each indicator and to justify these proposals. However, during the course of the work on work package 2, it became apparent that targets for the type of indicators that could be used to evaluate the WPP measures could not be scientifically justified, but instead could only be politically established[40]. Therefore, no targets are proposed for the indicators described in this chapter.

4.2 Measure areas and proposed indicators

4.2.1 General (horizontal) measures

Description of the measure area in the WPP (Ch. 4)

Ch. 4.1 "General (horizontal) measures":

"Research and development: Projects focused on waste prevention are to receive further support within the framework of existing support programmes and measures. Research will focus in particular on the development and/or optimisation of waste prevention technologies and utilisation concepts, including extending the average service life of technical products. In this context it is important to continue developing indicators and methods that could, among other things, serve as a basis for assigning

[40] Some of the exemplary target values given should look as follows: Share of federal states that should take certain measures; share of public waste management companies that should take part in actions during the European Week for Waste Reduction; number of implementation and action aids for industrial plants or eco-design implementation measures with waste avoidance requirements prepared up to time x.

an eco-label for waste-reducing materials and products. A further area is the identification of indicators to monitor the success of waste prevention measures as well as the advancement of life cycle assessment instruments for assessing the mitigating effects of certain waste prevention measures."

"Information and raising awareness: Practical information on waste prevention in the various areas (producers, consumers, companies) should be made more available and prepared in such a way that the various target groups can use the information in a practical and useful manner. Waste prevention campaigns and activities are essential to further raise awareness among the different target groups. The European Week for Waste Reduction is particularly noteworthy. This initiative has been the central event at the European level for years. It provides an institutional framework to present various initiatives and projects related to waste prevention in the Member States. It thus contributes to promoting best practice cases in waste prevention. Many institutions in Germany made their own contributions to the European Week for Waste Prevention in 2011 and 2012."

Note: To further develop the WPP, it is proposed to include general activities related to waste prevention as well as the general degree of organisation on the topic of waste prevention at federal state and municipal levels in this subject area in addition to the areas of research & development and information & raising awareness described in the WPP.

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 1: "Development of waste prevention concepts and plans by municipalities"
No. 2: "Cooperation between stakeholders"
No. 3: "Reduction of subsidies"
No. 4: "Research on waste-preventing technologies and utilisation concepts"
No. 5: "Funding programmes and measures for implementing waste prevention concepts and technologies"
No. 6: "Development and application of indicator systems with the aim of benchmarking"
No. 23: "Strengthening waste prevention in purchasing recommendations"
No. 24: "Education and public participation in waste prevention"
No. 25: "Practical introduction and implementation of sustainable, resource-friendly waste concepts in schools"
No. 26: "Support for municipalities as well as environmental and consumer associations to develop waste prevention campaigns"

Proposed indicators

1. Number of federal states that have carried out communication measures (campaign, provision of information, public events) on waste prevention in general (period-related)
2. Number of federal states that have implemented other activities (working group, events, conducting/assigning expert reports) on waste prevention in general (period-related)
3. Number of public authorities who have participated in or initiated actions during the European Week for Waste Reduction (EWWR)

Explanatory notes

This area covers a wide range of possible measures in the three areas of research and development, information and raising awareness and general organisation/general activities.

An indicator has already been proposed in work package 1 for the area of information and raising awareness in the population (see Chapter 3.3.2, Indicator 8). With regard to waste prevention measures, an additional indicator can be created to map activities at the state level in this area. In the federal state survey (see Wuppertal Institute et al., ongoing), eight federal states declared that they

had initiated a public campaign in recent years, eleven states held an event or events on waste prevention. Various types of measures would have to be differentiated and described while collecting information on this indicator. For instance only activities that qualify as a campaign should be recorded as such (individual flyers or individual events were also sometimes specified as a campaign in the federal state survey). It would be useful to also list the activities of the federal government here, but these should not be jointly counted with the activities of the federal states.

In addition to information campaigns, the other general activities on waste prevention should also be reflected. Supplementary qualitative information is also required for this indicator in addition to the purely numerical value, and it would be useful to include the activities of the federal government like in the previous example.

Numerous local initiatives take place to address the issue of waste prevention during the annual European Week for Waste Prevention (EWWP)[41]. These are registered by various actors (public authorities, associations, companies, educational institutions, private individuals, etc.) and many initiatives are supported by several joint actors. The German Association of Municipal Utilities (VKU) coordinates the EWWP in Germany and possesses data on the actors involved. Due to the diversity of these actors, it is useful to evaluate only a limited part (not "open-ended") for any given indicator. The public waste management authorities are the best option for this as hardly any other nationwide information on their activities is available. Additionally, the participating authorities and (public) educational institutions could be evaluated.

Other desirable indicators

It would be useful to record the general level of organisation for waste prevention in one indicator, but since the organisational structures in the federal states for example vary considerably, an indicator that only depicts part of it would not be very meaningful.

Since the public waste authorities also often have different waste prevention activities, it would be desirable to portray activities at the municipal level (e.g. existing waste prevention concepts and plans). This is however currently not possible due to the reasons given above (see Chapter 4.1.2).

In the area of promoting research and development, there is currently practically no specific funding for waste prevention projects. Some federal states mention subsidies (also) for waste prevention, but these are rather general subsidy programmes, e.g. for the municipal sector or waste management in general. In practice, it may be difficult to identify subsidies specifically used for waste prevention as a result. We therefore do not propose an indicator for this area.

Data collection

Indicator 1: Number of federal states that have carried out communication measures (campaign, provision of information, events for the public) in general to avoid waste (period-related)

- Current status: Eight federal states declared that they have performed a public campaign in response to the relevant question (see Wuppertal Institute et al., ongoing), but in fact it was partly other forms of supplying information or public relations work (information on websites, flyers for refugees, Kochbus Project). The query would therefore have to be refined for an indicator (time period, more precise definition of activities).
- Are the data completely available? – No

[41] See VKU (2018a): Week for Waste Prevention. Available online at: https://www.wochederabfallvermeidung.de/.

- Who collects the data / who is the data source? – The data source are the responsible state and federal authorities, the query would have to be specially carried out via a questionnaire
- Amount of material costs or personnel expenses (working days) for the data: Once the methodology of the survey has been established, a personnel expenditure of approx. 10 working days shall be budgeted to conduct and evaluate the survey for all indicators collected by the survey
- Are the data confidential? – Individual responses yes, but the aggregated/anonymised information for the indicator is not
- Frequency of updates: as needed
- (Stability of) data quality: Stable with the same methodology; the data quality depends on whether only the "correct" activities are actually mentioned; mandatory participation in the survey must be used to ensure that the data are complete

Indicator 2: Number of federal states that have implemented other activities (working group, events, implementation/awarding of expert opinions) on waste prevention in general (period-related)

- Current status: according to information from the federal states, 14 states have performed such activities (5 of these states have set up one or more working groups, 11 states have conducted one or more events, 11 states have had expert reports carried out), however about a quarter of these activities took place before 2013 (see Wuppertal Institute et al., ongoing). The query would therefore have to be refined for an indicator (time period, more precise definition of activities).
- Are the data completely available? – No
- Who collects the data / who is the data source? – The data source are the responsible state and federal authorities, the query would have to be specially carried out via a questionnaire
- Amount of material costs or personnel expenses (working days) for the data: Once the methodology of the survey has been established, a personnel expenditure of approx. 10 working days shall be budgeted to conduct and evaluate the survey for all indicators collected by the survey
- Are the data confidential? – Individual responses yes, but the aggregated/anonymised information for the indicator is not
- Frequency of updates: as needed
- (Stability of) data quality: Stable with the same methodology; the data quality depends on whether only the "correct" activities are actually mentioned; mandatory participation in the survey must be used to ensure that the data are complete

Indicator 3: Number of public authorities who have participated in or initiated actions during the European Week for Waste Reduction (EWWR)

- Current status: approx. 85 public waste authorities registered one or more actions as the main organiser in 2017, while additional public waste authorities are involved in actions (it is possible to request data for this information). In 2017, a total of 1,153 EWWR sites were involved in actions (by all actors) (see VKU 2018b).
- Are the data completely available? – Yes

- Who collects the data / who is the data source? – Query at the German Association of Municipal Utilities (VKU)[42]
- Amount of material costs or personnel expenses (working days) for the data: low expenditure
- Are the data confidential? – The VKU database is. But the required extract of information is not, it can be provided by the VKU
- Frequency of updates: annually
- (Stability of) data quality: good

Recommendation

Indicators 1-3 are recommended despite the limitations and gaps mentioned.

4.2.2 Waste prevention in companies

4.2.2.1 Implementing operator's obligation

Description of the measure area in the WPP (Ch. 4)

Chapter 4.1 "Waste prevention while operating industrial plants":

"The practice of waste prevention while operating industrial plants can be greatly improved in many cases. For this purpose, it is necessary to identify the state-of-the-art possibilities and potential for waste prevention for the various types of plants and to make this potential clear to both the plant operators and the licencing authorities. In this context, it would be useful to complement and update the relevant implementation and action aids for licencing authorities (...) in the coming years. There is also a need to train the licencing authorities to better include waste prevention aspects in approval procedures. (…)"

In addition, the WPP contains an audit engagement in Section 4.2 regarding the "equal treatment of certain installations not subject to approval with installations subject to approval in view of waste prevention obligations".

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 11: "Adapting the implementation and action aids for plants requiring approval to the state of the art for waste prevention"
No. 13: "Training for competent authorities on waste prevention requirements when issuing approvals"
No. 14: "Promoting uniform implementation of waste prevention obligations in plants both subject to and not subject to approval"

Proposed indicator

4. Number of industries/sectors for which current (i.e. not older than 5 years) substatutory state-of-the-art implementation and action aids are available for specifying operator obligations for waste prevention (as MVV, VDI-RL, ATV/DVM leaflet etc.)

Explanatory notes

There are currently no such implementation and action aids. However, they would be very useful as they are necessary as a reference point to enforce operator obligations. Preparing the implementation

[42] VKU Website (2018b): Action map, https://www.wochederabfallvermeidung.de/aktionskarte/ represents all registered actions, currently does not offer sufficient filter options for the data required.

and action aids is time consuming and they require the participation of a large number of actors. Depicting "sham activities" with the indicator is therefore rather unlikely. Due to the current lack of implementation and action aids and a low indicator value to be expected in the medium term, it would be useful and possible to collect and name qualitative information in addition to the pure number of implementation and action aids. Among other things, it is essential to name any sector where implementation and action aids are available; it could also be mentioned if and which further implementation and action aids are being prepared.

Measure No. 14 in the WPP Annex proposes pushing for waste prevention obligations in plants not subject to approval in addition to the plants subject to approval. However, this measure is subject to review for the individual installation types.

Data acquisition

Indicator 4: Number of industries/sectors for which current (i.e. not older than 5 years) substatutory state-of-the-art implementation and action aids are available for specifying operator obligations for waste prevention (as MVV, VDI-RL, ATV/DVM leaflet etc.)

- Current status: There are no such implementation and action aids available
- Are the data completely available? – No
- Who collects the data / who is the data source? – Survey at Bund/Länder-Arbeitsgemeinschaft Immissionsschutz (Federal/State Working Group on Immission Control; LAI)[43]
- Amount of material costs or personnel expenses (working days) for the data: low survey effort
- Are the data confidential? – No
- Frequency of updates: as needed
- (Stability of) data quality: Stable

Recommendation

Indicator 4 is recommended because it provides incentive to develop implementation and action aids which are a necessary reference point to enforce operator obligations.

4.2.2.2 Support for voluntary activities

Description of the area of action in the WPP (Ch. 4)

Chapter 4.1, "Waste prevention measures in companies":

"With regard to measures aimed at waste prevention in companies, special attention should be given to promoting environmental management systems (EMS) and their expansion to include waste prevention issues: [...] Additionally, the various regional and local training and consultation programmes for companies aimed at improving or optimising resource conservation and waste prevention shall continue to be supported by the local competent authorities and their use and visibility shall be developed and promoted where possible and appropriate."

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 12: "Consultations from public institutions with companies on their waste prevention potential"
No. 15: "Establish, continue and link existing programmes that sensitise and consult companies on waste prevention"
No. 16: "Waste prevention cooperation among industrial companies"
No. 18: "Agreements between industry/trade and government agencies on waste prevention"

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[43] LAI: https://www.lai-immissionsschutz.de/

No. 19: "Expand existing environmental management systems to include aspects of waste prevention"

Proposed indicators

5. Number of federal states that support waste prevention activities in companies (e.g. information campaign, information or consultation services, exchange of experience) (period-related)
6. Number of companies that have implemented an environmental management system (EMAS, ÖkoProfit, QuB, ISO 14001 certification)

Explanatory notes

The number of federal states that support waste prevention activities in companies is currently known through the federal state survey (cf. Wuppertal Institute et al., ongoing): These activities were performed or are being performed in 7 out of 11 federal states, as reported by these states that replied to the questionnaire on this subject. However, the states must provide precise details regarding the activities in order to be able to assess whether these are actually activities specifically aimed at waste prevention in companies. Qualitative information should also be recorded and presented. Any federal activities could be described as well.

A number of indicators can be formulated in the area of consulting for companies and environmental management systems (EMS) (e.g. number of consultations conducted, number of employed consultants, number of specially-trained consultants), but problems are likely to arise in determining which programmes/consultations actually substantially address waste prevention. However, it is possible for the appropriate organisations to produce a general census of the relevant EMS that were introduced through these consultations. This information can be used as a proxy indicator (the data for the different systems should be listed separately due to their differences). The four large systems that have available information regarding the number of certified establishments can be used for this. In addition to the pure numerical values, it is useful to describe the extent to which waste prevention plays a role in the various systems. There are also numerous other sector-specific environmental management labels, however covering these with the indicator would significantly increase the effort required for data collection.

Data collection

Indicator 5: Number of federal states that support waste prevention activities in companies (e.g. information campaign, information or consultation services, exchange of experience)

- Current status: 7 federal states (of the 11 states that answered the relevant questionnaire) support such activities (see Wuppertal Institute et al., ongoing)
- Are the data completely available? – No
- Who collects the data / who is the data source? – The data source are the responsible state and federal authorities, the query would have to be specially carried out via a questionnaire
- Amount of material costs or personnel expenses (working days) for the data: Once the methodology of the survey has been established, a personnel expenditure of approx. 10 working days shall be budgeted to conduct and evaluate the survey for all indicators collected by the survey
- Are the data confidential? – Individual responses yes, but the aggregated/anonymised information for the indicator is not
- Frequency of updates: as needed

- (Stability of) data quality: Stable with the same methodology; data quality depends on whether only the "correct" activities are actually mentioned; mandatory participation in the survey must be used to ensure that the data are complete

Indicator 6: Number of companies that have implemented an environmental management system (EMAS, EcoProfit, QuB, ISO 14001 certification)

- Current status (nationwide data): ISO 14001: 9,444 certificates (all sectors, 2016); EMAS: 1,233 certified organisations (all economic sectors, February 2018); EcoProfit: > 3,000 participating companies (2017); QuB: 326 companies (2017)
- Are the data completely available? – The data must be requested from the respective supporting organisations (partly available online, partly only accessible by telephone)
- Who collects the data / who is the data source? – Supporting EMS organisations[44]
- Amount of material costs or personnel expenses (working days) for the data: low personnel expenses
- Are the data confidential? – No
- Frequency of updates: annually
- (Stability of) data quality: good / constant; however, in some cases (EMAS, ISO 14001) authorities and associations are also recorded (these could be removed with certain additional effort) in addition to companies and in some cases companies can be recorded in several systems at the same time.

Recommendation

Indicator 5 is recommended. Indicator 6 is recommended despite the limitations and gaps mentioned.

4.2.3 Extending the product use phase

4.2.3.1 Supporting re-use of products

Description of the measure area in the WPP (Ch. 4)

Ch. 4.1 "Re-use of products":

"A key focus of waste prevention is promoting product re-use. Public authorities at all levels must make it clear through advertising and educational measures that re-using goods should be accompanied by sustainable resource management, waste prevention and low negative environmental impacts. Simultaneously, developing quality standards or quality seals should be promoted for used goods such as furniture, electrical appliances, etc. and the utilization of these goods should be promoted. It is of great importance from the point of view of waste prevention and re-use to establish structures for re-use or multiple use of products (second-hand goods) at the municipal level either by public institutions or private ones."

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 30: "Promotion of the re-use or multiple use of products (second-hand goods)"
No. 32: "Development of quality standards for re-use"

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44 ISO (2016): https://www.iso.org/the-iso-survey.html; EMAS (2018): http://www.emas.de/teilnahme/wer-hat-schon-emas/; EcoProfit (2017): https://www.muenchen.de/rathaus/Stadtverwaltung/Referat-fuer-Arbeit-und-Wirtschaft/Wirtschaftsfoerderung/Grundlagen/oekoprofit/oekoprofit-deutschland.html; QuB: Chamber of Trade for Middle Franconia (central QuB office), http://www.qub-info.de/derquh/der_quh.php.

Proposed indicators

7. Number of federal states that conduct their own re-use activities (e.g. information campaign, providing citizens with information, exchange of information between actors, surveys, expert reports, potential analyses, pilot projects) (period-related)
8. Mass and portion of mass of waste electrical and electronic equipment to be prepared for re-use

Explanatory notes

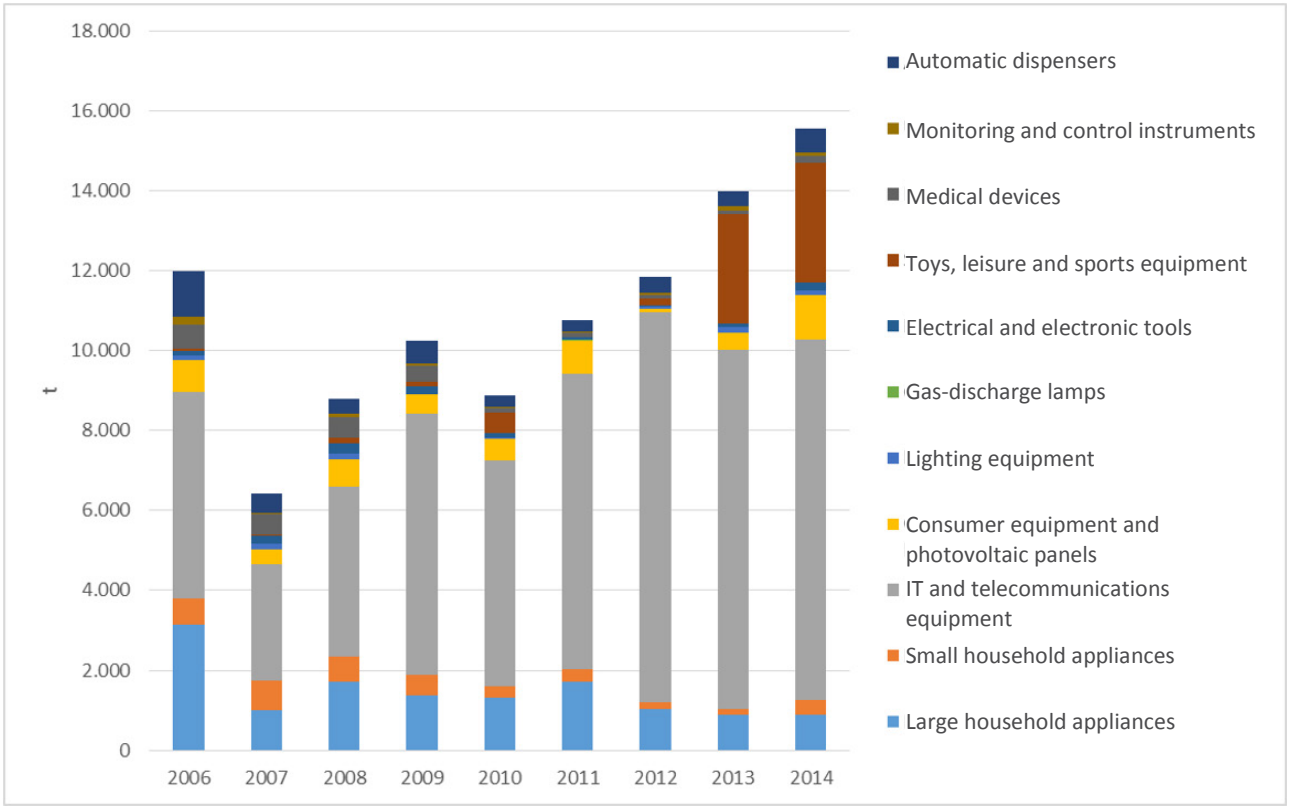
There are currently limited support activities for re-use in the federal states. The first indicator proposed depicts the sum of the federal states that are active in this area. Although municipalities and public waste authorities are the more important actors in this area, data cannot currently be collected for the reasons listed above (see Chapter 4.1.2). Qualitative information should also be recorded and presented. Any federal activities could be described as well.

Strictly speaking, the indicator for waste electrical and electronic equipment (WEEE) does not involve waste prevention, as the equipment is already considered waste from a legal standpoint. It does however have a waste preventing effect, as they are removed from the waste stream and is at least partially re-used (see note below). Since no comparable data are available for waste streams other than WEEE, only this section can be considered. Although the available WEEE data are not of the highest quality, they are at least freely accessible[45] (see Figure 12 and Figure 13)[46]. The absolute mass and percentage of equipment in the WEEE waste stream could be portrayed without much additional effort. Separate data are available for 11 different categories of equipment that could be differentiated. However, small quantities in individual sub-indicators could indicate variations that are purely random and the importance of these would be overestimated by presenting them separately. It would be better to show the amount of equipment that is actually ready for re-use after completing the preparation for re-use process instead of displaying the amount of equipment that goes into the process, but these data are not available. The possibility of separating equipment from private and commercial areas should also be considered.

45 See Eurostat (2017): Tables of waste electrical and electronic equipment by type of treatment.

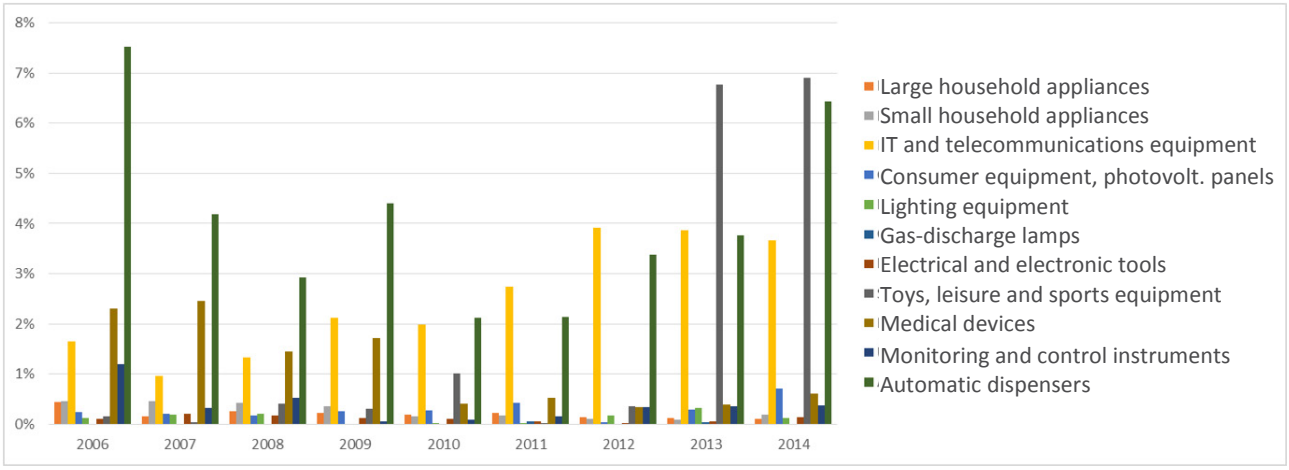
46 So far, data in this area have been collected by stiftung ear and Destatis. Data are collected in different ways and the Federal Environment Agency ensures that the data are aggregated and then reported to Eurostat. The only data available are from 2014 and earlier. There is currently a data gap because stiftung ear has been collecting data on the amount of equipment being prepared for re-use combined with the equipment being recycled since 2015. However, the Federal Environment Agency is interested in reintroducing separate data collection. Apart from this, the (somewhat less complete) data from Destatis could also be used (see Destatis 2017).

Figure 12: Volume being prepared for re-use in Germany from 2006 to 2014 (in tonnes)



Source: Sander et al. (2017).

Figure 13: Ratio of waste electrical and electronic equipment in preparation for re-use to mass of equipment placed on the market per category (data in mass %)



Source: Sander et al. (2017).

Data collection

Indicator 7: Number of federal states that conduct their own re-use activities (e.g. information campaign, providing citizens with information, exchange of information between actors, surveys, expert reports, potential analyses, pilot projects) (period-related)

- Current status: 7 federal states (of 8 states that answered the questionnaire) have such activities (see Wuppertal Institute et al., ongoing)
- Are the data completely available? – No
- Who collects the data / who is the data source? – The data source are the responsible state and federal authorities, the query would have to be specially carried out via a questionnaire
- Amount of material costs or personnel expenses (working days) for the data: Once the methodology of the survey has been established, a personnel expenditure of approx. 10 working days shall be budgeted to conduct and evaluate the survey for all indicators collected by the survey
- Are the data confidential? – Individual responses yes, but the aggregated/anonymised information for the indicator is not
- Frequency of updates: as needed
- (Stability of) data quality: Stable with the same methodology; the data quality depends on whether only the "correct" activities are actually mentioned; mandatory participation in the survey must be used to ensure that the data are complete

Indicator 8: Mass and portion of mass of waste electrical and electronic equipment to be prepared for re-use

- Current status: See data in Figure 12 and in Figure 13 – a total of approx. 15,500 tonnes of supplied equipment in preparation for re-use in 2014, which corresponds to a share of 0 % – 7 % depending on equipment group
- Are the data completely available? – Yes, with restrictions, see footnote 46
- Who collects the data / who is the data source? stiftung ear, Federal Environment Agency, Destatis, Eurostat (see footnote 46)
- Amount of material costs or personnel expenses (working days) for data: no additional expense if the data are collected again in the same manner as in 2014 and earlier
- Are the data confidential? – No
- Frequency of updates: Annually
- (Stability of) data quality: the data quality is limited, the data are not complete (see explanations in text above and in footnote 46)

Recommendation

Indicators 7 and 8 are recommended. As described in indicator 8, it would be advantageous if the data were to be collected again by stiftung ear like in 2014 and earlier.

4.2.3.2 Support for repair actors

Description of the measure area in the WPP (Ch. 4)

Support for repair activities in the WPP is integrated into the measure area "Re-use of products" (see Chapter 4.1):

"(…) The same applies to repair networks dedicated to repairing or further preparing used products, such as furniture, bicycles, electrical appliances, with the aim of re-using the products."

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 31: "Support for repair networks"

Note: This is a very limited area within the broader field of product repair, as it only covers activities in the narrow context of (preparation for) re-use. There are no measures to support (a broader spectrum of) repair such as requirements for manufacturers regarding the availability of spare parts or free access to repair information and diagnostic programmes, etc.

Proposed indicator

9. Number of federal states that conduct their own repair activities (e.g. information campaign, providing citizens with information, exchange of information between actors, surveys, expert reports, potential analyses, pilot projects) (period-related)

Explanatory notes

There are currently limited support activities for repair in the federal states. The first indicator proposed depicts the sum of the federal states that are active in this area. Although municipalities and public waste authorities are the more important actors in this area, data cannot currently be collected for the reasons listed above (see Chapter 4.1.2). Qualitative information should also be recorded and presented. Any federal activities could be described as well. Care should be taken to distinguish this indicator from Indicator 7 (re-use), so that only activities that (also) promote repair are covered. Conversely, pure repair-related measures should be excluded from Indicator 7.

It would also be desirable to include an indicator that displays the number of companies, employees or turnover in the repair trade and specialist shops offering repair services. However, the problem here is that most businesses offering repair services also sell new products and the repair services are not shown separately in their sales. This problem of distinguishing services is also particularly relevant in cases where, for example, electronic equipment is given to the original manufacturer for repair. In some sectors (shoemakers, tailors) there are companies that perform almost exclusively repairs, but these represent only a very small part of the repair trade as a whole and the data therefore do not seem to be sufficient to support an indicator.

Data collection

Indicator 9: Number of federal states that conduct their own repair activities (e.g. information campaign, providing citizens with information, exchange of information between actors, surveys, expert reports, potential analyses, pilot projects) (period-related)

- Current status: 4 federal states (of 8 states that answered the questionnaire) have relevant activities (see Wuppertal Institute et al., ongoing)
- Are the data completely available? – No
- Who collects the data / who is the data source? – The data source are the responsible state and federal authorities, the query would have to be specially carried out via a questionnaire
- Amount of material costs or personnel expenses (working days) for the data: Once the methodology of the survey has been established, a personnel expenditure of approx. 10 working days shall be budgeted to conduct and evaluate the survey for all indicators collected by the survey
- Are the data confidential? – Individual responses yes, but the aggregated/anonymised information for the indicator is not
- Frequency of updates: as needed

- (Stability of) data quality: Stable with the same methodology; the data quality depends on whether only the "correct" activities are actually mentioned (e.g. distinction between repair/re-use, see above); mandatory participation in the survey must be used to ensure that the data are complete

Recommendation

Indicator 9 is recommended despite the limitations mentioned (also due to a lack of alternatives).

4.2.4 Waste preventing product design

4.2.4.1 Support for voluntary measures to prevent waste in product design

Description of the measure area in the WPP (Ch. 4)

Ch. 4.1, "Eco-label":

"Labelling products manufactured to prevent waste using the "Blue Angel" eco-label system or other serious Type I labels for certain product groups can significantly assist consumers in determining which products contribute to waste prevention. (…)"

Note: There is no further description of additional voluntary measures in Chapter 4, but these are described in other areas such as measure No. 8, e.g. contests are mentioned as a tool.

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 8: "Disseminate information and raise awareness for waste-preventing product design"

No. 27: "Utilise product labels for products that conserve resources and thus prevent waste"

No. 34: "Support research and development of measures to extend service life"

Discussed and rejected indicator

- Share of Blue Angel certification criteria which outline waste prevention requirements combined with information as to whether there are label holders for these products (products that actually bear the Blue Angel)

Explanatory notes

There are currently approx. 120 Blue Angel certification criteria that would need to be examined. However, these partially include services. The indicator could focus on products for which repair options are particularly relevant from the perspective of waste prevention. However, there are almost always waste prevention requirements in the certification criteria where this is relevant, mostly with regard to the availability of spare parts (more rarely there are requirements going beyond this, e.g. regarding service life or upgradeability). The indicator value would therefore be quite high from the outset and there would be little room for change.

A possible alternative would be to provide the market share of each product with a Blue Angel label in selected product groups in which Blue Angel waste prevention requirements are particularly meaningful and/or demanding, as there are large variations. However, data on this are usually not available and publication of such data is also likely to be undesirable for the label holder in many cases. Additionally, a small market share of the certified products could lead to justification pressure for Blue Angel.

4.2.4.2 Implementation of mandatory requirements

Description of the measure area in the WPP (Ch. 4)

Ch. 4.1, "Product design":

"The federal government participates at the European level in scientific work to develop measurable criteria for the use of resources in product design (eco-design). Based on the research results, it is to be examined in the following for which products waste prevention criteria can be included in the implementing regulations of the EU Ecodesign Directive (2009/125/EC), if applicable."

The section "Further expansion of product responsibility" in Chapter 4.2 is also related to this content.

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 7: "Identification of product-specific requirements for product design that prevents waste within the framework of implementation measures of the EU Ecodesign Directive (2009/125/EC)"

No. 9: "Regulations on product-based waste management"

No. 10: "Standardisation that supports product design that prevents waste and conserves resources"[47]

Proposed indicator

10. The number or percentage of eco-design implementation measures that define waste-preventing, eco-design requirements

Explanatory notes

There are currently almost 30 eco-design implementation measures that would need to be reviewed. This mainly defines requirements for energy efficiency during operation in most cases, while waste prevention requirements currently exist in about four cases[48]. Waste prevention requirements in eco-design implementation measures can be very important, as the requirements of these measures apply to all products that fall within their scope across the EU.

It must be precisely defined which requirements are regarded as waste preventing. No generic requirements should be considered (example: information on disassembly or correct disposal at the end of the use phase), instead only specific requirements concerning service life, reparability, possibilities for re-use, etc.

It is possible for the indicator value to change as a result of structural changes which do not affect the content, e.g. if several regulations are merged into a single regulation (as is currently planned in the area of lighting). Some qualitative information on the nature of the requirements and the product groups concerned should therefore be provided in addition to the pure numerical value, at least as long as the number of measures containing waste prevention requirements is low.

Although the subject of the indicator is not decided at the national level but instead at the European level, federal authorities can influence whether waste prevention requirements are included in the implementation of the Ecodesign Directive through their opinions and voting behaviour in the decision-making body, the Regulatory Committee. Including the indicator in the assessment of the German WPP

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47 Although the standards are initially non-binding, they can form the basis for mandatory measures.

48 Regulations on vacuum cleaners (service life requirements for individual components) and lighting (currently three different regulations for different lamp types, each containing service life requirements for lamps). The regulation on computers also contains a requirement that laptops containing a battery that cannot be replaced by the user must be provided with appropriate information; it would have to be clarified in the context of data collection whether this is regarded as a waste prevention requirement.

would therefore contribute to increasing the importance of waste prevention requirements while implementing the Ecodesign Directive.

Data collection

Indicator 10: The number or percentage of eco-design implementation measures that define waste-preventing, eco-design requirements

- Current status: Approx. 4 of 28 eco-design implementation regulations currently contain requirements to prevent waste
- Are the data completely available? – No, they would have to be specifically compiled
- Who collects the data / who is the data source? – Data source of the regulations is the Official Journal of the EU or the list from the EU Commission[49]; the regulations would have to be evaluated for the indicator
- Amount of material costs or personnel expenses (working days) for the data: the personnel expenses include approx. 2-3 working days for the initial examination of the regulations and description of the waste prevention requirements, it is lower for subsequent updates
- Are the data confidential? – No
- Frequency of updates: as needed
- (Stability of) data quality: This depends on whether there is a continual understanding of evaluating which requirements are considered waste preventing; this should be ensured by jointly collecting qualitative information

Recommendation

Indicator 10 is recommended.

4.2.5 Product use increase – product service systems

Description of the measure area in the WPP (Ch. 4)

Ch. 4.1, "Consumer waste prevention":

"For consumer waste prevention, wider distribution and intensive use of product service systems is advocated. (...) These product service systems should be supported by appropriate legal and political conditions and promoted by public authorities as a concrete form of waste prevention."

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 21 "Promotion of waste preventing product service systems"

Discussed and rejected indicator

- Degree to which households are equipped with selected products

Explanatory notes

The degree to which households are equipped with selected consumer goods is calculated annually by the Federal Statistics Office.[50] Both the degree of equipment and the average number of goods per 100 households are determined during this process. This includes data regarding equipment with cars and other vehicles (including bicycles), consumer electronics, information and communication technology,

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49 European Commission (2018a): Ecodesign legislation, https://ec.europa.eu/energy/sites/ener/files/documents/list_of_ecodesign_measures.pdf.

50 See Destatis (2016a): Ongoing economic calculations: Equipment of private households with select consumer goods, Fachserie 15, Reihe 2. Wiesbaden.
Survey during current economic calculations, based on an inquiry of approx. 8,000 households.

household appliances and other appliances (e.g. washing machines, exercise bikes, printers, game consoles). Indicators could be created using the data collected by selecting individual goods that are particularly suitable for shared use or that have comparatively well-established systems for shared use. Unfortunately, data are not available for all products that can be easily shared (e.g. tools). In the second technical discussion conducted during the project, it was determined that the degree to which households were equipped with certain goods used as an indicator of the use of product service systems needed too much clarification and was not suitable and was therefore rejected.

Further possible indicators on implementing measures: A fundamental problem relating to intensification of use is to define the term "product service system" and, in particular, to determine which product service systems are to be classified as preventing waste. Counting the existing product service systems does not seem effective, as very different types of systems, shared products and system ranges would be mixed together. To the best of our knowledge, no such data is currently available.

4.2.6 Preventing food waste

Description of the measure area in the WPP (Ch. 4)

Food waste has not yet been given a separate section in the WPP but can be found in Ch. 4.1 in the second paragraph of "Consumer waste prevention measures" and in the last paragraph of "Waste prevention measures in companies":

"Information campaigns are being launched or continued as an essential component of sensitising consumers to aspects of waste prevention. Campaigns on purchases that prevent waste (quantities, package size, shelf life/expiration date, reusable packaging) will play a major role in this. (…)"

"With regard to preventing food waste, concerted actions and agreements between public institutions and industry/trade should be encouraged to reduce food waste generated along the production and supply chain. The aim is to reduce food waste by focusing on the entire value chain – not just consumer behaviour – in order to reduce waste".

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 17: "Voluntary agreements with retail and catering on training measures in view of ensuring that stores and restaurants are supplied with food in accordance with their needs"

No. 28: "Concerted action to prevent food waste"

Note: Many other possible measures that could be used to impact relevant areas are lacking so far, e.g. handling guidelines for the food industry and food consumed out of the house, information on waste prevention for handling in private households, integrating the topic into education, vocational and further training, consideration of food waste prevention when awarding catering contracts and cafeteria licences, etc.

Proposed indicator

11. Number of federal states that have conducted food waste prevention activities (e.g. information campaign, events, publication of recommendations, establishment of a working group, research project) (period-specific)

Explanatory notes

Most, but not all, of the federal states are quite active in food waste prevention. The proposed indicator depicts the sum of the federal states that are active in this area. It would be useful to collect and present some qualitative information on the nature of the activities, likewise the activities of the federal government could be presented with this information.

The information on the development of the volume of food waste (a "pressure" indicator) could also be assigned as an indicator, however this is already part of the proposed overarching indicators (see information on Indicator 3 in Chapter 3.2.1).

Data collection

Indicator 11: Number of federal states that have conducted food waste prevention activities (e.g. information campaign, events, publication of recommendations, establishment of a working group, research project) (period-specific)

- Current status: 10 federal states (of the 12 states that answered the questionnaire) report having conducted such activities (see Wuppertal Institute et al., ongoing)
- Are the data completely available? – No
- Who collects the data / who is the data source? – The data source are the responsible state and federal authorities, the query would have to be specially carried out via a questionnaire[51]
- Amount of material costs or personnel expenses (working days) for the data: Once the methodology of the survey has been established, a personnel expenditure of approx. 10 working days shall be budgeted to conduct and evaluate the survey for all indicators collected by the survey
- Are the data confidential? – Individual responses yes, but the aggregated/anonymised information for the indicator is not
- Frequency of updates: as needed
- (Stability of) data quality: Stable with the same methodology; the data quality depends on whether only the "correct" activities are actually mentioned; mandatory participation in the survey must be used to ensure that the data are complete

Recommendation

Indicator 11 is recommended.

4.2.7 Public procurement

Description of the measure area in the WPP (Ch. 4)

Ch. 4.1, "Waste prevention in public procurement":

"The current public procurement law already offers a wide range of possibilities for the ecologically sustainable procurement of products and services by the government authorities. This also generally includes the consideration of waste prevention aspects. However, in order to facilitate the work of the issuing offices, it is advisable to provide appropriate work aids (e.g. concrete tender recommendations) in a timely manner and to promote them accordingly. These must take into account the budgetary principles of efficiency and economy. (…)"

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 29 "Consideration of waste prevention aspects in public procurement"

No. 33 "Designing events in public institutions to prevent waste (reusable instead of disposable)"

[51] It was also proposed to use the German Federal Ministry for Food and Agriculture website https://www.lebensmittel-wertschaetzen.de/aktivitaeten/ for data collection, which lists food waste prevention activities. However, this includes mainly activities through private initiatives.

Proposed indicator

12. Number of federal states that have guidelines on public procurement in which the aspect of waste prevention is explicitly addressed

Explanatory notes

Although §45 KrwG and regulations at the state level provide for a testing obligation or target regulation for aspects such as longevity, ease of repair and re-use in public tenders, the testing obligation is hardly applied in practice. Some federal states have guidelines that address these aspects. While following such guidelines is voluntary and therefore their mere existence does not provide information on their real-life application, they do indicate a degree of involvement and attention to the issue in public procurement.

It is necessary to define which approaches to public procurement are regarded as waste prevention (e.g. procurement of used goods, durable, easy to repair products) for the indicator. Some qualitative information on the nature and scope of the requirements/proposals should also be collected in order to provide an indication as to how extensively and in depth the issue has been considered.

Data collection

Indicator 12: Number of federal states that have guidelines on public procurement in which the aspect of waste prevention is explicitly addressed

- Current status: Guidelines on sustainable procurement are available from several federal states (these have not been evaluated in detail) (source see footnote below)
- Are the data completely available? – No
- Who collects the data / who is the data source? – The data would have to be specifically collected. The guidelines have been compiled by organisations such as the Competence Centre for Sustainable Procurement (KNB)[52]; it would also be useful to conduct further research to find out whether other current guidelines are available
- Amount of material costs or personnel expenses (working days) for the data: Approx. 2 working days of personnel expenses are to be scheduled for the first compilation and evaluation of the present guidelines, less for subsequent updates
- Are the data confidential? – No
- Frequency of updates: as needed
- (Stability of) data quality: Depends on whether there is a consistent understanding in the evaluation of when the waste prevention aspect is explicitly addressed; this should be ensured by collecting qualitative information as well

Recommendation

Indicator 12 is recommended despite the limited binding nature of the guidelines (also due to a lack of alternatives).

[52] See Procurement Office of the Federal Ministry of the Interior (2012): The central portal for sustainable procurement of contracting authorities, http://www.nachhaltige-beschaffung.info/DE/Home/home_node.html.

4.2.8 Disposal costs based on the polluter pays principle

Description of the measure area in the WPP (Ch. 4)

Ch. 4.1, "Waste prevention through disposal costs based on the polluter pays principle":

"In the field of waste disposal structures, disposal costs based on the polluter pays principle incentivise waste prevention. Disposal costs often represent a larger cost centre, particularly for producers of large quantities of waste in industry and commerce. These costs can be reduced by appropriate streamlining and using materials more efficiently. Waste disposal fees also serve to sensitise citizens to the amount of waste they produce. The price effect also encourages them to better separate waste as well as to avoid purchases that generate waste. The waste prevention effect will only be achieved or enhanced if specific waste consulting measures accompany the introduction of waste prevention fees based on the polluter pays principle. The private disposal companies will determine the prices for disposal while the public waste authorities determine the waste fee systems. It must be ensured that waste is not disposed of improperly, i.e. illegal dumping, because of the pricing."

Related waste prevention measures from the Annex (Ch. 6 WPP)

No. 22: "Promotion of waste disposal structures and systems that promote waste prevention"

Desirable indicators

- Share of public waste authorities whose fee statutes provide for charging for residual waste according to the polluter-pays principle (better still would be: share of households connected to corresponding systems)
- Municipal waste connected to appropriate systems[53]

Explanatory notes

While it should be possible to make a fundamental distinction between "polluter-pays" tariffs and non-polluter-pays tariffs, in practice it may be difficult to identify the local authorities/municipalities that have established such a tariff. To the best of our knowledge, no aggregated data are available on this subject. We therefore assume that this area cannot currently be represented by indicators.

[53] This is a "pressure" indicator and not a "response" indicator.

5 Decomposition analyses and reference scenarios

5.1 Objective and procedure

A reference scenario must be created in many areas to develop indicators that can be used to monitor the success of waste prevention measures. This scenario would illustrate changes in waste quantities, etc. without specific waste prevention measures (business as usual reference scenario). The difference between reference scenario and real development could then theoretically be interpreted as successful waste prevention measures. However, in reality a variety of often interdependent factors impact waste generation, including overall economic development, population development, household size, plus factors that are much more difficult to measure such as product innovation, changes in consumption patterns, etc.

Simplifying assumptions of this reality are often made while developing waste management plans and concepts. These serve to develop waste reference scenarios. The necessary qualified baseline scenario was built on these pragmatic approaches that were developed further using the procedure outlined below.

A narrow selection of specific waste streams[54] was assigned a selection of influencing factors regarding social or economic basic development that can be presumed to be relevant for generating this specific waste. A decomposition analysis of these factors and the respective development of the volume of the specific waste stream in recent years was then carried out to identify the correlations between the development of the influencing factors and the development of the volume, thereby showing the effect that the drivers of the various waste streams have. The simulation models resulting from the findings of the decomposition analyses were then validated by means of historical time series and were subsequently used to develop the reference scenarios.

The decomposition analysis is used to estimate a suitable indicator for waste generation y as a result of the interaction of e.g. four driving or braking forces a, b, c and d:

$$y(t) = a(t) \cdot b(t) \cdot c(t) \cdot d(t)$$

The aim of the decomposition analysis is to explain the variation Δy of the indicator y between two points in time using the variations $\Delta a, \Delta b, \Delta c$ and Δd of the determinants a, b, c and d, or in other words to determine the weights w_a, w_b, w_c and w_d :

$$\Delta y(t) = w_a \cdot \Delta a(t) + w_b \cdot \Delta b(t) + w_c \cdot \Delta c(t) + w_d \cdot \Delta d(t)$$

The weights w_a to w_d will be re-used to develop a reference scenario by adopting assumptions for the variations of the determinants a to d. This generates scenario values for indicator y.

[54] These can be understood as a type of guiding waste streams of different waste generation and prevention processes.

5.2 Results

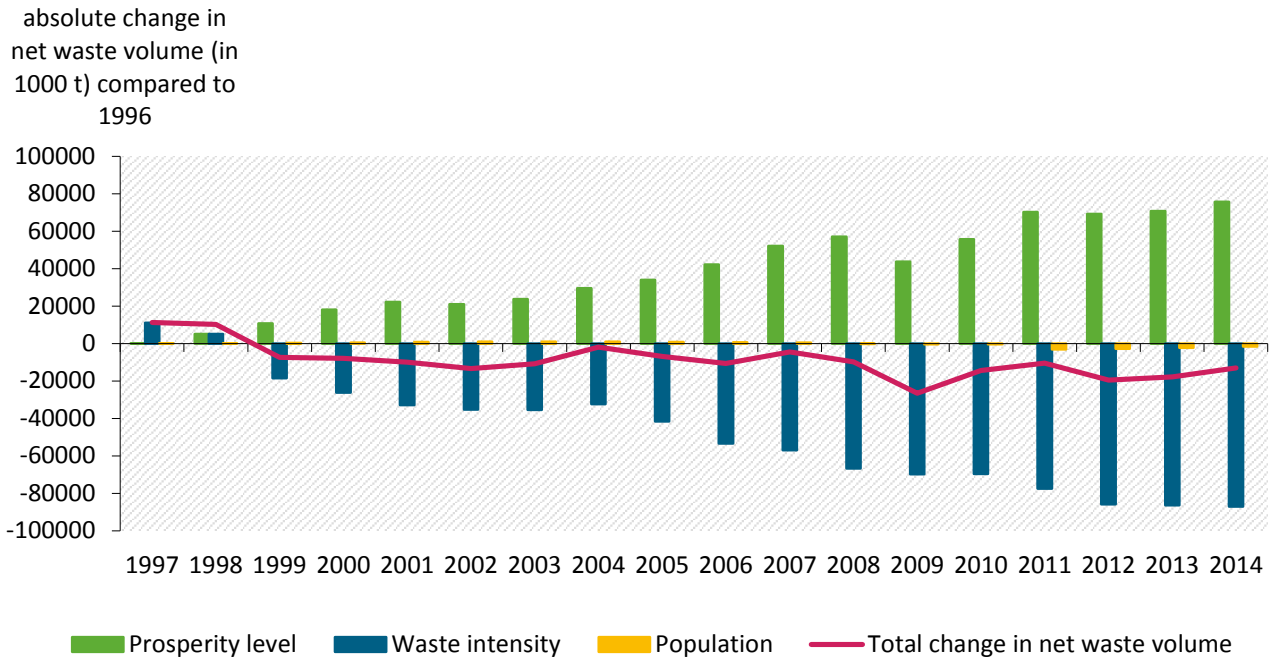
The most important results of the calculations for net waste volume and typical household waste are presented in the following. [55]

Results of the index decomposition analysis #1 – net waste volume (without construction and demolition waste)

The following index decomposition analysis contains economic and population determinants without distinguishing between industrial and service waste generation.
The index decomposition analysis (IDA) enables the contributions of the various determinants to be shown in isolation, thus illustrating the respective contributions to the changes in the net volume of waste (net waste volume without construction and demolition waste) during the calculated period between 1996 and 2014. By using the IDA, the direct effects on the changes in the net waste volume can be measured for the level of prosperity, the waste intensity of the entire economic sector and the population level. The following figure shows how much each determinant cumulatively contributed to increasing or decreasing the net waste volume compared to 1996. The total change in net waste volume is also depicted by a line in Figure 14. It is clear in the results that the annual change in the net waste volume indicator is small over time, yet it exhibits an overall declining trend. The variations in the main determinants of prosperity level (causes the net waste volume to increase) and waste intensity (causes the net waste volume to decrease) almost balance each other out. However, the contribution of waste intensity must be slightly stronger since the population level has almost no influence. This is hardly surprising given the relatively stagnant population.

55 The decomposition calculations presented in this chapter were performed with economic data at current prices rather than with more appropriate data at constant prices, as the latter were not available when the report was produced. Results from calculations with data at constant prices usually show only minor changes.

Figure 14: Index decomposition analysis of changes in the net waste volume (net waste volume without construction and demolition waste) for Germany (reference year 1996) using three determinants (prosperity level, waste intensity of the entire economic sector, population level)



Source: Own calculations

Ex-ante simulation – net waste volume (without construction and demolition waste)

Values for net waste volume during the period from 2015-2025 were simulated based on net waste volume simulations for the period from 2005-2014 using three variants for calculating the weights and validating the most suitable option. The result is shown in the following figure (red curve). The blue curve represents the statistical net waste volume data for 1996-2014, while the green curve represents the linear extrapolation of the net waste volume values from the 1996-2004 time period to the 2005-2025 time period (sim#0). The generated data points (sim#1) would therefore represent a reference scenario.

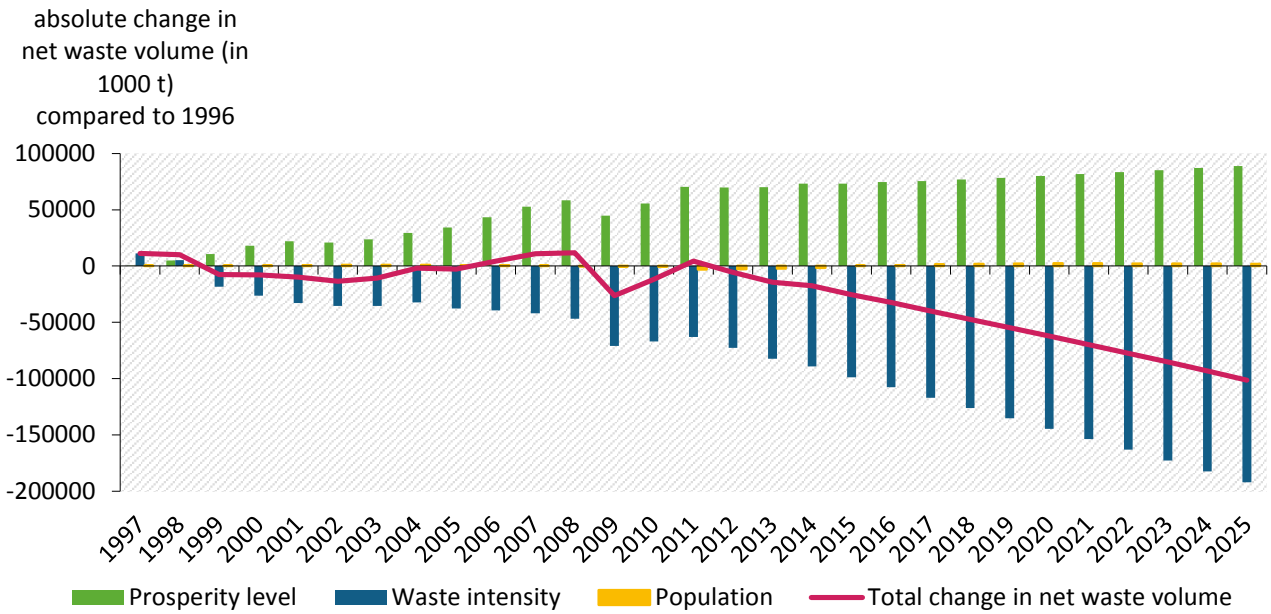
For the reference scenario in the figure below, a uniform GDP growth rate of +1.8 % per annum has been assumed until 2025.

Figure 15: Reference scenario until 2025 using variant 1 for the calculation of weights (net waste volume sim#1), compared with a linear extrapolation of net waste volume values from the 1996-2004 time range (net waste volume sim#0)

Source: Own calculations

An index decomposition analysis of the simulation results was performed with these projected data (Figure 16). The IDA shows that the declining waste intensity explains the declining net waste volume from the simulation. The effect of the waste intensity is therefore stronger than the increasing momentum of the wealth effect.

Figure 16: Index decomposition analysis of changes in the net waste volume (net waste volume without construction and demolition waste) for Germany (reference year 1996) using three determinants (prosperity level, waste intensity of the entire economic sector, population level). 1997–2004: statistical net waste volume values. 2005–2025: simulated net waste volume values (net waste volume sim#1)



Source: Own calculations

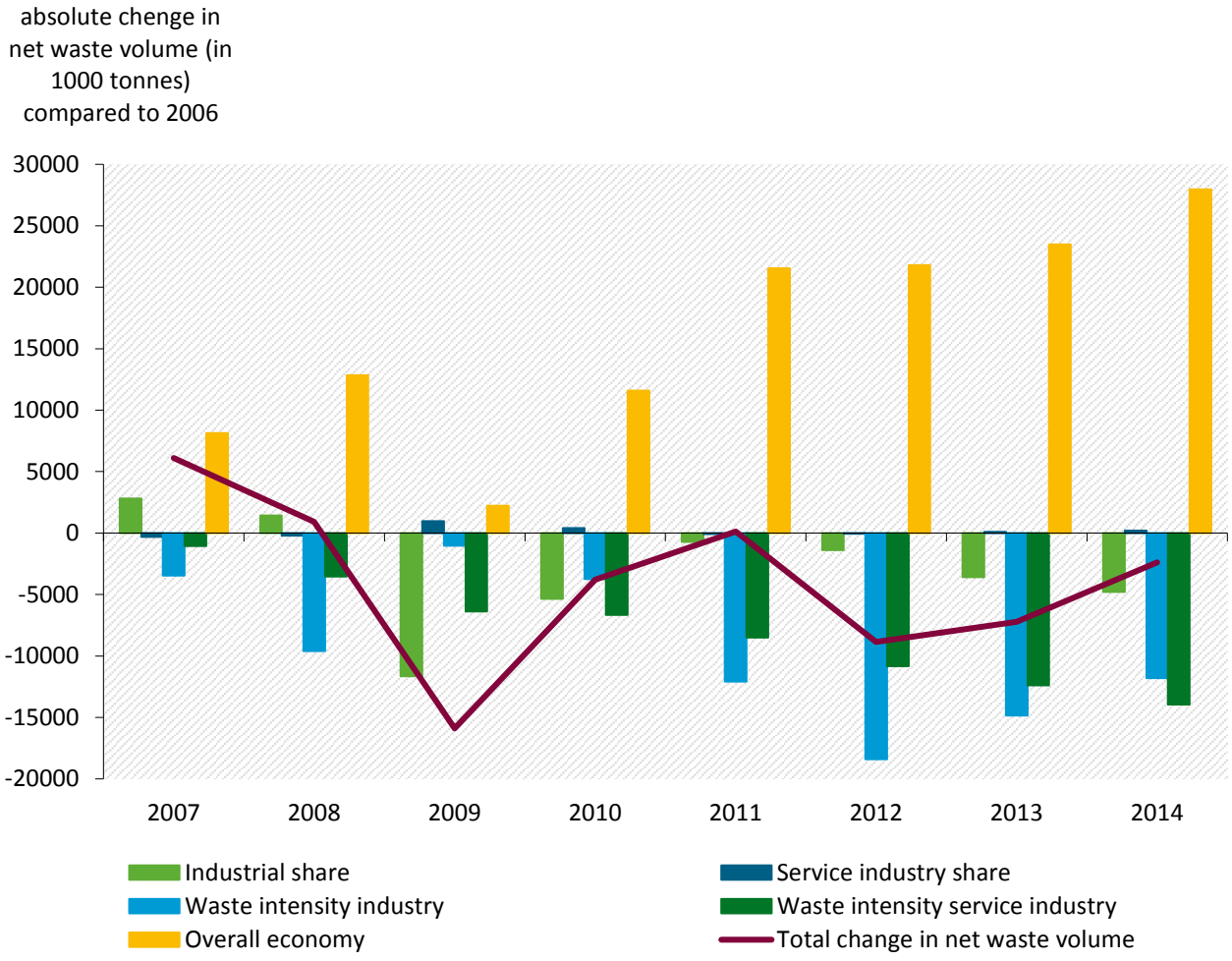
Results of the index decomposition analysis #2 – net waste volume (without construction and demolition waste)

The following index decomposition analysis contains separate economic determinants for industry and services.

The IDA isolated the contributions of the various determinants, which then explain the changes in net waste volume (net waste volume without construction and demolition waste) between 2006 and 2014. The IDA measured the direct effects of the economic structure (shares of industry and services in the total production value), the waste intensity of the industrial and service sectors and the production value of the economy as a whole on the changes in the net waste volume. Figure 17 shows how much each determinant contributed to increasing or decreasing the net waste volume compared to 2006. The entire change in net waste volume is also depicted.

The total production value acts as a driving factor for net waste volume. In 2007 and 2008, the increasing share of industry in the total production value also had a driving effect, albeit smaller. As of 2009, the share of industry in the total production value has decreased, thereby becoming a braking determinant. The declining waste intensities of both industry and the service sector also act as braking factors. Surprisingly, however, the increasing share of services in the total production value has no visible effect.

Figure 17: Index decomposition analysis of changes in net waste volume (net waste volume without construction and demolition waste) for Germany (reference year 2006) using five determinants

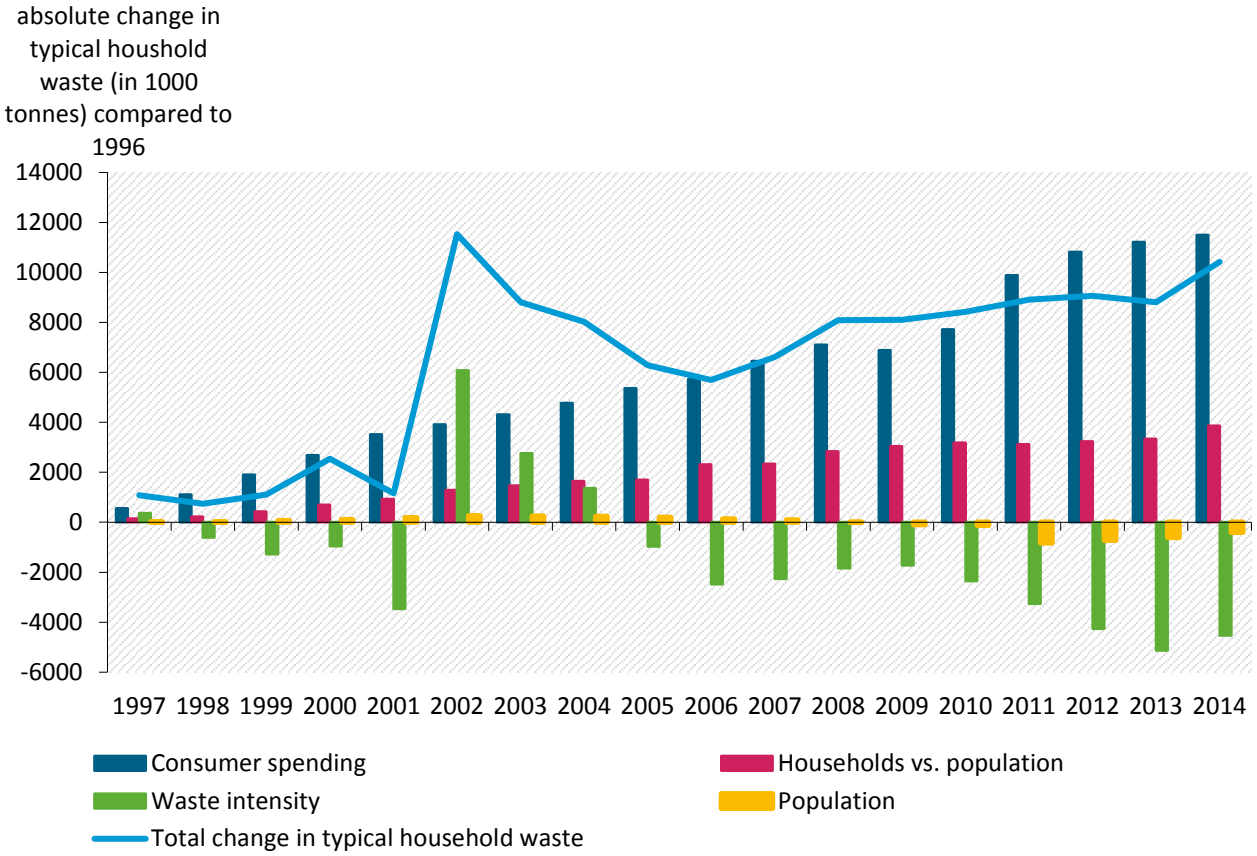


Source: Own calculations

Results of the index decomposition analysis – typical household waste

The following index decomposition analysis contains economic and household or population determinants.
The IDA enables the contributions of the various determinants to be shown in isolation, thus illustrating the contributions each determinant made to the changes in typical household waste between 1996 and 2014. The IDA consequently measures the direct effects of household consumption expenditure, the ratio of households to total population, the waste intensity of private consumption expenditure and the population level on changes in typical household waste. The following figure shows how much each determinant cumulatively contributed to increasing or decreasing typical household waste compared to 1996. The total change in typical household waste is also depicted by a line in Figure 18. It is clear in the results that the typical household waste indicator has risen overall compared to the level in 1996, although not at a constant rate. The variations in the main driving determinants of consumption expenditure per household (increasing typical household waste) are up to four times greater in absolute terms than the main braking variations in the determinants of waste intensity of private consumption expenditure (decreasing typical household waste, except for the period 2002-2004). Added to this is the further driving effect of the growing number of households compared to total population (i.e. the decreasing trend in average household size). The population level, as opposed to the other three determinants, has almost no influence. This is hardly surprising given the relatively stagnant population.

Figure 18: Index decomposition analysis of changes in typical household waste for Germany (reference year 1996) using four determinants (consumption expenditure per household, ratio of number of households to total population, waste intensity of private consumption expenditure, population level)



Source: Own calculations

5.3 Conclusion

The results of the decomposition analyses and the reference scenarios developed based on the analyses illustrate the complexity of the factors that ultimately lead to waste generation. A deeper understanding of the relevance of these factors and especially of their multiple interrelationships is required to develop customised waste prevention measures and especially to gauge the effectiveness of these measures.

The decomposition analyses conducted during the project refer particularly to the importance of the waste intensity factor, i.e. the ratio of waste generation to production value. In the past, clear decoupling of waste generation from economic growth could be observed in Germany. This was essentially due to an economic structural change towards a higher proportion of services, to technical progress and also possibly to measures taken by the public authorities to prevent waste. If this trend is adopted in decomposition analyses, the various scenarios will partly show a strong decrease in waste volume.

This is where we can also see the overall limits of the decomposition analysis approach, especially for scenario development. Past trends are adopted here in contrast to more complex macro-economic modelling. Conversely, the strength of the approach lies clearly in identifying drivers of waste generation; for example, the development of consumer spending has a much greater influence on household waste generation than the discernible reduction in the number of people living in households, which is also repeatedly cited as a factor. The results could thus represent a valuable basis for generating hypotheses on the sociological factors of waste prevention, such as those currently being investigated as part of an ongoing project.[56]

[56] Research project “Identifizierung soziologischer Bestimmungsfaktoren der Abfallvermeidung und Konzipierung einer zielgruppenspezifischen Kommunikation” (Identification of sociological determinants of waste prevention and conception of target group-specific communication; UFOPLAN research code 3717 34 333 0).

6 Further development of the waste prevention programme

The results obtained during this project provide numerous pointers that could be taken into account when revising the WPP of the federal government and the federal states in accordance with the requirements of the EU WFD.

Overall, the methodological challenges already mentioned in the WPP were confirmed when measuring the success of waste prevention measures in the public sector. A direct causal link between implemented measures such as waste prevention campaigns and the generation of waste cannot be demonstrated methodologically, particularly not in highly aggregated waste statistics. In particular, the available data cannot be used to derive any information on specifically avoided environmental impacts caused by waste, as these impacts can be extremely different depending on the spatial and temporal context.

Nevertheless, the approach developed during the project of a combined perspective allows for the development of aggregated waste and material flows along with the consideration of specific waste prevention measures to provide important information on

- possible priority areas for action, e.g. when specific waste streams increase;
- the possible need for additional government measures, for example if the development of repair networks has not yet led to the anticipated number of such measures
- or possibly on measures that are already sufficiently implemented by non-state actors, e.g. due to identified cost reduction potentials.

It can also be observed, however, that not all sub-targets mentioned in the WPP can be assigned to robust and reliable indicators, e.g. with regard to the intensity of use of different product groups. Changes in the volume of separately collected waste streams such as paper, cardboard and paperboard may also be attributed to waste prevention measures but are also determined by changes in collection logistics and no clear conclusions can be drawn from changes in the indicator.

The analysis of the available European and international waste prevention programmes and the indicators mentioned in the programmes shows that the term waste prevention is often not as narrowly defined as in the German WPP and that some measures in the foreign programmes are also covered by indicators in which, for example, the waste volume can be reduced through recycling and the use of secondary raw materials. The topic of littering is also partially covered by indicators under the title of waste prevention.

There is considerable uncertainty or need for research regarding the issue of possible waste prevention targets that can be measured in terms of degree of fulfilment by waste prevention indicators. Politically agreed targets exist only in individual cases such as food waste prevention. This poses particular challenges for the necessary data collection concept. However, there are still no suitable targets for the vast majority of waste or material flows or waste prevention activities. The analysis of the European and international waste prevention programmes shows, however, that in many cases such targets have been set politically in order to create incentive structures and connecting factors for actors in waste prevention. In the vast majority of cases, there is no scientific basis for these targets, similarly to politically set recycling quotas for example.

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8 Annexes

1. Annex I: Preselection of waste prevention indicators for RACER evaluation

Based on a total list of more than 400 indicators, the list was adjusted for

- duplication,
- obvious references to recycling instead of waste prevention and
- country-specific regulations without transferability to Germany.

The following list of 90 waste prevention indicators was used as an initial starting point to develop a set of indicators for Germany.

Table 18: Preselection of waste prevention indicators for RACER evaluation

No.	Indicator
1	Environmental education programmes or campaigns
2	Certified or eco-labelled products
3	Industrial waste volume
4	Hazardous waste volume
5	Amount of food in residual waste
6	Sharing of re-used electrical appliances
7	Packaging re-use
8	Number of training measures for waste prevention in certain regions
9	Share of waste management with polluter-pays waste fee system
10	Annual volume of municipal waste produced
11	Increasing the amount of separately collected municipal waste
12	Re-use rate of materials from the construction and demolition sectors
13	Number of authorised re-use centres
14	Size of the population served by the re-use centres
15	Ratio of distributed second-hand products to submitted quantity in re-use centres
16	Number of companies implementing ISO 14001
17	Number of events related to waste prevention
18	Amount of waste prevented
19	Number of companies reached through waste prevention programmes
20	Number of households/communities reached through waste prevention programmes
21	Number of stickers to stop advertising mail
22	Number of agreements to promote online communication
23	Number of companies selling loose/unpackaged products
24	Number of information campaigns promoting the use of tap water
25	Number of campaigns to raise consumer awareness to consume and recycle less waste-intensive EEE

No.	Indicator
26	Municipal and other waste collected and quantity in preparation for re-use
27	Collected WEEE and quantity in preparation for re-use
28	Collected amount of biodegradable municipal waste
29	Reduction of food waste
30	Reduction of the amount of textiles thrown away
31	Reduction of municipal waste per person per day
32	Reduction of packaging waste per person per day
33	Reduction of paper and cardboard waste per person per day
34	Total waste production
35	Amount of waste produced per economic sector
36	Amount of waste produced per year and GDP
37	Amount of construction and demolition waste per year and GDP
38	Amount of packaging waste per year
39	Amount of WEEE per year
40	Amount of end-of-life vehicles per year
41	Amount of used tyres per year
42	Amount of battery waste per year
43	Number and economic value of research and development, annually implemented innovation projects related to waste prevention and sustainable consumption
44	Number of waste awareness campaigns per year
45	Number of voluntary agreements reached per year
46	Total number of registrations for EMAS/other environmental management systems
47	Waste generation per unit of GVA in constant price conditions
48	Amount of waste produced per sector and per unit of GVA
49	Carbon intensity of waste
50	Development of sale of environmentally-friendly products regarding waste prevention
51	Development of renting/leasing
52	Development of repairs
53	Ecological impact combined with waste prevention measures
54	Prevented environmental impacts linked to less waste
55	Prevented environmental impacts due to compensation from waste prevention measures
56	Direct material input
57	Prevented raw material extraction
58	Number of households/people composting at home, quality of compost
59	Amount of disposable drinks per litre
60	Amount of printed free advertising brochures per year
61	Amount of waste produced by an individual company compared to the average

No.	Indicator
62	Voluntary procedure for retailers to reduce packaging waste
63	Use of waste management plans for construction sites
64	Promotion of waste prevention through eco-school programmes
65	Number of events with low waste generation
66	Number of participants in the training measures
67	Number of recycling centres and second-hand shops
68	Percentage of the population that regularly shops at second-hand stores
69	Quantity of food waste per year in tonnes
70	Quantity of secondary raw materials used in production per year in tonnes
71	Number of NPOs with activities to prevent waste and conserve raw materials
72	Number of new legal instruments
73	Number of voluntary agreements on waste prevention
74	Quantity of waste prepared for re-use
75	Decoupling household waste from household consumption expenditure
76	Decoupling the generation of non-hazardous, non-mineral waste from economic activity and GDP
77	Domestic material consumption
78	Amount of commercial and industrial waste
79	Greenhouse gas emissions associated with preventable food waste
80	Quantity of food waste produced vs. consumption of food in tonnes
81	Waste volume from the construction and demolition sectors per unit of GVA
82	Material consumption in building construction per floor area of new buildings
83	Ecological impact vs. consumption of building materials
84	Volume of WEEE per unit of GDP per capita
85	WEEE vs. EEE on the market
86	Number of second-hand shops offering EEE
87	Textile waste volume
88	Purchase of second-hand textiles
89	Share of second-hand products in total textile products on the market
90	Number of textile product models with eco-labels

Source: Own compilation