National waste prevention programs: indicators on progress and barriers

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Abstract
Defining the prevention of waste as top priority of the waste hierarchy—as confirmed by the revised Waste Framework Directive (WFD)—is much more than a simple amendment of ways to deal with waste, but means nothing less than a fundamental change of the socio-technical system of waste infrastructures and requires a transition from end-of-pipe technologies towards an integrated management of resources. The WFD therefore obligates member states to develop national waste prevention programs as a new policy instrument with the development of waste prevention indicators as one of the core elements. The article discusses the limitations of waste-based key figures and shows the need for more process-oriented indicators. As part of the development of national waste prevention programs such indicators reveal the relevance of different barriers that have to be overcome in order to make prevention an effective top priority in the waste hierarchy. With regard to path dependencies caused by sunk costs in end-of-pipe waste infrastructures the absolute amount of integrated environmental investments, as well as their share of the total waste-related investments, can be seen as indicators for the level of innovation activities aimed at waste prevention. Sector-specific indicators for the production phase could be used as benchmarks and to highlight differences in the need for policy interventions.

Keywords
Waste prevention, indicators, eco-innovation, path dependencies, waste incineration, incentives

Introduction
Defining the prevention of waste as the top priority of the waste hierarchy—as confirmed by the revised waste framework directive (WFD, Directive 2008/98/EC)—is much more than a simple amendment of ways of dealing with waste, but means nothing less than a fundamental change of the socio-technical system of waste infrastructures and requires a transition from end-of-pipe technologies towards an integrated management of resources (see ISWA, 2011). Facing the dimension and complexity of this task it is not surprising that waste-prevention as a policy approach has so far not gained sufficient relevance within the European Union (EU) (see Gentil et al., 2011). The WFD therefore obligates member states to develop national waste prevention programs (NWPPs) as a new policy instrument with the development of waste prevention indicators as one of the core elements.

This article highlights the challenges of such a program with regard to two questions: (i) How do we measure waste prevention?; and (ii) Where are the linkages to the waste management sector itself? The assumption is that a stronger focus and analysis of existing barriers for waste prevention are needed in order to boost innovations in the prevention of waste. The article is structured as follows: first, I describe the specific task of developing NWPPs; second, I focus on the question of waste prevention indicators. Then, I describe a theoretical framework which highlights the role of different path dependencies in the waste management sector for the success or failure of public waste prevention measures, in particular. Their relevance is described using Germany as an example. Conclusions are then drawn from these findings for the development of more process- and innovation-oriented indicators. Finally, there is a summary and a description of the requirement for further research.

Development of NWPPs
The amended EU WFD confirmed the prevention of waste as a priority measure to protect the environment with regard to the production and handling of waste. According to article 29 no. 1 WFD the prevention measures have to be planned in terms of waste prevention programs to be created by member states until 12 December 2013. These prevention programs have to describe existing waste prevention measures and must set specific waste prevention targets aiming at the decoupling of the environmental impacts associated with the generation of waste and economic growth. According to these requirements some member states...
have already developed NWPPs, which have mostly been included in waste management plans or other environmental programs, for example in Austria, Finland and Luxembourg.

In Germany, a research project funded by the Ministry of Environment and the Federal Environmental Agency has developed scientific and technical foundations for a NWPP. The project has collected and analyzed the vast number of public sector measures in Germany that already help to avoid waste generation in Germany. The analysis focused on public measures, but took also into account legal frameworks or economic incentives for private prevention measures. They are complemented by corresponding measures from abroad or measures taken from the literature as a basis for the NWPP in Germany (see Dehoust et al., 2010). More than 300 different measures are described, covering all fields of action mentioned in annex IV of the WFD:

- measures that can affect the framework conditions related to the generation of waste;
- measures that can affect the design and production, and distribution phase;
- measures that can affect the consumption and use phase.

Based on these results the contents of the German NWPP are developed in a second, ongoing research project with the participation of the federal states and other public stakeholders. The special challenge of such a program turns out to be the ecologic assessment of generic instruments beyond the specific context of their implementation. Criteria have to be developed under which conditions such instruments can be used efficiently and have relevant impacts.

**Indicators for waste prevention**

According to article 29 no. 3 WFD the member states shall determine appropriate specific qualitative or quantitative benchmarks for waste prevention measures adopted in the NWPPs in order to monitor and assess the progress of the measures. The member states are free to determine specific qualitative or quantitative targets, and indicators for the evaluation of their efforts.

This is in contrast to specific weight-based targets, for example for the recovery and recycling of different waste streams as set in article 11 ‘in order to move towards a European recycling society with a high level of resource efficiency’ (recital 41 WFD).

In the general context of environmental programs, indicators offer the opportunity to reflect specific effects and changes in complex systems. They provide the basis to evaluate existing and planned projects, to review the achievement of targets, and to facilitate dialogue with policy makers and public stakeholders. Benchmarking between different spatial entities motivates local actors to invest more time, effort and responsibility in the objectives (see OECD, 2004). In addition, indicators can also fulfill a second important function: facing the huge number of possible prevention measures that theoretically could be taken by the public sector, and, taking into account limited financial resources and also organizational capacities, indicators allow comparison of the effectiveness of different measures, and thus to select and prioritize, as an important step for the development of a NWPP.

On one hand, it is indicative that quantitative targets as an element of NWPPs could increase the binding nature of such programs. On the other hand, quantitative targets only make sense if these targets can be derived from a sound theoretical foundation and can be monitored by appropriate indicators. Both aspects are discussed in the following section.

**Targets of waste prevention according to the WFD**

Every waste prevention measure has to be based on article 1 of the WFD, which states that the directive ‘lays down measures to protect the environment and human health by preventing or reducing the adverse impacts of the generation and management of waste and by reducing overall impacts of resource use and improving the efficiency of such use’. NWPPs shall concentrate ‘on the key environmental impacts and taking into account the whole life-cycle of products and materials […] and should pursue the objective of breaking the link between economic growth and the environmental impacts associated with the generation of waste’ (recital 40 WFD).

In addition to these overall goals the directive describes sub-goals regarding the prevention of waste which can be derived from article 3 no. 12 WFD. The given definition states that waste prevention means ‘measures taken before a substance, material or product has become waste, that reduce:

a. the quantity of waste, including through the re-use of products or the extension of the life span of products;

b. the adverse impacts of the generated waste on the environment and human health; or

c. the content of harmful substances in materials and products.’

These sub-goals are no ends in themselves. Rather, it is assumed that their implementation normally supports to achieve the main goal of minimizing the adverse effects of waste generation on human health and the environment (see Dehoust et al., 2011).

Nevertheless, this leads to a relativization of the objective to reduce the total amount of waste. The generation of waste has to be put in relation to economic growth and its prevention is also subject to the condition that—taking into account life cycle-thinking on the overall impacts of the production and management of waste—it shows the best results in terms of environmental protection (see article 4 no. 2 WFD).

Given this variety of potentially conflicting targets, it is important to develop a systemic approach that takes into account these interdependencies in order to choose the targets as of waste prevention program. By choosing such a chain approach it is possible to assess which particular measures support each other, to identify the areas in which measures may be missing and how the most efficient combination of measures can be achieved.
Figure 1 shows such an assignment of different objectives and target levels. The main objectives of the program relate to the reduction of environmental impacts caused by waste generation throughout the value chain (target level I). Appropriate ways to achieve these reductions are, in particular, the reduction of waste and pollutant content in products (which will eventually become waste) relating to target level II in the figure. With regard to the use phase of products distribution also has to be taken into account for the prevention of waste, for example in the food sector.

Quantitative indicator systems for waste prevention

Indicators and benchmarks for waste prevention are, of course, an intensively discussed topic (see Bio Intelligence Service, 2009). A variety of indicator systems have been developed, which differ significantly in topics, target groups and scope. Nevertheless, there are huge knowledge gaps in their application: ‘Very little is understood about how to monitor and evaluate waste prevention particularly among local authority waste managers who are most likely to implement intervention campaigns’ (Sharp et al., 2010).

Most existing approaches to the evaluation of waste-prevention measures are based on waste statistics and focus on the amount of waste per capita or per household. Sharp et al. (2010) have undertaken a comparative study with regard to evaluations of waste prevention programs. Their results show that—if evaluations exist at all—they focus on tonnage data (with reductions of 0.5 kg and 1.87 kg of waste per week per household in the selection of studies they analyzed).

On behalf of the European Commission, Bio Intelligence Service (2009) has conducted a study on indicators already in use for waste prevention in the EU member states using a questionnaire for the responsible authorities in the member states. The indicators investigated also focus primarily on the generation of specific waste streams, for example:

- waste disaggregated to relevant main waste streams;
- household-related waste (kg per capita per year, total generation in households, etc.);
- amount of construction waste going to landfill waste;
- amount of organic waste going to landfill.

All these waste-based approaches for the ‘measurement’ of waste prevention focusing on waste quantities are always confronted with a general problem: How to measure something that does not exist because it has been prevented?

Limitations of waste-based indicator systems

Every statement about the success of a specific waste prevention measure requires comprehensive assumptions about what amount of waste would have been generated without the measure. For example, measures focusing on the design of durable goods have to take into account that effects occur with time delays depending on the products’ lifetimes (see Bifa, 2004).

Because prevention is closely linked to complex consumption patterns, even cultural changes, such as increasing environmental awareness, changes in the average size of households or changes in the industrial structure of an economy, are relevant factors for the interpretation of changes in the generation of waste—it is more or less impossible to isolate the effect of specific waste prevention measures in this complex system. This must be considered, in particular, in international comparisons of policies and

![Figure 1](image-url). Target levels of waste prevention in the life cycle of products. Source: Dehoust et al. (2011).
their potential transferability. The guidelines of the European Commission on waste prevention (Arcadis et al., 2010) also point to the particular problem of data availability in the area of prevention: as waste statistics focus mainly on the treatment and fate of wastes, they are often of limited value for prevention of waste because they don’t give sufficient information about their origins or reasons for their generation.

Empirical analyses have shown that on the aggregated national level neither the volume of waste or pollutants nor the use of natural resources can be linked in a serious and significant way to waste prevention programs because beyond the different measures the changes in the economic framework conditions dominate the generation of waste (see Bel, 2010). Looking at the causes of waste generation, the Organisation for Economic Co-operation and Development (OECD) has analyzed that consumption expenditures for household waste and the economic growth for construction and demolition wastes are the most relevant drivers (see OECD, 2004). This has been proved clearly by the decrease of waste generation in 2009 and 2010, which is clearly not a result of prevention measures, but to the global economic crisis.

**Path dependencies and their relevance for the prevention of waste**

Waste prevention is often assumed to be a win–win situation for all stakeholders (see Bio Intelligence Service, 2009), but, nevertheless, the amounts of wastes are increasing: ‘Although waste prevention has been the paramount objective of both national and EU waste management policies for many years, limited progress has been made in transforming this objective into practical action. Neither the Community nor the national targets set in the past have been satisfactorily met’ (European Commission, 2012).

Taking the case study of the socio-technical waste regime in German metropolitan regions this article focuses on an aspect for the success or failure of waste prevention measures or programs that so far has been widely neglected in the discussion about the evaluation of policy interventions aimed at the avoidance of waste: the relationship between physical waste infrastructures, actor constellations in waste governance and incentives for waste prevention. Based on interviews with decision-makers in waste policies, waste management administration and waste management companies, it must be mentioned that how we progress towards waste prevention can actually be measured in a comprehensive way by extending the evaluation of waste prevention on aspects of path dependencies in the ways the society deals with waste. Up to this point the actors of the waste regime regard treatment and prevention of waste as completely separate policy fields. From a static perspective this statement is, of course, absolutely correct: waste that ends up in treatment facilities can no longer be prevented. This perspective changes by looking at the management of waste beyond treatment technologies and technical artifacts, and from the perspective of socio-technical regimes as a part of the comprehensive management of resources along their entire life cycle.

**The perspective of regimes and path dependencies**

Socio-technical regimes can be defined as ‘the whole complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, and institutions and infrastructures that make up the totality of a technology’ (Kemp et al., 1998). According to Konrad et al. (2004) such socio-technical regimes are developed and optimized not with regard to the technology, but to their societal function. Thus, the prevention of waste has a fundamentally different function than the environmentally-friendly, reliable and cheap treatment of waste.

The conceptualization as a regime indicates that these various components are connected with each other in many ways. All regime components interact in these systems—changes of a single artifact will affect the whole system so that its specific characteristics do not derive from the individual parts, but from their systemic context. With regard to waste management this is relevant because the high-quality treatment of waste, which has minimized the direct environmental impacts, reduces the pressure in the overall system to avoid waste at the start.

The concept of regimes is ‘to raise awareness for path dependencies, steady trends and dynamics of change’ (Konrad et al., 2004). From such a system theory-based perspective path dependencies are a central obstacle for innovation because they prevent optimal solutions prevailing in the market despite environmental and economic benefits. Path dependencies can be understood as ‘self-reinforcing feedback loops’ meaning that once a decision for a system design is made, this is favored over all other, as well as future alternatives. This does not exclude any evolutionary process of variation, but the diffusion of better solutions is also disadvantaged. In extreme cases a so-called lock-in of a system is reached, limiting the system’s capability for innovation completely; thus, the chosen technology path will be continued unconditionally.

Factors leading to such effects are economies of scale, which, on one hand, lower average costs in centrally-organized systems. On the other hand, such systems are usually characterized by enormous sunk costs: highly specific investments that would massively decrease in value when technical development paths are changed because, owing to their specific characteristics, it would be extremely costly to adapt them to new technologies and changed usage patterns. Waste incineration plants can be seen as sunk costs in the waste regime, but the same is true, for example, for standards, norms and routines, on which a society agreed by choosing certain development paths. Thus, not only economic considerations, but also legal regulations can make it difficult to change a regime, for example in the form of long-term contracts, as they are often concluded in the waste management sector.

Innovations are particularly slowed down when the decision-maker fears that a regime change would cause an irreversible loss of know-how: if the innovations fails, this would mean that a return would be possible only at very high costs (see Kemp et al., 1998). Actors on the supply side of technical regime services fear
the depreciation of their core competencies through radical innovations. At the same time there is a high degree of risk aversion on the side of technology users: as long as there is no or only little experience with the new technology, they will rely on established routines and systems, in spite of the high-presumed advantages of new technologies.

**The German market for waste incineration**

More or less all these different aspects of path dependencies can be found in the management of waste as obstacles for the success of waste prevention. The industry and consumers often have no incentives to prevent waste as long as the waste regime offers cheap alternatives—as required by waste legislation, which still focuses on sufficient capacities to get rid of waste. These mechanisms and causal relations can be highlighted by the case study of overcapacities in the German incineration market.

The technical infrastructure of waste management in central Europe is characterized mainly by a variety of waste incineration plants: ‘We find ourselves in a time period in which the incineration of waste, which cannot be recovered, is most widely accepted’. (Mineur, 2007) This is especially true for Germany where the landfilling of untreated waste has been banned since 2005. Waste incineration plants are characterized by their particular capital intensity: incinerators, such as those Cologne, Frankfurt or Stuttgart with an annual capacity of 400,000 t, have resulted in construction costs of hundreds of million Euros. These artifacts of classical waste infrastructures are designed and planned for decades, with the majority of the first generation of incinerators built in the 1970s still in operation in Germany. This high level of investment and the associated long payback periods are identified as one key barrier to serious waste prevention, even by stakeholders in waste management. Both private and public investors have an interest in using these existing infrastructures for as long as possible in order to achieve high returns from written-off investments. The very capital-intensive waste incinerators are extremely irreversible investments; they cannot be used for any other purpose and could be sold only for scrap value. A public waste manager mentioned: ‘They are actually screaming for waste’ (personal communication).

Although investments in incineration capacity are usually undertaken according to economic criteria and are based mostly on long-term contracts with ‘bring or pay’ clauses to ensure a sufficient utilization, the total capacity in Germany is generally regarded as exceeding actual needs. In particular, the private recycling industry complains about ‘bad investments of the municipal waste management companies’ (EUWID, 2010) in the region of approximately €4 billion. In addition to the German surplus capacities, new incineration plants in the Netherlands and Poland influence the German market. One of the main reasons for this abundance of incineration capacity is the uncoordinated parallel planning for conventional incinerators and new substitute fuel power [refuse-derived fuel (RDF)] plants. RDF power plants have gained in importance dramatically since 2005—on one hand because of high prices for waste incineration after the landfill ban and, on the other hand, because of the significantly increased costs for primary energy sources. In contrast to conventional waste incineration facilities RDF plants are relatively small, steam-power plants in which medium- to high-calorific waste is incinerated and the resulting energy is used by combined heat and as process steam, or district heating for industrial facilities. The RDF business model is thus based on three pillars: the operators accept deliveries of waste against payment, burn it along with their own waste, and save energy costs. In contrary to the classic German waste incineration market, RDF plants are almost exclusively run by private operators, mostly industries with a very high energy demand and with suitable waste to burn, for example the paper industry (NABU, 2009).

In a very short time licensing procedures for RDF power plants with capacity of nearly 5 million Mg have been granted. Although some of these project have been cancelled because of the world economic crisis, more plants are in currently in operation or construction than RDF input materials will be available; the forecasts assume that the generation of high-calorific industrial wastes will soon decrease considerably in Germany (see Alwast, 2009). This decline is inter alia caused by efforts to increase resource efficiency in the industry. It should be noted that waste incineration and RDF are not completely separate markets. These amounts of waste are now missing in the incinerators. Until 2015 this results—taking into account normal waste incineration plants, RDF plants and co-incineration—in an overcapacity of around 7%, even if expiring capacity will not be renewed (otherwise it is about 15%; see NABU, 2009). A study conducted on behalf of the German Ministry of Economics revealed that in 2007 only 66.3% of the incineration capacity in Germany was used (GIB/ARGUS, 2009).

Thus, it can be expected that the decline in prices for waste incineration will continue in the future. Henkes (2010) points out that the landfill ban and uncoordinated investments in incineration plants ‘have contributed to overcapacities in thermal waste treatment plants that have become so large that the recycling companies are missing of the necessary waste for recycling’. Owing to the very high share of fixed costs in waste incineration plants they can be operated at dumping prices—even if this might not be profitable in the long run, it results in lower losses than if they are operated at reasonable prices with lower utilization. Owing to the fierce competition for commercial waste in particular, prices for the incineration of one ton of waste have decreased in some parts of Germany to €60 and even down to €30 euros in the Netherlands (Henkes 2010). For high-caloric waste as input for RDF plants it has been reported that some companies have even paid for this type of waste in order to maintain their production of electricity and heat production. This low price level for waste incineration has caused a wave of insolvencies in the medium-sized recycling industry because for many waste fractions it is now cheaper to burn them instead of recovering the materials (see EUWID, 2010). However, the incentive structures for waste prevention depend on a certain level of disposal costs in order to make it profitable for the companies to change their...
production routines towards less waste-intensive technologies. It is not only the absolute price level, but the sharp price fluctuations in waste incineration that represent a massive barrier to waste prevention because they undermine the strategic change in the industry towards resource efficiency.

Process-oriented indicators

As described, sunk costs in the form of investments in technical infrastructure can be one of many possible causes for path dependencies by which the prevention of waste gets even more complicated owing to the success of waste management in the past. It shows, in particular, that under these circumstances it can be perfectly rational for the actors involved to continue to rely on the incineration of waste. For decades waste management as an end-of-pipe approach has been optimized at all steps. The various regime components, such as technical regulations, consumer behavior, education and training, etc., have adapted to each other and have established a regime that shows significant tendencies of inertia. With regard to the question of NWPPs and the development of suitable indicators, this requires a new approach that complements result-oriented indicators, such as the described waste generation per capita or sector-specific waste intensities with information and indicators that focus on the process of waste prevention and that are linked to the development of innovation and ongoing changes in this sector. New policies are needed that enable the huge variety of innovative projects, approaches and technologies for waste prevention to develop, to learn and to build-up the necessary networks to get fit for the competition with the existent waste regime.

With regard to consumption patterns, the first ideas and concepts on which such an approach can build have already been discussed inter alia within the Interreg IVC project Pre-Waste where result- and impact-oriented, but also so-called resource-oriented, indicators for waste prevention have been developed. These indicators include all types of costs and efforts (both in monetary and non-monetary values), which are invested in a specific waste prevention measure, for example spent working hours, equipment, the use of communication devices and media, etc. (see Bel, 2010). A recent study on behalf of DG Environment mentions so-called ‘output indicators’ which include the number of leaflets or the use of other communication tools and also the existing level of knowledge and interest in eco-efficiency in certain industries (see Arcadis et al., 2010). The great advantage of this type of indicator is the close connection to the measure itself—the disadvantage is the often weak or absent direct reference to positive effects on the prevention or avoidance of environmental impacts. The use of representative pilot and control groups can provide a suitable basis for the evaluation of waste prevention measures (see Sharp et al., 2010). In Germany, aspects such as the relevance of waste prevention for consumption behavior could be integrated into representative surveys carried out every two years since 1996 in the name of the Federal Environment Agency.

So far, less attention has been paid to indicators for the production phase. Path dependencies particularly affect the implementation of innovation, which has to be seen as the foundation of future prevention successes, particularly in the field of production patterns. Frondel et al. (2004) point out that because of the dominance of end-of-pipe technologies and regulations, Germany had the lowest share of investment in cleaner production technologies among the OECD countries. Resource efficiency has clearly gained importance in the last few years, but a study on behalf of the German Ministry of Economics also shows that only 12.9% of the waste management companies are planning to take investment at all in the next 3 years (GIB/ARGUS, 2009). Also, waste management companies with an annual turnover of more than €50 million invest only 2% in research and development (BMU, 2009).

According to statistical analysis of investments in the German manufacturing industry based on a survey of 10,000 companies (see Destatis, 2011), a total of €5,576 billion has been invested in the protection of the environment (investments that are exclusively or primarily aimed at protecting the environment from harmful impacts caused by production processes). Ten and a half percent of these investments are related to the reduction and prevention of waste generation. Based on the German law on environmental statistics (Umwelstastistikgesetz) these investments can be differentiated into additive and integrated types of investments. The former is separated from the actual production process aimed at the reduction of impacts by waste already generated and the latter is aimed at the prevention of waste or its hazardous components before it is generated at all. In Germany in 2009, 13.7% of these financial resources has been invested in integrated measures for environmental protection related to the field of waste.

Table 1 shows the most relevant sectors with a special focus on the processing industry with regard to environmental investments, specific waste related investments and their share of integrated measures for waste prevention. The results show significant differences between the different sectors. Whereas the paper and cardboard industry still seems to focus on end-of-pipe solutions, the chemical industry invests a three-times-larger share into integrated measures of waste prevention.

Conclusions

The article has discussed the need for process-oriented indicators for waste prevention. As part of the development of NWPPs such indicators aim at the relevance of different barriers that have to be overcome in order to make prevention an effective top priority in the waste hierarchy. With regard to path dependencies caused by sunk costs in end-of-pipe waste infrastructures, the absolute amount of integrated environmental investments, as well as their share of the total waste-related investments, can be seen as indicators for the level of innovation activities aimed at waste prevention. Sector-specific indicators for the production phase could be used as benchmarks and highlight differences in the need for policy interventions. The German case study highlights that further research is needed in the field of demand-side management for waste infrastructures. Indicators for waste prevention could also be useful parameters in avoiding over-capacity in the lower steps of the waste hierarchy. Nevertheless, more participation of
relevant waste producers is needed in infrastructure planning and waste prevention potentials have to be taken into account systematically from the beginning.

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Table 1. Sector-specific environmental investments in the processing industry, Germany 2009

<table>
<thead>
<tr>
<th>Industry sectors, WZ 2008</th>
<th>Total environmental investments, in 1000 euros</th>
<th>Environmental waste investments, in 1000 euros</th>
<th>Integrated environmental waste investments, in 1000 euros</th>
<th>Sector-specific share of integrated waste investments</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 Metal industry</td>
<td>164.363</td>
<td>24.931</td>
<td>8.109</td>
<td>32.5%</td>
</tr>
<tr>
<td>20 Chemical industry</td>
<td>291.218</td>
<td>22.033</td>
<td>12.806</td>
<td>58.1%</td>
</tr>
<tr>
<td>29 Automotive industry</td>
<td>158.448</td>
<td>8.301</td>
<td>2.869</td>
<td>34.6%</td>
</tr>
<tr>
<td>17 Paper and cardboard</td>
<td>71.428</td>
<td>7.972</td>
<td>1.524</td>
<td>19.1%</td>
</tr>
<tr>
<td>22 Rubber and plastics industry</td>
<td>43.794</td>
<td>7.156</td>
<td>3.499</td>
<td>48.9%</td>
</tr>
<tr>
<td>10 Food industry</td>
<td>117.104</td>
<td>6.047</td>
<td>3.156</td>
<td>52.2%</td>
</tr>
<tr>
<td>28 Machinery industry</td>
<td>90.212</td>
<td>5.273</td>
<td>1.571</td>
<td>29.8%</td>
</tr>
<tr>
<td>Others</td>
<td>681.091</td>
<td>35.570</td>
<td>9.876</td>
<td>27.8%</td>
</tr>
<tr>
<td>Total</td>
<td>1,617.638</td>
<td>117.283</td>
<td>43.410</td>
<td>37.0%</td>
</tr>
</tbody>
</table>

Source: Destatis (2011), own calculations.


